RECLAMATION

Managing Water in the West

Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project

Central Valley Project, California
Mid-Pacific Region

Final Biological Assessment

October 2019

U.S. Department of the Interior
Bureau of Reclamation

Mission Statements

The mission of the Department of the Interior is to protect and manage the Nation's natural resources and cultural heritage; provide scientific and other information about those resources; and honor its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated 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.

Table of Contents

List of Figures

List of Tables

List of Abbreviations / Acronyms

Abbreviation	Definition
°C	Celsius
°F	Fahrenheit
7DADM	7 day average daily maximum
ACID	Anderson Cottonwood Irrigation District
AFRP	Anadromous Fish Restoration Program
AFSP	Anadromous Fish Screen Program
ARG	American River Group
AT	acoustic tag
AUCo	AUC of the overlapping portions
AUCt	area under the curve
Banks Pumping Plant	Harvey O Banks Pumping Plant
Bay-Delta	San Francisco Bay/Sacramento-San Joaquin- Delta
BMPs	Best Management Practices
BO	Biological Opinion
Caltrans	California Department of Transportation
CAMT	Collaborative Adaptive Management Team’s
CCC	Central California Coast
CCF	Clifton Court Forebay
CCR	Clear Creek
CCWD	Contra Costa Water District
CDFW	California Department of Fish and Wildlife
CESA	California Endangered Species Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CM1	conceptual model
CNDDB	California Natural Diversity Database
CNFH	Coleman National Fish Hatchery
CNOR	Candidate Notice of Review
CNPS	California Native Plant Society
CNRA	California Natural Resources Agency
COA	Coordinated Operations Agreement
COS	Current Operations
CSAMP	Collaborative Science and Adaptive Management Program
CV	Central Valley
CVO	Central Valley Operations Office
CVP	Central Valley Project
CVPA	Central Valley Project Act
CVPCP	Central Valley Project Conservation Program
CVPIA	Central Valley Project Improvement Act
CVSMP	Central Valley Steelhead Monitoring Program

Abbreviation	Definition
CWT	Coded Wire Tag
DADM	Daily Average Daily Maximum
DAT	Daily Average Temperature
DCC	Delta Cross Channel
Delta	Sacramento-San Joaquin Delta
DFW's	Department of Fish and Wildlife’s
DJFMP	Delta Juvenile Fish Monitoring Program
DLO	driver-linkage-outcome
DMC	Delta-Mendota Canal
DO	dissolved oxygen
dph	days post hatch
DPS	distinct population segment
DWR	Department of Water Resources
EATSM	Enhanced Acoustic Tag Salmonid Monitoring
eDNA	Environmental DNA
EDSM	Enhanced Delta Smelt Monitoring
EFH	Essential Fish Habitat
EMP	Environmental Monitoring Program
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FCCL	Fish Conservation and Culture Laboratory
FERC	Federal Energy Regulatory Commission
FMS	Flow Management Standard
FMWT	Fall Midwater Trawl
FR	Federal Register
FRFH	Feather River Fish Hatchery
FRWP	Freeport Regional Water Project
GCID	Glenn Colusa Irrigation District
HAB	armful algal blooms
HAPC	Habitat Areas of Particular Concern
HFC	High Flow Channel
HLT	Middle River at Holt
HORB	Head of Old River Barrier
HRP	Habitat Restoration Program
IEP	Interagency Ecological Program
Intertie	Delta-Mendota Canal/California Aqueduct Intertie
IPaC	Information for Planning and Conservation
IPO	Interim Plan of Operations
ISP	Invasive Spartina Project
JSATS	Juvenile Salmon Acoustic Telemetry System
km	kilometers
LFC	Low Flow Channel

Abbreviation	**Definition**
LOBO	Long-term Operations Biological Opinions
LSNFH	Livingston Stone National Fish Hatchery
LSZ	low-salinity zone
M&I	municipal and industrial
MAF	million acre-feet
MHHW	mean higher high water
MIDS	Morrow Island Distribution System
MMPA	Marine Mammal Protection Act
MOA	Memorandum of Agreement
MRR	Minimum Release Requirement
Napa County FC&WCD	Napa County Flood Control and Water Conservation District
NBA	North Bay Aqueduct
NMFS	National Marine Fisheries Service
NMI	New Melones Index
NOAA	National Oceanic and Atmospheric Administration
O&M	operations and maintenance
OCO	Operations Control Office
OID	Oakdale Irrigation District
OMR	Old and Middle River
OTMI	Oroville Temperature Management Index
PA	proposed action
PAHs	polyaromatic hydrocarbons
PBDEs	polybrominated diphenyl ethers
PBFs	Physical and Biological Features
PBT	parentage based tagging
PCBs	polychlorinated biphenyls
PCEs	primary constituent elements
PFMC	Pacific Fishery Management Council
PG&E	Pacific Gas and Electric Company
PGS	Pittsburg Generating Station
ppt	parts per thousand
PSMFC	Pacific States Marine Fisheries Commission
RBDD	Red Bluff Diversion Dam
Reclamation	United States Department of the Interior, Bureau of Reclamation
RHJV	Riparian Habitat Joint Venture
RPA	reasonable and prudent alternative
RRDS	Roaring River Distribution System
RSFS	Rock Slough Fish Screen
RST	rotary screw trap
SacPAS	Central Valley Prediction and Assessment of Salmon
SAIL	Salmon and Sturgeon Assessment of Indicators by Lifestage
SCARF	San Joaquin River Conservation and Research Facility

Abbreivation	**Definition**
SCDD	Spring Creek Debris Dam
SCWA	Solano County Water Agency
SDWSC	Sacramento Deepwater Ship Channel
sf	square feet
SJRA	San Joaquin River Agreement
SJRRP	San Joaquin River Restoration Program
SKT	Spring Kodiak Trawl
SMPA	Suisun Marsh Preservation Agreement
SMSCG	Suisun Marsh Salinity Control Gates
SONCC	Southern Oregon/Northern California Coast
SRCD	Suisun Resource Conservation District
SRP	Stepped Release Plan
SRS	Sacramento River Settlement
SRTTG	Sacramento River Temperature Task Group
SRWTP	Sacramento Regional Wastewater Treatment Plan
SSJID	South San Joaquin Irrigation District
SST	Salmonid Scoping Team
Suisun Marsh Plan	Suisun Marsh Habitat Management, Preservation, and Restoration Plan
SWP	State Water Project
SWPAO	State Water Projects Analysis Office
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
TBP	Temporary Barrier Project
TCD	Temperature Control Device
TFCF	Tracy Fish Collection Facility
TMDLs	total maximum daily load programs
TNS	Townet Survey
TOC	top of conservation pool
Trinity ROD	Trinity River Record of Decision
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WCM	Water Control Manual
WDRs	Waste Discharge Requirements
WERC	Western Ecological Research Center
WIIN Act	Water Infrastructure Improvements for the Nation Act
WOA	Without Action
WQCP	Water Quality Control Plan
WUA	Weighted Usable Area

Chapter 1 Introduction

On August 2, 2016, the United States Department of the Interior, Bureau of Reclamation (Reclamation) and the California Department of Water Resources (DWR) jointly requested the Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project (CVP) and State Water Project (SWP, or Project). The United States Fish and Wildlife Service (USFWS) accepted the reinitiation request on August 3, 2016, and the National Marine Fisheries Service (NMFS) accepted the reinitiation request on August 17, 2016. This biological assessment supports Reclamation's consultation under Section 7 of the Endangered Species Act (ESA) of 1973, as amended, and documents the potential effects of the proposed action on federally listed endangered and threatened species that have the potential to occur in the action area and critical habitat for these species. It also fulfills consultation requirements for the Magnuson-Stevens Fishery Conservation and Management Act of 1976 for Essential Fish Habitat (EFH).

Reclamation's mission is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. Reclamation is the largest wholesale water supplier in the United States, and the nation's second largest producer of hydroelectric power. Its facilities also provide substantial flood control, recreation, and fish and wildlife benefits. In Northern California, Reclamation operates the CVP in coordination with DWR's operation of the SWP. The mission of DWR is to manage the water resources of California, in cooperation with other agencies, to benefit the state's people and to protect, restore, and enhance the natural and human environment.

The CVP consists of 20 dams and reservoirs that together can store nearly 12 million acre-feet (MAF) of water. Reclamation holds over 270 contracts and agreements for water supplies that depend upon CVP operations. Through operation of the CVP, Reclamation delivers water in 29 of California's 58 counties in the following approximate amounts: 5 MAF of water for farms; 600 thousand acre-feet (TAF) of water for municipal and industrial (M&I) uses (enough water to supply about 2.5 million people for a year); and 355 TAF of water for wildlife refuges. Reclamation operates the CVP under water rights granted by the State of California, including those intended to protect agricultural and fish and wildlife beneficial uses in the Sacramento–San Joaquin Delta (Delta). The CVP generates approximately 4.5 million megawatt hours of electricity annually on average.

The SWP's main facilities are Oroville Dam, the Harvey O Banks Pumping Plant (Banks Pumping Plant), and San Luis Reservoir. These facilities are operated and connected by a network of canals, aqueducts, and other facilities of the SWP to deliver on average approximately 2.6 MAF of contracted water supplies annually. DWR holds contracts with 29 public agencies in the Feather River Area, North Bay Area, South Bay Area, San Joaquin Valley, Central Coast, and Southern California for water supplies from the SWP. Water stored in the Lake Oroville facilities, along with excess water available in the Delta, is captured in the Delta and conveyed through several facilities to SWP contractors. Through the SWP, DWR provides flood control below Oroville Dam and water for agricultural, M&I, recreational, and environmental purposes. DWR conserves water in Lake Oroville and makes releases to meet regulatory obligations and agreements tied to the operations of the SWP. Releases also serve three contractors in the Feather River area and two contractors from the North Bay Aqueduct. DWR pumps water at the Banks Pumping Plant in the Delta for delivery to the remaining 24 public water agencies in the SWP service areas south of the Delta.

The proposed action analyzed in this consultation centers on a Core Water Operation that provides for Reclamation and DWR to operate the CVP and SWP for water supply and to meet the requirements of State Water Resources Control Board (SWRCB) Water Right Decision 1641 (D-1641), along with other project purposes. The Core Water Operation consists of operational actions that do not require subsequent concurrence or extensive coordination to define annual operation. The proposed action also includes conservation measures designed to minimize or reduce the effects of the action on listed species. In addition, this biological assessment and resulting consultation evaluates actions that will require further development and may change during repeated implementation as more information becomes available (i.e., “collaborative planning”). Collaboratively planned actions will require additional coordination prior to implementation through program-specific teams established by Reclamation and DWR with input and participation from partner agencies and stakeholders.

In 2015, the USFWS and NMFS (collectively, the Services) promulgated an addition to the regulations on Interagency Cooperation (50 Code of Federal Regulations [CFR] § 402) that is relevant to this consultation. The regulation added a “mixed programmatic action” for the purpose of issuing an Incidental Take Statement for take authorization. The regulation describes a mixed programmatic action as “a Federal action that approves action(s) that will not be subject to further Section 7 consultation, and also approves a framework for the development of future action(s) that are authorized, funded, or carried out at a later time, and any take of a listed species would not occur unless and until those future action(s) are authorized, funded, or carried out and subject to further Section 7 consultation.”

This distinction allows for an Incidental Take Statement to be issued for those parts of the action that are specific enough that the Services can meet the regulatory burden of reasonable certainty. Where that degree of certainty is not met, the Services may analyze the future action to determine whether jeopardy of a listed species or destruction or adverse modification of designated critical habitat is likely to result from the entirety of the proposed action, and make an overall conclusion for the listed species and designated critical habitat. Once sufficient detail is available for future actions, Reclamation agrees to initiate targeted Section 7 consultation on these actions.

The proposed action includes immediate site-specific actions, as well as future actions that may be subject to subsequent site-specific Section 7 consultation. This aligns with the description of a “mixed programmatic action,” and Reclamation proposes to consult on the overall action as such.

On December 12, 2018, the California Natural Resources Agency (CNRA) presented a framework for Voluntary Agreements to the SWRCB in response to proposed Bay-Delta Water Quality Control Plan (WQCP) amendments. This framework was the result of years of coordination between CNRA, Reclamation, and several public water agencies in California. The SWRCB is currently considering the Voluntary Agreements as part of its proceeding, with upcoming dates in 2019 for deliberation. If approved, the Voluntary Agreements would provide additional flows, facility improvements, and habitat restoration that benefit listed species, with a proposed funding mechanism to implement these enhancements. Reclamation and DWR support the Voluntary Agreements and continue to participate in their development. Preliminary analysis indicates that when combined with the Core Water Operation proposed in this consultation, the Voluntary Agreements are beneficial to listed species and critical habitat. However, Reclamation is not consulting on Voluntary Agreements in this biological assessment.

1.1 Background

In this biological assessment, consistent with the ESA and applicable regulations, Reclamation separates the proposed action from the environmental baseline in order to determine whether the action is likely to adversely affect ESA-listed species. Reclamation’s analysis is informed by the complex history of water and infrastructure development in California. The environmental baseline includes impacts to ESA-listed species resulting from the original construction and development of dams in the action area as well as decades of man-made and and other alterations to fish species that occurred during the last 300 years (as described below).

When developing and assessing the potential effects of the proposed action, Reclamation considers the context of the complex history of water and land development in California in order to separate the proposed action from the environmental baseline and determine whether it is likely to adversely affect ESA-listed species.

Water storage and diversion in California began in 1772, with a 12-foot high dam on the San Diego River. The discovery of gold in the Sierra Nevada in 1849 intensified the human development of the Central Valley. Natural water flows were diverted to aid in hydraulic mining, and the Sacramento River and San Joaquin River watersheds were polluted with contaminants originating from historic and active mine sites. Major flood protection efforts began in 1840 with levee construction along Grand Island. Revetments and bank armoring, and other protection measures to prevent erosion along the levees, caused and continue to cause channel narrowing and incision and prevent channel migration. Levees have also isolated former floodplains from the river channel, preventing access for rearing for juvenile salmonids.

Commercial harvest of salmon began in the 1850s (CDFG 1929) and gill net salmon fisheries became well established in the lower Sacramento and San Joaquin Rivers by 1860. In 1910, there were 10 million pounds of commercial salmon catch; that yield declined to 4.5 million pounds by 1919, when the last inland cannery closed (CDFG 1929).

Striped Bass (*Morone saxatilis*), introduced from the East Coast in the 1880s, supported a commercial fishery for almost 50 years and currently provide a recreational fishery. Striped Bass and other introduced species prey upon listed species. A Striped Bass population of 1,000,000 could consume 9 percent of out-migrating Winter-Run Chinook Salmon (*Oncorhynchus tshawytscha*) based on Bayesian population dynamics modeling (Lindley and Mohr 2003). Other invasive animal and plant species alter sediment dynamics, compete for resources, change the physical habitat, and disrupt the foodweb. Invasive clams were first introduced in the 1940s, and the invasion of the Amur River clam (*Potamocorbula amurensis*) in 1986 fundamentally altered the Delta foodweb. These filter feeders significantly reduce the phytoplankton and zooplankton concentrations in the water column, reducing food availability for native fishes, such as Delta Smelt (*Hypomesus transpacificus*) and young Chinook Salmon.

1.1.1 Construction and Operation of the CVP and SWP

Congress authorized Reclamation to develop the CVP for the public good of delivering water and generating power, while providing flood protection to downstream communities and protecting water quality for water users within the system. Congress envisioned a large, complex project integrated across multiple watersheds that Reclamation would operate to ensure the most beneficial use of water released into the system.

The 1935 Rivers and Harbors Act authorized Reclamation to take over the CVP from the State of California and its initial features were authorized for construction. In 1937, the Rivers and Harbors Act reauthorized the CVP under Reclamation Law. The 1937 Act and subsequent authorizations completed Friant Dam in 1942, Shasta Dam in 1944, Folsom Dam in 1956, San Luis Dam in 1967, Trinity Dam in 1962, and New Melones Dam in 1978. Today, Reclamation operates the CVP consistent with the CVP’s federally authorized purposes, including:

- river regulation;
- improvement of navigation;
- flood control;
- water supply for irrigation and municipal and industrial uses;
- fish and wildlife mitigation, protection, and restoration;
- power generation; and
- fish and wildlife enhancement.

The Burns-Porter Act, approved by the California voters in November 1960 (Water Code [Wat. Code] §§ 12930–12944), authorized issuance of bonds for construction of the SWP. DWR's authority to construct state water facilities or projects is derived from the Central Valley Project Act (CVPA) (Wat. Code § 11100 et seq.), the Burns-Porter Act (California Water Resources Development Bond Act) (Wat. Code §§ 12930–12944), the State Contract Act (Pub. Contract Code § 10100 et seq.), the Davis-Dolwig Act (Wat. Code §§ 11900–11925), and special acts of the State Legislature.

In 1978, the SWRCB issued Water Rights Decision 1485 (D-1485). D-1485 required spring outflow and set salinity standards in the Delta while setting standards for the diversion of flows into the Delta during winter and spring.

In 1986, Public Law 99-546 directed the Secretary of the Interior to execute the Coordinated Operations Agreement (COA). The COA defined CVP and SWP facilities and their water supplies, coordinated operational procedures, identified formulas for sharing joint responsibility for meeting Delta standards (such as those in D-1485), identified how unstored flow was shared, and established a framework for exchange of water and services between the projects.

In 1992, Public Law 102-575 included Title 34, the Central Valley Project Improvement Act (CVPIA) that refined water management for the CVP. The CVPIA added fish and wildlife mitigation, protection, and restoration as a project purpose with the same priority as water supply, and also added fish and wildlife enhancement as a project purpose with the same priority as power generation. In addition, the CVPIA prescribed a number of actions to improve anadromous fish and provided for other fish and wildlife benefits.

In 1999, the SWRCB issued D-1641, obligating the CVP and SWP to the 1995 Bay-Delta Water Quality Control Plan. Revised in 2000, D-1641 provided standards for fish and wildlife protection, M&I water quality, agricultural water quality, and Suisun Marsh salinity. A new export to inflow ratio limited exports at Banks and Jones Pumping Plants to 35 percent of total Delta inflow from February through June, and 65 percent of total Delta inflow from July through January. Additionally, flow and salinity requirements on the San Joaquin River near Vernalis were imposed.

1.1.2 Current Requirements

The coordinated long-term operations of the CVP and SWP are currently subject to the 2008 and 2009 biological opinions issued pursuant to Section 7 of the ESA. Each of these biological opinions included Reasonable and Prudent Alternatives (RPAs) to avoid the likelihood of jeopardizing the continued existence of listed species, or the destruction or adverse modification of critical habitat that were the subject of consultation.

The 2008 USFWS Biological Opinion concluded that the long-term operations of the CVP and SWP were likely to jeopardize the continued existence of Delta Smelt and were likely to destroy or adversely modify their designated critical habitat. Therefore, an RPA was included with five components comprising three types of actions to avoid jeopardy:

- Reduce the magnitude of net reverse Old and Middle River (OMR) flows to reduce Delta Smelt entrainment;
- Implement a “Fall X2” standard requiring that the location of the low-salinity zone (defined as 2 parts per thousand isohaline) be located at no greater than 46 and 50 miles (74 and 81 kilometers [km]) from the Golden Gate Bridge in September, October, and November of wet and above normal years, respectively, to improve rearing conditions for Delta Smelt; and
- Implement 8,000 acres of tidal restoration in Suisun Marsh and/or the north Delta to provide suitable habitat for Delta Smelt.

The OMR and Fall X2 actions have been implemented to various degrees, and portions of the 8,000 acres of tidal restoration are currently in the planning, development, or construction stages.

The 2009 NMFS Biological Opinion concluded that the long-term operations of the CVP and SWP were likely to jeopardize the continued existence of Sacramento River Winter-Run Chinook Salmon, Central Valley Spring-Run Chinook Salmon, California Central Valley Steelhead (*Oncorhynchus mykiss*), Southern distinct population segment (DPS) of North American Green Sturgeon (*Acipenser medirostris*), and Southern Resident DPS of Killer Whale (*Orcinus orca*). In addition, it concluded that the long-term operations of the CVP and SWP were likely to destroy or adversely modify designated critical habitat for Sacramento River Winter-Run Chinook Salmon, Central Valley Spring-Run Chinook Salmon, California Central Valley Steelhead and proposed (subsequently designated) critical habitat for the Southern DPS of North American Green Sturgeon. Therefore, an RPA was included consisting of a suite of actions that addressed Delta and upstream conditions throughout the CVP and SWP to avoid jeopardy of these species and the destruction or adverse modification of critical habitat for these species.

Several components of the NMFS RPA have been implemented or are in the planning stages. Examples include Delta operational changes implemented since 2009 intended to reduce entrainment loss of Chinook Salmon and Steelhead; current planning efforts for the restoration of the Yolo Bypass; changes in water operations to improve temperature conditions for aquatic resources in the Sacramento, American, and Stanislaus Rivers; adjustments to the operations of the Suisun Marsh Salinity Control Gates and the Delta Cross Channel (DCC); investigation into the efficacy of non-physical barriers in the Delta to improve salmonid survival; upstream habitat improvement projects; and a host of monitoring activities, studies, and investigations to better understand the ongoing effects of CVP and SWP operations.

1.1.2.1 *Mitigation Measures Included in the 2009 State Water Project Longfin Smelt Incidental Take Permit*

The 2009 SWP Longfin Smelt (*Spirinchus thaleichthys*) Incidental Take Permit (ITP) was issued by the California Department of Fish and Wildlife (CDFW) on February 23, 2009. The ITP was extended by 1 year on December 31, 2018, subject to DWR’s compliance with and implementation of Conditions of Approval. Several conditions have the potential to affect species addressed in this biological assessment. Conditions include minimizing entrainment at Banks Pumping Plant (Conditions 5.1 and 5.2); minimizing entrainment at Morrow Island Distribution System in Suisun Marsh (Condition 6.1); improving salvage efficiencies (Conditions 6.2 and 6.3); maintaining fish screens at North Bay Aqueduct (NBA), Roaring River Distribution System (RRDS), and Sherman Island diversions (Condition 6.4); fully mitigating through the restoration of 800 acres of intertidal and associated subtidal wetland habitat in a mesohaline part of the estuary (Conditions 7.1–7.3); and monitoring and reporting (Conditions 8.1-8.5). Conditions 5.1 and 5.2 are being implemented through DWR's participation in the Smelt Working Group. Conditions 6.1 through 6.4 are currently being planned or implemented, and are in various stages of completion. Conditions 7.1 through 7.3 are being planned consistent with the planning for restoration required for the 2008 RPA described above. Additionally, the various monitoring programs required in Conditions 8.1–8.5 are being planned or implemented consistent with the settlement agreement associated with the permit.

1.1.2.2 *WIIN Act*

The Water Infrastructure Improvements for the Nation Act (WIIN Act) (Pub. L. 114–322, 130 Stat. 1628), is among the federal statutes that govern operation of the CVP and SWP. Section 4001 of the WIIN Act directs the Secretary of the Interior and the Secretary of Commerce to provide the maximum quantity of water supplies practicable to CVP contractors and SWP contractors by approving, in accordance with federal and applicable state laws, operations or temporary projects to provide additional water supplies as quickly as possible, based on available information. Although the duration of this biological assessment and the biological opinion(s) from this consultation may extend beyond the expiration of the WIIN Act, the congressional direction provided by the WIIN Act governs the preparation of the biological opinion(s) that will result from this ongoing Section 7 consultation. Moreover, the general principles that underlie the direction provided by Congress in section 4001 of the WIIN Act are consistent with the purposes of the proposed action and federal interests. In addition, the science and general principles behind sections 4002 and 4003 warrant incorporation into the proposed action to govern operations of the CVP and SWP beyond expiration of the WIIN Act.

Section 4004 provides for cooperation with state and local agencies to resolve water resource issues in concert with conservation of endangered species, consistent with the ESA. Public water agencies in particular shall be informed by the consulting agency, the USFWS, or NMFS, of the schedule for preparation of the biological opinion at such time as the biological assessment is submitted to the consulting agency by the action agency; receive a copy of any draft biological opinion and have the opportunity to review that document and provide comment to the consulting agency through the action agency, which comments will be afforded due consideration during the consultation; have the opportunity to confer with the action agency and applicant, if any, about reasonable and prudent alternatives prior to the action agency or applicant identifying one or more reasonable and prudent alternatives for consideration by the consulting agency; and where the consulting agency suggests a reasonable and prudent alternative, be informed how each component of the alternative will contribute to avoiding jeopardy or adverse modification of critical habitat and the scientific data or information that supports each component of the alternative, and why other proposed alternative actions that would have fewer adverse water supply and economic impacts are inadequate to avoid jeopardy or adverse modification of critical habitat. Additional provisions provide for coordination with Collaborative Science and Adaptive Management Program (CSAMP) and quarterly stakeholder meetings.

1.2 Action Area

The action area is defined as all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). For the purposes of this biological assessment, the action area encompasses the following reservoirs, rivers, and the land between the levees adjacent to the rivers: (1) Trinity Reservoir and Trinity River downstream of Lewiston Reservoir to the Pacific Ocean; (2) Sacramento River from Shasta Lake downstream to and including the Sacramento–San Joaquin Delta; (3) Clear Creek from Whiskeytown Reservoir to its confluence with the Sacramento River; (4) Feather River from the FERC boundary downstream to its confluence with the Sacramento River; (5) American River from Folsom Reservoir downstream to its confluence with the Sacramento River; (6) Stanislaus River from New Melones Reservoir to its confluence with the San Joaquin River; (7) San Joaquin River from Friant Dam downstream to and including the Sacramento–San Joaquin Delta; (8) San Francisco Bay and Suisun Marsh; and (9) the nearshore Pacific Ocean on the coast from Point Conception to Cape Falcon in Oregon. The action area was derived by considering several factors to account for potential effects of the proposed action.

Shasta, Whiskeytown, Oroville, Folsom, and New Melones dams and reservoirs are part of the Central Valley Project operations, and therefore within the Action Area.

Reclamation diverts water from the Trinity River watershed to the Sacramento River through Carr Powerplant and Spring Creek tunnel. The amount of this diversion affects flows in both the Trinity and Sacramento Rivers, affecting both Sacramento River listed species and Trinity River listed species. Therefore, the Trinity River downstream of Lewiston Reservoir, as well as the lower Klamath River downstream of the Trinity River to the Pacific Ocean, is included in the action area.

DWR already has undergone Section 7 consultation on the operations of Oroville Dam on the Feather River through the Federal Energy Regulatory Commission's (FERC) process. Oroville Dam is part of the coordinated operations of the CVP and SWP; however, its effects have been addressed previously in the USFWS and NMFS biological opinions through the FERC process. This consultation addresses effects of Oroville operations that are downstream of the FERC boundary in the Feather River to the Delta, and coordinated effects with CVP operation.

Starting in 2016, Friant Dam and the Upper San Joaquin River have been hydrologically re-connected to the Delta through the release of San Joaquin River Restoration Program flows and recapture of those flows in the Lower San Joaquin River or Delta. Therefore, the San Joaquin River from Friant Dam downstream to and including the Sacramento–San Joaquin Delta is included in the action area.

The CVP and SWP affects the abundance of Central Valley Chinook Salmon originating from the Sacramento and San Joaquin Rivers, which is a prey species for Southern Resident Killer Whale, a listed species under the ESA. The range of Central Valley Chinook Salmon in the ocean is approximately from Point Conception to Cape Falcon, Oregon (Satterthwaite et al. 2013; Can J Fish Aq Sci). Therefore, while Southern Resident Killer Whale has a larger range, the effects of this action are limited to the range of Chinook Salmon. Hence, the action area is limited to portions of the California and Oregon coasts.

Figures 1-1 through 1-8 below show the extent of the action area. Figure 1-1 has grey boxes to indicate subsequent zoomed-in maps. On Figure 1-2, the grey box indicates the action area in the Pacific Ocean.

Figure 1-1. Overview of the CVP and SWP

Figure 1-2. Action Area—Coastal Extent

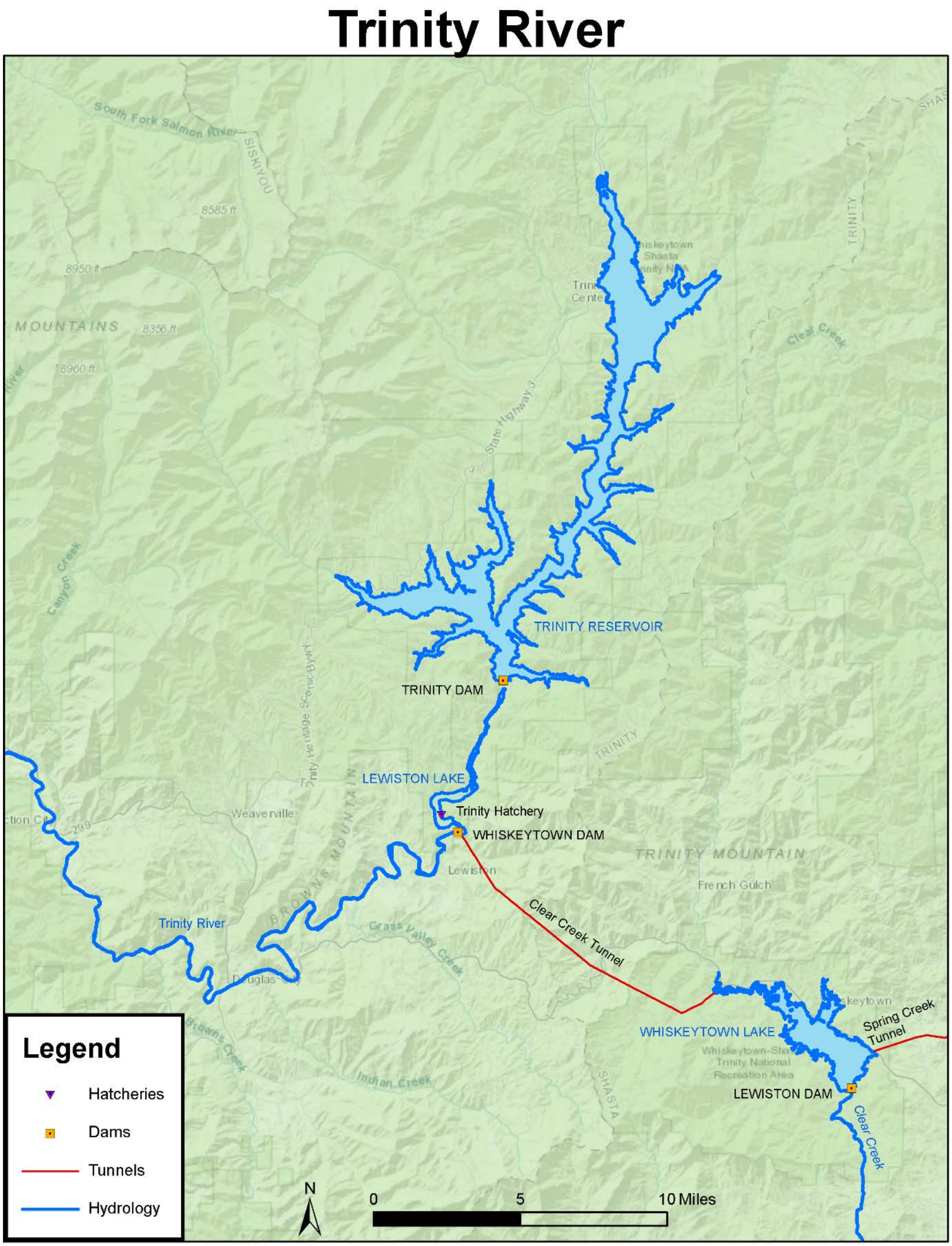


Figure 1-3. Action Area—Trinity River

Sacramento River

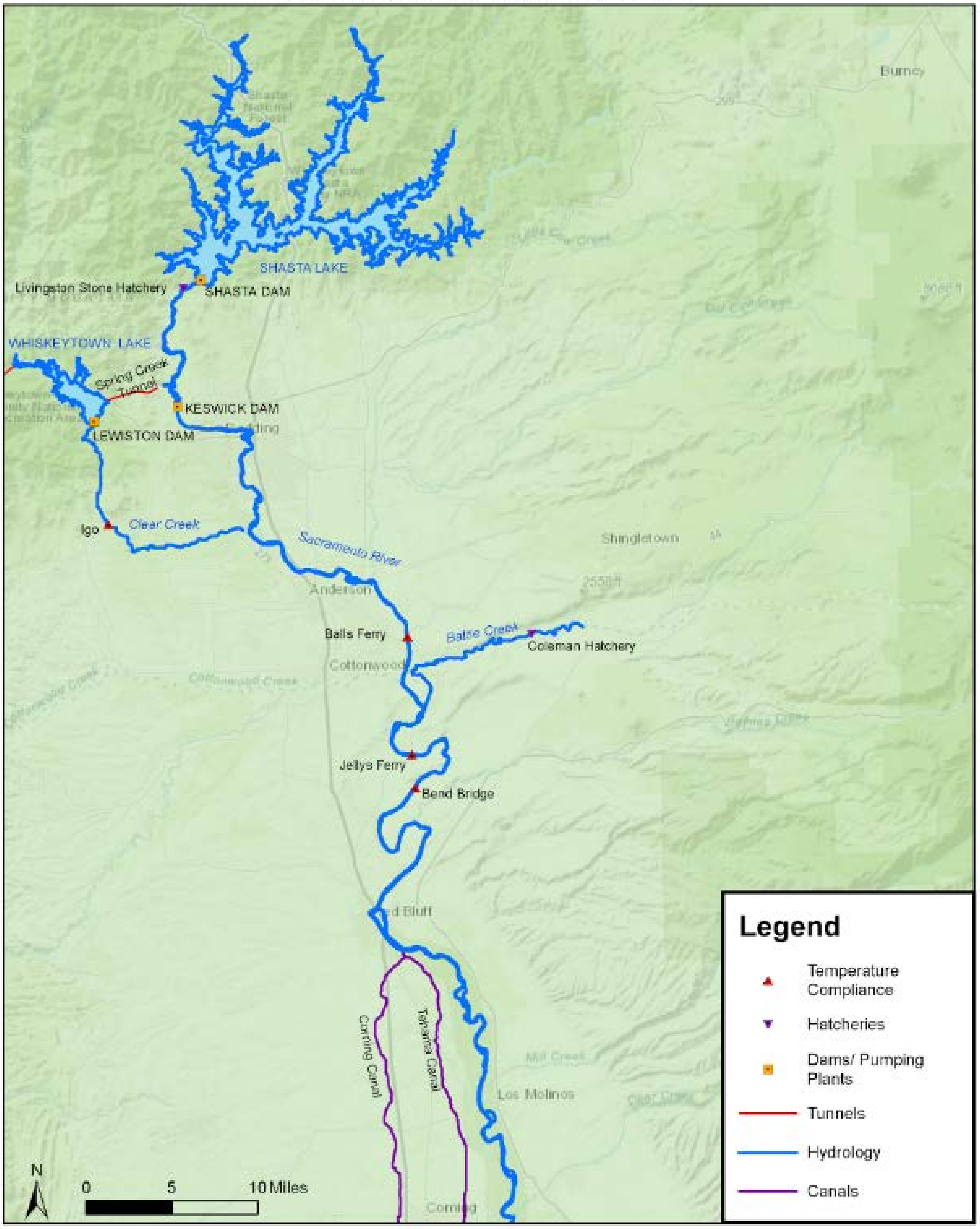


Figure 1-4. Action Area—Sacramento River

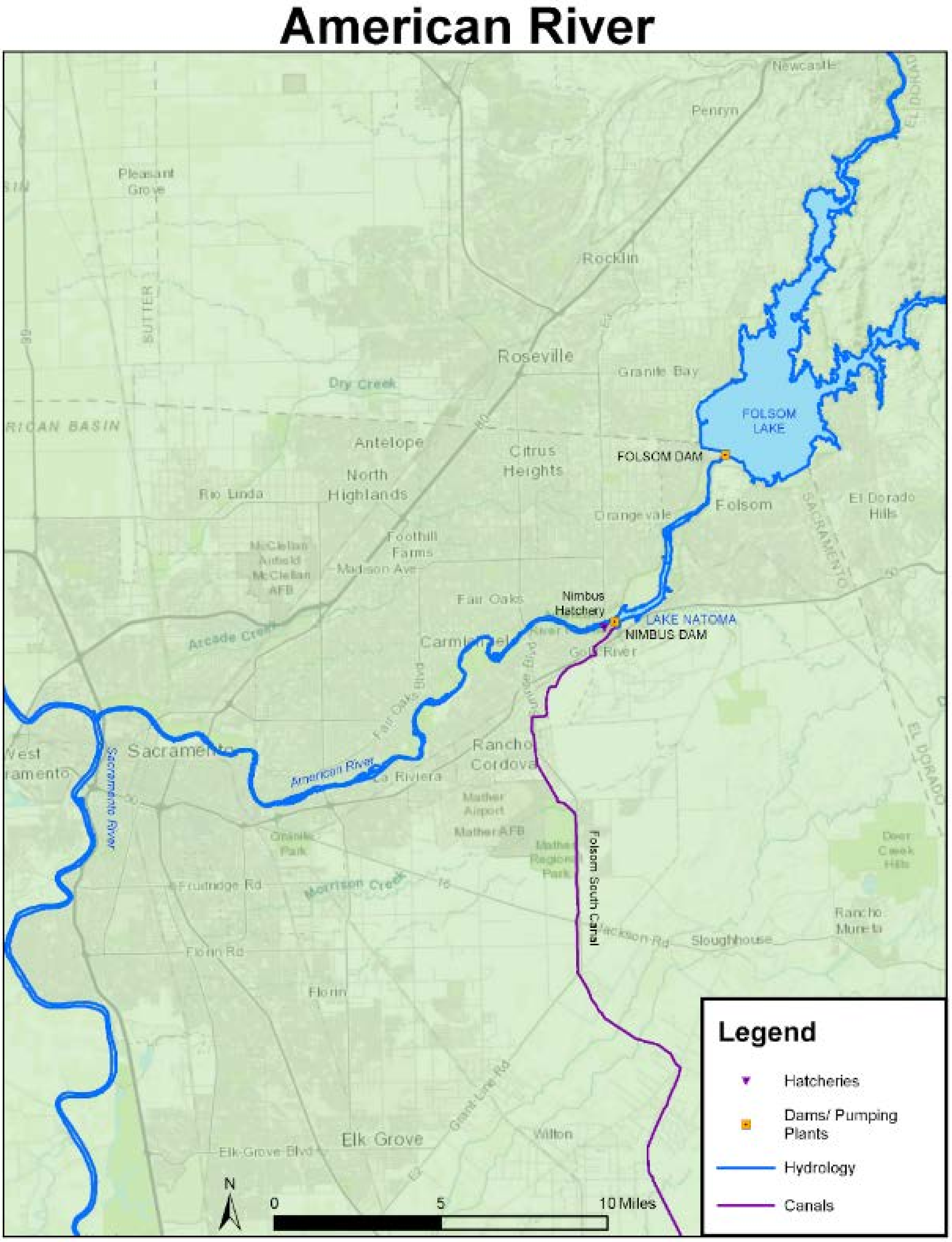


Figure 1-5. Action Area—American River

Delta

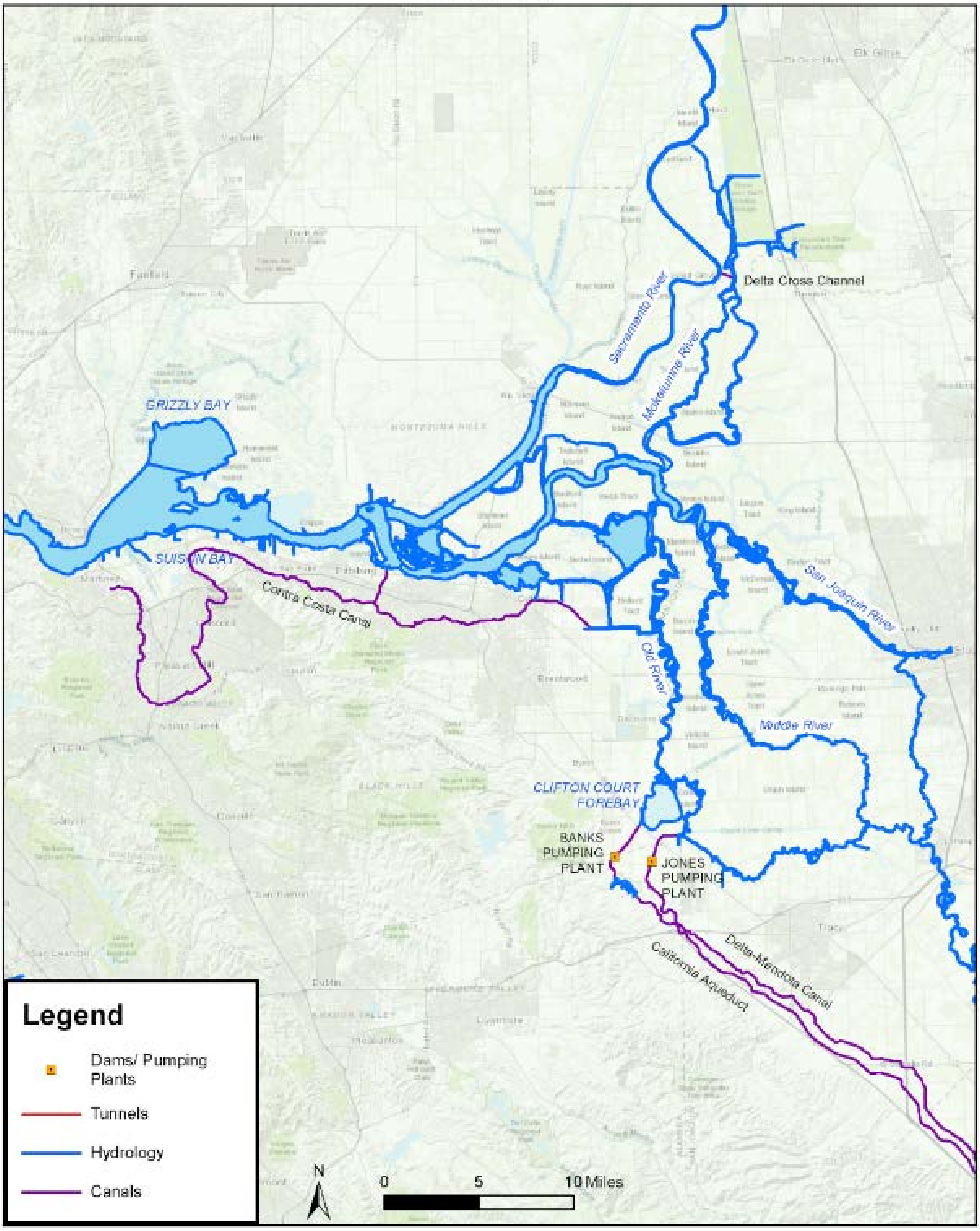


Figure 1-6. Action Area—Delta

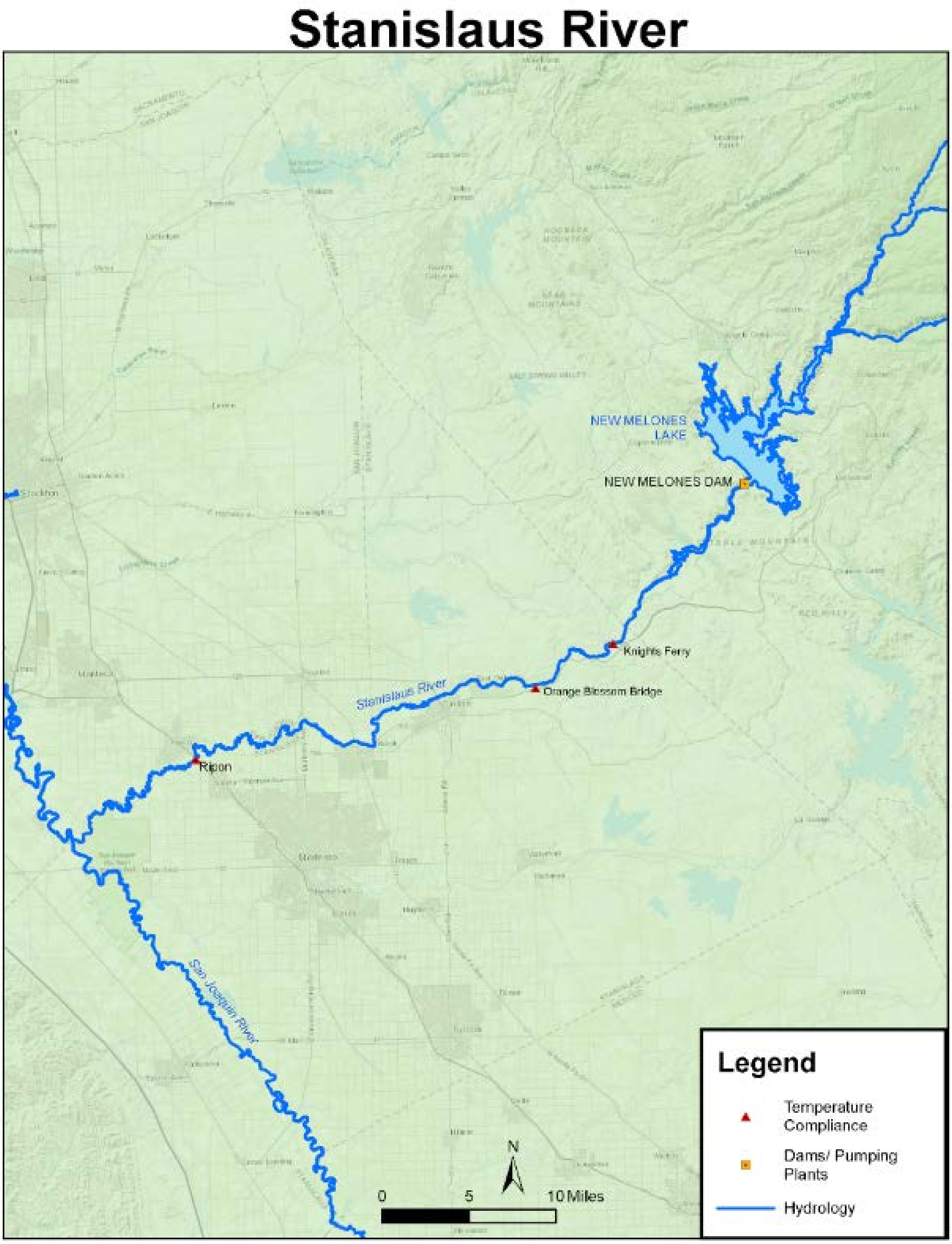


Figure 1-7. Action Area—Stanislaus River

Figure 1-8. Action Area—San Joaquin River

1.3 Species Considered

Pursuant to the interagency consultation requirements of Section 7 of the ESA, this biological assessment has been prepared to assess the potential effects of the proposed action on federally protected species and designated critical habitat. Aquatic and terrestrial 0073pecies considered in this biological assessment include those that are federally listed as threatened or endangered. The following input was used to determine which listed species should be considered for inclusion in this biological assessment:

- ESA-listed species distributional maps and literature review of species life-history requirements and habitat use
- Environmental documentation prepared in support of other Reclamation projects
- Discussions with federal and state agencies
- NMFS and CDFW online species lists (NMFS 2017; CDFW 2018)
- USFWS Information for Planning and Conservation (IPaC) system (USFWS 2018a)
- California Natural Diversity Database (CNDDB) Rarefind 5 online application
- California Native Plant Society (CNPS) Online Inventory of Rare and Endangered Vascular Plants of California (CNPS 2018)

Based on this information, the species to be addressed are shown in Table 1-1.

Table 1-1. Federally Protected Species and Critical Habitat Addressed in this Biological Assessment

Species	Status	Jurisdiction	Critical Habitat
Sacramento River Winter-Run Chinook Salmon ESU (*Oncorhynchus tshawytscha*)	Endangered	NMFS	Designated in action area
Central Valley Spring-Run Chinook Salmon ESU (*Oncorhynchus tshawytscha*)	Threatened	NMFS	Designated in action area
Central Valley Steelhead DPS (*Oncorhynchus mykiss*)	Threatened	NMFS	Designated in action area
Central California Coast Steelhead DPS (*Oncorhynchus mykiss*)	Threatened	NMFS	Designated in action area
Green Sturgeon Southern DPS (*medirostris*)	Threatened	NMFS	Designated in action area
Southern Resident Killer Whale (*Orcinus orca*)	Endangered	NMFS	Designated but not in action area
Southern Oregon/Northern California Coastal Coho Salmon ESU (*Oncorhynchus kisutch*)	Threatened	NMFS	Designated in action area

Species	**Status**	**Jurisdiction**	**Critical Habitat**
Eulachon *(Thaleichthys pacificus)*	Threatened	NMFS	Designated in action area
Delta Smelt (*Hypomesus transpacificus*)	Threatened	USFWS	Designated in action area
Riparian brush rabbit (*Sylvilagus bachmani riparius*)	Endangered	USFWS	None designated
Riparian woodrat (*Neotoma fuscipes riparia*)	Endangered	USFWS	None designated
Salt marsh harvest mouse (*Reithrodontomys raviventris*)	Endangered	USFWS	None designated
California clapper rail (*Rallus obsoletus*)	Threatened	USFWS	None designated
Least Bell's vireo (*Vireo bellii pusillus*)	Endangered	USFWS	Designated but not in action area
Yellow-billed cuckoo[1] (*Coccyzus americanus*)	Threatened	USFWS	Proposed
Giant garter snake (*Thamnophis gigas*)	Threatened	USFWS	None designated
Soft bird's beak (*Cordylanthus mollis* ssp. *Mollis*)	Endangered	USFWS	Designated in action area
Suisun thistle (*Cirsium hydrophilum* var. *hydrophilum*)	Endangered	USFWS	Designated in action area
Valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*)	Threatened	USFWS	Designated in action area
Vernal Pool Fairy Shrimp (*Branchinecta lynchi*)	Threatened	USFWS	None designated
Vernal Pool Tadpole Shrimp (*Lepidurus packardi*)	Endangered	UWFWS	Designated but not in action area
California Tiger Salamander (*Ambystoma californiense*)	Endangered	USFWS	Designated but not in action area

Species	Status	Jurisdiction	Critical Habitat
California Least Tern (*Sterna antillarum browni*)	Endangered	USFWS	None designated
California red-legged frog (*Rana draytonii*)	Threatened	USFWS	Designated but not in action area

ESU = Evolutionarily Significant Unit; NMFS = National Marine Fisheries Service; DPS = distinct population segment; USFWS = United States Fish and Wildlife Service

[1] = species included for programmatic construction actions

1.3.1 Species Considered but Not Addressed Further

In addition to the species listed in Table 1-2, a number of species and their critical habitat were considered for inclusion because initial review indicated they could occur in the Project vicinity. Although listed as potentially occurring within the wider surrounding area based on agency and county lists, several species can be considered as highly unlikely to occur in the action area and therefore do not warrant analysis of potential project impacts. These species considered but not addressed further are the following: giant kangaroo rat (*Dipodomys ingens*), gray wolf (*Canis lupus*), southern sea otter (*Enhydra lutris nereis*), California condor (*Gymnogyps californianus*), marbled murrelet (*Brachyramphus marmoratus*), northern spotted owl (*Strix occidentalis caurina*), short-tailed albatross (*Phoebastria [=Diomedea] albatrus*), western snowy plover (*Charadrius nivosus nivosus*), Alameda whipsnake *[=striped Racer]* (*Masticophis lateralis euryxanthus*), green sea turtle (*Chelonia mydas*), San Francisco garter snake (*Thamnophis sirtalis tetrataenia*), tidewater goby (*Eucyclogobius newberryi*), Bay checkerspot butterfly (*Euphydryas editha bayensis*), callippe silverspot butterfly (*Speyeria callippe callippe*), Delta green ground beetle (*Elaphrus viridis*), Lange's metalmark butterfly (*Apodemia mormo langei*), mission blue butterfly (*Icaricia icarioides missionensis*), Myrtle's silverspot butterfly (*Speyeria zerene*), San Bruno elfin butterfly (*Callophrys mossii bayensis*), California freshwater shrimp (*Syncaris pacifica*), Conservancy fairy shrimp (*Branchinecta conservation*), longhorn fairy shrimp (*Branchinecta longiantenna*), Shasta crayfish (*Pacifastacus fortis*), Antioch dunes evening-primrose (*Oenothera deltoides* ssp. *Howellii*), beach layia (*Layia carnosa*), Butte County meadowfoam (*Limnanthes floccosa* ssp. *Californica*), California seablite (*Suaeda californica*), Chinese Camp (*Brodiaea Brodiaea pallida*), clover lupine (*Lupinus tidestromii*), Colusa grass (*Neostapfia colusana*), Contra Costa goldfields (*Lasthenia conjugens*), Contra Costa wallflower (*Erysimum capitatum* var. *angustatum*), El Dorado bedstraw (*Galium californicum* ssp. *Sierra*), fleshy owl's-clover (*Castilleja campestris* ssp. *Succulent*, Franciscan manzanita *Arctostaphylos franciscana*, fountain thistle (*Cirsium fontinale* var. *fontinale*), Greene's tuctoria (*Tuctoria greenei*), hairy Orcutt grass (*Orcuttia pilosa*), Hartweg's golden sunburst (*Pseudobahia bahiifolia*), Hickman's potentilla (*Potentilla hickmanii*), Hoover's Spurge (*Chamaesyce hooveri*), Keck's checker-mallow (*Sidalcea keckii*), large-flowered fiddleneck (*Amsinckia grandiflora)*, Layne's butterweed (*Senecio layneae)*, Marin dwarf-flax (*Hesperolinon congestum)*, marsh sandwort (*Arenaria paludicola)*, Mcdonald's rock-cress (*Arabis macdonaldiana*), Metcalf Canyon jewelflower (*Streptanthus albidus* ssp. *Albidus*), pallid manzanita (*Arctostaphylos pallida*), palmate-bracted bird's beak (*Cordylanthus palmatus*), Pine Hill ceanothus (*Ceanothus roderickii*), Pine Hill flannelbush *Fremontodendron californicum* ssp. *Decumbens*), Presidio clarkia (*Clarkia franciscana*), Presidio manzanita (*Arctostaphylos hookeri* var. *ravenii*), red hills vervain *Verbena californica*), robust spineflower (*Chorizanthe robusta* var. *robusta*), Sacramento Orcutt grass (*Orcuttia viscida*), San Francisco lessingia (*Lessingia germanorum [=L.g.* var. *germanorum]*), San Joaquin Orcutt grass (*Orcuttia inaequalis*), San Mateo thornmint (*Acanthomintha obovata* ssp. *Duttonii*), San Mateo woolly sunflower (*Eriophyllum*), Santa Clara Valley dudleya (*Dudleya setchellii*), Santa Cruz tarplant (*Holocarpha macradenia*), Sebastopol meadowfoam (*Limnanthes vinculans*), Showy Indian Clover

(*Trifolium amoenum*), slender Orcutt grass (*Orcuttia tenuis*), Sonoma alopecurus (*Alopecurus aequalis* var. *sonomensis*), Sonoma spineflower (*Chorizanthe valida*), Sonoma sunshine (*Blennosperma bakeri*), Stebbins' morning-glory *Calystegia stebbinsii*), Tiburon paintbrush (*Castilleja affnis* ssp. *Neglecta*), white-rayed pentachaeta (*Pentachaeta bellidiflora*), and yellow larkspur (*Delphinium luteum*), Fresno kangaroo rat (*Dipodomys nitratoides*), San Joaquin kit fox (*vulpes macrotis mutica*), and Blunt Nosed-Leopard Lizard (*Gambelia sila*). NMFS (2009, p.75) noted that DWR's Suisun Marsh Salinity Control Gates (SMSCG) in Montezuma Slough are located to the east of the three Suisun Marsh steelhead streams and Central California Coast Steelhead (CCC Steelhead) (*Oncorhynchus mykiss*) are unlikely to travel 10-15 miles eastward through Montezuma Slough to the SMSCG. Therefore, NMFS (2009, p.75) concluded that it would be unlikely that CCC Steelhead will encounter the SMSCG or the Delta pumping facilities during their upstream and downstream migrations, because their spawning streams are located in the western portion of Suisun Marsh. Therefore, Reclamation concluded no effect to CCC Steelhead.

1.4 Consultation History

Reclamation has consulted with the USFWS and NMFS on CVP operations as species were listed and critical habitat designated since the early 1990s. The most recent consultation on CVP operations was completed in 2008 and 2009. Both biological opinions were conditionally accepted by Reclamation and were challenged in federal court. On appeal, the biological opinions were upheld and Reclamation issued a Record of Decision to adopt them in 2016. Table 1-2 provides a summary of this consultation history.

Table 1-2. Consultation History

Date	Issuer	Document	Rationale for Consultation	Subject / Species	Finding
February 1992	USBR	Interim Central Valley Project Operations Criteria and Plan		OCAP	
June 1993	NMFS	BO	Winter-Run listed in 1991	Winter-Run Chinook Salmon	Jeopardy
March 1995	USFWS	BO	Delta Smelt listed in March 1993; Splittail proposed in 1994	Delta Smelt and Splittail	Non-jeopardy
June 2004	USBR	BA	Combined ESA species consultation in one assessment	Winter-Run Chinook Salmon, Spring-Run Chinook Salmon, Steelhead, Coho Salmon, Delta Smelt	Likely to Adversely Affect: Winter-run, Spring-run, CV Steelhead; May Affect/Not Likely to Adversely Affect: Coho, Delta Smelt

Date	**Issuer**	**Document**	**Rationale for Consultation**	**Subject / Species**	**Finding**
July 2004	USFWS	BO	Coordinate with combined NMFS ESA species consultation	Delta Smelt	Non-Jeopardy
October 2004	NMFS	BO	Combined ESA species consultation	Winter-Run Chinook Salmon, Spring-Run Chinook Salmon, Steelhead, Coho Salmon	Non-Jeopardy
May 2008	USBR	BA	Green Sturgeon was listed in 2006; Pelagic Organism Decline	Winter-Run Chinook Salmon, Spring-Run Chinook Salmon, Steelhead, Green Sturgeon, Coho Salmon, Delta Smelt	Adversely Affect: Delta Smelt; LAA: CV steelhead, Winter-run, spring-run; Green Sturgeon; NLAA: Coho Salmon
December 2008	USFWS	BO	Pelagic Organism Decline; conflicts with Sturgeon	Delta Smelt	Jeopardy
June 2009	NMFS	BO and Conference Opinion	Green Sturgeon listed in 2006	Winter-Run Chinook Salmon, Spring-Run Chinook Salmon, Steelhead, Green Sturgeon	Jeopardy and Adverse Mod
January 2019	USBR	BA	Drought; New Science; Declining status	Winter-Run Chinook Salmon, Spring-Run Chinook Salmon, Steelhead, Green Sturgeon, Coho, Delta Smelt	See Effects Determination in this document

Chapter 2 Status of Aquatic and Terrestrial Species and Designated Critical Habitat

2.1 Sacramento River Winter-Run Chinook Salmon ESU

2.1.1 ESA Listing Status

NMFS, under an emergency interim rule, listed the Sacramento River Winter-Run Chinook Salmon Evolutionarily Significant Unit (ESU) as a threatened species under the ESA in August 1989 (54 Federal Register [FR] 32085). In 1994, NMFS reclassified the ESU as endangered due to several factors: the continued decline and increased variability of run sizes including expected weak returns due to small year classes in 1991 and 1993, and continuing threats to the species (59 FR 440). The ESU consists of one population in the mainstem of the Upper Sacramento River in California's Central Valley below Keswick Dam. NMFS reaffirmed the listing of the Sacramento River Winter-Run Chinook Salmon ESU as endangered on June 28, 2005 (70 FR 37160), and expanded the ESU to include Winter-Run Chinook Salmon produced by the Livingston Stone National Fish Hatchery (LSNFH) artificial propagation program in the ESU.

On May 26, 2016, after a third 5-year status review (81 FR 33468), NMFS (2016a) determined that the viability of the ESU had continued to decline on average 15 percent per year, or from 38 percent to 67 percent since 2010. Although the population size and catastrophe rate and effect have remained at the low-risk threshold (<90 percent decline in one generation, or annual run size of less than 500 spawners) since the 2010 status review, the population decline and hatchery influence criteria have both been elevated to a moderate extinction risk (NMFS 2016a). NMFS concluded that the ESU classification as an endangered species is appropriate and should be maintained (NMFS 2016a).

2.1.2 General Life-History and Habitat Requirements

Chinook Salmon in the Central Valley have four distinct races: Fall, Late-Fall, Winter, and Spring. The name of the runs come from the peak migration timing with peak runs for Fall-Run occurring during August to November, late-fall occurring November to February, Winter-Run January to May, and Spring-Run April to August (Vogel and Marine 1991). Fall and late-fall enter as mature and ready to spawn. Winter-Run and Spring-Run return immature and hold in the river until reaching maturity. The adults enter freshwater in an immature state and migrate far upstream where spawning is delayed for weeks or months (Healey 1991). Juveniles migrate out to sea in November through April after several months of rearing in streams (Healey 1991). The adult Winter-Run Chinook Salmon upstream spawning migration in the Sacramento River occurs from December through July, with the majority of the run passing the Red Bluff Diversion Dam from January through May, peaking in mid-March (NMFS 2009; NMFS 2014). Adults prefer to hold in deep cold pools until they are sexually mature and ready to spawn during spring or summer. Winter-Run Chinook Salmon spawn primarily between mid-April and mid-August, with peak spawning generally occurring in June (Vogel and Marine 1991).

Spawning occurs in gravel substrate in relatively fast-moving, moderately shallow riffles or along banks with relatively high water velocities to promote higher oxygen levels and eliminate fines in the substrate. Depending on ambient water temperature, embryos hatch within 40 to 60 days, and alevin (yolk-sac fry) remain in the gravel beds for an additional 4 to 6 weeks. As their yolk-sacs become depleted, fry begin to emerge from the gravel and start exogenous feeding typically in late July to early August and continuing through October (Fisher 1994). Emergence usually occurs in late July, but as early as mid-June through mid-October. Post-emergent fry inhabit calm, shallow waters with fine substrates and depend on fallen trees, undercut banks, and overhanging riparian vegetation for refuge (Healey 1991).

Winter-Run Chinook Salmon fry and juvenile emigration past the Red Bluff Diversion Dam occurs as early as mid-July and extends as late as the end of March during dry water years (Vogel and Marine 1991; NMFS 1997, both as cited in NMFS 2014), although primary migration ends in December (Poytress and Carillo 2010, 2011, 2012). A large pulse of juvenile Winter-Run Chinook Salmon have been observed to emigrate past Knights Landing and into the Delta during and shortly after the first large autumn storm event (del Rosario et al. 2013). They occur in the Delta as early as November through as late as April (SacPAS, see Figure 2.1-1). Ocean entry begins as early as November and continues through May (Fisher 1994; Myers et al. 1998, both as cited in NMFS 2014). Winter-Run Chinook Salmon then, for the most part, spend 3 years in the ocean before returning to the river as spawning adults.

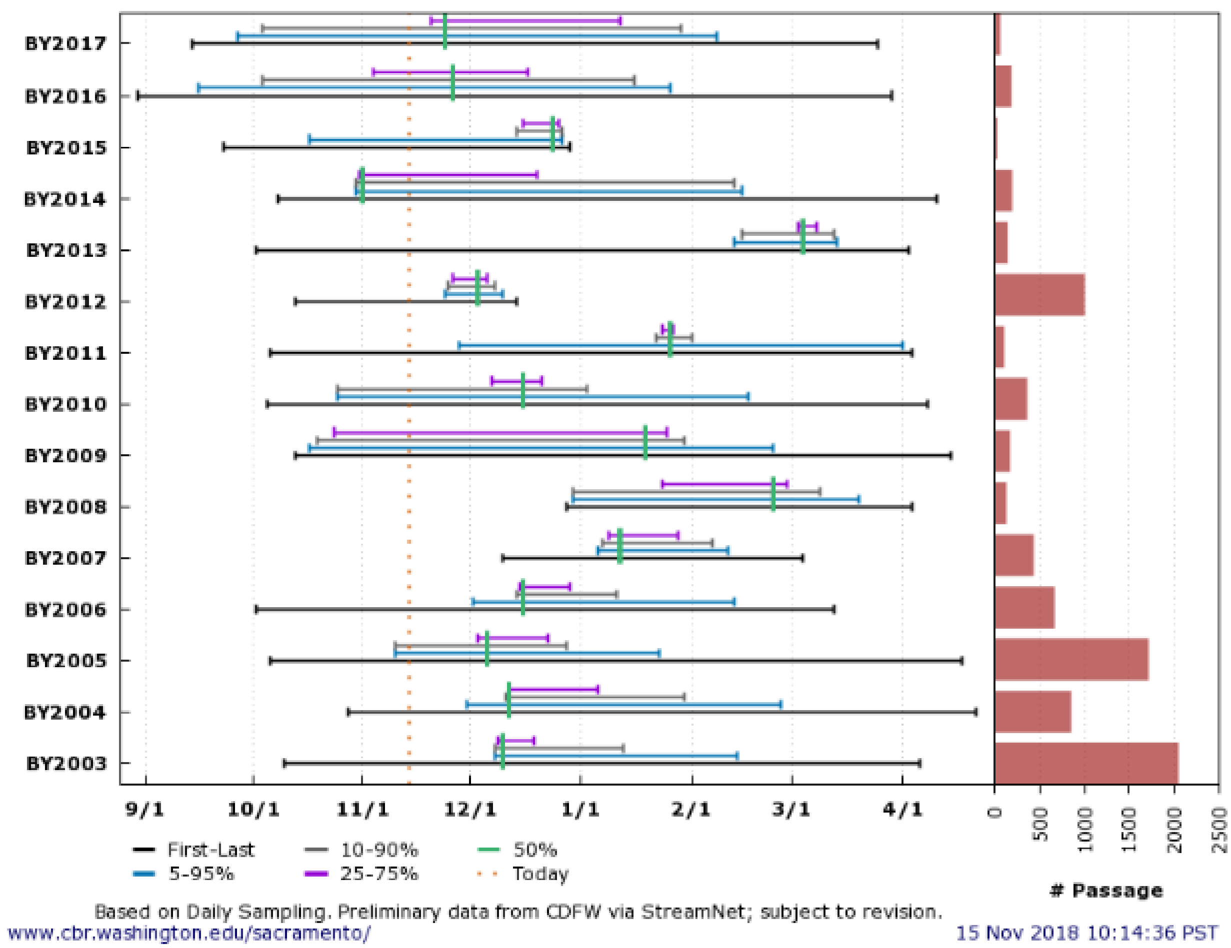


Figure 2.1-1. Migration Timing, Brood Years 2003–2017—Juvenile Winter Chinook, Knight's Landing RST, 7/1–6/30

During juvenile rearing and downstream movement, salmonids prefer stream margin habitats with sufficient depths and velocities to provide suitable cover and foraging opportunities. Ephemeral habitats, such as floodplains and the lower reaches of small streams, are also very important to rearing Chinook Salmon as these areas can be much more productive than the main channel and provide refuge from predatory fishes (Maslin et al. 1997; Sommer et al. 2001a). However, side channels with narrow inverts and nearshore areas with broad flat areas including low-gradient floodplains also can strand and isolate juveniles when high flows subside quickly (NMFS 1997). The greater availability of prey and favorable rearing conditions in floodplains increases juvenile growth rates compared with conditions in the mainstem and this can lead to improved survival rates during both their migration through the Delta and later in the marine environment (Sommer et al. 2001a). However, newer research has not found that the Yolo Bypass, a large floodplain, consistently provides better survival conditions for Chinook Salmon than the mainstem of the Sacramento River (Sommer et al. 2005; Takata et al. 2017).

2.1.3 Historical and Current Distribution and Abundance

Areas where Winter-Run Chinook Salmon historically spawned are now inaccessible due to Keswick and Shasta Dams. Streams in which populations of Winter-Run Chinook Salmon were known to historically exist were fed by cool, constant springs that provided the flows and low temperatures required for spawning, incubation, and rearing during the summer season (Slater 1963). Winter-Run Chinook Salmon spawning occurs in the summer months. Naturally occurring summer flows in river reaches below Keswick Dam would have historically precluded spawning. This suggests that the area below Shasta and Keswick dams was likely utilized for Winter-Run Chinook Salmon juvenile rearing and migration only. The life-history timing of the Winter-Run Chinook Salmon, requiring cold summer flows, indicates that the run historically occurred upstream of Keswick and Shasta dams and included the upper Sacramento River, McCloud River, Pit River, Fall River and Hat Creek and Battle Creek a tributary below Keswick and Shasta Dams (Yoshiyama et al. 1996, 2001; Lindley et al. 2004; NMFS 2014b), where summer flow and water temperature requirements were met (Yoshiyama et al. 2001).

Winter-Run Chinook Salmon are currently found in the mainstem Sacramento River downstream of Keswick dam. This population is maintained through cold water releases from Shasta Reservoir that create spawning and rearing habitat in the reach between Redding and the Red Bluff Diversion Dam. The construction of the Anderson-Cottonwood Irrigation District Diversion Dam in 1916 created a partial passage barrier as did the Red Bluff Diversion Dam in 1962. Since completion of Shasta Dam in 1945, primary spawning and rearing habitats have been confined to the cold water areas between Keswick Dam and the Red Bluff Diversion Dam (NMFS 2014).

Yearly Winter-Run escapement was estimated by counts in traps at the top of fish ladders at the Red Bluff Diversion Dam and more recently has been estimated using carcass counts. Escapements have declined from the 1960s and 1970s. The run size in 1969 was approximately 120,000, while run sizes averaged 600 fish from 1990 to 1997 (Moyle 2002). Escapement subsequently increased after Red Bluff Diversion Dam operations were modified and temperature control shutters were installed on Shasta Dam, but has declined since 2005 (Reclamation 2008; NMFS 2016). Winter-Run Chinook Salmon adult escapement data for the Sacramento River Basin from 1974 to 2016 are included in Figure 2.1-2 below (CDFW 2018). Preliminary data show a decline since 2012.

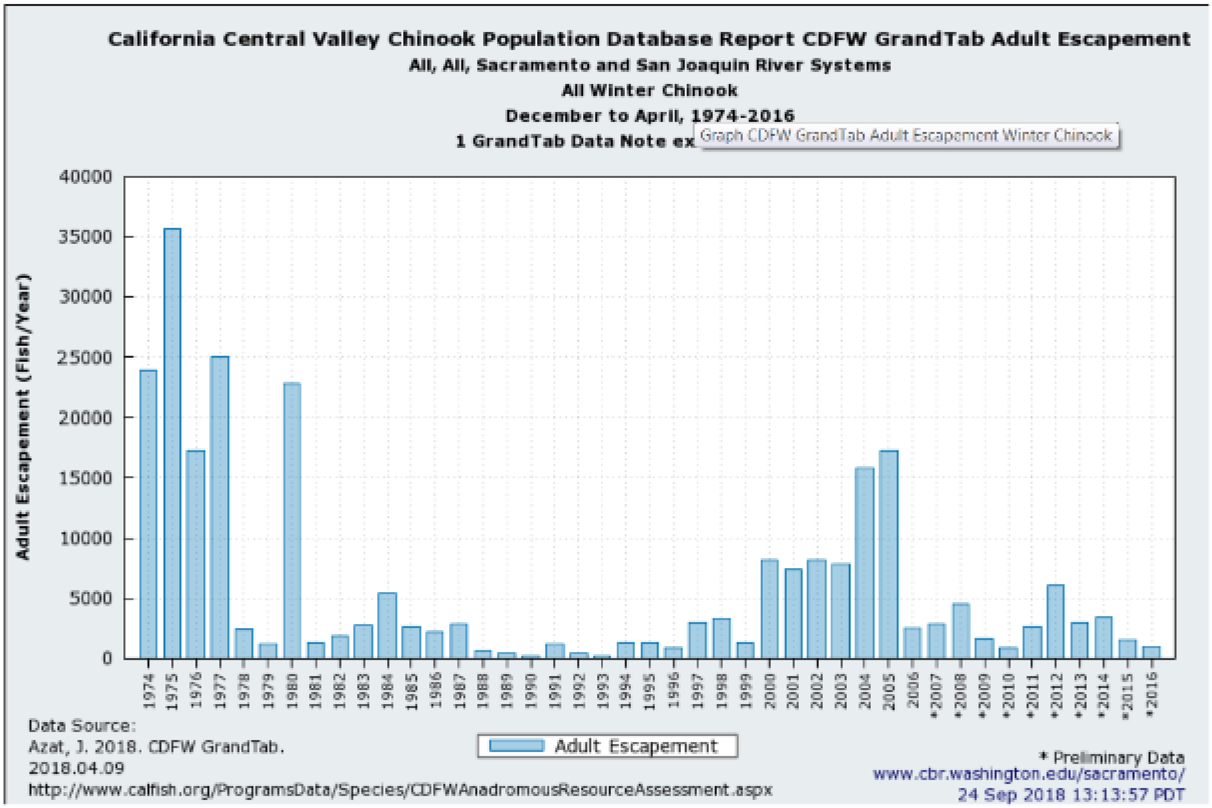


Figure 2.1-2. Winter-Run Chinook Salmon Adult Escapement (1974–2016) (CDFW 2018)

In addition to the Sacramento River, Juvenile Winter-Run Chinook Salmon have also been found to rear in areas including the lower American River, lower Feather River, Battle Creek, Mill Creek, Deer Creek, and the Delta (Phillis et al. 2018). Phillis et al. (2018) found with isotope data that 44 to 65 percent of surviving Winter-Run Chinook Salmon adults reared in non-natal habitats as juveniles. The lower reaches of the Sacramento River, the Delta, and San Francisco Bay serve as migration corridors for the downstream migration of juvenile and upstream migration of adult Winter-Run Chinook Salmon.

Until recent years, salmon passage was not allowed above the Coleman Hatchery barrier weir located on Battle Creek. No Winter-Run Chinook Salmon spawning has been observed in Battle Creek but Winter-Run Chinook Salmon were detected above the weir in 2006 (high flow year). All Winter-Run Chinook Salmon production currently occurs in the Sacramento River or Livingston Stone Fish Hatchery (CDFG 2004).

2.1.4 Limiting Factors, Threats, and Stressors

The major factor that limits the range of Winter-Run Chinook Salmon is the existence of dams, which have created barriers to upstream migration. Factors currently limiting abundance include the altered flow regime, which has led to changed water temperatures, reduced gravel mobilization, reduced riparian recruitment, etc; deteriorated habitat quality; entrainment in water diversions; predation pressure on juveniles; and loss of riparian and floodplain habitat. These factors are discussed below and in the "Past and Present Impacts" section of Chapter 3, Environmental Baseline, Biological Assessment.

Warm water releases from Shasta Dam have been a significant stressor to Winter-Run Chinook Salmon, especially when releases were warmer than usual because of the recent extended drought in California from 2012 through 2015 (NMFS 2016). The optimal water temperature for egg incubation ranges from 46 degrees Fahrenheit (°F) to 56°F (7.8 degrees Celsius (°C) to 13.3°C), and a significant reduction in egg viability occurs in mean daily water temperatures above 57.5°F (14.2°C) (Seymour 1956, Boles 1988, USFWS 1999, EPA 2003, Richter and Kolmes 2005, Geist et al. 2006). New temperature modeling show higher sensitivity to increases in water temperature due to exponential increases in oxygen demand with rise in temperature during the final weeks of egg-embryo maturation before the alevin stage (Martin et al. 2016, Anderson 2018). Despite Reclamation’s best efforts to maintain appropriate spawning temperatures, there was increased mortality during the 2012-2015 drought. Warm water releases from Shasta Reservoir in 2014 and 2015 contributed to 5.9 percent and 4.2 percent egg-to-fry survival rates respectively, to the Red Bluff Diversion Dam.

Climate experts predict physical changes to ocean, river and stream environments along the West Coast that include warmer atmospheric temperatures, diminished snow pack resulting in altered stream flow volume and timing, lower late summer flows, a continued rise in stream temperatures, and increased sea-surface temperatures and ocean acidity resulting in altered marine and freshwater food-chain dynamics (Williams et al. 2016). Climate change and associated impacts on water temperature, hydrology, and ocean conditions are generally considered likely to have substantial effects on Chinook Salmon populations in the future (NMFS 2014). Global parameters, such as ocean conditions, have also demonstrated a marked effect on adult escapement (Lindley et al. 2009).

Impacts from hatchery fish (i.e., reduced fitness, weaker genetics, smaller size, less ability to avoid predators) have deleterious impacts on natural in-river populations (Matala et al. 2012). These impacts are associated with hatchery fish spawning naturally (i.e., second generational). During recent years, when the hatchery program was scaled up in size and natural production faltered, hatchery fish made up the vast majority of winter Chinook that spawned both in the river and at LSNFH. The Winter-Run Chinook Salmon conservation program at LSNFH is controlled by the USFWS to reduce such impacts. The average annual hatchery production at LSNFH is approximately 176,348 Winter-Run Chinook Salmon per year compared to the estimated natural production that passes the Red Bluff Diversion Dam, which is approximately 878,000 per year based on the 2012 to 2018 average (Voss et al. 2018), or 4.7 million per year based on the 2002 to 2010 average (Poytress and Carrillo 2011). Therefore, hatchery production can be up to approximately 20 percent of the total in-river juvenile production in any given year.

2.1.4.1 *Habitat Quality*

Construction of Keswick and Shasta Dam for agricultural, municipal, and industrial water supply has eliminated access to historical holding and spawning grounds above Keswick Dam, approximately 200 river miles (Yoshiyama et al. 1996). Rearing habitat quantity and quality has been reduced in the upper Sacramento River as a result of channel modification and levee construction (Lindley et al. 2009). Much of the historical floodplain habitat has been developed or converted, this has decreased shallow water habitat that has high residence time needed for food production (Jefferes et al. 2008; Katz et al. 2018; Ahearn et al. 2006).

More information on stressors of native fish, including physical, hydrologic, and biological alteration are described in the environmental baseline. Additional factors include other water quality parameters (e.g., dissolved oxygen), food quality and quantity, biotic interactions (e.g., predation and competition), altered hydrology in the Sacramento–San Joaquin Delta, loss of tidal marsh, commercial and/or recreational harvest, and predation from introduced species such as striped bass (NMFS 2014).

2.1.5 Water Operations Management

The Sacramento River system includes several major features and facilities that are relevant to temperature management: (1) Shasta Dam and Lake, and the installed Temperature Control Device (TCD); (2) interbasin transfers from the Trinity River Basin, which are conveyed through Whiskeytown Lake, the Clear Creek Tunnel and Carr Powerhouse, and the Spring Creek Tunnel; and (3) Keswick Reservoir, which regulates releases from Shasta Dam and Spring Creek Powerhouses, resulting in a stable flow regime for release from Keswick Dam.

Reclamation currently uses the Shasta TCD to improve temperatures while minimizing power loss. At Shasta Reservoir, Reclamation seeks to build cold water pool for Winter-Run Chinook Salmon spawning and incubation in the summer. Reclamation seeks to build storage through the fall, winter, and spring months. When higher releases from Shasta Dam are required in the fall through spring timeframe, this may reduce the summer cold water pool. Higher releases may be requested to avoid Winter-Run and Fall-Run Chinook Salmon redd dewatering, spring pulses for juvenile outmigration, or increased releases to meet Delta outflow or salinity requirements per D-1641. Usually, flows in the Sacramento River are kept high until the Winter-Run Chinook Salmon fry have emerged from the gravel. However, higher flows sometimes overlap the period in which Fall-Run Chinook Salmon begin to spawn, leading to Fall-Run Chinook Salmon spawning in shallow locations that may be out of water when Reclamation reduces flows for building storage. Once the Fall-Run Chinook Salmon begin spawning, fish agencies frequently want to maintain releases at the same level as where spawning occurred to avoid redd dewatering.

The Sacramento River Temperature Task Group (SRTTG) is a multiagency group, formed pursuant to SWRCB Water Rights Orders 90-5 and 91-1, to assist with increasing and stabilizing Chinook populations in the Sacramento River. Annually, Reclamation develops operation plans for controlling temperatures within the Shasta and Trinity divisions of the CVP. These plans consider impacts on Winter-Run and other races of Chinook Salmon, and associated project operations. Meetings are held initially in the spring to discuss biological, hydrologic, and operational information, objectives, and alternative operations plans for temperature control. Once an operation plan for temperature control is recommended, Reclamation submits the report to the SWRCB, generally on or before June 1 each year. The SRTTG may continue to meet throughout the year or other groups may be formed to discuss temperature management.

Fish agencies generally seek to maintain a 56 degree compliance location as far downstream as possible for as long as possible. Maintaining cold water too far downstream risks prematurely using up the cold water pool and results in warmer-than-desired temperatures at the end of the temperature control season. Fish agencies have further requested that Reclamation operate to experimental water temperature control regimes. The primary examples are the 7 Daily Average Daily Maximum (DADM) () and the 53.5°F Daily Average Temperature (DAT) at the Clear Creek gage on the Sacramento River (CCR). The requested temperature control regimes may deplete cold water faster than the objective of 56°F at Balls Ferry accorning to D-90-5 and pose substantial operational challenges.

Reclamation and DWR coordinate regarding downstream requirements (Delta outflow, Delta salinity, turbidity, etc) under D-1641 via the COA. Reclamation and DWR split requirements between the CVP and SWP. After splitting requirements with the SWP, Reclamation plans how to the meet the CVP share of the requirements via a combination of releases from Folsom Reservoir, releases from Shasta Reservoir, and/or reducing exports. The amount of water from each reservoir depends upon reservoir storage, channel capacity, fishery concerns, projected inflows, and projected end-of-September storage. Reclamation balances releases so that no one reservoir bears the full burden of meeting downstream requirements.

Congress authorized Shasta and Trinity Dams to work in an integrated fashion for “the principal purpose of increasing the supply of water available for irrigation and other beneficial uses” in the Central Valley. 69 Stat. 719. Exports from Trinity Reservoir helped decrease the demand on Shasta Reservoir for water supply and brought colder water directly into the Sacramento River system, preserving a larger cold water pool volume in Shasta Reservoir. Reclamation heavily relies on both reservoirs to meet multiple obligations for listed fish species in both basins. First, there are limitations on transbasin diversions from the Trinity Basin due to requirements in the Trinity River. The 2000 Trinity River Record of Decision (Trinity ROD) strictly limits Reclamation’s transbasin diversions to 55 percent of annual inflow on a 10-year average basis for the restoration and protection of the Trinity fishery, which restricts the amount of water authorized for exportation to the Central Valley. Pursuant to the Trinity ROD, the Trinity Reservoir now also provides flows for the Trinity River Restoration Program to improve conditions for the native fisheries on the Trinity River.

During the extraordinary conditions in 2014 and 2015, under extreme drought, as part of a coordinated response to improve Shasta Reservoir cold water pool management, a number of measures were taken on a temporary basis that included: (1) work with the State Board and water users to lower Wilkins Slough navigational flow requirements; (2) request that the State Board relax D-1641 Delta water quality requirements; (3) delay Sacramento River Settlement Contractor depletions, and transfer a volume of their water in the fall rather than increase depletions throughout the summer; (4) target slightly warmer temperatures during the Winter-Run Chinook Salmon holding period (before spawning occurs); and (5) install temporary improvements on the Shasta Dam TCD curtain (in 2015).

In 2017, Reclamation agreed to a long-term plan to provide fall augmentation flows for the Lower Klamath River. For the previous 15 years, and now under the 2017 long-term plan through 2030, Reclamation has released fall augmentation flows to help support fish health (this practice began following controversy and litigation over a large fish die off event that occurred in 2002 due to low flows).

2.1.6 Recovery and Management Actions

The following sections are actions that have been taken to benefit Winter-Run Chinook Salmon.

2.1.6.1 *Anadromous Fish Restoration Program*

Reclamation annually expends funding for the CVPIA Anadromous Fish Restoration Program (AFRP), CVPIA 3406(b)(1), to undertake reasonable measures to not less than double anadromous fish populations from the 1967-1991 time period and to mitigate other adverse environmental effects. Winter-Run actions are described in the Final Plan for the AFRP (2001).

2.1.6.2 *Anadromous Fish Screen Program*

Section 3406(b)(21) of the CVPIA authorized the Anadromous Fish Screen Program (AFSP) to assist the State of California on unscreened diversions. The AFRP screens or installs “fish protective devices” on diversions. The AFSP has developed guidelines to prioritize screening projects. Factors taken into account include location of the diversion in relation to areas used by anadromous fish for spawning and rearing, size of the diversion (or percent flow diverted in tributaries), season of diversion in relation to anadromous fish use of the stream or reach, and placement of the diversion. All but one of the diversions greater than 100 cubic feet per second (cfs) on the Sacramento River have fish screens.

2.1.6.3 *Anderson Cottonwood Irrigation District*

The Anderson Cottonwood Irrigation District (ACID) operates a diversion dam across the Sacramento River located 3.2 miles downstream from Keswick Dam. The ACID Diversion Dam was improved in 2001 and 2015 with the addition of new fish ladders and fish screens around the diversion. Since upstream passage was improved a substantial shift in Winter-Run Chinook Salmon spawning has occurred. In recent years, more than half of the Winter-Run Chinook Salmon redds have typically been observed above the ACID diversion dam (Killam 2008).

2.1.6.4 *Battle Creek Restoration Program*

The Battle Creek Salmon and Steelhead Restoration Project has a long history that includes research by various organizations and collaboration among many resource agencies and public interest groups. In 1999, a cooperative effort among Reclamation, USFWS, NMFS, CDFW, and the Pacific Gas and Electric Company (PG&E) led to the signing of a Memorandum of Understanding (MOU). The Battle Creek Salmon and Steelhead Restoration Project includes modifications to facilities and adjustments to operations for anadromous fish, including Winter-Run Chinook Salmon. Construction is anticipated to be complete in 2023.

2.1.6.5 *Spawning and Rearing Habitat Restoration*

Reclamation expends annual funding for the CVPIA under Section 3406(b)(13) Spawning and Rearing Habitat Program. The CVPIA (b)(13) program partners with other federal, state, and local agencies, water users, and other stakeholders to develop and implement a continuing program for the purpose of restoring and replenishing, as needed, salmonid spawning gravel lost due to the construction and operation of Central Valley Project dams and other actions that have reduced the availability of spawning gravel and rearing habitat in the Sacramento River.

The upper Sacramento River between Keswick Dam and the Red Bluff Diversion Dam presents several opportunities for improving and restoring salmonid spawning and rearing habitats. Reclamation annually injects spawning gravel into reaches of the Sacramento River where the majority of Winter-Run Chinook Salmon spawn.

2.1.6.6 *Glenn Colusa Irrigation District Hamilton City Fish Screen*

Glenn Colusa Irrigation District (GCID) diverts a maximum of 3,000 cfs from the Sacramento River at the Hamilton City pump station. The peak demand occurs in the spring, often at the same time as the peak outmigration of juvenile salmon. Because GCID diverts up to 25 percent of the Sacramento River flow at Hamilton City, GCID pumping operations were identified as a significant impediment to the downstream juvenile salmon migration. In 2000, GCID and Reclamation completed a 620-foot-long fish screen extension and channel improvements to minimize entrainment of salmonids into GCID’s facility.

2.1.6.7 *Livingston Stone National Fish Hatchery*

The USFWS manages a conservation hatchery program for Winter-Run Chinook Salmon at the LSNFH. This hatchery program supplements the natural population according to strict guidelines developed in conjunction with NMFS. Based on a review of available genetic and other information, this hatchery stock was considered part of the Sacramento River Winter-Run Chinook Salmon ESU in 2005 (70 FR 37160).

2.1.6.8 *Red Bluff Diversion Dam*

The Red Bluff Diversion Dam was decommissioned in 2013 providing unimpaired juvenile and adult fish passage, so that adult Winter-Run Chinook Salmon could migrate through the structure at a broader range of flows reaching spawning habitat upstream of that structure. This project was authorized by CVPIA 3406(b)(10).

2.1.6.9 *Salmon Resiliency Strategy*

The Sacramento Valley Salmon Resiliency Strategy, published in June 2017 by the State of California, is an approach to improving species viability and resiliency by implementing specific habitat restoration actions. Actions include: restoration on Battle Creek, Implement McCloud Reintroduction Pilot Plan, Provide Instream Flows to Support Chinook Salmon and Steelhead in Mill, Deer, Antelope, and Butte Creeks, Restore Fish Passage and Habitat in Upper Sacramento Tributaries, Restoration of Instream Habitats in Upper Sacramento River, Improve Fish Passage by Removing Sunset Pumps Rock Dam on the Feather River, Restore Off-Channel Rearing, Streambank, and Riparian Habitats and Migratory Conditions along Upper/Middle/Lower Reaches of the Sacramento River, Complete Fish Screen Construction on Major Diversions along the Sacramento River, Improve Sutter Bypass and Associated Infrastructure to Facilitate Adult fish Passage and Improved Stream Flow Monitoring, Improve Yolo Bypass Adult Fish Passage, Increase Juvenile Salmonid Access to Yolo Bypass, and Increase Duration and Frequency of Yolo Bypass Floodplain Inundation, Construct Permanent Georgiana Slough Non-Physical Barrier, Restore Tidal Habitat in the Delta, and other actions.

2.1.6.10 *Shasta Temperature Control Device*

Reclamation constructed the Shasta Temperature Control Device (TCD) under the CVPIA 3406(b)(6). Reclamation operates the Shasta TCD to conserve the available cold pool in the reservoir for spawning and egg incubation temperatures for Winter-Run Chinook Salmon without hydropower bypass. Reclamation manages releases to maintain suitable depths over Winter-Run Chinook Salmon redds to avoid dewatering when possible.

2.1.6.11 *Whiskeytown Reservoir Spring Creek and Oak Bottom Temperature Curtains*

Reclamation has replaced both the Spring-Creek and Oak Bottom temperature curtains in Whiskeytown Reservoir to improve temperature flexibility and build cold water pool temperature compliance for Clear Creek and Sacramento River.

2.1.6.12 *Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project*

Most salmonid floodplain rearing habitat in the Sacramento Valley was altered or blocked from use by dams and levees. The Yolo Bypass is the largest remaining floodplain in the Sacramento Valley, but is only accessible when the Sacramento River exceeds the crest of the Fremont Weir during high flow events. The Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project is a joint effort undertaken by DWR and Reclamation. The project largely focuses on infrastructure modifications to increase the number of juvenile salmonids that have access to floodplain habitat in the Yolo Bypass through Fremont Weir; and, to increase the ability of adult salmon and sturgeon to migrate from the Yolo Bypass to the Sacramento River.

2.1.6.13 *California EcoRestore*

California EcoRestore is an initiative to help coordinate and advance at least 30,000 acres of critical habitat restoration in the Sacramento–San Joaquin Delta (Delta) by 2020. The program includes a broad range of habitat restoration projects, including aquatic, sub-tidal, tidal, riparian, flood plain, and upland ecosystem.

Projects completed to date include the following:

- Fremont Weir Fish Passage Modification—This project widened and deepened the existing fish ladder at the Fremont Weir and the upstream and downstream adjoining channels were reconfigured to accommodate migratory fish passage. Existing earthen agricultural road crossings were replaced by permanent crossings that allow for the clear passage of migratory fish.
- Knights Landing Outfall Gates—A positive fish barrier, was constructed (with new concrete wing walls and installation of a metal picket weir) on the downstream side of the existing Knights Landing Outfall Gate in the Colusa Basin Drain. This project serves primarily as a fish passage improvement action that will prevent salmon entry into the Colusa Basin Drain where they become trapped with no access back to the Sacramento River.
- Wallace Weir—The project consisted of constructing a permanent earthen weir that was hardened to withstand winter floods to prevent adult salmon entry into the Colusa Basin Drain. A fish rescue facility was incorporated into the weir so fish that arrive at the Wallace Weir via the Yolo Bypass can be safely and effectively rescued and returned to the Sacramento River to resume their migration to upriver spawning grounds.
- Lindsey Slough—The project restored habitat function and connectivity to 159 acres of freshwater emergent wetlands and 69 acres of alkali wetlands, and recreated and reconnected a 1-mile tidal channel.
- Sherman Island—The project constructed levee setbacks in Mayberry Slough that will augment existing riparian vegetation and restore tidal wetland that will provide habitat for native species including salmonids.

2.1.6.14 *Battle Creek Winter-Run Chinook Salmon Reintroduction Plan*

The Battle Creek Winter-Run Chinook Salmon Reintroduction Plan is a key action in the NMFS Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon. Reintroduction of Winter-Run Chinook Salmon into North Fork Battle Creek is part of a larger strategy in the NMFS Recovery Plan to restore some of the spatial structure of the ESU by reintroducing populations to habitats from which they have been extirpated.

2.1.6.15 *Flyway Farms Tidal Habitat Restoration Project*

This project has restored seasonal wetland and cattle grazing land to sub-tidal, intertidal and seasonal wetlands to benefit native fish species. The project involves restoring and enhancing approximately 300 acres of tidal freshwater wetlands, and an additional 30 acres of seasonal wetlands, at the southern end of the Yolo Bypass. It isdesigned to maximize residency time and foodweb production by capturing and slowly draining water through the excavation of two breaches along the Yolo Bypass Toe Drain and interior channels to connect and enhance existing wetlands on site. The goal is to improve habitat conditions for salmonids by providing rearing habitats for out-migrating juveniles and migratory habitats for adults.

2.1.6.16 *Shasta Dam Fish Passage Evaluation*

The Shasta Dam Fish Passage Evaluation was an effort to determine the feasibility of reintroducing Winter-Run and Spring-Run Chinook Salmon and Steelhead to tributaries above Shasta Dam. The evaluation was part of Reclamation's response to the June 4, 2009, NMFS *Biological Opinion (BO) and Conference Opinion on the Long-Term Operation of the Central Valley Project (CVP) and State Water Project (SWP)* (NMFS 2009).

2.1.6.17 *Harvest Management*

NMFS' current Winter-Run Chinook Salmon harvest management is set based on a 2012 RPA from the NMFS Winter-Run Chinook Salmon ocean harvest fishery consultation. During the consultation, the Pacific Fisheries Management Council expressed concern as initially no fishing was allowed below 500 forecasted Age 3 fish, and the rule did not account for drought. In response to these comments, NMFS proposed a new rule that continues to allow for harvest down to a forecasted population of 0 Age 3 Winter-Run Chinook Salmon (NMFS, March 2018).

Figure 2.1-3 shows the 2012 harvest control rule compared to the 2018 harvest control rule. The x-axis is the forecasted number of Age 3 Winter-Run Chinook Salmon. The y axis is the Impact Rate Cap, a metric of the ocean harvest.

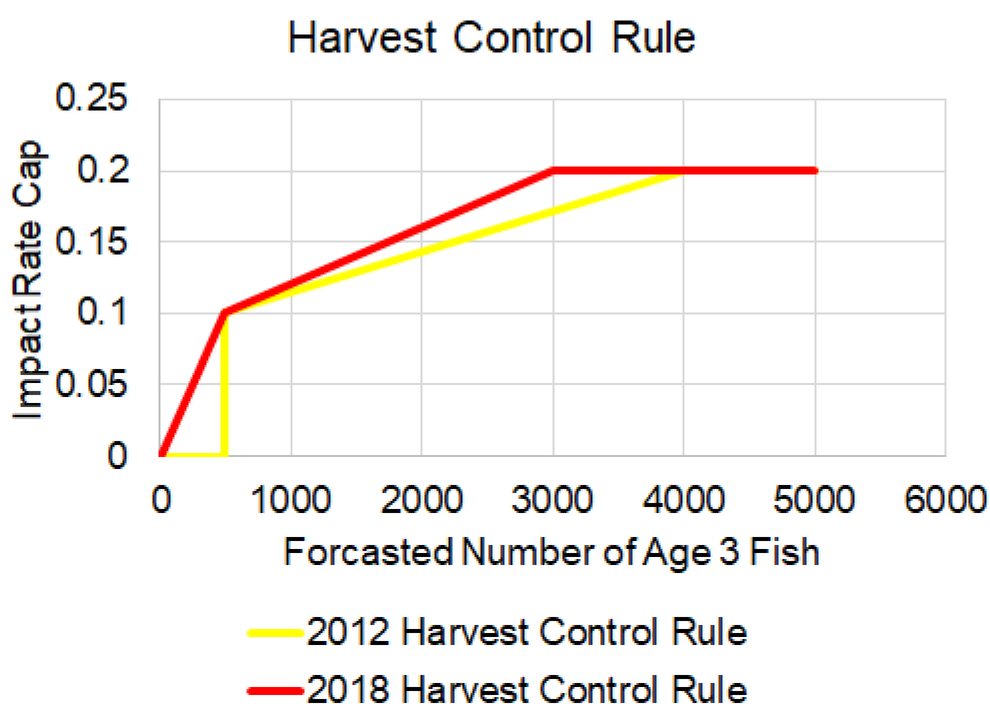


Figure 2.1-3. 2012 Harvest Control Rule

Under the 2018 rules, NMFS has increased harvest pressures on Winter-Run Chinook Salmon.

2.1.7 Monitoring and Research Programs

Monitoring and research programs help provide information on Winter-Run Chinook Salmon migration, survival, and redd distribution. Since 2015, Reclamation has started Enhanced Acoustic Tag Salmonid Monitoring (EATSM). EATSM is part of the Salmon and Sturgeon Assessment of Indicators by Lifestage (SAIL) program, which improves monitoring by addressing vital population statistics rather than reliance upon indexes. In 2018, EATSM conducted studies on hatchery-origin Winter-Run Chinook Salmon movement (Figure 2.1-4), which represents fish arrivals per day at Tower Bridge in downtown Sacramento (DOSS 2018). The two studies shown represent 20.7 percent survival (in red) and 26.9 percent survival (in teal).

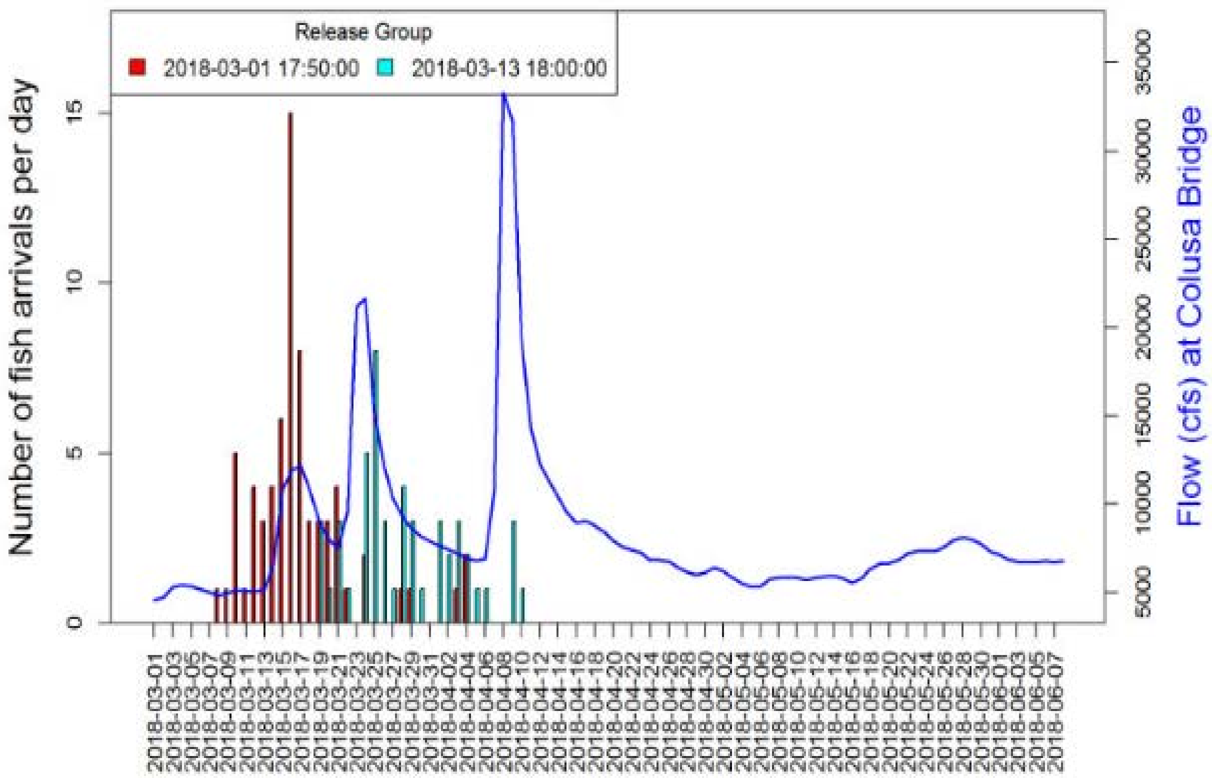


Figure 2.1-4. Tagged Hatchery Winter-Run Chinook Salmon Migration between Redding and Sacramento in 2018

CDFW annually conducts aerial redd surveys and carcass counts. Table 2.1-1 shows the distribution of Winter-Run Chinook Salmon redds from 2001 to 2018, a period after the ACID fish ladders were installed. For the period of 2001–2018, the furthest downstream observed Winter-Run Chinook Salmon redd was upstream of Tehama with over 98 percent of all observed redds occurring in the upper 20 river miles.

Surveys also help CDFW compile annual population estimates of Chinook Salmon. Information is entered into CDFW’s GrandTab and is accessible through www.calfish.org. Reclamation funds monitoring, evaluation, and web-based data services through the Central Valley Prediction and

Assessment of Salmon (SacPAS) tool online. This service also provides a publicly accessible reporting system of historical and current information (www.cbr.washington.edu/sacramento/).

Table 2.1-1. Winter-Run Chinook Spawning Distribution, 2001–2018

Reach	Miles below Dam	2001–2018 Distribution	Yearly Average	Percent Distribution
Keswick to ACID Diversion Dam	3	3,482	226	45
ACID Diversion Dam to Highway 44 Bridge	5.5	2,606	154	34
Highway 44 Bridge to Airport Road Bridge	19	1,566	95	20
Airport Rd. Bridge to Balls Ferry Bridge	27	75	4	1
Balls Ferry Bridge to Battle Creek	32	10	1	0
Battle Creek to Jellys Ferry Bridge	36	7	0	0
Jellys Ferry Bridge to Bend Bridge	45	10	1	0
Bend Bridge to Red Bluff Diversion Dam	60	0	0	0
Red Bluff Diversion Dam to Tehama Bridge	74	11	1	0
Total		7,767	482	100

2.2 Winter-Run Chinook Salmon Critical Habitat

NMFS designated critical habitat for the Sacramento River Winter-Run Chinook Salmon ESU on June 16, 1993 (58 FR 33212). Designated critical habitat encompasses the Sacramento River from Keswick Dam (river mile 302) to Chipps Island (river mile 0) at the westward margin of the Delta, all waters from Chipps Island westward to Carquinez Bridge, including Honker, Grizzly, and Suisun Bays, and 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) from San Pablo Bay to the Golden Gate Bridge (59 FR 440).

In the Sacramento River, critical habitat is the river water column, river bottom, and adjacent riparian zone and the water column and essential foraging habitat and food resources west of Chipps Island including the San Francisco Bay to the Golden Gate Bridge.

Critical habitat consists of physical and biological habitat features considered essential for the conservation of a species, which are referred to as Physical and Biological Features (PBFs). PBFs outlined in the designation of critical habitat (57 FR 36626) include the following:

1. Unimpeded access from the Pacific Ocean to appropriate spawning areas in the upper Sacramento River;
2. The availability of clean gravel for spawning substrate;
3. Adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles;
4. Water temperatures between 42.5 and 57.5oF for successful spawning, egg incubation, and fry development;
5. Habitat and prey that is free of contaminants;
6. Riparian habitat that provides for successful juvenile development and survival; and
7. Unimpeded passage of juveniles downstream from the spawning grounds to San Francisco Bay and the Pacific Ocean.

2.3 Chinook Salmon, Central Valley Spring-Run ESU

2.3.1 ESA Listing Status

The Central Valley Spring-Run Chinook Salmon ESU was listed as threatened under the ESA in 1999 because of the reduced range and small size of remaining Spring-Run Chinook Salmon populations (64 FR 50393). On June 28, 2005, NMFS published the final hatchery listing policy (70 FR 37204) and reaffirmed the threatened status of the ESU (70 FR 37160). The ESU consists of naturally spawned Spring-Run Chinook Salmon originating from the Sacramento River and its tributaries, and also from the Feather River Fish Hatchery (FRFH) Spring-Run Chinook Program (NMFS 2016b).

Based on a review of the available information, NMFS (2016b) recommends that the Central Valley Spring-Run Chinook Salmon ESU remain classified as a threatened species. NMFS’ review also indicates that the biological status of the ESU has probably improved since the previous status review in 2010–2011 and that the ESU’s extinction risk may have decreased. However, the ESU is still facing substantial risks (Williams et al. 2016). Spring-Run Chinook Salmon escapement data for the Sacramento River Basin (CDFW 2018b) indicate that Spring-Run Chinook Salmon populations have steadily declined in abundance from 2014 through 2017 since peaking in 2013. As part of the 5-year review, NMFS also re-evaluated the status of the FRFH stock and concluded that it should remain part of the Central Valley Spring-Run Chinook Salmon ESU.

2.3.2 General Life-History and Habitat Requirements

Adult Spring-Run Chinook Salmon enter freshwater as immature fish between mid-February and July and remain in deep cold pools in proximity to spawning areas until they are sexually mature and ready to spawn in late summer and early fall, depending on water temperatures (CDFG 1998; NMFS 2009).

Spawning occurs in gravel substrate in relatively fast-moving, moderately shallow riffles or along banks with relatively high water velocities to promote higher oxygen levels and eliminate fines in the substrate. Fry emerge from the gravel from November to March (Moyle 2002) and can have highly variable emigration timing based on various environmental factors (NMFS 2009). Post-emergent fry inhabit calm, shallow waters with fine substrates and depend on fallen trees, undercut banks, and overhanging riparian vegetation for refuge (Healey 1991).

Some juveniles begin emigrating soon after emergence from the gravel, whereas others over-summer and emigrate as yearlings with the onset of intense fall storms (CDFG 1998). The emigration period for Spring-Run Chinook Salmon can extend from November to early May, with up to 69 percent of the young-of-the-year fish outmigrating through the lower Sacramento River and Delta during this period (CDFG 1998 as cited in NMFS 2009). Peak movement of yearling Spring-Run Chinook Salmon in the Sacramento River at Knights Landing occurs in December and again in March and April for young-of-the-year juveniles (NMFS 2009).

During juvenile rearing and downstream movement, salmon prefer stream margin habitats with sufficient depths and velocities to provide suitable cover and foraging opportunities. As described for Winter-Run Chinook Salmon, off-channel areas and floodplains can provide important rearing habitat. The greater availability of prey and favorable rearing conditions in floodplains increases juvenile growth rates compared with conditions in the mainstem Sacramento River, which can lead to improved survival rates during both their migration through the Delta and later in the marine environment (Sommer et al. 2001a).

2.3.3 Historical and Current Distribution and Abundance

Spring-Run Chinook Salmon populations historically occupied the headwaters of all major river systems in the Central Valley up to any natural barrier (Yoshiyama et al. 1998; Reclamation 2008). The Sacramento River was used as a migratory corridor to spawning areas in upstream tributaries and headwater streams (CDFG 1998). The most complete historical record of Spring-Run Chinook migration timing and spawning is contained in reports to the U.S. Fish Commissioners of Baird Hatchery operations on the McCloud River (Stone 1893, 1895, 1896a, 1896b, 1896c, 1898; Williams 1893, 1894; Lambson 1899, 1900, 1901, 1902, 1904, all as cited in CDFG 1998). Spring-Run Chinook migration in the upper Sacramento River and tributaries extended from mid-March through the end of July with a peak in late May and early June. Baird Hatchery intercepted returning adults and spawned them from mid-August through late September. Peak spawning occurred during the first half of September. The average time between the end of Spring-Run spawning and the onset of Fall-Run spawning at Baird Hatchery was 32 days from 1888 through 1901.

Construction of the Shasta and Keswick Dams in 1945 and 1950, respectively, has blocked passage to areas of historic spawning habitat, limiting potential spawning habitat to areas downstream of the dams. The presence of dams on the Sacramento River has blocked upstream passage of Spring-Run Chinook Salmon to historically available spawning habitat and confined them to a much smaller area of the watershed. Current spawning is restricted to limited areas in mainstem reaches below the lowermost impassable dams and in a few select tributaries with reduced habitat availability. However, Spring-Run spawned and continue to spawn in rivers other than the Sacramento River. The Central Valley drainage as a whole is estimated to have supported annual runs of Spring-Run Chinook Salmon as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). Following construction of Shasta, Keswick, and Friant dams, annual runs were estimated to be no more than 26,000 fish in the 1950s and 1960s (CDFW GrandTab data; Yoshiyama et al. 1998). Before the construction of Friant Dam (completed in 1942), nearly 50,000 adults were counted in the San Joaquin River (Fry 1961). The San Joaquin populations were essentially extirpated by the 1940s, with only small remnants of the run that persisted through the 1950s in the Merced River (Hallock and Van Woert 1959; Yoshiyama et al. 1998).

The Central Valley Spring-Run Chinook Salmon ESU has displayed broad fluctuations in adult abundance. Estimates of Spring-Run Chinook Salmon in the Sacramento River and its tributaries (not including the lower Yuba and Feather rivers because CDFW's GrandTab does not distinguish between Fall-Run and Spring-Run Chinook Salmon in-river spawners, and not including the FRFH) have ranged from 1,105 in 2017 to 25,890 in 1982.

Since 1995, Spring-Run Chinook Salmon annual run size estimates typically have been dominated by Butte Creek returns. Of the three tributaries producing naturally spawned Spring-Run Chinook Salmon (Mill, Deer, and Butte creeks), Butte Creek has produced an average of two-thirds of the total production over the past 10 years (DWR and Reclamation 2017; CDFW 2018b). During recent years, Spring-Run Chinook Salmon escapement estimates (excluding in-river spawners in the Yuba and Feather rivers) have ranged from 23,696 in 2013 to 1,796 in 2017 throughout the tributaries to the Sacramento River surveyed (CDFW 2018b).

Spring-Run Chinook Salmon population estimates remain low. Spring-Run Chinook escapement was estimated to be 6,453 in 2016 and 1,105 in 2017 (Figure 2.3-1; Azat 2018). In addition, fish monitoring is conducted throughout the year at the Tracy Fish Collection Facility (TFCF) and the John E. Skinner Delta Fish Protective Facility (Skinner Fish Facility) (collectively referred to as the Delta fish facilities). During WY 2017, 26,551 wild juvenile Spring-Run and 963 hatchery Spring-Run were observed at the Delta fish facilities, and 9,487 wild juvenile Spring-Run and 1,010 hatchery Spring-Run were observed during WY 2018. Fish monitoring is also conducted at the Rock Slough Intake by the Contra Costa Water District (CCWD). No Spring-Run have been collected in CCWD's Fish Monitoring Program at the Rock Slough Intake since 2008.

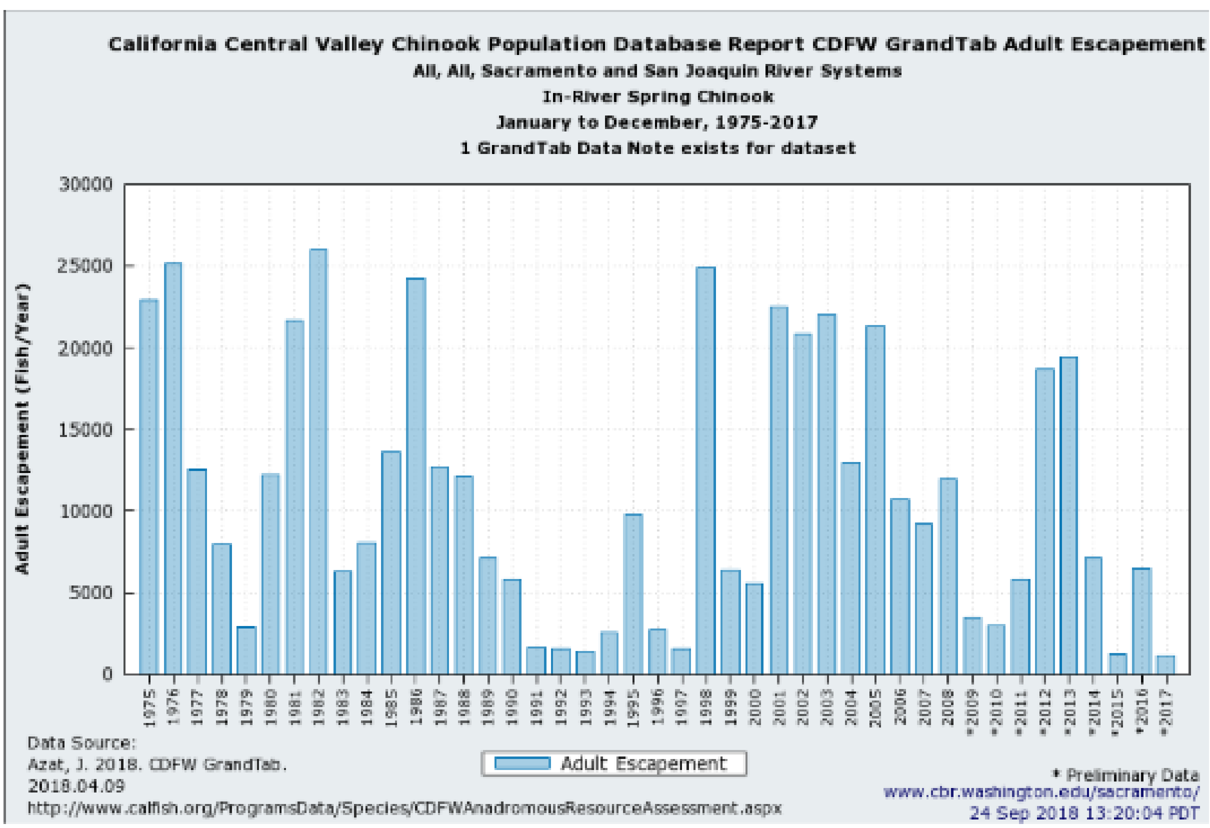


Figure 2.3-1. Estimates of Central Valley Spring-Run Chinook Salmon Escapement, 1975–2017

2.3.4 Limiting Factors, Threats, and Stressors

As discussed in the Winter-Run Chinook Salmon section and in Section 3.1, Past and Present Impacts, , the habitat that remains for Spring-Run Chinook Salmon has been negatively impacted by inadequate flows and increased water temperatures from dam and water diversion operations on streams throughout the Sacramento River Basin including on Deer, Mill, and Antelope Creeks. Losses of suitable spawning gravel, the development of deep channels and levees, pollutants and siltation from urban development, mining, and water diversions are also stressors on this ESU (NMFS 2009; 2014).

The degradation and simplification of aquatic habitat in the Central Valley has greatly reduced the resiliency of Spring-Run Chinook Salmon to respond to additional stressors such as an extended drought and poor ocean conditions. Levee construction and maintenance projects have greatly simplified riverine habitat and have disconnected rivers from the floodplain (NMFS 2016b).

Climate change poses a further threat to the species with increasingly high water temperatures and changes to ocean conditions. Spring-Run Chinook Salmon may be particularly vulnerable as adults over-summer in freshwater streams before spawning in autumn. The Central Valley Spring-Run Chinook Salmon spawn primarily in the tributaries to the Sacramento River, and those tributaries without cold water refugia will be more susceptible to impacts of climate change. Even in tributaries with cool water springs, in years of extended drought and warming water temperatures, unsuitable conditions may occur (NMFS 2016b). Juveniles often rear in their natal stream for one to two summers prior to emigrating, and would be susceptible to warming water temperatures.

2.3.5 Water Operations Management

Spring-Run requirements do not typically control the operation of Shasta, Oroville, Folsom, or New Melones Dams. On Clear Creek, Reclamation has a requirement from its 2002 water right as well as the 2000 Reclamation / USFWS /CDFW agreement to provide 50 cfs flow year-round, increasing to 70 cfs in November and December of critical years and increasing to 100 cfs in November and December of normal years. In addition to these flows, Reclamation makes releases as part of the CVPIA b(2) and (b)(12) program. Reclamation's operations follow the CVPIA AFRP guidelines (USFWS 2001) which, for Clear Creek, are: "200 cfs October 1 to June 1 from Whiskeytown dam for Spring-Run, Fall-Run, and Late Fall-Run Salmon spawning, egg incubation, emigration, gravel restoration, spring flushing and channel maintenance; and release 150 cfs or less, from July through September to maintain less than 60°F temperatures in stream sections utilized by Spring-Run Chinook Salmon." Additionally, the less water available for the transbasin diversion, the greater potential impact to Clear Creek temperatures as adequate temperatures in Clear Creek are dependent to a large degree on the volume of water moving through Lewiston and Whiskeytown reservoirs.

2.3.6 Recovery and Management

The NMFS 2014 Recovery Plan for Sacramento River Winter-Run Chinook Salmon, Central Valley Spring-Run Chinook Salmon, and Central Valley Steelhead outlines actions to restore habitat, access, and improve water quality and quantity conditions in the Sacramento River to promote the recovery of listed salmonids.

Under the CVPIA, Reclamation has funded the Service to undertake a number of actions to improve Spring-Run including, but not limited to, the restoration of Butte Creek and passage improvements to facilities on Mill Creek and Deer Creek. Spawning and rearing habitat improvements on the Upper Sacramento River also benefit Spring-Run. For more details concerning Spring-Run Chinook in Clear

Creek, see the 2017 Clear Creek Technical Team Annual Report for the Coordinated Long-Term Operation Biological Opinion.

2.3.6.1 *Clear Creek Restoration Program*

Reclamation annually expends funding for the CVPIA, Section 3406(b)(12) Clear Creek Restoration Program. The goals of the Clear Creek Restoration Program are to (1) provide flows to allow sufficient spawning, incubation, rearing, and outmigration for Salmon and Steelhead; (2) restore the stream channel and associated instream habitat; and (3) determine impacts of restoration actions on anadromous fish and geomorphology. The program manages flows and temperatures through releases from Whiskeytown Dam on a year-round basis to support the different life stages of Salmon and Steelhead in Clear Creek. The amounts of water, considering timing, magnitude, and duration, and water temperature are controlled to meet this goal. The Clear Creek Restoration Program is working on restoration of a 2-mile section of Clear Creek floodplain and stream channel degraded by aggregate and gold mining, dams and diversions, and annually injects gravel to recharge and maintain the system (approximately 8,000 to 10,000 tons of gravel per year). The Clear Creek Restoration Program aims to create and maintain 347,288 square feet of usable spawning habitat in Clear Creek.

2.3.6.2 *Ocean Management*

All of California’s Chinook Salmon stocks are impacted to some extent by ocean fisheries (NMFS, 2000). As NMFS (2000) states, “the lack of an annual estimate of ocean harvest rate for the Central Valley fall chinook stocks targeted by ocean fisheries makes assessment of fishery impacts on listed stocks difficult. While the harvest rates on listed ESUs are believed to be less than that occurring on Central Valley fall chinook, the lack of a harvest rate estimate for even the targeted Central Valley stocks requires the Pacific Fisheries Management Council and NMFS to address recovery of weak stocks through “adaptive management” strategies, in which fishing effort is either eliminated or reduced by somewhat judgemental amounts and the effect is then assessed by monitoring spawning escapement in subsequent years.” The 2000 BO on ocean harvest’s effect (the Pacific Coast Salmon Plan) on Spring-Run Chinook Salmon concluded that continued harvest was not likely to jeopardize the continued existence of Central Valley Spring-Run Chinook Salmon (NMFS 2000).

To address the lack of an annual estimate of ocean harvest rate, one approach would be to estimate age-specific ocean fishing mortality rates by using cohort reconstructions applied to tagged Feather River Hatchery salmon (Satterthwaite et al. 2018). Harvest models that predict how Spring-Run would be affected by fishing regulations could be developed from reference harvest rates (Satterthwaite et al. 2018). Data and monitoring needs to better guide management of Central Valley Spring-Run Chinook including genetic sampling of juvenile emigrants to improve juvenile production data (Satterthwaite et al. 2018). Increased tagging and sampling of Spring-Run is needed to directly estimate ocean fishing mortality rates.

2.3.7 Monitoring and Research Programs

2.3.7.1 *San Joaquin River Restoration Program Experimental Population Management and Monitoring*

The San Joaquin River Restoration Program (SJRRP) has conducted and is in the process of conducting a large number of Spring-Run monitoring and research programs. The SJRRP has released a combination of FRFH and San Joaquin River Conservation and Research Facility (SCARF) Spring-Run Chinook Salmon juveniles to the San Joaquin River since 2014. All juvenile Spring-Run Chinook Salmon released are adipose fin-clipped and coded wire tagged. More information is available here: https://www.westcoast.fisheries.noaa.gov/central_valley/san_joaquin/san_joaquin_reint.html.

Because of previous release/reintroduction efforts, 2017 was the second year that adult Spring-Run Chinook Salmon had the potential to return to the San Joaquin River. However, due to an above average water year that prevented the placement of collection or counting stations, only limited monitoring occurred during the anticipated migration period. No unmarked Spring-Run Chinook (indicating wild origin) were seen in the lower reaches of the river.

UC Davis initiated a 2-year study in 2017 to calculate reach-specific survival and migration conditions for juvenile salmonids in the Lower San Joaquin River and south Delta. In March 2017, 700 individual SJRRP juveniles were tagged with acoustic JSATS tags and released in two evenly sized groups.

The SJRRP has established a parentage based tagging (PBT) program for the San Joaquin River Chinook Salmon populations. PBT involves the annual sampling and genotyping of adult Chinook Salmon returning to the Restoration Area; these data are being used to create a database of genotypes for future parentage assignment of their progeny. Genetic sampling of the San Joaquin River Fall-Run Chinook Salmon population began in 2013. As such, all adult Chinook Salmon returning to the Restoration Area in 2017/2018 were tissue sampled for genetic testing.

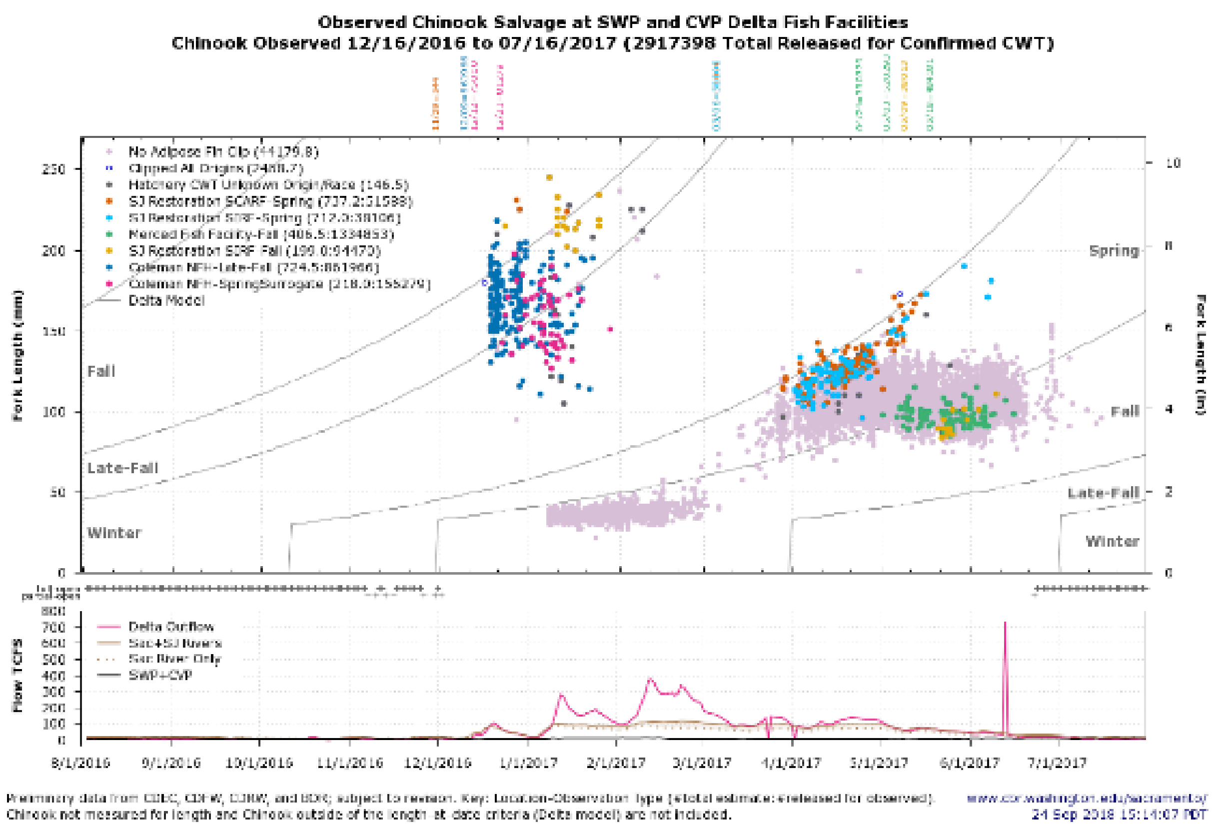


Figure 2.3-2. Observed Chinook Salvage at SWP and CVP Delta Fish Facilities during WY 2017

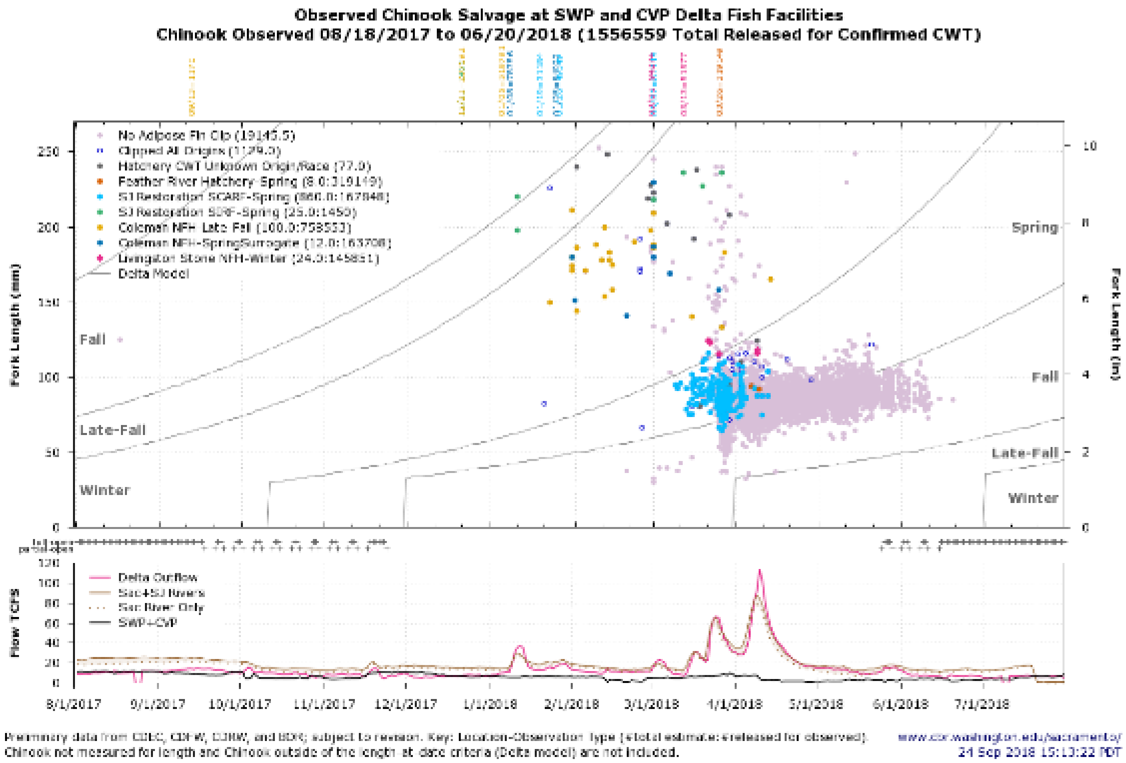


Figure 2.3-3. Observed Chinook Salvage at SWP and CVP Delta Fish Facilities during WY 2018

2.4 Spring-Run Chinook Critical Habitat

Critical habitat for the Central Valley Spring-Run Chinook Salmon was designated on September 2, 2005, and includes the mainstem Sacramento River from Chipps Island (RM 0) to Keswick Dam, and tributary reaches, including the Feather and Yuba rivers; Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks; and portions of the northern Delta (70 FR 52488).

Physical and Biological Features (PBFs) essential for the conservation of listed Chinook Salmon ESUs are those sites and habitat components that support one or more life stages and include:

1. Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development.
2. Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.
3. Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.
4. Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover

such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.

5. Nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels.
6. Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.

2.5 Central Valley Fall-Run and Late Fall-Run Chinook Salmon, Evolutional Significant Unit

2.5.1 ESA Listing Status

The Fall-Run and Late Fall–Run Chinook Salmon includes all spawning populations of Fall-Run and Late Fall–Run Chinook Salmon in the Sacramento and San Joaquin River basins and their tributaries east of Carquinez Strait, California (64 FR 50394). After reviewing the best available scientific and commercial information, NMFS on September 16, 1999, determined that listing Central Valley Fall-Run and Late Fall–Run Chinook Salmon was not warranted. On April 15, 2004, the Central Valley Fall-Run and Late Fall–Run Chinook Salmon ESU was identified by NMFS as a Species of Concern (69 FR 19975).

Freshwater Essential Fish Habitat (EFH) for Pacific Salmon in the California Central Valley includes waters currently or historically accessible to salmon within the Central Valley ecosystem as described in Myers et al. (1998). EFH includes not only the watersheds of the Sacramento and San Joaquin River basins but also the San Joaquin Delta (Delta), Suisun Bay, and the Lower Sacramento River.

2.5.2 General Life-History and Habitat Requirements

Chinook Salmon have evolved a broad array of life history patterns that allow them to take advantage of diverse riverine conditions throughout the year. These life history patterns generally fall into two main generalized freshwater life history types: stream-type and ocean-type (Healey 1991). Ocean-type Chinook Salmon like Fall-Run and Late-Fall–Run enter freshwater in late summer and fall and spawn soon after, and juveniles typically migrate to the ocean as young-of-the-year after several months or rearing.

Adult Fall-Run Chinook Salmon migrate through the Delta and into Central Valley rivers from June through December. Individuals spawn in the Sacramento River and eggs and alevins are in the gravel primarily between September and January, with a peak during October through December. Most individuals (83.4 percent) spawn upstream of Red Bluff Diversion Dam, although, unlike other races of Chinook salmon, a moderate percentage (16.6 percent) spawn below Red Bluff Diversion Dam (Table 2.5-1).

Table 2.5-1. The Temporal Occurrence of Adult and Juvenile Fall-Run Chinook Salmon at Locations in the Central Valley

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult												
Delta[1]												
Sacramento River Basin[2]												
San Joaquin River[2]												
Juvenile												
Sacramento River at Red Bluff[3]												
Delta (beach seine)[4]												
Mossdale (trawl)[4]												
West Sacramento River (trawl)[4]												
Chipps Island (trawl)[4]												
Knights Landing (trap)[5]												

Relative Abundance: = High = Medium = Low

Note: Darker shades indicate months of greatest relative abundance.

Sources:

[1] State Water Project and Federal Water Project fish salvage data 1981–1988.

[2] Yoshiyama et al. 1998; Moyle 2002; Vogel and Marine 1991.

[3] Martin et al. 2001.

[4] U.S. Fish and Wildlife Service 2001b.

[5] Snider and Titus 2000.

Source: DWR and Reclamation 2016, p.11A–103

Table 2.5-2 shows the timing of the upstream presence of adult and juvenile life stages Late Fall-Run Chinook Salmon in the Sacramento River. The months included in this table represent the periods during which the majority (more than approximately 90 percent) of fish in a life stage are present. The life history characteristics of Late Fall–Run Chinook Salmon are not well understood. Late Fall–Run Chinook Salmon spawn in the Sacramento River and eggs and alevins are in the gravel primarily between December and June, with a peak during January through March. Most adults (83.4 percent) spawn upstream of Red Bluff Diversion Dam, and roughly two thirds (67.6 percent) spawn just below Keswick Dam in the reach to the ACID Dam (Table 2.5-2).

Table 2.5-2. The Temporal Occurrence of Adult and Juvenile Late Fall-Run Chinook Salmon at Locations in the Central Valley

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult												
Delta[1]												
Sacramento River Basin[2]												
Juvenile												
Sacramento River at Red Bluff[3]												
West Sacramento River (trawl)[4]												
Delta (beach seine)[4]												
Chipps Island (trawl)[4]												
Knights Landing (trap)[5]												

Relative Abundance: = High; = Medium; = Low

Note: Darker shades indicate months of greatest relative abundance.

Sources:

[1] Moyle 2002.

[2] Yoshiyama et al. 1998; Moyle 2002; Vogel and Marine 1991.

[3] Martin et al. 2001.

[4] U.S. Fish and Wildlife Service 2001b.

[5] Snider and Titus 2000.

Source: DWR and Reclamation 2016, p.11A–104

In the Sacramento River, adult Fall-Run Chinook Salmon migrate upstream to spawn primarily during July through December, with a peak during August and September (Table 2.5-1). Adults that reach spawning grounds early in the season during July and August may hold before spawning (D. Swank, pers. comm.). Adult Late Fall-Run Chinook Salmon migrate upstream primarily during November through April (Table 2.5-2.).

Spawning occurs in gravel substrate in relatively fast-moving, moderately shallow riffles or along banks with relatively high water velocities to promote higher oxygen levels and eliminate fines in the substrate. Depending on ambient water temperature, embryos hatch in 40 to 60 days, and alevin (yolk-sac fry) remain in the gravel beds for an additional 4 to 6 weeks. As their yolk-sacs become depleted, fry begin to emerge from the gravel and start exogenous feeding. Fall-Run Chinook Salmon fry (i.e., juveniles shorter than 2 inches long) in the Sacramento River generally emerge from December through March, with peak emergence occurring by the end of January. In general, Fall-Run Chinook Salmon fry abundance in the Delta increases following high winter flows. Most Fall-Run Chinook Salmon fry rear in fresh water from December through June, with emigration occurring from December through June and a peak from January through March (Table 2.5-1). Smolts that arrive in the estuary after rearing upstream migrate quickly through the Delta and Suisun and San Pablo Bays. A very small number (generally less than 5 percent) of Fall-Run juveniles spend over a year in fresh water and emigrate as yearling smolts the following November through April.

Late Fall–Run Chinook Salmon fry generally emerge from March through June. Late Fall–Run fry rear upstream until about July (Table 2.5-2) and in fresh water from April through the following April and emigrate as smolts from November through May.

2.5.3 Historical and Current Distribution and Abundance

Central Valley Fall-Run Chinook Salmon historically spawned in all major tributaries, as well as the mainstem of the Sacramento and San Joaquin Rivers. The historical distribution of Central Valley Late Fall–Run Chinook Salmon is not well understood, but is thought to be less extensive than that of Fall-Run. Late Fall–Run adults most likely spawned in the Upper Sacramento and McCloud Rivers in reaches now blocked by Shasta Dam, as well as in major tributaries with adequate cold water in summer. There is also some evidence they once spawned in the San Joaquin River in the Friant region and in other large San Joaquin tributaries (Yoshiyama et al. 1998).

Currently Fall-Run Chinook spawn below rim dams and barriers to migration in the Sacramento and San Joaquin Rivers and their tributaries. Some smaller streams that lack unpassable barriers have runs that extend into historical Fall-Run habitat. Late Fall–Run currently spawn almost exclusively in the Upper Sacramento River from Keswick Dam to ACID Dam.

Abundance of Central Valley Fall-Run and Late Fall–Run Chinook Salmon escapement before 1952 is not well documented. Production estimates of Fall-Run and Late–Fall Run Chinook Salmon on the San Joaquin River historically approached 300,000 adults and probably averaged approximately 150,000 adults (Reynolds et al.1993.). Calkins et al. (1940) estimated Fall-Run and Late Fall–Run Chinook Salmon abundance at 55,595 adults in the Sacramento River basin from 1931 to 1939. Adult Fall-Run and LateFall–Run Chinook Salmon escapement in the early 1960s, was estimated to be 327,000 in the Sacramento River basin (California Department of Fish and Game 1965). Estimates of Fall-Run and Late Fall–Run Chinook Salmon escapement in the mid-1960s, to the San Joaquin River basin was about 2,400 fish (Reynolds et al. 1993). Sacramento and San Joaquin Rivers in river Fall-Run estimates of escapement from 1975 to 2017 (Figure 2.5-1.). Fall-Run Chinook Salmon of hatchery origin are included in the Pacific Coast Salmon Fishery Management Plan and are included in an EFH type analysis (Pacific Fishery Management Council 2014). Hatchery Fall-Run Chinook Salmon in the Sacramento and San Joaquin Rivers have ranged from over 700,000 in 2005 to just over 20,000 in 2009 (Figure 2.5-2.). Sacramento and San Joaquin River Fall-Run Chinook have been described as primarily a hatchery stock with a smaller natural component. The San Joaquin River Fall-Run Chinook Salmon population also has hatchery and natural components. Huber and Carlson (2015) provide a synthesis of trends in release number, location, size, and timing of Fall-Run Chinook Salmon released from the five Central Valley hatcheries between 1946 and 2012. They found since the mid-1980s the proportion of hatchery Fall-Run Chinook Salmon juveniles released downstream of the Delta has varied from around 20 to 60 percent.

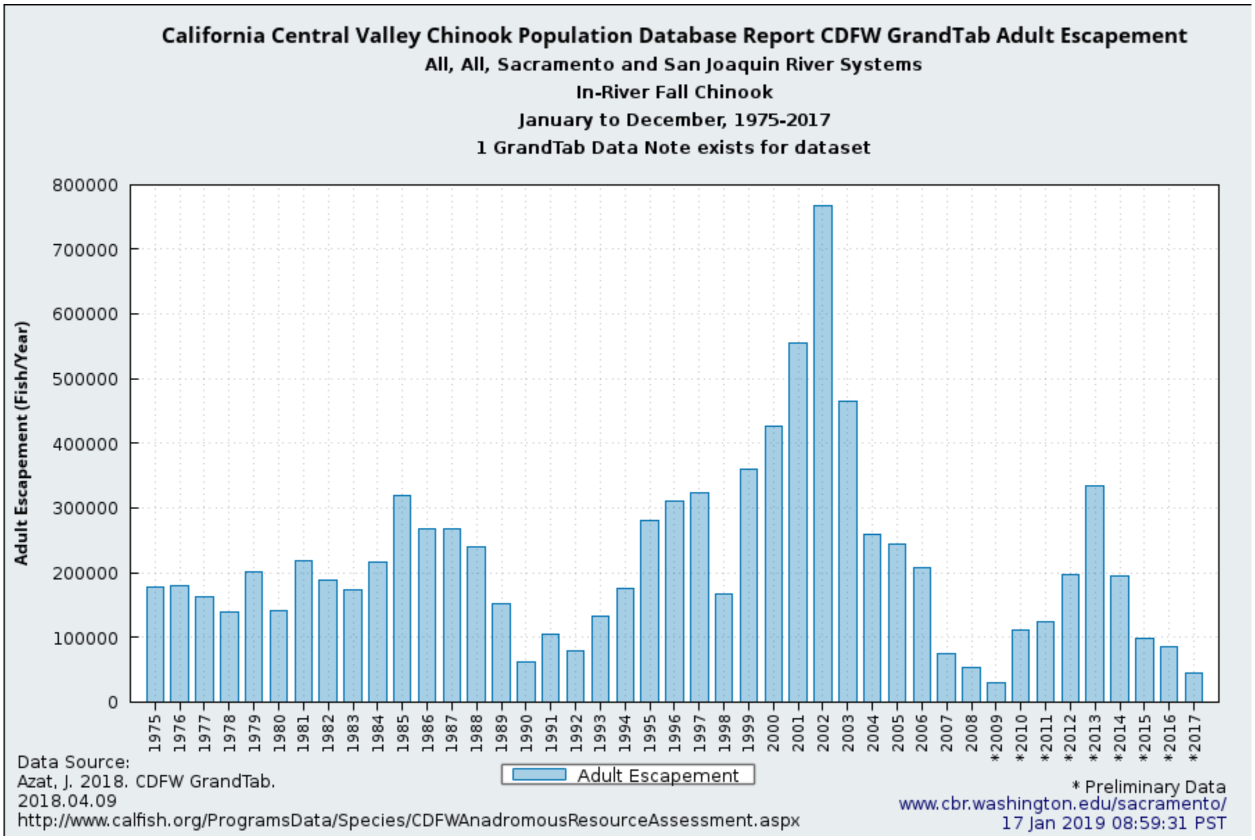


Figure 2.5-1. In-River Escapement Numbers of Fall-Run Chinook, Sacramento and San Joaquin River Systems

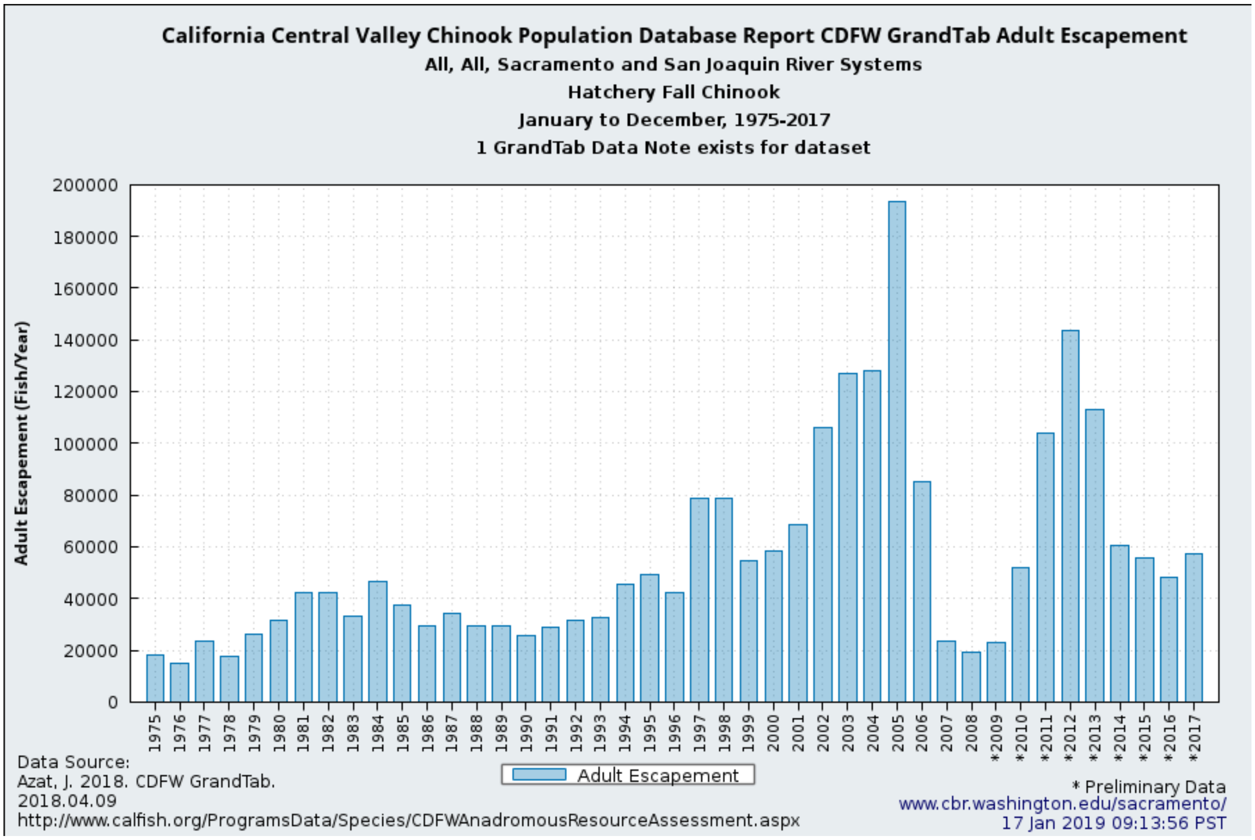


Figure 2.5-2. Hatchery Escapement Numbers of Fall-Run Chinook, Sacramento and San Joaquin River Systems

In the Sacramento and San Joaquin River from 1975 through 2017 adult escapement estimates for Late Fall–Run Chinook Salmon have ranged from several hundred adults to over 40,000 adults (Figure 2.5-3.). Between 1971 and 1997, adult escapement showed a general trend of declining abundance. From 1990 through 2006, escapement increased substantially, but was also highly variable from year to year. Escapement estimates were lower than the previous 4 years in 2008 and 2009, but not on the magnitude that was observed for Fall-Run Chinook Salmon (California Department of Fish and Wildlife 2016). Sacramento River Late Fall–Run Chinook Salmon stock has hatchery and natural components from the Upper Sacramento River basin (Figure 2.5-4).

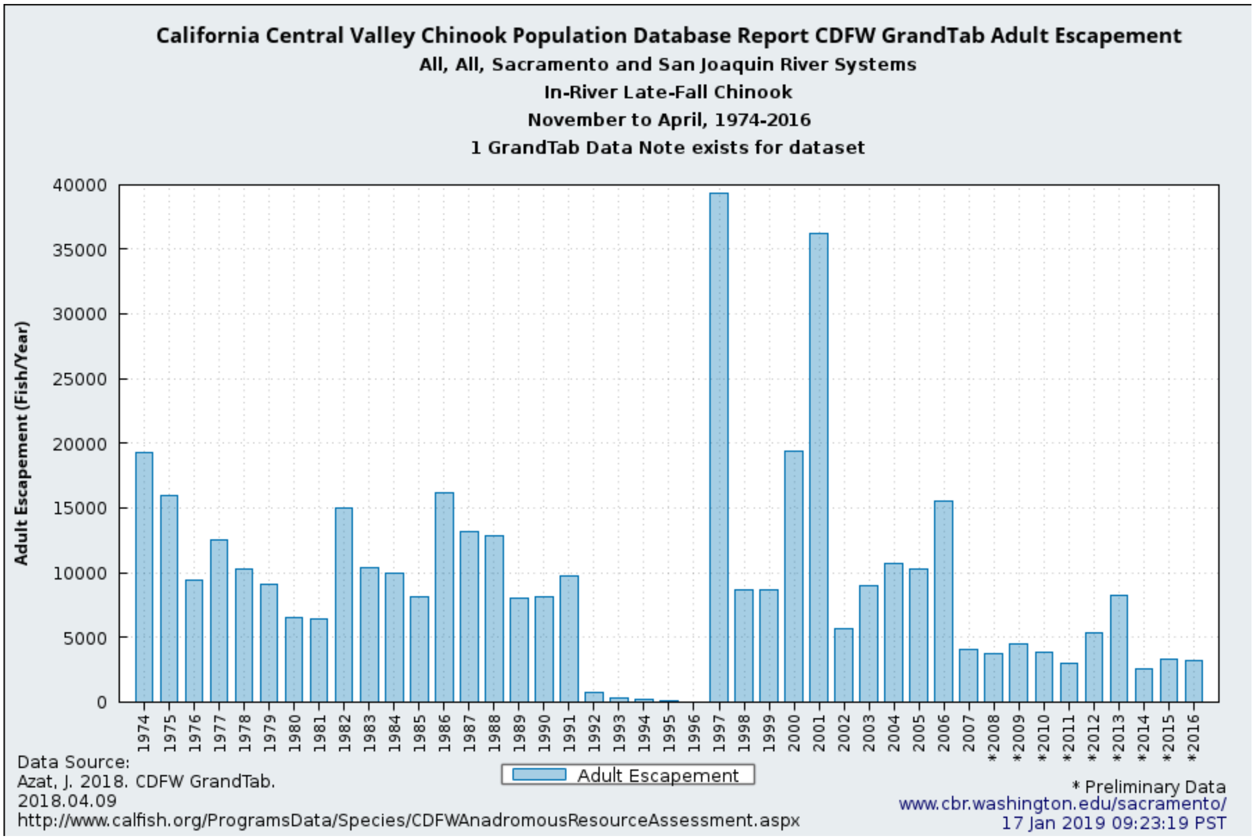


Figure 2.5-3. In-River Escapement Numbers of Late Fall-run Chinook, Sacramento and San Joaquin River Systems 1974–2017

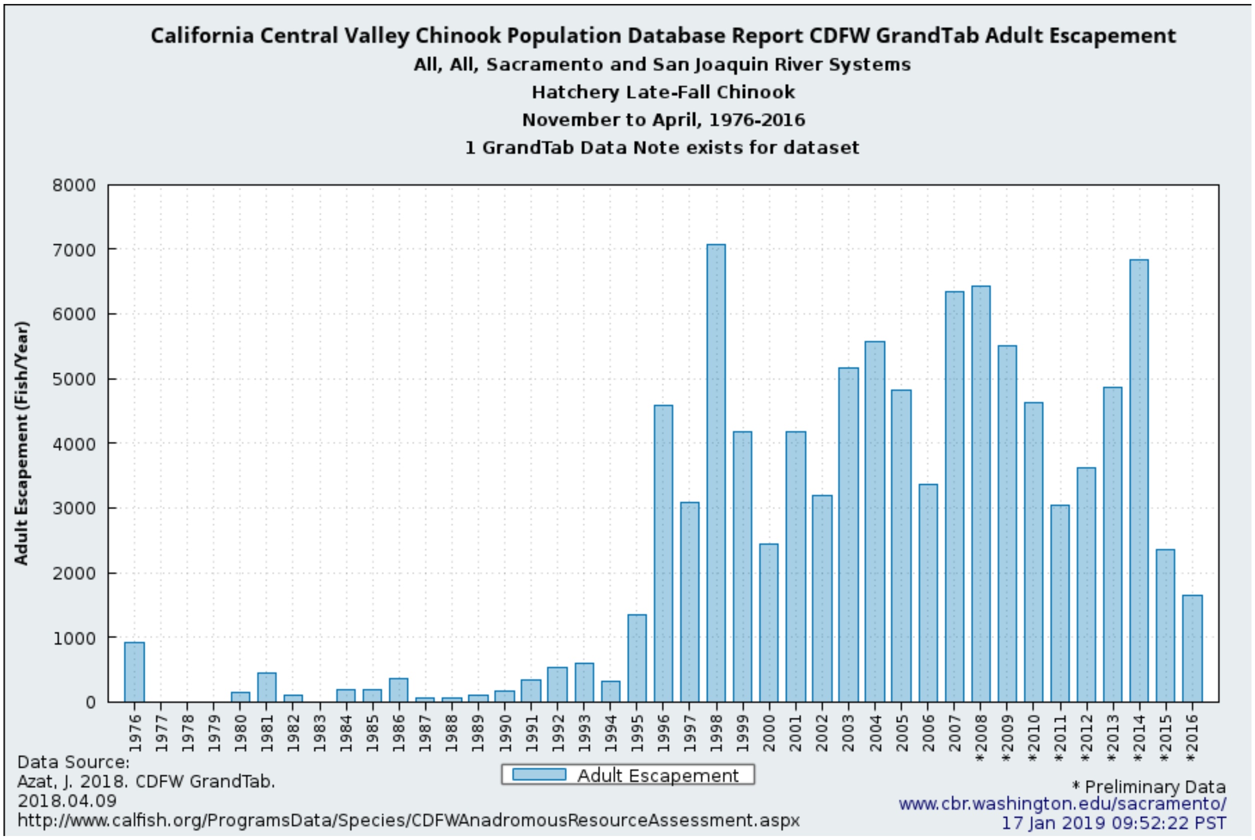


Figure 2.5-4. Hatchery Escapement Numbers of Late Fall-run Chinook, Sacramento and San Joaquin River Systems 1974–2017

2.5.4 Limiting Factors, Threats, and Stressors

The major factors that limit the range and abundance of Chinook Salmon are barriers to upstream migration, altered flow regime, high water temperature, habitat quality, entrainment in water diversions, loss of riparian and floodplain habitat, and ocean conditions.

Access to much or all of their historical spawning habitat was eliminated by high dams with no fish passage structures, although Fall-Run Chinook Salmon were less affected by these barriers than other Chinook races because much of their historical spawning habitat included the lower gradient reaches downstream of these dams (Reynolds et al. 1993; McEwan 2001). Changes in hydrologic patterns like the loss of spring peak flows and extended summer flows resulting from water and power operations have altered water temperatures and other habitat conditions for Fall-Run and Late Fall–Run Chinook (Williams 2006).

Migration and emigration corridors that previously contained high-value habitat types, such as dendritic channel systems, perched stream banks, floodplains and marshes, have been marginalized through channelization and leveed banks lined with riprap (Brandes and Mclain 2001). Natural flow regimes have been modified by upstream reservoirs that capture water during high flow events, thus, dampening the hydrograph and lowering the extent and duration of floodplain inundations and other off-channel, flow-dependent habitat used by emigrating juvenile Chinook salmon (70 FR 52488; Sommer et al. 2001; California Department of Water Resources 2005). Tidal and floodplain habitat areas provide important rearing habitat for foraging juvenile salmonids, including Fall-Run Chinook Salmon. Studies have shown that these salmonids 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 on juvenile salmonids (Williams 2009). Similarly, channel margins provide valuable rearing and connectivity habitat along migration corridors, particularly for smaller juvenile fry, such as Fall-Run Chinook Salmon.

Predation on juvenile salmon by nonnative fish has been identified as an important threat to Fall-Run and Late Fall–Run Chinook Salmon in areas with high densities of nonnative fish that prey on outmigrating juvenile salmon (e.g., Smallmouth and Largemouth Bass, Striped Bass, and Catfish) (Lindley and Mohr 2003). Reduced habitat diversity (e.g., lack of cover) of channelized waterways in the rivers and Delta reduce refuge space for salmon from predators (Raleigh et al. 1984; Missildine et al. 2001; 70 FR 52488).

Climate experts predict physical changes to ocean, river, and stream environments along the West Coast that include warmer atmospheric temperatures, diminished snow pack resulting in altered stream flow volume and timing, lower late summer flows, a continued rise in stream temperatures, and increased sea-surface temperatures and ocean acidity resulting in altered marine and freshwater food-chain dynamics (Williams et al. 2016). Climate change and associated impacts on water temperature, hydrology, and ocean conditions are generally considered likely to have substantial effects on Chinook Salmon populations in the future (NMFS 2014). Global parameters, such as ocean conditions, have also demonstrated a marked effect on adult escapement (Lindley et al. 2009).

Impacts from hatchery fish (i.e., reduced fitness, weaker genetics, smaller size, less ability to avoid predators) have deleterious impacts on natural in-river populations (Hindar et al. 1991; Ryman et al. 1994; Waples 1994; McLean et al. 2005; Ford et al. 2006).

2.5.5 Recovery and Management

The following sections describe recovery and management actions that have been taken to benefit Fall-Run and Late Fall–Run Chinook Salmon.

2.5.5.1 *Anadromous Fish Restoration Program*

Reclamation annually expends funding for the CVPIA AFRP (CVPIA 3406(b)(1)) to undertake reasonable measures to not less than double anadromous fish populations of the 1967 to 1991 period and to mitigate other adverse environmental effects. Fall-Run and Late Fall–Run conservation actions are described in the final plan for the AFRP (2001).

2.5.5.2 *Anadromous Fish Screen Program*

Section 3406(b)(21) of the CVPIA authorized the AFSP to assist the State of California on unscreened diversions. The AFRP screens or installs “fish protective devices” on diversions. The AFSP has developed guidelines to prioritize screening projects. Factors taken into account are location of the diversion in relation to areas used by anadromous fish for spawning and rearing, size of the diversion (or percent flow diverted in tributaries), season of diversion in relation to anadromous fish use of the stream or reach, and placement of the diversion. All but one of the diversions greater than 100 cfs on the Sacramento River have fish screens.

2.5.5.3 *Anderson Cottonwood Irrigation District*

The ACID operates a diversion dam across the Sacramento River located 5 miles downstream from Keswick Dam. The ACID Diversion Dam was improved in 2001 and 2015 with the addition of new fish ladders and fish screens around the diversion. (Killam 2008).

2.5.5.4 *Battle Creek Restoration Program*

The Battle Creek Salmon and Steelhead Restoration Project has a long history that includes research by various organizations and collaboration among many resource agencies and public interest groups. In 1999, a cooperative effort among Reclamation, USFWS, NMFS, CDFW, and PG&E led to the signing of a MOU. The Battle Creek Salmon and Steelhead Restoration Project includes modifications to facilities and adjustments to operations for anadromous fish. Construction is anticipated to be complete in 2021.

2.5.5.5 *Spawning and Rearing Habitat Restoration*

Reclamation expends annual funding for the CVPIA under Section 3406(b)(13) Spawning and Rearing Habitat Program. Federal, state, and local agencies, water users, and other stakeholders have partnered to develop and implement a continuing program for the purpose of restoring and replenishing, as needed, salmonid spawning gravel lost due to the construction and operation of CVP dams and other actions that have reduced the availability of spawning gravel and rearing habitat in the Sacramento River.

The Upper Sacramento River between Keswick Dam and Red Bluff Diversion Dam presents several opportunities for improving and restoring salmonid spawning and rearing habitats.

2.5.5.6 *Glenn Colusa Irrigation District Hamilton City Fish Screen*

Glenn Colusa Irrigation District (GCID) diverts a maximum of 3,000 cfs from the Sacramento River at the Hamilton City pump station. The peak demand occurs in the spring, often at the same time as the peak outmigration of juvenile salmon. Because GCID diverts up to 25 percent of the Sacramento River flow at Hamilton City, GCID pumping operations were identified as a significant impediment to the downstream juvenile salmon migration. In 2000, GCID and Reclamation completed a 620-foot-long fish screen extension and channel improvements to minimize entrainment of salmonids into GCID's facility.

2.5.5.7 *Red Bluff Diversion Dam*

The Red Bluff Diversion Dam was decommissioned in 2013, providing unimpaired juvenile and adult fish passage so that adult Chinook salmon could migrate through the structure at a broader range of flows and reach spawning habitat upstream of the structure. This project was authorized by CVPIA 3406(b)(10).

2.5.5.8 *Shasta Temperature Control Device*

Reclamation constructed the TCD in under the CVPIA 3406(b)(6). Reclamation operates the Shasta TCD to conserve the available cold pool in the reservoir for spawning and egg incubation temperatures for Chinook salmon without power bypass. Reclamation manages releases to maintain suitable depths over Chinook salmon redds to avoid dewatering.

2.5.5.9 *Whiskeytown Reservoir Spring Creek and Oak Bottom Temperature Curtains*

Reclamation has replaced both the Spring-Creek and Oak Bottom temperature curtains in Whiskeytown Reservoir to improve temperature flexibility and build a cold water pool for Clear Creek and Sacramento River temperature compliance.

2.5.5.10 *Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project*

Most salmonid floodplain rearing habitat in the Sacramento Valley was altered or blocked from use by dams and levees. The Yolo Bypass is the largest remaining floodplain in the Sacramento Valley, but is only accessible when the Sacramento River exceeds the crest of the Fremont Weir during high flow events. The Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project is a joint effort undertaken by DWR and Reclamation. The project largely focuses on infrastructure modifications to increase the number of juvenile salmonids that have access to floodplain habitat in the Yolo Bypass through Fremont Weir and to increase the ability of adult salmon and sturgeon to migrate from the Yolo Bypass to the Sacramento River.

2.5.5.11 *California Ecorestore*

California EcoRestore is an initiative to help coordinate and advance at least 30,000 acres of critical habitat restoration in the Delta by 2020. The program includes a broad range of habitat restoration projects, including aquatic, subtidal, tidal, riparian, flood plain, and upland ecosystems. Projects completed to date include include the following:

- Fremont Weir Fish Passage Modification—Fremont Weir Adult Fish Passage Modification Project widened and deepened the existing fish ladder at the Fremont Weir and the upstream and downstream adjoining channels were reconfigured to accommodate migratory fish passage. Existing earthen agricultural road crossings were replaced by permanent crossings that allow for the clear passage of migratory fish.
- Knights Landing Outfall Gates—A positive fish barrier was constructed (with new concrete wing walls and installation of a metal picket weir) on the downstream side of the existing Knights Landing Outfall Gate in the Colusa Basin Drain. This project serves primarily as a fish passage improvement action that will prevent salmon entry into the Colusa Basin Drain, where they become trapped with no access back to the Sacramento River.
- Wallace Weir—The project consisted of constructing a permanent earthen weir that was be hardened to withstand winter floods to prevent adult salmon entry into the Colusa Basin Drain. A fish rescue facility was incorporated into the weir so fish that arrive at the Wallace Weir via the Yolo Bypass can be safely and effectively rescued and returned to the Sacramento River to resume their migration to upriver spawning grounds.
- Lindsey Slough—The project restored habitat function and connectivity to 159 acres of freshwater emergent wetlands and 69 acres of alkali wetlands, and recreated and reconnected a 1-mile tidal channel.
- Sherman Island—The project constructed levee setbacks in Mayberry Slough that will augment existing riparian vegetation and restore tidal wetland that will provide habitat for native species including salmonids.
- Sacramento River Temperature Task Group—The SRTTG is a multiagency group formed pursuant to SWRCB Water Rights Orders 90-5 and 91-1 to assist with improving and stabilizing

Chinook population in the Sacramento River. Annually, Reclamation develops temperature operation plans for the Shasta and Trinity divisions of the CVP. These plans consider impacts on Winter-Run and other races of Chinook Salmon, and associated project operations. The SRTTG meets initially in the spring to discuss biological, hydrologic, and operational information, objectives, and alternative operations plans for temperature control.

2.5.5.12 *Flyway Farms Tidal Habitat Restoration Project*

Restored seasonal wetland and cattle grazing land to sub-tidal, intertidal and seasonal wetlands to benefit native fish species. Involves restoring and enhancing approximately 300 acres of tidal freshwater wetlands, and an additional 30 acres of seasonal wetlands, at the southern end of the Yolo Bypass. Designed to maximize residency time and food web production by capturing and slowly draining water through the excavation of two breaches along the Yolo Bypass Toe Drain and interior channels to connect and enhance existing wetlands on site. The goal is to improve habitat conditions for salmonids by providing rearing habitats for outmigrating juveniles and migratory habitats for adults.

2.5.5.13 *Shasta Dam Fish Passage Evaluation*

The Shasta Dam Fish Passage Evaluation was an effort to determine the feasibility of reintroducing Winter-run and Spring-Run Chinook Salmon and Steelhead to tributaries above Shasta Dam. The evaluation was part of Reclamation's response to the June 4, 2009, NMFS BO *Biological Opinion (BO) and Conference Opinion on the Long-Term Operation of the Central Valley Project (CVP) and State Water Project (SWP)* (NMFS 2009).

2.5.6 Water Operations Management

2.5.6.1 *Sacramento River*

The Sacramento River system includes several major features and facilities that are relevant to temperature management: (1) Shasta Dam and Lake and the installed TCD; (2) interbasin transfers from the Trinity River Basin, which are conveyed through Whiskeytown Lake, the Clear Creek Tunnel and Carr Powerhouse, and the Spring Creek Tunnel; and (3) Keswick Reservoir, which regulates releases from Shasta Dam and Spring Creek Powerhouses, resulting in a stable flow regime for release from Keswick Dam.

Reclamation currently strives to meet Sacramento River storage and temperature requirements (NMFS RPA Actions I.2.1 through I.2.4), as well as holding the Sacramento River Temperature Task Group meetings, providing operations plans each year, and using the Shasta TCD to strive to meet temperature targets while minimizing power loss.

Measures taken in 2014 and 2015 as part of a coordinated drought response to improve Shasta Reservoir cold water pool management included: (1) working with the SWRCB and water users to lower Wilkins Slough navigational flow requirements; (2) requesting that the SWRCB relax D-1641 Delta water quality requirements; (3) delaying Sacramento River Settlement Contractor depletions and transfering a volume of their water in the fall rather than increase depletions throughout the summer; (4) targeting slightly warmer temperatures during the Sacramento River Winter-Run Chinook Salmon holding period (before spawning occurs); and (5) installing a Shasta Dam TCD curtain in 2015.

2.5.6.2 *Clear Creek*

Reclamation has a requirement from its 2002 water right as well as the 2000 Reclamation/USFWS/DFW agreement for 50 cfs year-round in all years, increasing to 70 cfs in November and December of critical years and increasing to 100 cfs in November and December of normal years.

Reclamation's operations on Clear Creek follow the CVPIA AFRP guidelines (USFWS 2001) of 200 cfs October 1 to June 1 from Whiskeytown dam for anadromous salmonids and their habitat. A flow of 150 cfs or less, from July through September to maintain 60ºF temperatures in stream sections utilized by Spring-Run Chinook Salmon.

2.5.6.3 *Stanislaus River*

Reclamation operates the Stanislaus River separately from the other Central Valley Project reservoirs. While releases from New Melones Reservoir provide inflow to the Delta, Reclamation does not operate New Melones for Delta salinity, outflow, or export requirements. Reclamation operates New Melones Reservoir to meet instream flow objectives (see 2009 BO, Table 2E flows), dissolved oxygen standards as measured at Ripon, salinity objectives at Vernalis (as set in SWRBC D-1641) and Vernalis flow objectives as set in D-1641 and updated in the 2009 BO.

Prior to the 2009 BO Table 2E flows, instream releases on the Stanislaus River were set pursuant to the 1987 CDFG agreement. This agreement was intended to only be in place for 10 years while a specific set of fishery studies was completed to help inform the decision on what instream flows would be most beneficial. However, while studies have been completed, the agreement has never been updated. Each year Reclamation determines the annual volume of water available to be utilized for fishery releases and transmits that volume to the CDFW. CDFW is then responsible for determining the pattern of water release. Since the initiation of this agreement, the CDFW has routinely put 0 cfs as the required release during the summer months. Reclamation has a separate obligation to meet dissolved oxygen standards at Ripon during the summer months as required by Reclamation's water rights. DFW has always assumed that Reclamation will have to release approximately 300 cfs to meet the dissolved oxygen standards. This allowed CDFW to concentrate their fishery volume in other months. However, this was not the intent of the agreement and had the effect of stressing the reservoir resources, particularly in dry years. Since the BO, this has generally not been a problem because the 2009 NMFS BO Table 2E flows have generally been greater than those requested by CDFW. However, in some years or months, such as December 2018, the requested CDFW releases are higher than the Table 2E releases, reducing storage and affecting other authorized purposes of the reservoir.

2.5.6.4 *American River*

2.5.6.4.1 <u>Flow</u>

Flow releases from Folsom Reservoir are made for both flood control and to meet water quality objectives and demands in the Delta. This can result in rapid increases and decreases of flow during the winter and spring. As a result, dewatering and isolation of Steelhead redds has been documented (Hannon et al. 2003; Water Forum 2005; Hannon and Deason 2008). In addition to flow fluctuations, low flows also can negatively affect Lower American River Steelhead. At low flow levels, the availability of bar complexes and side channel areas characterized by habitat complexity in the form of velocity shelters, hydraulic roughness elements, and other forms of cover is limited.

Reclamation operates Folsom Dam and Reservoir to provide water for irrigation, M&I uses, hydroelectric power, recreation, water quality, flood control, and fish protection. Reclamation, operating under the SWRCB Decision 893 (D-893) adopted in 1958, allows flows at the mouth of the American River to fall as low as 250 cubic feet per second (cfs) from January through mid-September, with a minimum of 500 cfs required between September 15 and December 31. The D-893 decision does not address the requirements of the CVPIA, the 1995 Bay-Delta Plan, or biological opinions issued to protect Central Valley Steelhead. Reclamation and the SWCB and many stakeholders (Water Forum) agreed that D-893 did not provide sufficient protections for Central Valley Steelhead in the Lower American River. Recently, Reclamation has operated the Folsom/Nimbus complex to more modern protective requirements and habitat management plans by providing flows that far exceed those required in D-893.

NMFS provided a reasonable and prudent alternative (RPA) in their 2017 amendment to the 2009 RPA. In this amended RPA, NMFS requires the action of implementing the flow schedule specified in the Water Forum Flow Management Standard. This flow schedule developed by the Water Forum, Reclamation, USFWS, NMFS, and CDFW addresses minimum flows needed for Central Valley Steelhead and Fall-Run Chinook Salmon in the Lower American River. Furthermore, Reclamation shall convene the American River Group (ARG), composed of representatives from Reclamation, NMFS, USFWS, CDFW and the Water Forum, to make recommendations for management within the constraints of the Flow Management Standard. Reclamation shall ensure that flow, water temperature, Steelhead spawning, and Steelhead rearing monitoring is conducted annually to help inform the ARG process and to evaluate take associated with flow fluctuations and warm water temperatures.

2.5.6.4.2 Temperature

Water temperatures in the Lower American River are influenced by operations. In the Lower American River water temperatures are a function of the timing, volume, and temperature of water releases from Folsom and Nimbus Dams. Once water is released, river distance and environmental heat flux influences the water temperature further as it moves through the Lower American River (Bartholow 2000).

In response, NMFS issued an RPA action to maintain suitable oversummering temperatures for juvenile Central Valley Steelhead in the Lower American River. In the action, Reclamation is to prepare a draft Operations Forecast and Temperature Management Plan based on forecasted conditions and submit the draft plan to NMFS for review by May 1 of each year. The information provided in the Operations Forecast will be used in the development of the Temperature Plan. Reclamation will use an iterative approach, varying proposed operations, with the objective to attain the temperature compliance point at Watt Avenue Bridge. Operation of Folsom/Nimbus Dam complex and the water temperature control shutters at Folsom Dam will be used to maintain a daily average water temperature of 65°F or lower at Watt Avenue Bridge from May 15 through October 31.

2.5.6.5 *Feather River*

DWR will operate Oroville Dam consistent with the applicable NMFS and USFWS biological opinions for the Oroville Complex (FERC Project #2100-134). During the summer, DWR typically releases water from Lake Oroville to meet instream flow requirements and to supplement non-project Delta inflows needed to meet D-1641 requirements. Releases also include water for local deliveries and south-of-Delta export at Banks Pumping Plant.

DWR balances the cumulative storage between Lake Oroville and San Luis Reservoirs so as to meet its flood control requirements, Sacramento–San Joaquin Delta requirements, and deliver water supplies to its contracted water agencies consistent with all environmental constraints. Lake Oroville may be operated to convey water through the Delta to San Luis Reservoir via Banks under different schedules depending on Delta conditions, reservoir storage volumes, and storage targets. Decisions as to when to move water from Lake Oroville to San Luis Reservoir are based on many real-time factors.

2.5.6.6 *San Joaquin River*

Reclamation operates the Friant Division for flood control, irrigation, M&I, and fish and wildlife purposes. Facilities include Friant Dam, Millerton Reservoir, and the Friant-Kern and Madera Canals. Friant Dam provides flood control on the San Joaquin River, provides downstream releases to meet senior water rights requirements above Gravelly Ford, provides Restoration Flow releases under Title X of Public Law 111-11, and provides conservation storage as well as diversion into Madera and Friant-Kern Canals for water supply. Water is delivered to about a million acres of agricultural land in Fresno, Kern, Madera, and Tulare Counties in the San Joaquin Valley via the Friant-Kern Canal south into Tulare Lake Basin and via the Madera Canal north to Madera and Chowchilla Irrigation Districts. A minimum of 5 cfs is required to pass the last holding contract diversion located about 40 miles downstream of Friant Dam near Gravelly Ford.

The SJRRP implements the San Joaquin River Restoration Settlement Act in Title X of Public Law 111-11. USFWS and NMFS issued programmatic biological opinions in 2012 that included project-level consultation for SJRRP flow releases. Programmatic ESA coverage is provided in both the USFWS and NMFS biological opinions for flow releases, recapture of those flows in the lower San Joaquin River and the Delta, and all physical restoration and water management actions listed in the Settlement.

The Stipulation of Settlement of NRDC vs. Rogers, is based on two goals: the Restoration Goal and the Water Management Goal. To achieve the Restoration Goal, the Settlement calls for, among other things, releases of water from Friant Dam to the confluence of the Merced River (referred to as Restoration Flows) according to the hydrographs in Settlement Exhibit B. To achieve the Water Management Goal, the Settlement calls for the development and implementation of a plan for recirculation, recapture, reuse, exchange, or transfer of Restoration Flows for the purpose of reducing or avoiding impacts on water deliveries to all of the Friant Contractors caused by Restoration Flows. Recapture of Restoration Flows must occur downstream of the Merced River confluence. Recapture can occur at Banta-Carbona, Patterson, or West Stanislaus Irrigation District facilities, or at Jones or Banks Pumping Plants. Recapture of Restoration Flows in the Sacramento–San Joaquin Delta under this proposed action would average 33 TAF and range from about 17 TAF in a critical-high year to about 44 TAF in a normal-wet year. If Voluntary Agreements are approved, up to 50 percent of the February through June volume could be dedicated to Delta Outflow, up to an annual maximum of 50 TAF.

2.5.6.7 *Delta*

The main CVP and SWP facilities in the Delta provide for the export of water to the San Joaquin Valley and Southern California. The major CVP features are the Delta Cross Channel (DCC), Contra Costa Canal, Jones Pumping Plant, TFCF, Delta-Mendota Canal/California Aqueduct Intertie (Intertie), and Delta-Mendota Canal (DMC). The DCC is a controlled diversion channel between the Sacramento River and Snodgrass Slough. The CCWD diversion facilities use CVP water resources, and other water rights, to serve CCWD customers directly and to operate CCWD’s Los Vaqueros Project. The Jones Pumping Plant diverts water from the Delta to the head of the DMC. The main SWP Delta features are Suisun Marsh facilities, Banks Pumping Plant, Clifton Court Forebay (CCF), Skinner Fish Facility, and Barker Slough Pumping Plant. DWR also currently installs agricultural barriers between April and July to improve diversions for Delta water users.

2.5.7 Monitoring and Research Programs

Monitoring and research programs help provide information on Fall-Run and Late Fall–Run Chinook Salmon migration, survival, redd distribution. Since 2015, Reclamation has started Enhanced Acoustic Tag Salmonid Monitoring (EATSM). EATSM is part of the Salmon and Sturgeon Assessment of Indicators by Lifestage (SAIL) program, which improves monitoring by addressing vital population statistics rather than reliance upon old indexes. CDFW annually conducts aerial redd surveys and has gone through the process of digitizing recorded Fall-Run and Late Fall–Run Chinook Salmon redds in the upper Sacramento from 1990 to 2014.

Surveys also help CDFW compile annual population estimates of Chinook salmon. Information is entered into CDFW's GrandTab and is easily accessible through www.calfish.org. Reclamation funds monitoring, evaluation, and web-based data services through the Central Valley Prediction and Assessment of Salmon (SacPAS) tool online. This service also provides a publicly accessible reporting system of historical and current information (www.cbr.washington.edu/sacramento/).

2.5.7.1 Monitoring Programs for Chinook Salmon

Table 2.5-3. Summary of Chinook Salmon (SRWC) Monitoring Surveys, Protocols, and Precisions

Life Stage	Location	Agency	Protocol	Level of Precision	Protocol Citation
Upper River					
Adults	Upper river	CDFW	Carcass mark–recapture; McCormick Jolly Seber	Abundance 90% CI 10%	Bergman et al. 2012
Juveniles	RBDD	USFWS	Mark–recapture; gear efficiencies	Abundance 90% CI 35%	Poytress et al. 2014
Middle River					
Juveniles	GCID	GCID	RST	Counts reported	
	Tisdale	CDFW	RST	Counts reported	
	Knights Landing	CDFW	RST	Counts reported	
	Yolo Bypass	DWR	RST; Beach seines	Counts reported	
Tidal Estuary					
Juveniles	Sacramento	USFWS	Kodiak trawl	Counts reported	Honey et al. 2004
	Delta	USFWS	Beach seines	Counts reported	Honey et al. 2004
	Chipps Island	USFWS	Mid-water trawl	Abundance CV 20–-40%	Pyper et al. 2013
	Fish Protective Facility	USBR/ CDWR	Salvage; Loss estimate	Expanded counts per water volume	
Ocean					
Adults	Ocean fishery	NMFS	CWT recoveries; Cohort reconstruction	Not estimated for impact rates	O'Farrell et al. 2012
Multiple regions					
Hatchery juveniles	Multiple regions	NMFS	Reach-specific survival and movement rates; JSAT Acoustic Telemetry	Errors vary by reach	Michel et al. 2015
Adult migration	Flood bypasses	CDFW	Strandings and rescues	Counts reported	Purdy et al. 2015

2.5.7.2 Fall-Run and Late Fall-Run Essential Fish Habitat

EFH is defined as those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity. In 1999, the Pacific Fishery Management Council (PFMC) identified EFH for Central Valley Chinook Salmon stocks to include the Sacramento and San Joaquin Rivers and their tributaries as EFH. EFH includes not only the watersheds of the Sacramento and San Joaquin River basins but also the San Joaquin Delta (Delta) hydrologic unit, Suisun Bay hydrologic unit, and the Lower Sacramento hydrologic unit. Freshwater EFH for Chinook Salmon consists of four major habitat functions:

1. Spawning and incubation
2. Juvenile rearing

3. Juvenile migration corridors
4. Adult migration corridors and adult holding habitat

Projected impacts associated with the proposed action are expected to eliminate, diminish, and/or disrupt these EFH habitat functions for Fall-Run and Late Fall–Run Chinook Salmon at many sites within the action area.

2.6 Steelhead, California Central Valley DPS

2.6.1 ESA Listing Status

The California Central Valley Steelhead DPS was originally listed as threatened under the ESA on March 19, 1998 (63FR 13347), and the listing was reaffirmed on January 5, 2006 (71 FR 834) and updated April 14, 2014 (79 FR 20802). The 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. The DPS includes all naturally spawned Steelhead populations below natural and man-made impassable barriers in the Sacramento and San Joaquin Rivers and their tributaries (63 FR 13347). Steelhead in two artificial propagation programs, the Coleman National Fish Hatchery (CNFH) and FRFH Steelhead hatchery programs, are considered to be part of the DPS. NMFS determined that these artificially propagated stocks are no more divergent relative to the local natural population(s) than what would be expected between closely related natural populations within the DPS (71 FR 834).

In May 2016, NMFS completed a 5-year status review of the Central Valley Steelhead DPS. Based upon a review of available information, NMFS (2016c) recommended that the Central Valley Steelhead DPS remain classified as a threatened species. However, NMFS also indicated that the biological status of the DPS has declined since the previous status review in 2011. NMFS indicated that natural production of Steelhead continues to decline and is now at very low levels (NMFS 2016c). Their continued low numbers in most hatcheries, domination by hatchery fish, and relatively sparse monitoring makes the continued existence of naturally reproduced Steelhead a concern. Due to this declining trend, NMFS suggests that the DPS is likely to become endangered within the foreseeable future throughout all or a significant portion of its range (NMFS 2016c).

Based on new genetic evidence described by Pearse and Garza (2015), NMFS recommended that Steelhead originating from the Mokelumne River Hatchery be added to the Central Valley Steelhead DPS (just as FRFH fish are considered to be a native Central Valley stock and are listed as part of the DPS). NMFS also recommended that the status of the DPS should be monitored and Hatchery and Genetic Management Plans should mandate that all Central Valley Steelhead hatcheries collect a full set of biological data, including scale samples, length, weight, sex, origin, and state of maturity, from a subset of all returning fish (NMFS 2016c) Hatcheries also should be required to conduct studies of smolt survival using modern tagging methods such as PIT tags and/or acoustic tags.

2.6.2 General Life-History and Habitat Requirements

Steelhead have a complex suite of life history traits, including the capability to be anadromous or to be resident (i.e., rainbow trout). Spawning and rearing habitat for Steelhead is usually characterized as perennial streams with clear, cool to cold, fast flowing water with a high dissolved oxygen content and abundant gravels and riffles. The preferred flow velocity is in the range of one to three feet per second

(Raleigh et al. 1986). Steelhead use various mixtures of sand-gravel and gravel-cobble substrate for spawning, but optimal spawning substrate reportedly ranges from 0.25 to 4.0 inches in diameter (Reiser and Bjornn 1979). Optimal water temperatures for Steelhead adult immigration are reported to range from 46°F to 52°F (NMFS 2002; SWRCB 2003). Optimal conditions for Steelhead spawning and embryo incubation reportedly occur at water temperatures 52°F (NMFS 2002; SWRCB 2003). Water temperatures between 45°F and 65°F have been reported as preferred for fry and juvenile Steelhead rearing (NMFS 2002). Upper lethal temperatures for adult Pacific salmonids are in the range of 75°F to 77°F for continuous long-term exposure (Brett et al. 1982). NMFS (2002) reported 65°F as the upper water temperature limit preferred for the growth and development of Sacramento and American river juvenile Steelhead. Steelhead successfully undergo the smolt transformation at water temperatures between 43.7°F to 52.3°F (Myrick and Cech 2001).

Adult Steelhead immigration into Central Valley streams typically begins in August, continues into March or April (McEwan 2001; NMFS 2014), and generally peaks during January and February (Moyle 2002), but adult Steelhead immigration can potentially occur during all months of the year (NMFS 2009). Steelhead spawning generally occurs from December through April, with peaks from January through March, in small streams and tributaries (NMFS 2009).

Eggs usually hatch within 4 weeks, depending on stream temperature, and the yolk sac fry remain in the gravel after hatching for another 4 to 6 weeks (CDFG 1996). After fry emerge, they inhabit shallow areas along the stream margin and prefer areas with cobble substrates, then use a greater variety of habitats as they grow and develop (CDFG 1996). Habitat use is affected by the presence of predators and juvenile Steelhead survival increases when cover, such as wood debris and large cobble, is available (Mitro and Zale 2002). The preferred range of water depths for spawning Steelhead has been observed most frequently between 0.3 and 4.9 feet (Moyle 2002). The reported preferred water velocity for Steelhead spawning is 1.5 to 2.0 feet per second (USFWS 1995).

Juvenile Central Valley Steelhead typically migrate to the ocean after spending 1 to 3 years in freshwater (CDFG 1996). Steelhead fry and fingerlings rear and migrate downstream in the Sacramento River during most months of the year, but the peak period of emigration is January to June (Hallock et al. 1961; McEwan 2001). Based on CDFW sampling at Knights Landing, juvenile Steelhead emigration occurs primarily from January through April, with peaks during January and February (NMFS analysis of 1998-2011 CDFW data.). Because of their varied freshwater residence times Steelhead fry and fingerlings can be rearing and migrating in the Sacramento River year-round (McEwan 2001).

2.6.3 Historical and Current Distribution and Abundance

Historically, Central Valley steelhead were distributed from the upper Sacramento and Pit river systems (upper Sacramento, McCloud, Pit and Fall rivers) south to the Kings River (and possibly Kern river systems in wet years) and in both east- and west- side tributaries of the Sacramento River and east-side tributaries of the San Joaquin River (McEwan 2001). Presently, Central Valley Steelhead are found in the Sacramento River downstream of Keswick Dam and in the major tributary rivers and creeks in the Sacramento River watershed. Zimmerman et al. (2009) found Steelhead present in three tributaries to the San Joaquin River (Stanislaus, Tuolumne, and Merced rivers) as well as in the Calaveras Rivers, and a hatchery supported Steelhead population occurs in the the Mokelumne River. The populations in the Feather and American Rivers are supported primarily by the Feather and Nimbus hatcheries. Other major Steelhead populations in the Sacramento River watershed are found in Battle, Mill, Deer, Clear and Butte Creeks. Steelhead also occur in many tributaries to the Sacramento River including Stony and Thomes Creeks (McEwan 2001), as well as intermittent streams in the Redding area.

In the 1950s, Central Valley Steelhead populations numbered approximately 40,000 fish, while during the mid-1960s, the Steelhead population was estimated at 27,000 (DFG 1965, as cited in McEwan and Jackson 1996). McEwan and Jackson (1996) estimated the annual run size for Central Valley Steelhead to be less than 10,000 fish by the early 1990s. Since 2015, Steelhead population estimates continue to demonstrate significant variation as reflected by the hatchery returns for Feather River Hatchery (Figure 2.6-1), Nimbus Hatchery (Figure 2.6-2), Mokelumne River Hatchery (Figure 2.6-3), and CNFH (Figure 2.6-4). Steelhead returns have been lower than average (n = 1,480) on the American River during recent years with a return of 756 in 2016, 1,032 in 2017, and 513 in 2018. Furthermore, Steelhead redd counts on the American River have been lower than average (n = 122) with 53 redds counted in 2015, 10 in 2017, and 63 counted in 2018 (Figure 2.6-5).

Monitoring efforts throughout the Central Valley inform Central Valley Steelhead abundance and distribution. During WY 2018, Steelhead catches in the Sacramento River drainage totaled: 5 at Tisdale weir; 3 at Knights Landing; none in the Sacramento beach seines; 4 in the Sacramento trawls; 12 in the Chipps Island trawls; 9,298 at Red Bluff Diversion Dam (Figure 2.6-6). In the San Joaquin River drainage, steelhead catches totaled: 11 adults (6 with adipose fin clips) at the Stanislaus weir; no juveniles at the Caswell rotary screw trap (RST); no adults at the Tuolumne weir (juvenile catch at the Tuolumne RST was not reported); and 8 smolts in the Mossdale trawls (USFWS 2018a; Stanislaus Operations Group 2018; Turlock Irrigation District and Modesto Irrigation District 2018). During WY 2017, Steelhead catches in the Sacramento River drainage totaled: 3 at Tisdale weir; 10 at Knights Landing; none in the Sacramento beach seines; 13 in the Sacramento traw16ls; 16 in the Chipps Island trawls; and 22,961 at Red Bluff Diversion Dam (Figure 2.6-7). In the San Joaquin River drainage, steelhead catches totaled: 26 adults (14 with adipose fin clips) at the Stanislaus weir; one adult at the Tuolumne weir; none at the Tuolumne RST (juvenile catch at the Stanislaus RST was not reported); and none in the Mossdale trawls (USFWS 2018a; Stanislaus Operations Group 2018; Turlock Irrigation District and Modesto Irrigation District 2017). During WY 2017, 65 wild juvenile and 43 hatchery Steelhead were observed at the Delta fish facilities, and 1,118 wild juvenile and 732 hatchery Steelhead were observed during WY 2018 (Figures 2.6-8 and 2.6-9). Steelhead have not been observed in CCWD's Fish Monitoring Program at the Rock Slough Intake since 2012.

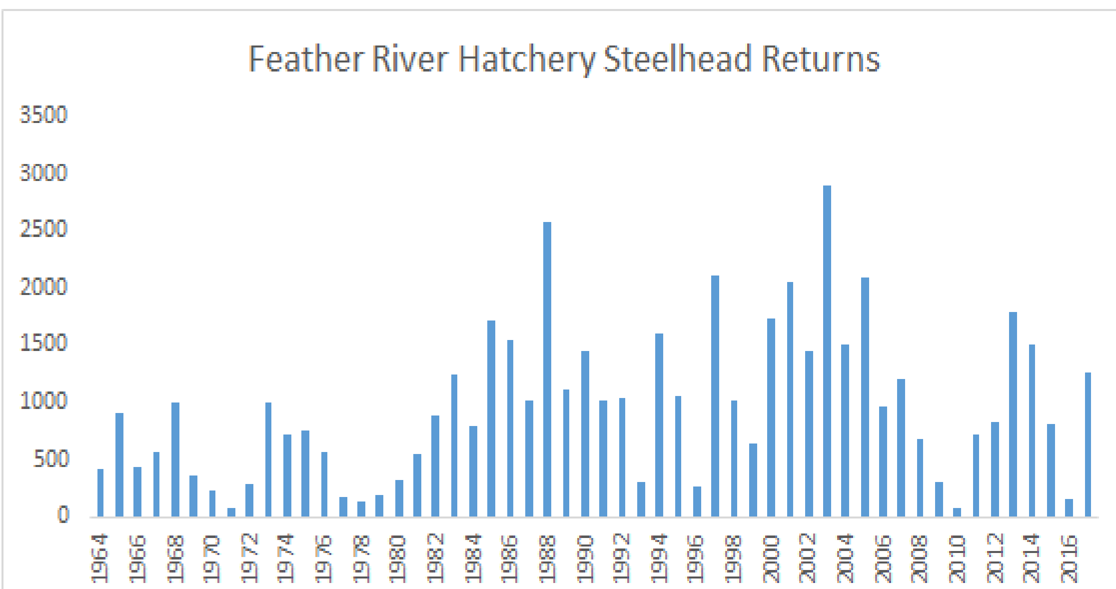


Figure 2.6-1. Steelhead Returns to the Feather River Hatchery, 1956–2017

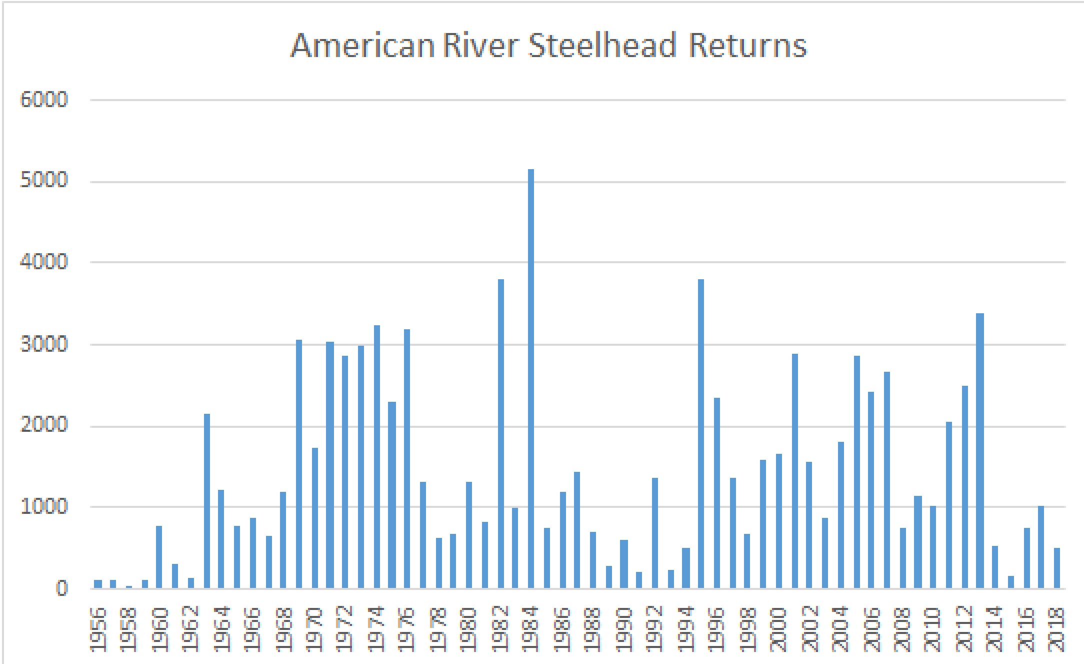


Figure 2.6-2. Steelhead Returns to the Nimbus Hatchery, 1956–2018

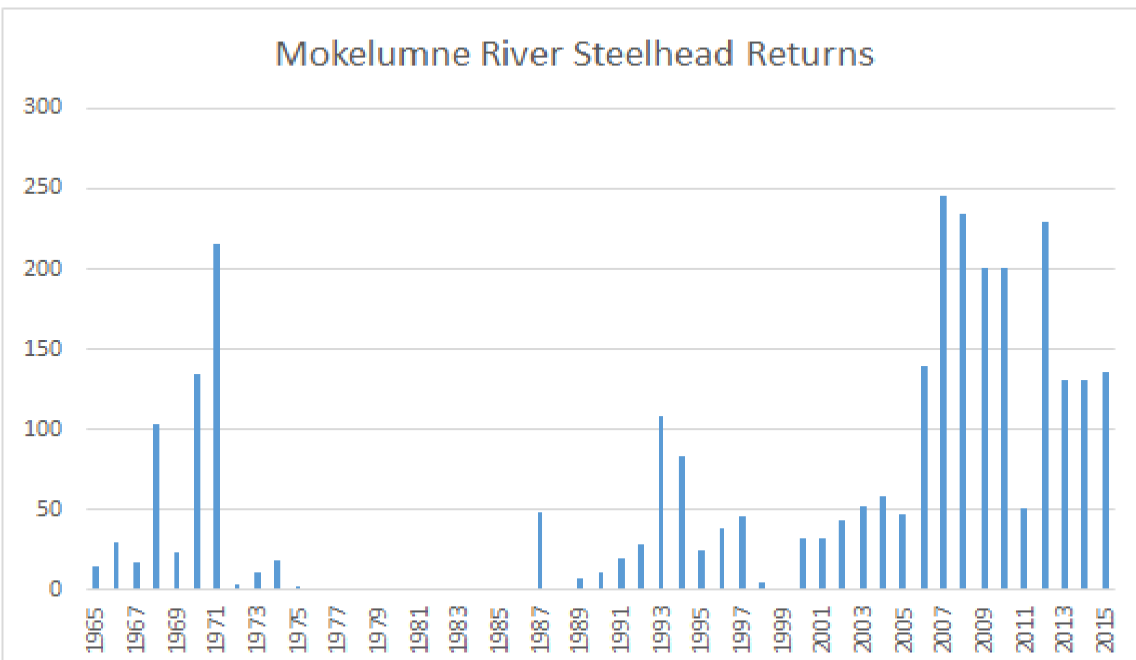


Figure 2.6-3. Steelhead Returns to the Mokelumne River, 1965–2015

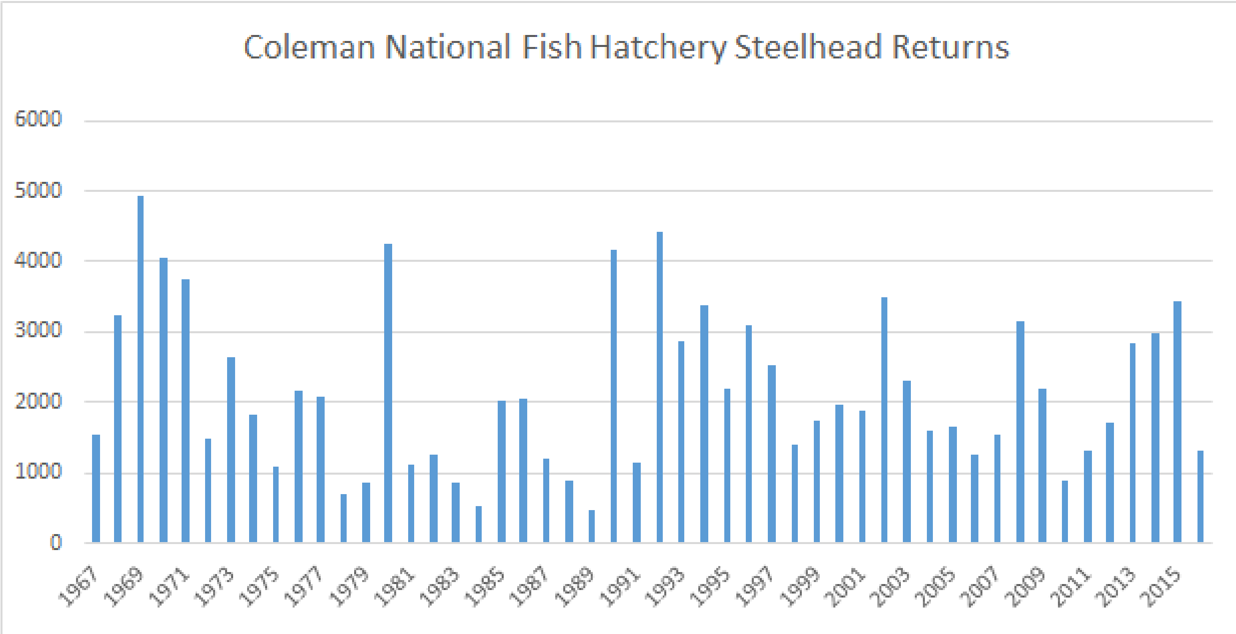


Figure 2.6-4. Steelhead Returns to Coleman National Fish Hatchery, 1967–2016

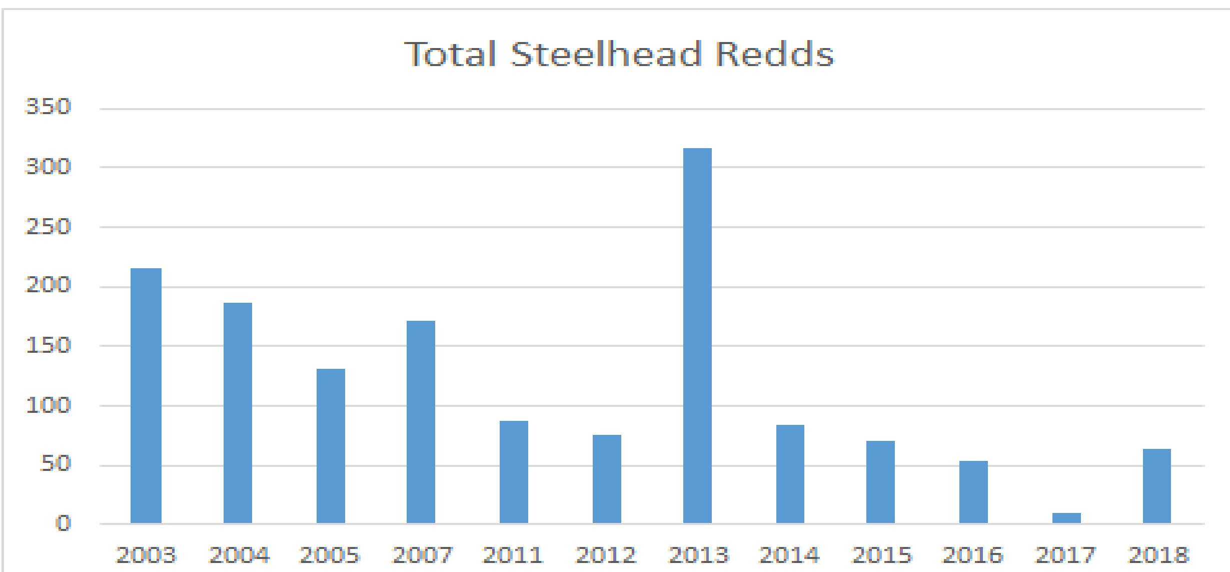


Figure 2.6-5. Total Steelhead Redds on the American River, 2003–2005, 2007, 2011–2018

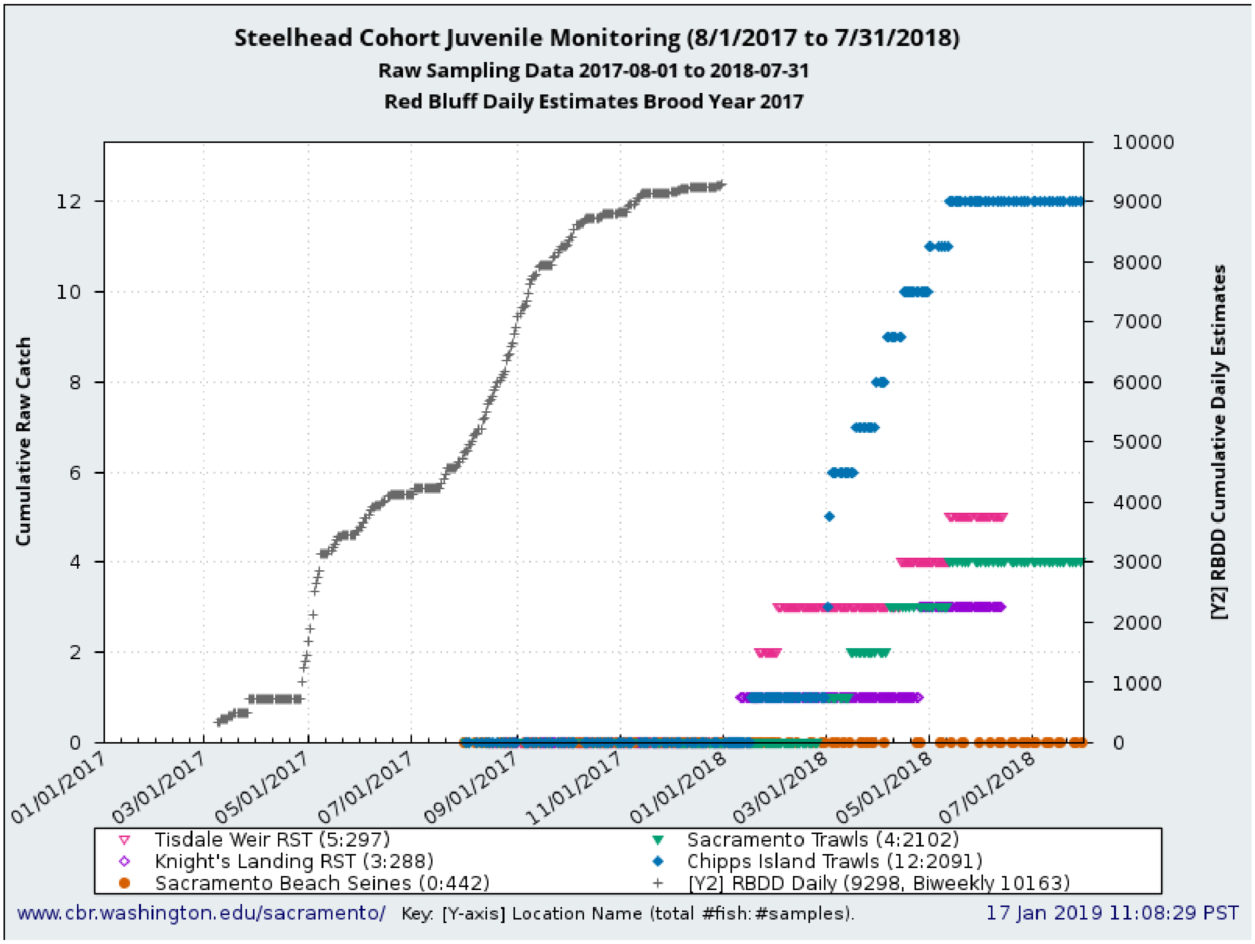


Figure 2.6-6. Juvenile Central Valley Steelhead Monitoring at Tisdale, Knights Landing, Sacramento Beach Seines, Sacramento Trawl, Chipps Island Trawl, and Red Bluff Diversion Dam for WY 2018

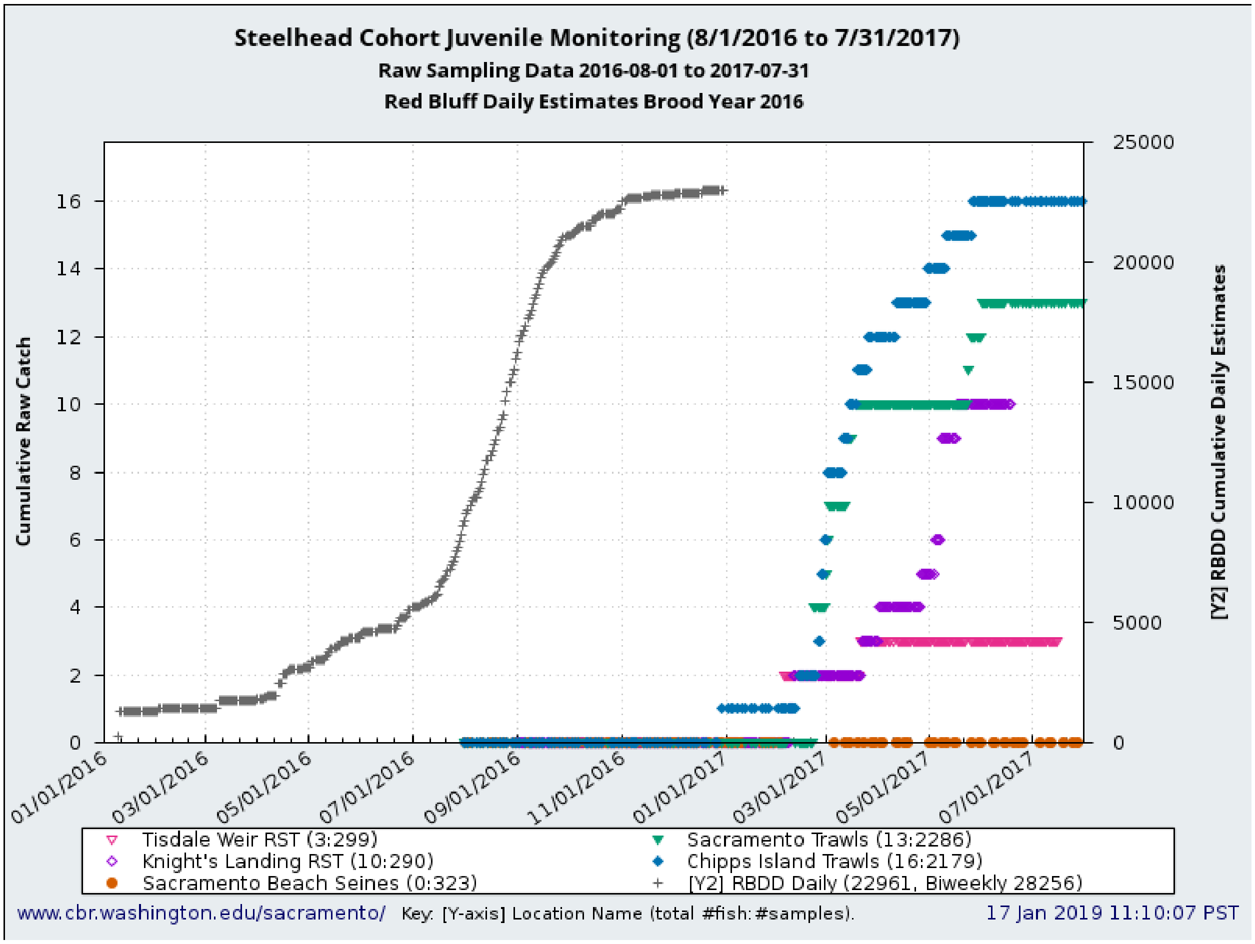


Figure 2.6-7. Juvenile Central Valley Steelhead Monitoring at Tisdale, Knights Landing, Sacramento Beach Seines, Sacramento Trawl, Chipps Island Trawl, and Red Bluff Diversion Dam for WY 2017

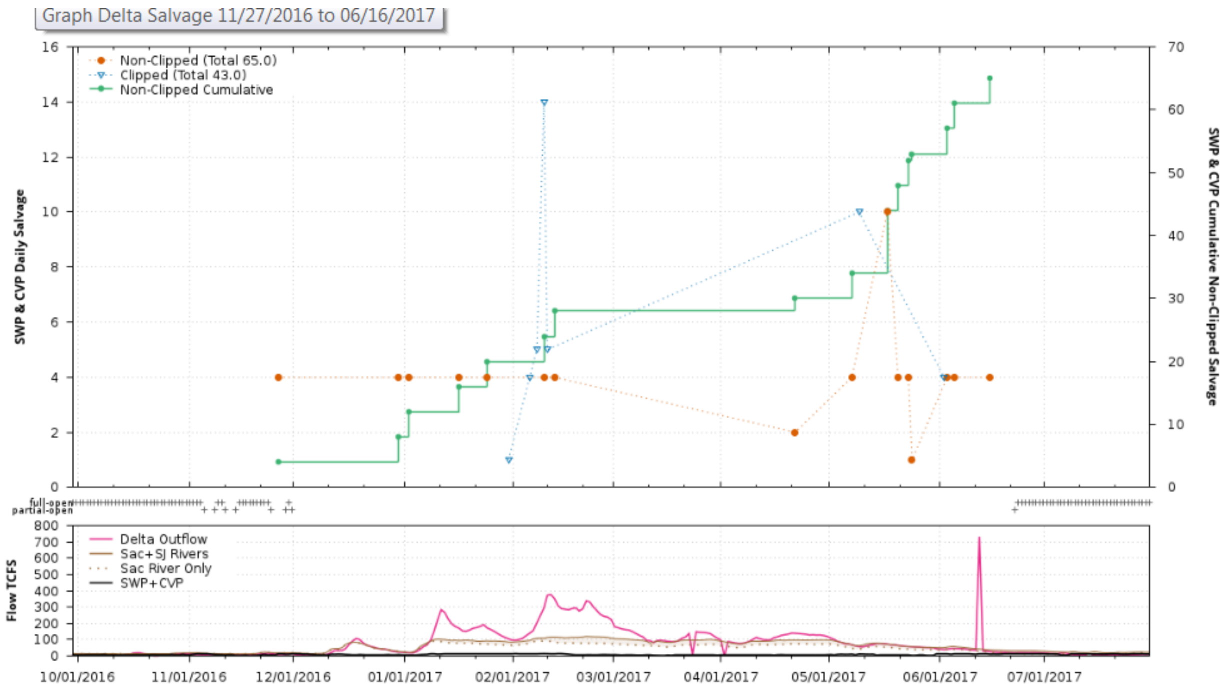


Figure 2.6-8. Central Valley Steelhead Salvage at the Delta Fish Facilities during WY 2017

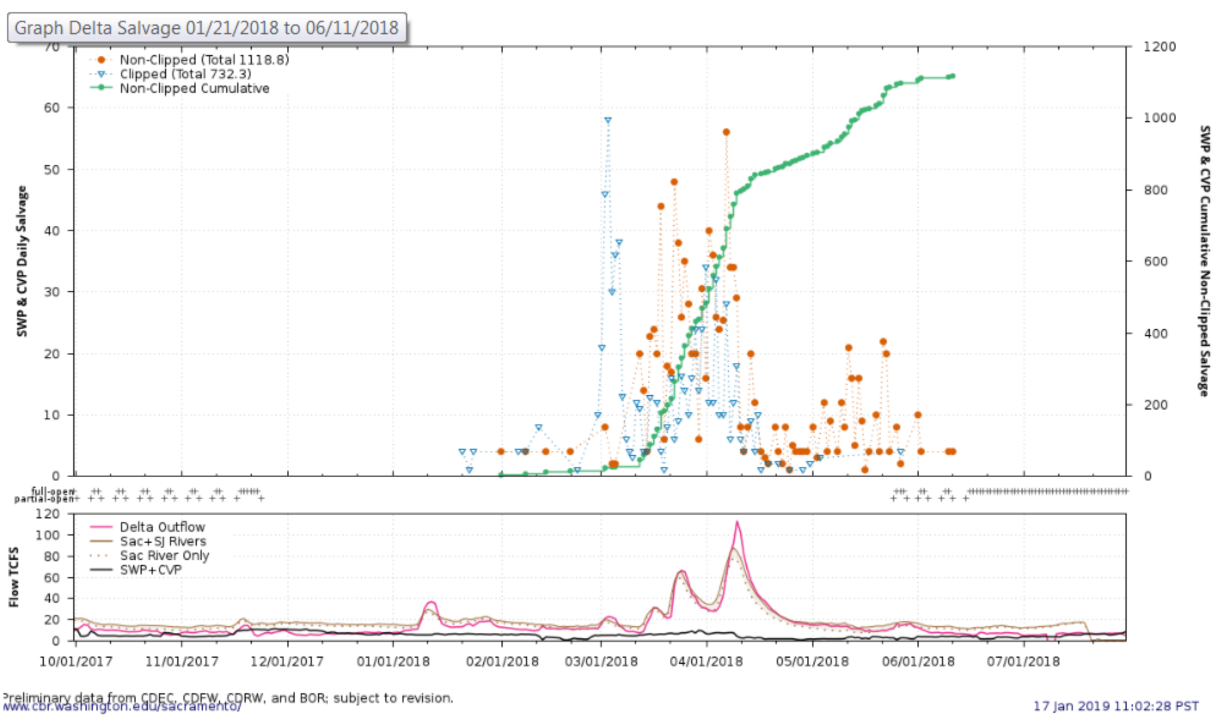


Figure 2.6-9. Central Valley Steelhead Salvage at the Delta fish facilities during WY 2018

2.6.4 Limiting Factors, Threats, and Stressors

As with the other salmonid species described above and further discussed in Section 3.1, high water temperatures in remaining rearing areas, effects from hatcheries and the rearing of out of basin stocks, limited quantity and quality of rearing habitat, ocean conditions, and predation and entrainment into diversions at the CVP and SWP pumping facilities all affect the species. Degradation of the remaining accessible habitat through reducing flow variability, blocking coarse sediment recruitment, operation of outdated fish screens, ladders and diversion dams, simplified habitat due to levee construction and maintenance and disconnection of off-channel habitat, water delivery and hydroelectric operation on both the Sacramento and Feather Rivers affect natural flow regimes.

Future increasing temperatures and altered precipitation patterns due to climate change will also pose stressors on Central Valley Steelhead. These factors are the same for Steelhead as those described previously for Chinook Salmon.

Figure 2.6-10 below shows water year type average flows on the American River along with timing of the fish species in the American River.

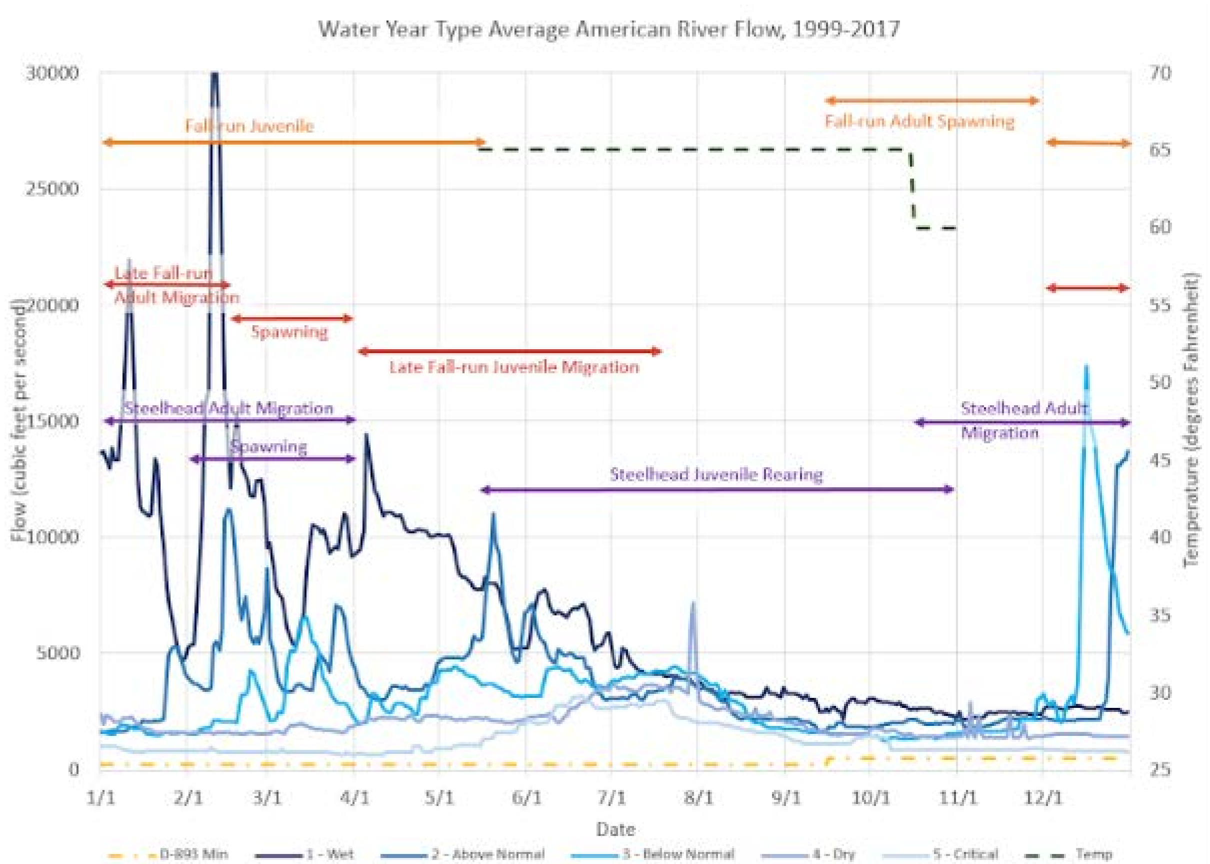


Figure 2.6-10. Water Year Type Average American River Flow, 1999–2017

2.6.5 Recovery and Management

As discussed above in Section 5.1.6, the NMFS 2014 Recovery Plan for Sacramento River Winter-Run Chinook Salmon, Central Valley Spring-Run Chinook Salmon, and Central Valley Steelhead outlines actions to restore habitat, access, and improve water quality and quantity conditions in the Sacramento River to promote the recovery of listed salmonids. Many of the Recovery and Management Action for Winter-Run and Spring-Run Chinook Salmon also benefit Steelhead.

2.6.6 Water Operations Management

2.6.6.1 *Upper Sacramento River*

Water Operations Management for the upper Sacramento River for Central Valley Steelhead would be the same as those in Winter-Run Chinook species account.

2.6.6.2 *American River*

Reclamation operates Folsom Dam and Reservoir to provide water for irrigation, municipal and industrial uses, hydroelectric power, recreation, water quality, flood control, and fish protection. Reclamation operation under SWRCB Decision 893 (D-893) adopted in 1958 allows flows at the mouth of the American River to fall as low as 250 cfs from January through mid-September, with a minimum of 500 cfs required between September 15 and December 31. The D-893 decision does not address the requirements of the CVPIA, the 1995 Bay Delta Plan, or biological opinions issued to protect Central Valley Steelhead.

Reclamation’s 2008 Biological Assessment proposed implementing the Water Forum Flow Management Standard. This flow schedule, developed by the Water Forum, Reclamation, USFWS, NMFS, and CDFW, addresses minimum flows for Central Valley Steelhead and Fall-Run Chinook in the Lower American River.

Reclamation convenes the American River Group (ARG), comprised of representatives from Reclamation, NMFS, USFWS, CDFW and the Water Forum, to make recommendations for management within the constraints of the Flow Management Standard. Reclamation ensures that flow, water temperature, Steelhead spawning, and Steelhead rearing monitoring is conducted annually in order to help inform the ARG process and to evaluate take associated with flow fluctuations and warm water temperatures.

Flow releases from Folsom Reservoir are made for both flood control and to meet water quality objectives and demands in the Delta. This can result in rapid increases and decreases of flow during the winter and spring. Dewatering and isolation of Steelhead redds has been documented (Hannon *et al*. 2003, Water Forum 2005, Hannon and Deason 2008) as a result. In addition to flow fluctuations, low flows also can negatively affect lower American River Steelhead. At low flow levels, the availability of bar complexes and side channel areas characterized by habitat complexity in the form of velocity shelters, hydraulic roughness elements, and other forms of cover is limited.

Water temperatures in the lower American River are influenced by the timing, volume, and temperature of water releases from Folsom and Nimbus dams. Once released, river distance and environmental heat flux influences the water temperature further as it moves through the Lower American River (Bartholow 2000). The NMFS RPA Action II.2 requires suitable over summering temperatures for juvenile CV Steelhead in the Lower American River. In the RPA, Reclamation is to prepare a draft Operations

Forecast and Temperature Management Plan based on forecasted conditions and submit the draft Plan to NMFS for review by May 1 of each year. The information provided in the Operations Forecast will be used in the development of the Temperature Plan. Reclamation uses an iterative approach, varying proposed operations, with the objective to attain the temperature compliance point at Watt Avenue Bridge. Operation of Folsom/Nimbus Dam complex and the water temperature control shutters at Folsom Dam are used to maintain a daily average water temperature of 65°F or lower at Watt Avenue Bridge from May 15 through October 31.

2.6.6.3 *Clear Creek*

Water Operations Management for Clear Creek for Central Valley Steelhead would be the same as those in the Fall-run Chinook species account.

2.6.6.4 *Stanislaus River*

Water Operations Management for the Stanislaus River for Central Valley Steelhead would be the same as those in the Fall-run Chinook species account.

2.6.7 Monitoring and Research Programs

The Central Valley Steelhead Monitoring Program (CVSMP), a pilot study, began implementing monitoring projects on the Sacramento River and select tributaries to help identify Central Valley Steelhead populations. The CVSMP projects include (1) Mainstem Sacramento River Mark-Recapture; (2) Upper Sacramento River Tributary Escapement Monitoring; (3) Sacramento River Tributary Mark-Recapture Monitoring; and (4) Hatchery Broodstock and Angler Harvest Sampling. These projects began July 2015 under contract with Pacific States Marine Fisheries Commission (PSMFC). The objective of the CVSMP pilot study was to evaluate the efficacy and success of these monitoring projects in order to expand these techniques throughout the Sacramento and San Joaquin watersheds.

Reclamation performed a 6-year Steelhead telemetry study on the Stanislaus River and currently working to continue an acoustic tagging study on the San Joaquin River to determine entrainment of SJR origin Steelhead into Tracy and Jones Pumping Plants.

The Stanislaus River Research and Monitoring Program is the most comprehensive and longest running Salmon and Steelhead monitoring programs in California’s San Joaquin Basin, although data is not publicly available. Initiated by FISHBIO personnel in 1993 for the Oakdale and South San Joaquin Irrigation Districts and Tri-Dam Project, the program’s suite of ongoing monitoring activities tracks the abundance, distribution, migration characteristics, and habitat use of salmon and Steelhead trout.

2.7 Steelhead, Central Valley Critical Habitat

Critical habitat for the Central Valley Steelhead DPS was designated in 2005 and includes all river reaches accessible to Steelhead in the Sacramento and San Joaquin rivers and their tributaries, the Delta, and the Yolo Bypass (70 FR 52488). A 2016 status review found that the DPS continues to be at a high risk of extinction (NMFS 2016c). In the Sacramento and San Joaquin Rivers and tributaries, critical habitat includes the river water column, river bottom, and adjacent riparian zone and including the water column and essential foraging habitat and food resources west of Chipps Island including San Francisco Bay to the Golden Gate Bridge.

Critical habitat consists of PBFs considered essential for the conservation of a species. PBFs outlined in the designation of critical habitat (70 FR 52488) are:

1. Unimpeded access from the Pacific Ocean to appropriate spawning areas in the Sacramento and San Joaquin River and their tributaries
2. The availability of clean gravel for spawning substrate
3. Adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles
4. Water temperatures between 42.5 and 57.5°F for successful spawning, egg incubation, and fry development
5. Habitat and prey free of contaminants
6. Riparian habitat that provides for successful juvenile development and survival
7. Unimpeded passage of juveniles downstream from the spawning grounds to San Francisco Bay and the Pacific Ocean

2.8 Steelhead, Central California Coast DPS

2.8.1 ESA Listing

The Central California Coast (CCC) Steelhead DPS was listed as threatened under the ESA on January 5, 2006 (71 FR 834). The CCC Steelhead DPS includes all naturally spawned Steelhead populations below natural and human-made impassable barriers in California streams from the Russian River (inclusive) to Aptos Creek (inclusive), and the drainages of San Francisco, San Pablo, and Suisun bays eastward to Chipps Island at the confluence of the Sacramento and San Joaquin Rivers. Tributary streams to Suisun Marsh include Suisun Creek, Green Valley Creek, and an unnamed tributary to Cordelia Slough, excluding the Sacramento-San Joaquin River Basin, as well as two artificial propagation programs (NMFS 2009).

2.8.2 General Life-History and Habitat Requirements

Steelhead return to their natal streams to spawn typically as 2- to 4-year-old adults. Adults generally migrate upstream from November through March to spawn, but may extend into April (NMFS 2011) (Table 2.8-1). Spawning occurs between January and April. Time of incubation and hatching varies with region, habitat, water temperature, and spawning season. CCC Steelhead incubation occurs between January and May. Alevins emerge from their redds following yolk sac absorption and are ready to feed as fry or juveniles. Following emergence, fry live in small schools in shallow water along streambanks. The diet of juvenile Steelhead includes emergent aquatic insects, aquatic insect larvae, snails, amphipods, opossum shrimp, and small fish (Moyle 2002). Steelhead usually do not eat when migrating upstream and often lose body weight. As Steelhead grow, they establish individual feeding territories; juveniles typically rear for 1 to2 years (and up to 4 years) in streams before emigration as smolts (NMFS 1996). Steelhead may remain in the ocean from 1 to 4 years, growing rapidly as they feed in the highly productive currents along the continental shelf (Barnhart 1986).

Table 2.8-1. Timeline of Steelhead Life Stages

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning	•	•	•	•								
Migration	•	•	•	•							•	•
Incubation	•	•	•	•	•							
Rearing	•	•	•	•	•	•	•	•	•	•	•	•

Source: NMFS 2011

2.8.3 Historical and Current Distribution and Abundance

Historically, approximately 70 populations of Steelhead existed in the CCC Steelhead DPS (Spence et al. 2008; Spence et al. 2012): 37 independent or potentially independent and 33 dependent. While historical and present data on abundance are limited, CCC Steelhead populations are substantially reduced from historical levels. CDFG (1965) estimated a total of 94,000 adult Steelhead spawned in the rivers and streams of this DPS during the mid-1960s, including 50,000 fish in the Russian River—the largest population within the DPS. Near the end of the 20th Century, the Steelhead population in the Russian River was believed to have declined substantially and local CDFG biologists estimated the wild run population in the Russian River Watershed was between 1,700-7,000 fish (McEwan and Jackson 1996). Abundance estimates for smaller coastal streams in the DPS indicate low but stable levels with individual run size estimates for several streams (Lagunitas, Waddell, Scott, San Vicente, Soquel, and Aptos creeks) of approximately 500 fish or less (62 FR 43937). Some loss of genetic diversity has been documented and attributed to previous out-of-basin transfers of hatchery stock as well as local hatchery production (Bjorkstedt et al. 2005, Good et al. 2005). In particular, for streams that are tributary to San Francisco Bay, reduced population sizes and habitat fragmentation caused by intense urbanization and water resource development have also led to a loss of genetic diversity in these populations.

CCC Steelhead have experienced significant declines in abundance and long-term population trends suggest a negative growth rate. This indicates the DPS may not be viable in the long term. Independent populations that historically provided enough Steelhead immigrants to support nearby dependent populations may no longer be able to do so, placing these dependent populations at increased risk of extirpation. However, because CCC Steelhead remain present in most streams throughout the DPS, roughly approximating the known historical range, CCC Steelhead may possess a resilience that is likely to slow their decline relative to other salmonid DPSs or ESUs in worse condition. Their iteroparous life history and variation in time spent in streams and the ocean have helped the Steelhead populations respond to different pressures on their population (Busby et al. 1996).

The 2005 status review concluded the CCC Steelhead DPS remains "likely to become endangered in the foreseeable future" (Good et al. 2005). In its most recent 5-year review of the DPS, NMFS determined that the DPS should remain listed as threatened (NMFS 2016; Williams et al. 2016).

2.8.4 Limiting Factors, Threats and Stressors

Limiting factors affecting Central Coast Steelhead include degradation of habitat through water quality, water quantity, wetland loss, timber harvest, agriculture including marijuana-related diversion dams, urbanization, and impaired passage; illegal harvest; predation; invasive species; drought and climate change; and the existing small population size.

In addition, the 2012-2015 drought has revealed that during low storage levels, Coyote Valley Dam is known to release highly turbid water for extended periods well after turbidity levels in reservoir inflows and unregulated tributaries have diminished (NMFS 2008a). Turbid flows result in degraded salmonid spawning and rearing habitat (Everest 1969), and may impair food availability for juvenile salmonids by reducing habitat diversity for benthic invertebrates and eliminating certain guilds of invertebrates from the food chain. Similarly, extended periods of warm, turbid, and reduced flow releases have been noted at dams in the San Francisco Bay Area during periods of low storage (Leicester and Smith 2014).

Freshwater poaching or unintentional take of CCC Steelhead may occur. Where current abundance is below the “high risk” threshold (as described in Spence et al. 2008), losing adult fish to poaching could significantly impact population productivity and genetic diversity.

Many populations of CCC Steelhead have declined in abundance to levels that are well below low-risk abundance targets, and several are, if not already extirpated, likely below the high-risk depensation thresholds specified by Spence et al. (2008). Recently the largest donor population in the Russian River has declined, increasing the risk. As natural populations get smaller, stochastic processes may cause alterations in genetics, breeding structure, and population dynamics. Even though recent data suggests some CCC Steelhead populations are doing better than others, all populations remain at severely depressed levels, suggesting stochastic processes continue to remain a high threat to the species (NMFS 2016).

2.8.5 Water Operations Management

Operations of the Suisun Marsh Salinity Control Gates and other infrastructure in Suisun Marsh could affect CCC Steelhead by blocking or allowing access to Suisun Creek, where a population of California Central Coast Steelhead exists.

2.8.6 Recovery and Management

Recovery actions for CCC Steelhead include over 7000 actions ranging from increasing the quality and extent of estuarine habitat to requesting that the SWRCB review and/or modify water use based on the needs of Steelhead and authorized diverters (NMFS Recovery Plan, October 2016).

2.8.7 Monitoring and Research Programs

Reclamation does not currently conduct research or monitoring on CCC Steelhead.

2.9 Steelhead, Central Valley California Coast Critical Habitat

CCC Steelhead critical habitat was designated September 2, 2005. Five watersheds with CCC Steelhead are in the San Francisco-San Pablo Suisun Bay estuarine complex which provides rearing and migratory habitat for this ESU.

2.10 North American Green Sturgeon, Southern DPS

2.10.1 ESA Listing Status

NMFS listed the southern DPS of North American Green Sturgeon as threatened in 2006 (71 FR 17757). In 2015, NMFS issued an updated status review in which the threatened status was confirmed (NMFS 2015). Green Sturgeon are known to spawn in the Sacramento and Klamath Rivers in California, and the Rogue River in Oregon (Moyle et al. 1992; Adams et al. 2002). Genetic analyses indicates that the Sacramento, Klamath, and Rogue Rivers support two distinct reproducing populations identified as southern and northern DPS Green Sturgeon (Israel et al. 2004). The threatened southern DPS is limited to a single reproducing population in the Sacramento River (71 FR 17757). The Northern DPS includes sturgeon from the Klamath and Rogue Rivers and is considered by NMFS a Species of Concern.

2.10.2 General Life-History and Habitat Requirements

Green Sturgeon are anadromous, with larval and juvenile life stages residing in natal rivers and subadult and adult life stages residing in estuarine and coastal marine waters before returning to freshwater to spawn. Green Sturgeon are long lived, reaching maturity at about age 15 and typically spawning every 3 to4 years (NMFS 2015). Adult Green Sturgeon enter San Francisco Bay in late winter through early spring and migrate to spawning areas in the Sacramento River primarily from late February through April. Spawning primarily occurs April through late July although late summer and early fall spawning may also occur based on the presence of larvae in the fall (Heublein et al. 2017). Elevated water flow appears to be an important cue in triggering migration and subsequent spawning of adult Green Sturgeon (Benson et al. 2007; Erickson and Webb 2007; Heublein et al. 2009). Spawning of Southern DPS Green Sturgeon primarily occurs in the mainstem Sacramento River although a spawning event was documented in 2011 in the lower Feather River at the Thermalito Afterbay Outlet (Seesholtz et al. 2012).

Green Sturgeon spawn in deep pools in large, turbulent, freshwater river mainstems (Moyle et al. 2002). Green Sturgeon eggs are generally broadcast eggs over large gravel and cobble substrates where they adhere or settle into crevices (Van Eenennaam et al. 2001; Poytress et al. 2011). Substrates in spawning pools range from small to medium-sized sand to boulders and bedrock (Klimley et al. 2015a; Poytress et al. 2015; Wyman et al. 2018). Water temperature is an important factor for Green Sturgeon spawning and egg viability. Temperatures in the upper Sacramento River during the spawning period have ranged from 10.1°C to 17.6°C (Poytress et al. 2012). Wyman et al. (2017) studied the physical variables selected by adult Green Sturgeon during their spawning period using a two-dimensional model to integrate fish locations, physical habitat characteristics, discharge, bathymetry, and simulated velocity and depth. Results indicated that Green Sturgeon prefer spawning habitats with velocities between 1.0 and 1.1 meters per second, depths of 8 to 9 meters, and gravel and sand substrate (Wyman et al. 2017). After spawning, adults spend variable lengths of time in the river and estuaries before returning to the ocean (Heublein et al. 2017b). Outmigration may occur in late spring or summer (possibly in response to elevated flows) but most adults appear to remain in spawning and holding areas through the summer and leave in the fall (Benson et al. 2007; Heublein et al. 2009).

Development and survival of Green Sturgeon embryos is temperature dependent. Laboratory studies of Northern DPS Green Sturgeon indicate that eggs hatch after 144 to192 hours when incubated at a temperature of 15.7 ± 0.2°C (Deng et al. 2002). Based on exposure of eggs to water temperatures ranging from 11°C to 26°C, Van Eenennaam et al. (2005) found that optimal water temperatures for development generally range from 14°C to 17°C. Water temperatures above 17°C resulted in increased rates of deformities and mortality risk, with total mortality occurring at temperatures of 23°C and above (Van Eenennaam et al. 2005).

After hatching, Green Sturgeon larvae possess limited swimming ability and generally seek refuge in low-velocity habitat, suggesting that complex habitat such as large cobble substrate is critical for this life stage (Kynard et al. 2005). Larvae transition from endogenous to exogenous feeding at approximately 15 days after hatching and initiate downstream migration at approximately 18 days (Gisbert et al. 2001, Poytress et al. 2011). Laboratory studies of nDPS Green Sturgeon indicate that optimal water temperatures for growth of larvae generally range from 17°C to 20°C when food is not limiting. Metamorphosis of Green Sturgeon larvae to juveniles occurs at approximately 45 days post-hatch at lengths of 62 to94 mm (Deng et al. 2002).

Little is known about rearing, migratory behavior, and general emigration patterns of juvenile Southern DPS Green Sturgeon. Based on captures of juveniles in the Sacramento River near Red Bluff, it is likely that juveniles rear near spawning habitat for a few months or more before migrating to the Delta (Heublein et al. 2017a). The lack of juveniles less than 200 mm FL in Delta capture records further supports extended upriver rearing of juveniles before entering the estuary (CDFG 2002), as well as the lack of catch in the 20-mm survey reported in Dege and Brown (2004). Growth of juvenile nDPS Green Sturgeon is rapid as they move downstream, reaching up to 300 mm TL in the first year and more than 600 mm TL in years 2 and 3 (Nakamoto et al. 1995). Laboratory studies of nDPS Green Sturgeon indicate that optimal bioenergetic performance (growth, metabolic rate, temperature preference, and swimming performance) occurs at 15°C to 19°C (Mayfield and Cech 2004). Estuarine residence appears to be variable with some entering the ocean in their first year and others remaining in the Delta for 2 to3 years (Heublein et al. 2017a).

After Green Sturgeon enter the ocean, they appear to make northerly migrations within nearshore waters along the west coast and congregate in non-natal coastal bays and estuaries during the late summer and early fall (Lindley et al. 2008; 2011; Huff et al, 2012).

Feeding data recorded for adult Green Sturgeon indicate that they consume benthic invertebrates such as shrimp, mollusks, amphipods, and small fish (Moyle et al. 1992).

2.10.3 Historical and Current Distribution and Abundance

North American Green Sturgeon are long-lived, wide ranging, and the most marine-oriented species of the sturgeon family. Green Sturgeon spend the majority of their lives in coastal waters between northern Baja California and the Aleutian Islands, Alaska (Moyle et al. 1992). They are known to spawn in the Sacramento and Klamath Rivers in California, and the Rogue River in Oregon (Moyle et al. 1992; Adams et al. 2002). The actual historical and current spawning distribution is unclear because Green Sturgeon make non-spawning movements into coastal lagoons and bays, and because their original spawning distribution may have been reduced because of migration barriers, flow regulation, and other anthropogenic effects (Mora et al. 2009). Based on surveys of sites where adult Green Sturgeon aggregate in the upper Sacramento River in 2010-2015, the total number of adults in the Southern DPS was estimated to be 2,106 ± 1,246-2,966 (Mora 2018).

Based on data from acoustic tags, adult Green Sturgeon currently migrate upstream as far as the mouth of Cow Creek near Bend Bridge on the Sacramento River (NMFS 2009). Spawning occurs from Hamilton City (rkm 332.5) to Cow Creek (rkm 451) based on adult distribution (Heublein et al. 2009; Klimley et al. 2015a; Mora et al. 2018). Egg mat sampling confirmed spawning between Hamilton City and Inks Creek (rkm 426) (Poytress et al. 2015). Green Sturgeon spawning also has been documented in the Feather

(Seesholtz et al. 2015) and Yuba Rivers (Beccio 2018). Records of Green Sturgeon in the San Joaquin River and its tributaries are rare and limited to information from angler report cards. However, Anderson et al. (2018) recently confirmed an adult Green Sturgeon holding in a deep pool near Knights Ferry in the Stanislaus River.

Based on records of spawning distribution and captures of larval Green Sturgeon, the distribution of larvae is estimated to extend at least 100 km downstream from spawning habitats on the Sacramento and Feather rivers in high flow years (NMFS 2018). Captures of larvae in traps at the Red Bluff Diversion Dam during 2003-2012 (27.3 mm average median TL) occurred primarily from May through August, with peak counts typically occurring in June and July, while captures of juveniles occurred sporadically from August through November (Poytress et al. 2014). Current information indicates that juvenile Green Sturgeon rear for up to 3 years in the Sacramento River, Delta, and San Francisco Bay before entering the ocean, but there is little information on residence times, movements, and emigration patterns of juveniles following metamorphosis in the Sacramento River. The lack of juveniles less than 200 mm FL in Delta capture records suggests extended upriver rearing of juveniles before entering the estuary (CDFG 2002).

2.10.4 Limiting Factors, Threats, and Stressors

The principal factor in the decline of the Southern DPS of Green Sturgeon is the reduction in historical spawning habitat (NMFS 2015). The population also is threatened by elevated water temperatures in spawning areas, entrainment and stranding in water and flood diversions, indirect effects of invasive species, potential poaching, and exposure to contaminants (NMFS 2015).

Fish passage barriers such as dams, weirs, and other flood control structures block or impede Green Sturgeon migration. Adams et al. (2007) hypothesized that significant amounts of historically-utilized Green Sturgeon spawning habitat may be blocked by Shasta Dam and Oroville Dam on the Feather River. According to habitat and observance monitoring and statistics by Mora et al. (2009), Shasta Dam and reservoir blocks access to reaches of the Pit, McCloud and Little Shasta rivers that contain apparently suitable habitat for Green Sturgeon. Similarly, Oroville Dam and reservoir block some areas of suitable habitat on the middle fork of the Feather River, and Daguerre Point Dam blocks some habitat on the Yuba River (Mora et al. 2009). Other potential migration barriers include the Sacramento Deep Water Channel Locks, Fremont Weir, Sutter Bypass, the DCC in the Sacramento River, and Shanghai Bench and Sunset Pumps on the Feather River.

Quality of the remaining spawning habitat is also of concern in terms of water flow and temperature in the Sacramento, Yuba, and Feather Rivers. Comparative analyses of historic and contemporary hydrologic and thermal regimes indicate that habitats in all of these rivers are different than they were before dam construction (NMFS 2015).

Flood bypass systems along the Sacramento River pose a challenge to Southern DPS Green Sturgeon during spawning migrations. Green Sturgeon are particularly affected at the Yolo and Sutter Bypasses and by Tisdale and Fremont Weirs (Thomas et al. 2013). Reclamation and DWR are working on the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project which will improve Sturgeon passage at the Yolo Bypass and Fremont Weir. Green Sturgeon mature late, live long, and do not reproduce every year, which makes the population susceptible to loss of even a small number of reproductive females. In long-lived species with delayed reproductive maturity, including Sturgeon, population growth rate is most sensitive to adult survival (Heppell 2007). Therefore, stranding of even a few reproductive individuals at flood control structures could have a large impact on the population.

Population impacts also arise from bycatch in fisheries, poaching, and small population size. Climate change could result in elevated water temperatures that would be detrimental to the reproductive success of the Green Sturgeon population if water temperatures in remaining spawning areas became elevated above that suitable for egg incubation and hatching success.

2.10.5 Water Operations Management

Reclamation does not currently manage for Green Sturgeon. However, many operational changes made for Chinook Salmon or Steelhead also benefit Green Sturgeon. Removal of the Red Bluff Diversion Dam in 2013 adds additional spawning habitat for Green Sturgeon in the upper Sacramento River.

2.10.6 Recovery and Management

Heublein et al. (2017) developed a conceptual model to support management and recovery of Sturgeon species in the San Francisco Estuary watershed. Additionally, NMFS issued a final recovery plan for the southern DPS of North American Green Sturgeon in 2018. Reduction of potential spawning habitat, severe threats to the single remaining spawning population coupled with the inability to alleviate these threats using current conservation measures, and the continued observance of declining numbers of juveniles collected in the past two decades threaten the species (NMFS 2015).

Fishing regulations and conservation measures represent a reduction in risk to Green Sturgeon. Recent implementation of Sturgeon fishing restrictions in Oregon and Washington and protective efforts put in place on the Klamath, Trinity, and Eel Rivers in the 1970s, 1980s, and 1990s may offer protection to the Southern DPS.

The retention of Green Sturgeon is prohibited along the west coast of North America. California also revised its regulations to provide additional protection for Green Sturgeon. Effective March 1, 2010, Sturgeon fishing was prohibited year-round in the mainstem Sacramento River from Highway 162 to Keswick Dam to protect spawning adults (NMFS 2015).

One of the most important conservation actions that has occurred in the last 10 years is the permanent removal of the gates of the Red Bluff Diversion Dam, where originally, the dam was closed year-round (NMFS 2015) and prevented Sturgeon passage. Further conservation efforts include floodplain and river restoration; riparian habitat protection; fish screening and passage projects; environmental water acquisitions; and contaminant studies conducted under the CVPIA, the Anadromous Fish Restoration Program, and the California Bay-Delta Program for the conservation of the southern DPS Green Sturgeon and other anadromous fishes.

Rescue of stranded individuals trapped behind weir structures can have a positive impact on this slow-reproducing species, but does not offer a viable long-term solution to maintaining the population. Thomas et al. (2013) present a modeling analysis indicating that rescue of the animals is important for population viability, but also note that fish passage improvement (rather than continued rescue) is a more appropriate long-term goal for mitigating this threat.

2.10.7 Monitoring and Research Programs

Research needs for Green Sturgeon in the Sacramento-San Joaquin Watershed are described in Klimley et al. (2015) and Heublein et al. (2017). Additionally, priority monitoring programs are described in the NMFS (Acipenser medirostris) (2018).

During July 2018, CDFW and University of California Davis began a 3-year monitoring study to investigate rearing and migratory behavior of Green Sturgeon in the lower Sacramento River (CDFW 2018). Results indicate that Green Sturgeon recruitment may be low during critically dry years.

Reclamation funds the USFWS to establish a Green Sturgeon monitoring program in the upper Sacramento River. Large numbers of larvae (n=4,881; greater than the long-average) and juveniles (n=26) were observed at the Red Bluff fish monitoring RSTs between May 28 and November 17, 2017. Eighty-five juveniles ranging in size from 72 to 322 mm mean = 176 mm) were collected in benthic trawl during 2017. Juvenile Salmon Acoustic Telemetry System (JSATS) acoustic tags were implanted into 45 of these fish. All juveniles were sampled between downtown Red Bluff and below Woodson Bridge over an approximately 60 river kilometer reach. A strong correlation was observed between movement and flow events (i.e., discharge or turbidity). Approximately 83 percent of Sturgeon movement detected during 2017 occurred from November 15 to November 22, 2017 while flows were increasing (Poytress personal communication 2017).

Sampling tools that are less invasive are especially useful for monitoring ESA-listed species. Environmental DNA (eDNA) is a quick, inexpensive method that could be used to efficiently monitor distribution of fish. Green Sturgeon have been identified using eDNA techniques in the Sacramento River (Bergman et al. 2016).

Research on physiological processes are important for informing temperature ranges for survival and targeting future restoration sites. Poletto et al. (2018) studied the effects of temperature and food availability on the growth of larval Green Sturgeon. The study indicated that larval sturgeon that reared and the greatest temperature tests exhibited optimal condition when fed optimally; however, when food was restricted larval sturgeon condition was the poorest at the greatest temperature tested (Poletto et al. 2018). Sardella and Kultz (2014) assessed Green Sturgeon ability to tolerate salinity fluctuations. They found that Sturgeon can acclimate to changes in salinity; however, these salinity fluctuations result in cellular stress (Sardella and Kultz 2014).

2.11 Green Sturgeon Critical Habitat

On October 9, 2009, NMFS designated critical habitat for the southern DPS of North American Green Sturgeon. In the Central Valley, critical habitat for Green Sturgeon includes the Sacramento River downstream of Keswick Dam, the Feather River downstream of Fish Barrier Dam, the Yuba River downstream of Daguerre Point Dam, a portion of the lower American River, the Sutter and Yolo bypasses, the Sacramento–San Joaquin Delta, and the San Francisco Estuary (74 FR 52300). Critical habitat also includes marine waters (out to the 60-fathom depth bathymetry line, relative to Mean Low Low Water) and several coastal bays and estuaries extending from Monterey Bay, California northward to the Strait of Juan de Fuca, Washington (74 FR 52300).

NMFS has outlined specific PBFs essential for the conservation of the Southern DPS in freshwater riverine systems, estuarine areas, and coastal marine areas (74 FR 52300):

Freshwater riverine systems:

1. Food resources—Abundant prey items for larval, juvenile, subadult, and adult life stages.
2. Substrate type or size - Substrates suitable for egg deposition and development (e.g., bedrock sills and shelves, cobble and gravel, or hard clean sand, with interstices or irregular surfaces to

”collect” eggs and provide protection from predators, and free of excessive silt and debris that could smother eggs during incubation), larval development (e.g., substrates with interstices or voids providing refuge from predators and from high flow conditions), and subadults and adults (e.g., substrates for holding and spawning).

3. Water flow—A flow regime (i.e., the magnitude, frequency, duration, seasonality, and rate-of-change of fresh water discharge over time) necessary for normal behavior, growth, and survival of all life stages.
4. Water quality—Water quality, including temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages.
5. Migratory corridor—A migratory pathway necessary for the safe and timely passage of Southern DPS fish within riverine habitats and between riverine and estuarine habitats (e.g., an unobstructed river or dammed river that still allows for safe and timely passage).
6. Depth—Deep (≥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.
7. Sediment quality - Sediment quality (i.e., chemical characteristics) necessary for normal behavior, growth, and viability of all life stages.

Estuarine habitats:

1. Food resources—Abundant prey items within estuarine habitats and substrates for juvenile, subadult, and adult life stages.
2. Water flow—Within bays and estuaries adjacent to the Sacramento River (i.e., the Sacramento–San Joaquin Delta and the Suisun, San Pablo, and San Francisco Bays), sufficient flow into the bay and estuary to allow adults to successfully orient to the incoming flow and migrate upstream to spawning grounds.
3. Water quality—Water quality, including temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages.
4. Migratory corridor—A migratory pathway necessary for the safe and timely passage of Southern DPS fish within estuarine habitats and between estuarine and riverine or marine habitats.
5. Depth—A diversity of depths necessary for shelter, foraging, and migration of juvenile, subadult, and adult life stages.
6. Sediment quality—Sediment quality (i.e., chemical characteristics) necessary for normal behavior, growth, and viability of all life stages.

Nearshore coastal marine areas:

1. Migratory corridor—A migratory pathway necessary for the safe and timely passage of Southern DPS fish within marine and between estuarine and marine habitats
2. Water quality—Nearshore marine waters with adequate dissolved oxygen levels and acceptably low levels of contaminants (e.g., pesticides, organochlorines, elevated levels of heavy metals) that may disrupt the normal behavior, growth, and viability of subadult and adult Green Sturgeon.
3. Food resources—Abundant prey items for subadults and adults, which may include benthic invertebrates and fishes

2.12 Killer Whale, Southern Resident DPS

2.12.1 ESA Listing Status

The Southern Resident DPS of Killer Whales was listed as endangered under the Endangered Species Act on November 18, 2005 (70 FR 69903). Their range in the Northeastern Pacific Ocean overlaps with other whale populations classified as transient, resident, and offshore populations. The Southern Resident population consists of three pods designated J, K and L, each containing 22, 18 and 34 members, respectively (Center for Whale Research 2018). These pods generally spend late spring, summer and fall in inland waterways of Washington State and British Columbia. They are also known to travel as far south as central California and as far north as the Queen Charlotte Islands. Winter and early spring movements are largely unknown for this DPS.

On August 2, 2012, National Marine Fisheries Service (NMFS) received a petition to delist the Southern Resident Killer Whale DPS under ESA submitted by the Pacific Legal Foundation on behalf of the Center for Environmental Science Accuracy and Reliability, Empresas Del Bosque, and Coburn Ranch (Pacific Legal Foundation 2012). The petitioners claimed that there is no scientific basis for the designation of the unnamed North Pacific Resident subspecies of which the Southern Resident Killer Whales are a purported DPS. Therefore, because NMFS is without authority to list a DPS of a subspecies, the listing of the Southern Resident Killer Whale DPS is illegal and NMFS should delist the DPS.

On November 27, 2012, NMFS indicated that the petition to delist the DPS was warranted and they would initiate a status review to determine whether delisting is warranted and to examine the application of the DPS policy (77 FR 70733).

On August 5, 2013, NMFS determined that the delisting of Southern Resident Killer Whale DPS was not warranted because, after a legal and scientific review, they found that there was no new information leading to a different conclusion from that reached in the 2005 rulemaking, and the weight of evidence continues to support their conclusion that the North Pacific Resident Killer Whales represent a taxonomic subspecies (78 FR 47277).

On April 25, 2014, NMFS accepted a petition from the Center for Biological Diversity to review the critical habitat designation for the Southern Resident Killer Whale DPS. The petition requested that NMFS revise the critical habitat designation to include inhabited Pacific Ocean marine waters along the West Coast of the United States that constitute essential foraging and wintering areas (79 FR 22933).

On February 23, 2015, National Oceanic and Atmospheric Administration (NOAA) Fisheries announced a 12-month finding on a petition to revise the Critical Habitat Designation for the Southern Resident Killer Whale DPS was warranted (80 FR 9682).

2.12.2 General Life-History and Habitat Requirements

Wild female Southern Resident Killer Whales give birth to their first surviving calf between the ages of 12 and 16 years (mean = about 14.9 years) (Olesiuk et al. 1990; Matkin et al. 2003). Females produce an average of 5.4 surviving calves during a reproductive life span lasting about 25 years (Olesiuk et al. 1990). Males become sexually mature at body lengths ranging from 5.2-6.4 meters, which corresponds to between the ages of 10 to 17.5 years (mean = about 15 years) (Christensen 1984; Perrin and Reilly 1984; Olesiuk et al. 1990), and are presumed to remain sexually active throughout their adult lives (Olesiuk et al. 1990).

Most mating of Southern Resident Killer Whales in the North Pacific is believed to occur from May to October (Olesiuk et al. 1990); however, conceptions apparently happen year-round because births of calves are reported in all months. The mean interval between viable calves is 4 years (Bain 1990). Mothers and offspring maintain highly stable social bonds throughout their lives and this natal relationship is the basis for the matrilineal social structure in the Southern Resident population (Bigg et al. 1990; Baird and Whitehead 2000).

As the oceans' apex predator, Killer Whales feed on a great diversity of prey. More than 120 species of fishes, invertebrates, sea turtles, sea birds and marine mammals have been recorded in the species' diet (Ford and Ellis 2006). Most published information on Southern Resident Killer Whale prey originates from studies (Ford et al. 1998; Ford and Ellis 2005) in British Columbia, including southeastern Vancouver Island. These studies focused primarily on Northern Residents and included a relatively small number of observations for Southern Residents. Of the 487 records of apparent fish predation events from 1974 to2004, only 68 (14 percent) observations came from Southern Residents. The study recorded surface observations from predation events and also analyzed the stomach contents from stranded Killer Whales. Southern Resident Killer Whales are known to consume 22 species of fish and one species of squid (Ford et al. 1998, 2000; Saulitis et al. 2000; Ford and Ellis 2005). In recent years, additional data have been collected on Southern Resident Killer Whales in parts of Puget Sound (Hanson et al. 2010). In addition to collections of scales from observed predation events, fecal samples have also been collected for analysis.

Ford and Ellis (2005) found that salmon represent over 96 percent of the prey consumed during the spring, summer, and fall. Chinook Salmon were selected over other species, comprising over 70 percent of the identified salmonids taken. This preference occurred despite the much lower abundance of Chinook in the study area in comparison to other salmonids, and is probably related to the species' large size, high fat and energy content, and year-round occurrence in the area. Other salmonids eaten in smaller amounts include Chum (22 percent of the diet), pink (3 percent), Coho (2 percent), Sockeye (less than 1 percent), and Steelhead (less than 1 percent) (Ford and Ellis 2005). This work suggested an overall preference of these whales for Chinook during the summer and fall, but also revealed extensive feeding on Chum Salmon in the fall.

Ford et al. (2016) confirmed the importance of Chinook Salmon to Southern Residents in the summer months using DNA sequencing from whale feces. Ford et al. found that more than 90 percent of the whales' inferred diet consisted of salmonids; almost 80 percent was Chinook Salmon. Bellinger et al. (2015) estimated that Central Valley Chinook Salmon made up about 22 percent of the Chinook Salmon sampled off the Oregon coast and about 50 percent of those sampled off the California coast (south to Big Sur). While this apex predator certainly eats a variety of other species as well, Central Valley Chinook Salmon (all runs) can be estimated to make up approximately 40 percent of the Killer Whale diet when Killer Whales are off the California coast, and 18 percent of the Killer Whale diet when the Killer Whales are off the Oregon coast.

The Southern Resident population of Killer Whales is thought to move with the seasonal abundance of salmonids returning to natal rivers to spawn from early summer through fall. There are correlations between the occurrence of Southern Residents and commercial and sport salmon fishery catches in U.S. waters off southeastern Vancouver Island and in Puget Sound (Heimlich-Boran 1986). This population of Killer Whales is commonly found off southeastern Vancouver Island and in Puget Sound, Washington, from late spring to late fall (Ford 2006; Osborne 1999). The winter distribution of Southern Resident Killer Whales is poorly known. Several of the Southern Resident pods have been observed off the mouth of the Columbia River and in Monterey Bay, California, associated with local concentrations of Chinook Salmon (Wiles 2004; Balcomb 2006).

2.12.3 Historical and Current Distribution and Abundance

Southern Resident Killer Whales are found throughout the coastal waters off Washington, Oregon, and Vancouver Island, and are known to travel as far south as central California and as far north as the Queen Charlotte Islands, British Columbia (Figure 2.12-1). Southern Resident Killer Whales spend considerable time from late spring to early autumn in inland waterways of Washington and British Columbia, such as the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound (Bigg 1982; Ford et al. 2000; Krahn et al. 2002; table 4-10). Typically, J, K, and L Pods are increasingly present in May or June and spend considerable time in the core area of Georgia Basin and Puget Sound until at least September. During this time, the pods (particularly K and L) make frequent trips from inland waters to the outer coasts of Washington and southern Vancouver Island, which typically last a few days (Ford et al. 2000).

Southern Residents were formerly thought to range southward along the coast to about Grays Harbor (Bigg et al. 1990) or the mouth of the Columbia River (Ford et al. 2000). However, recent sightings of members of K and L Pods in Oregon and in California as far south as Monterey Bay, have considerably extended the southern limit of their known range (NMFS 2008b, 2014b, 2016). The historical abundance of Southern Residents was estimated based on genetic data to have ranged from 140 to 200 individuals (Krahn et al. 2002; NMFS 2008). The population was depleted by live captures for aquarium programs during the 1960s and 1970s (Balcomb et al. 1982; Olesiuk et al. 1990). Following a steep decline of 20 percent between 1996 and 2001 (from 97 whales to 78) (Krahn et al. 2002, 2004), the population was listed as endangered in the United States and Canada. The population rebounded to 98 whales by 2005 and was 82 whales as of September 2013 (Center for Whale Research 2013). As of July 1, 2018, the total population of Southern Resident Killer Whales was 74, with J Pod having 22 individuals, K Pod having 18, and L Pod having 34, representing the lowest population in 34 years (Center for Whale Research 2018). Because the population is small and the probability of quasi-extinction is sufficiently likely, NMFS (2008) has determined that representation from all three pods is necessary to meet biological criteria for Southern Resident Killer Whale downlisting and recovery.

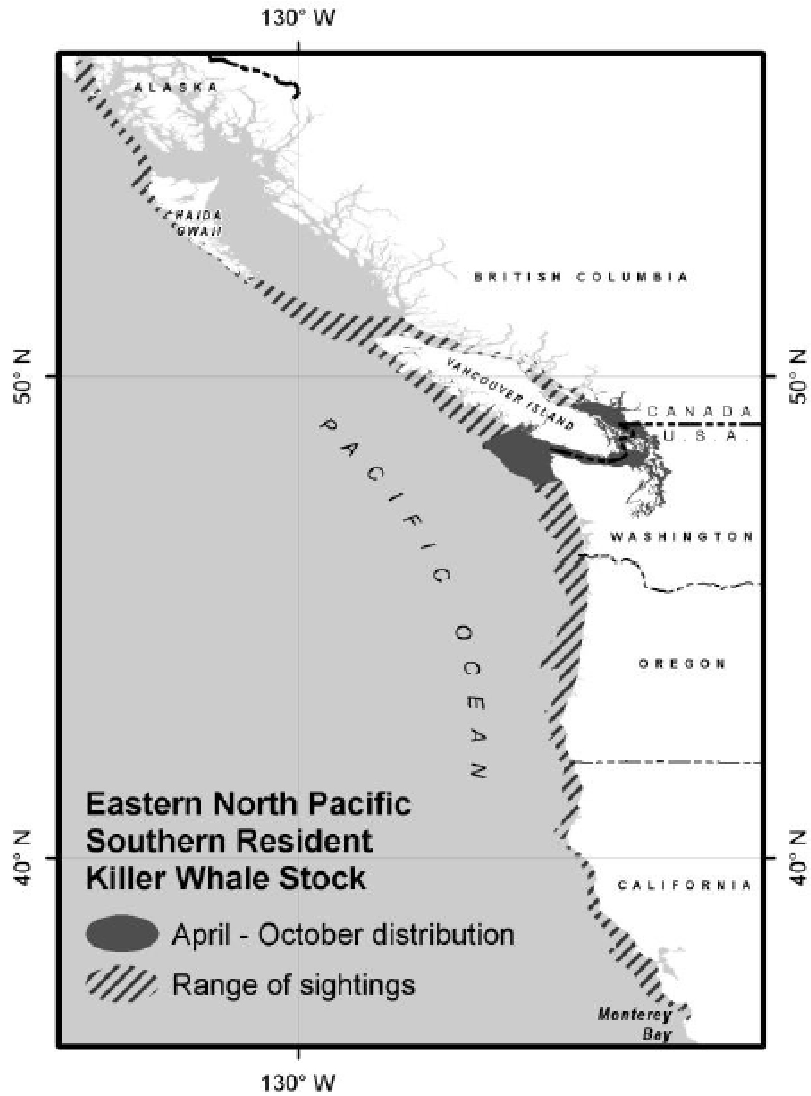


Figure 2.12-1. Southern Killer Whale Range off the Pacific West Coast

Most of the coastal sightings have occurred within 10 miles of shore (NMFS 2006), and there is no evidence that Southern Residents travel more than about 31 miles offshore (Ford et al. 2005). Although new evidence shows that Southern Residents range spans the coastal waters of Washington, Oregon, and California during the winter months (Ford 2013). A tracking study found that Southern Residents traveled extensively between Cape Flattery, Washington, and Point Reyes, California, from December 2012 to March 2013. Whales during this period generally confined their offshore movements to the continental shelf and slope, ranging to a maximum distance of 76 km offshore (Michael J. Ford, NMFS). Southern Resident Killer Whales live in highly cohesive matrilineal groups consisting of older females and one or two generations of their offspring of both sexes (Bigg et al. 1990; Baird and Whitehead 2000). Matrilineal groups tend to associate consistently in pods that travel together most of the time. Pods that share a common range and frequently associate form a community, for example, the Southern Resident community (Bigg et al. 1990; Parsons et al. 2009). The Southern Resident Killer Whale community is considered a single population. Different Southern Resident pods frequently intermingle for brief periods, likely for socialization and breeding (Hauser et al. 2007).

Increased sightings in the Strait of Juan de Fuca in late fall suggest that activity shifts to the outer coasts. Most sightings along the outer coast from 1975 to the present have been in the period of January through April. Given that Southern Resident Killer Whales occur during winter months as far south as Monterey Bay and that Central Valley Chinook Salmon compose a large percentage of the Chinook Salmon available south of the Columbia River, it is reasonable to expect that the whales could be affected by a change in the availability of Central Valley Chinook Salmon (Reclamation and DWR 2016).

2.12.4 Limiting Factors, Threats, and Stressors

As discussed in the original listing notice (70 FR 69903), the three main human-caused factors that have affected the Southern Resident Killer Whale population and may continue to impede the recovery of this species are contaminants, vessel traffic, and reductions in prey availability. Reductions in prey availability are caused by a large number of factors, including entrainment, predators, and climate change.

Exposure to contaminants may result in harm to the species. The presence of high levels of persistent organic pollutants, such as polychlorinated biphenyls (PCBs) and DDT, have been documented in Southern Resident Killer Whales (Ross et al. 2000; Ylitalo et al. 2001; and Herman et al. 2005). Many organochlorines are highly fat soluble (lipophilic) and accumulate in the fatty tissues of animals (Ross et al. 2000,). Some are highly persistent in the environment and resistant to metabolic degradation. These and other chemical compounds have the ability to induce immune suppression, impair reproduction, and produce other adverse physiological effects, as observed in studies of other marine mammals. High levels of “newly emerging” contaminants that may have similar negative effects, such as flame retardants, have been documented in Killer Whales, and are also becoming more prevalent in the marine environment (Rayne et al. 2004). Although contaminants enter marine waters and sediments from numerous sources, these chemical compounds enter Killer Whales through their prey. Because of their long life span, position at the top of the food chain, and their blubber stores, Killer Whales are capable of accumulating high concentrations of contaminants (Ylitalo et al. 2001; Grant and Ross 2002).

Commercial shipping, whale watching, ferry operations, and recreational boat traffic have increased in recent decades. Several studies have linked vessels with short-term behavioral changes in Northern and Southern Resident Killer Whales (Kruse 1991; Williams et al. 2002; Foote et al. 2004). Although the potential impacts from vessels and the sounds they generate are poorly understood, these activities may affect foraging efficiency, communication, and/or energy expenditure through their physical presence, increased underwater sound level, or both. Collisions with vessels are another potential source of serious injury and mortality and have been recorded, although rarely, for both Southern and Northern Resident Killer Whales.

Healthy Killer Whale populations are dependent on adequate prey levels. Reductions in prey availability may force whales to spend more time foraging and might lead to reduced reproductive rates and higher mortality rates. The Southern Resident Killer Whale prey base is composed primarily of salmonids, particularly Chinook Salmon between late spring and early fall (Ford and Ellis 2005; Hanson et al. 2010). Salmon populations available as prey to Southern Resident Killer Whale have declined because of degradation in aquatic ecosystems from modern land use changes, harvest, and hatchery practices, and 27 ESUs of Salmon and Steelhead in Washington, Oregon, Idaho, and California have been listed as threatened or endangered under the ESA (NMFS 2008). Reductions in prey availability may increase the amount of time whales must spend foraging, reduce reproductive output, and lead to higher mortality.

Chinook Salmon stocks that are important to Southern Resident Killer Whales have been identified by NOAA Fisheries and Washington Department of Fish and Wildlife. A framework was developed by including three factors that contribute to the identification of priority Chinook Salmon populations: (1)

observed part of Southern Resident Killer Whale diet, (2) consumed during reduced body condition or diversified Southern Resident Killer Whale diet, and (3) degree of spatial and temporal overlap (NOAA/WDFW 2018). These three factors were evaluated and scored (zero to five) to develop the priority list of Chinook Salmon populations (see details in Chapter 5, Effects Analysis).

2.12.5 Water Operations Management

While neither the CVP nor SWP operate for Killer Whales, occasional modifications to operations are made for Fall-Run Chinook Salmon, the commercial fishery of importance as prey to Southern Resident Killer Whales in California. For example, when cold water pool considerations are minimal, Reclamation keeps Keswick Dam releases high in the fall to avoid dewatering the last Fall-Run Chinook Salmon redds.

2.12.6 Recovery and Management

The final *Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*)* was issued in January 2008 (NMFS 2008). The ultimate goal of the recovery plan is to achieve the recovery of the Southern Resident Killer Whale DPS and its ecosystem to a level sufficient to warrant its removal from the Federal List of Endangered and Threatened Wildlife and Plants under the ESA. The intermediate goal is to reclassify the DPS from endangered to threatened. The recovery plan also provides a recovery program that includes a set of specific management, research, and monitoring actions intended to reduce threats and restore the population to long-term sustainability.

Because NMFS determined that the Southern Resident stock was below its optimum sustainable population, the DPS was designated as “depleted” under the Marine Mammal Protection Act (MMPA) in 2003 (68 FR 31980) and a Proposed Conservation Plan was announced in 2005 (70 FR 57565). The plan provides a strategy to conserve and restore Southern Resident Killer Whales so that they are no longer considered depleted under the MMPA.

The following conservation measures were included in the final recovery plan for the DPS’s ESA listing (NMFS 2008):

- Support salmon restoration efforts in the region including habitat, harvest, and hatchery management considerations and continued use of existing NMFS authorities under the ESA and Magnuson-Stevens Fishery Conservation and Management Act to ensure an adequate prey base.
- Clean up existing contaminated sites, minimize continuing inputs of contaminants harmful to Killer Whales, and monitor emerging contaminants.
- Continue evaluating and improving guidelines for vessel activity near Southern Residents and evaluate the need for regulations or protected areas.
- Prevent oil spills and improve response preparation to minimize effects on Southern Residents and their habitat in the event of a spill.
- Continue agency coordination and use of existing MMPA mechanisms to minimize potential impacts from anthropogenic sound.
- Enhance public awareness, educate the public on actions they can participate in to conserve Killer Whales, and improve reporting of Southern Resident sightings and strandings.
- Improve responses to live and dead Killer Whales to implement rescues, conduct health assessments, and determine causes of death to learn more about threats and guide overall conservation efforts.

- Coordinate monitoring, research, enforcement, and complementary recovery planning with international, federal, and state partners.
- Conduct research to facilitate and enhance conservation efforts. Continue the annual census to monitor trends in the population, identify individual animals, and track demographic parameters

2.12.7 Monitoring and Research Programs

Many programs are conduct monitoring and research with Southern Resident Killer Whales. These are a few of the programs:

- NMFS—Northwest Fisheries Science Center—Marine Mammal Ecology Team conducts research to understand the factors that may limit this population including studies about their taxonomy, behavior, ecology, health, and human-caused impacts. (https://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/killer_whale/rpi_monitoring_research.html)
- The Center for Whale Research has been collecting detailed demographic data on the Southern Resident Killer Whale population, recording all observed births and deaths and also conducted an aerial observation study (Center for Whale Research 2018)
- The National Marine Fisheries Service Southwest Fisheries Science Center and SR3: SeaLife Response, Rehabilitation and Research utilize photogrammetry to make quantitative measurements (particularly aerial photographs) of length, growth and body condition/nutritional status and to describe the abundance and structure of pods (https://www.westcoast.fisheries.noaa.gov/stories/2018/25_09252018_give_whales_space.html)
- The University of Washington—Center for Conservation Biology conducts research by acquiring scat samples to extract and assay DNA stress, reproductive and nutritional hormones, as well as toxicants (http://conservationbiology.uw.edu/research-programs/killer-whales/)
- The National Fish and Wildlife Foundation - Killer Whale Research and Conservation Program supports projects to help study and protect Killer Whales in the wild (https://www.nfwf.org/killerwhales/Pages/home.aspx)

2.13 Killer Whale Critical Habitat

Critical habitat for the Southern Resident DPS was designated under the Endangered Species Act on November 29, 2006 (71 FR 69054). The critical habitat designation encompasses the Summer Core Area in Haro Strait and the waters around the San Juan Islands, the Strait of Juan de Fuca and all of Puget Sound (Figure 2.13-1), but does not include any areas in California.

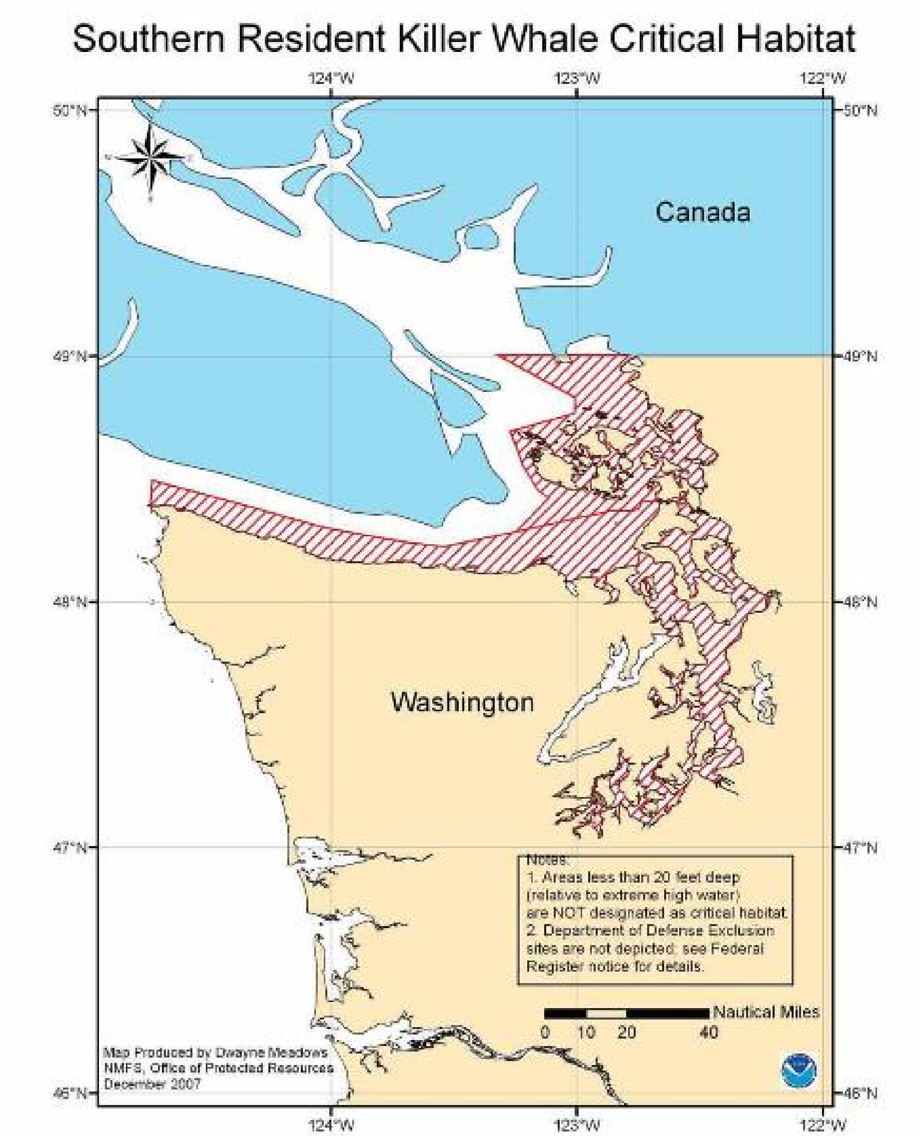


Figure 2.13-1. Southern Killer Whale Designated Critical Habitat

The critical habitat designation identified the following primary constituent elements considered essential for the conservation of the ESU.

1. Water quality to support growth and development;
2. Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and
3. Passage conditions to allow for migration, resting, and foraging.

The Center for Biological Diversity proposes that the critical habitat designation be revised and expanded to include the addition of the Pacific Ocean region between Cape Flattery, WA, and Point Reyes, CA, extending approximately 47 miles (76 km) offshore. Based on new information, NOAA Fisheries intends to proceed with the petitioned action to revise critical habitat for Southern Resident Killer Whales (80 FR 9682).

2.14 Delta Smelt

2.14.1 ESA Listing

The USFWS proposed to list the Delta Smelt (*Hypomesus transpacificus*) as threatened with proposed critical habitat on October 3, 1991 (USFWS 1991). The USFWS listed the Delta Smelt as threatened on March 5, 1993 (USFWS 1993), and designated critical habitat for the species on December 19, 1994 (USFWS 1994). The Delta Smelt was one of eight fish species addressed in the *Recovery Plan for the Sacramento–San Joaquin Delta Native Fishes* (USFWS 1996). A 5-year status review of the Delta Smelt was completed on March 31, 2004 (USFWS 2004). The 2004 review concluded that Delta Smelt remained a threatened species. A subsequent 5-year status review recommended uplisting Delta Smelt from threatened to endangered status (USFWS 2010a). A 12-month finding on a petition to reclassify the Delta Smelt as an endangered species was completed on April 7, 2010 (USFWS 2010b). After reviewing all available scientific and commercial information, the USFWS determined that reclassifying the Delta Smelt from threatened to endangered was warranted but was precluded by other higher priority listing actions (USFWS 2010c). The USFWS annually reviews the status and uplisting recommendation for Delta Smelt during its Candidate Notice of Review (CNOR) process. Each year, the CNOR has recommended the uplisting from threatened to endangered. Electronic copies of these documents are available at http://ecos.fws.gov/docs/five_year_review/doc3570.pdf and http://www.gpo.gov/fdsys/pkg/FR-2013-11-22/pdf/2013-27391.pdf (USFWS 2010a; USFWS 2010b; USFWS 2012b).

2.14.2 General Life History and Habitat Requirements

The Delta Smelt is endemic to the San Francisco Bay–Delta where it primarily occupies open-water habitats in Suisun Bay and marsh and the Sacramento–San Joaquin Delta. The Delta Smelt is primarily an annual species, meaning that it completes its life cycle in 1 year, which typically occurs from April to the following April plus or minus 1 or 2 months. In captivity, Delta Smelt can survive to spawn at 2 years of age (Lindberg et al. 2013), but this appears to be rare in the wild (Bennett 2005; Damon et al. 2016), where very few individuals reach lengths over 3.5 inches (90 mm).

Delta Smelt spawning likely occurs at night with several males attending a female that broadcasts her eggs onto bottom substrate (Bennett 2005). Although preferred spawning substrate is unknown, spawning habits of Delta Smelt's closest relative, the Surf Smelt (*Hypomesus pretiosus*), as well as unpublished experimental trials, suggest that sand or small pebbles may be the preferred substrate (Bennett 2005). Hatching success peaks at temperatures of 15°C to 16°C (59°F to 61°F) and decreases at cooler and warmer temperatures. Hatching success nears 0 percent as water temperatures exceed 20°C (68°F) (Bennett 2005). Water temperatures suitable for spawning occur most frequently during the months of March to May, but ripe female Delta Smelt have been observed as early as January and larvae have been collected as late as July. Delta Smelt spawn in the estuary and have one spawning season for each generation, which makes the timing and duration of the spawning season important every year. Freshwater flow affects how much of the estuary is available for Delta Smelt to spawn (Hobbs et al. 2007), but water temperature controls how long Delta Smelt can spawn each season.

Although adult Delta Smelt can spawn more than once, mortality is high during the spawning season and most adults die by May (Polansky et al. 2018). The egg stage averages about 10 days before the embryos hatch into larvae. The larval stage averages about 30 days. Metamorphosing “post-larvae” appear in monitoring surveys from April into July of most years. By July, most Delta Smelt have reached the juvenile life stage. Delta Smelt collected during the fall are called “subadults,” a stage which lasts until winter when fish disperse toward spawning habitats. This winter dispersal usually precedes sexual maturity (Sommer et al. 2011).

Most Delta Smelt complete their entire life cycle within or immediately upstream of the estuary’s low-salinity zone. The low-salinity zone is frequently defined as waters with a salinity range of about 0.5 to 6 parts per thousand (ppt) (Kimmerer 2004). The 0.5 to 6 ppt and similar salinity ranges reported by various authors were chosen based on analyses of historical peaks in phytoplankton and zooplankton abundance, but recent physiological and molecular biological research has indicated that the salinities typical of the low-salinity zone are also within the tolerance range (0 to 18 ppt) for Delta Smelt (Komoroske et al. 2016). Komoroske et al. (2016) also found that acclimating to salinities outside the low-salinity zone (LSZ) could impose energetic costs that constrain the species’ ability to exploit these habitats. The low-salinity zone is a dynamic habitat with size and location responding rapidly to changes in tidal and river flows. By local convention the location of the low-salinity zone is described as “X2” in terms of the distance from the 2 ppt isohaline to the Golden Gate Bridge. The low-salinity zone magnitude and dimensions change when river flows into the estuary are high, placing low-salinity water over a larger and more diverse set of nominal habitat types than occurs under low flow conditions. During periods of low outflow, the low-salinity zone contracts and moves upstream.

Delta Smelt mainly occupy an arc of habitat in the north Delta, including Liberty Island and the adjacent reach of the Sacramento Deepwater Shipping Channel (Sommer and Mejia 2013), Cache Slough to its confluence with the Sacramento River, and the Sacramento River from that confluence downstream to Chipps Island, Honker Bay, and the eastern part of Montezuma Slough (see Figure 2.14-5). The reasons Delta Smelt are believed to permanently occupy this part of the estuary are the year-round presence of fresh- to low-salinity water that is comparatively turbid and of a tolerable water temperature. These appropriate water quality conditions overlap an underwater landscape featuring variation in depth, tidal current velocities, edge habitats, and food production (Sweetnam 1999; Nobriga et al. 2008; Feyrer et al. 2011; Murphy and Hamilton 2013; Hammock et al. 2015; Bever et al. 2016). Field observations are increasingly supported by laboratory research on the physiological response of Delta Smelt to variation in salinity, turbidity, water temperature, and environmental variables associated with changes in climate, freshwater flow, and estuarine bathymetry (Hasenbein et al. 2014, 2016; Komoroske et al. 2014, 2016).

2.14.3 Historical and Current Distribution

The 2018 (WY 2019) CDFW Fall Midwater Trawl (FMWT) Index was zero, the lowest on record. The CDFW Spring Kodiak Trawl (SKT) monitors the adult spawning stock of Delta Smelt and serves as an indication for the relative number and distribution of spawners in the system. The 2018 SKT Abundance Index was 2.1, the second lowest on record. All CDFW relative abundance indices show a declining trend since the early 2000s (Figure 2.14-1).

In 2016, the USFWS began calculating an absolute abundance estimate using January and February SKT catch data, which have been available since 2002. This calculation was modified in 2017 and resulting estimates and ranges are shown in Figure 2.14-1.

The 2018 absolute abundance estimate is the second lowest; however the confidence intervals overlap so strongly that it cannot be stated that 2018 actually had higher adult abundance than 2016. The January through February 2016 point estimates are the lowest since the SKT survey began in 2002 and suggest Delta Smelt experienced increased natural mortality during the extreme drought conditions occurring during 2013–2015. While the estimate may have increased slightly in 2017, it appears to have decreased again in 2018. The continued low spawning stock of Delta Smelt relative to historical numbers suggests the population would continue to be vulnerable to stochastic events and operational changes occurring in response until successive years of increased population growth results in a substantial increase in abundance.

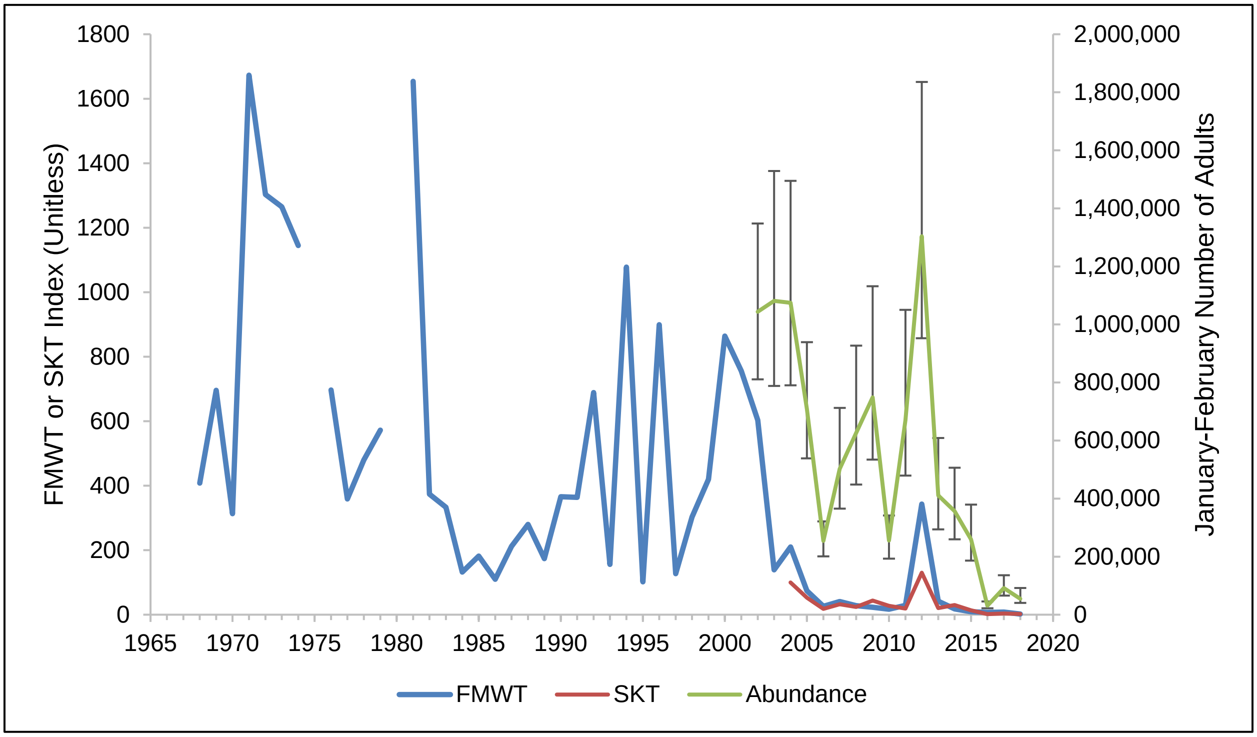


Figure 2.14-1. Fall Midwater Trawl Index, Spring Kodiak Trawl Index, and January-February Spring Kodiak Trawl Abundance Estimate (With 95% Confidence Interval), Water Years 2002-2018.

In addition to these abundance estimates, the CDFW conducts four fish surveys from which it develops indices of Delta Smelt's relative abundance. Each survey has variable capture efficiency (Mitchell et al. 2017), and in each, the frequency of zero catches of Delta Smelt is very high, largely due to the species' rarity (Latour 2016; Polansky et al. 2018).

The Townet Survey (TNS) and FMWT abundance indices for Delta Smelt have documented the species' long-term decline, while the newer 20-mm and SKT abundance indices have generally confirmed the recent portions of the trends implied by the older surveys (Figures 2.14-2 and 2.14-3). During the period of record, Delta Smelt relative abundance has declined from peak levels observed during the 1970s. The TNS and FMWT abundance indices both declined rapidly during the early 1980s, increased somewhat during the 1990s, and then collapsed in the early 2000s. Since 2005, the TNS and the FMWT have produced indices that reflect less year to year variation than their 20-mm and SKT analogs, but overall, the trends in both sets of indices are similar. During the past decade, the index has continued to decrease and currently reflects 0.5 percent of the relative abundance recorded in 1970–1971.

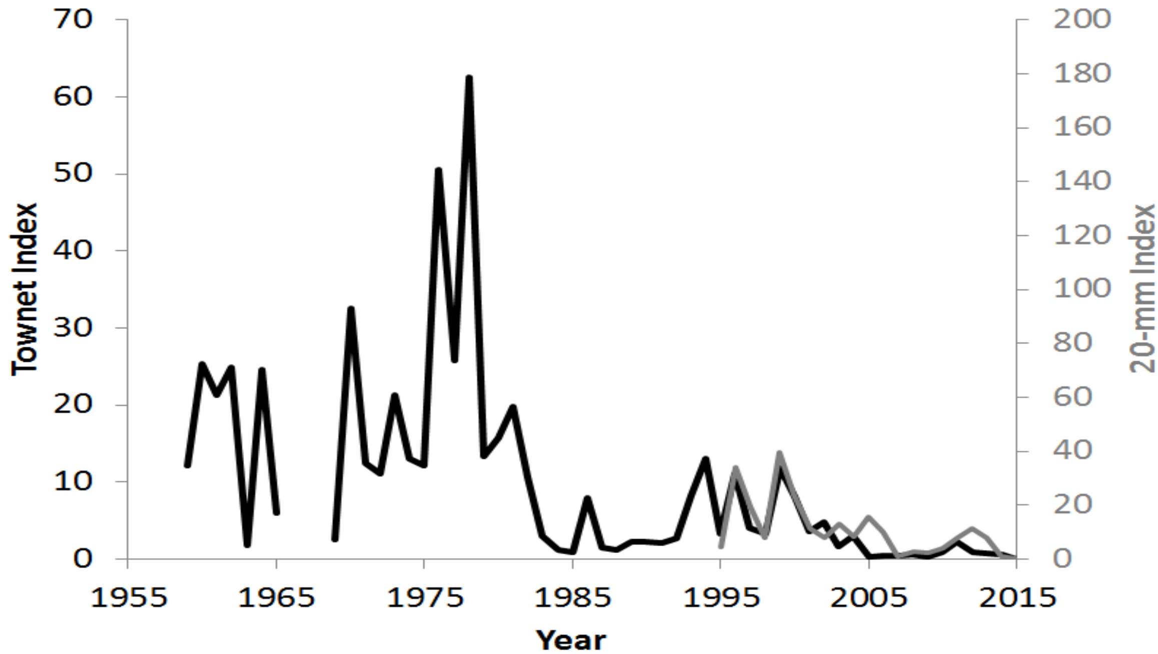


Figure 2.14-2. Time Series of the CDFW's Summer TNS (black line; primary y-axis) and 20-mm Survey (gray line; secondary y-axis) Abundance Indices for Delta Smelt

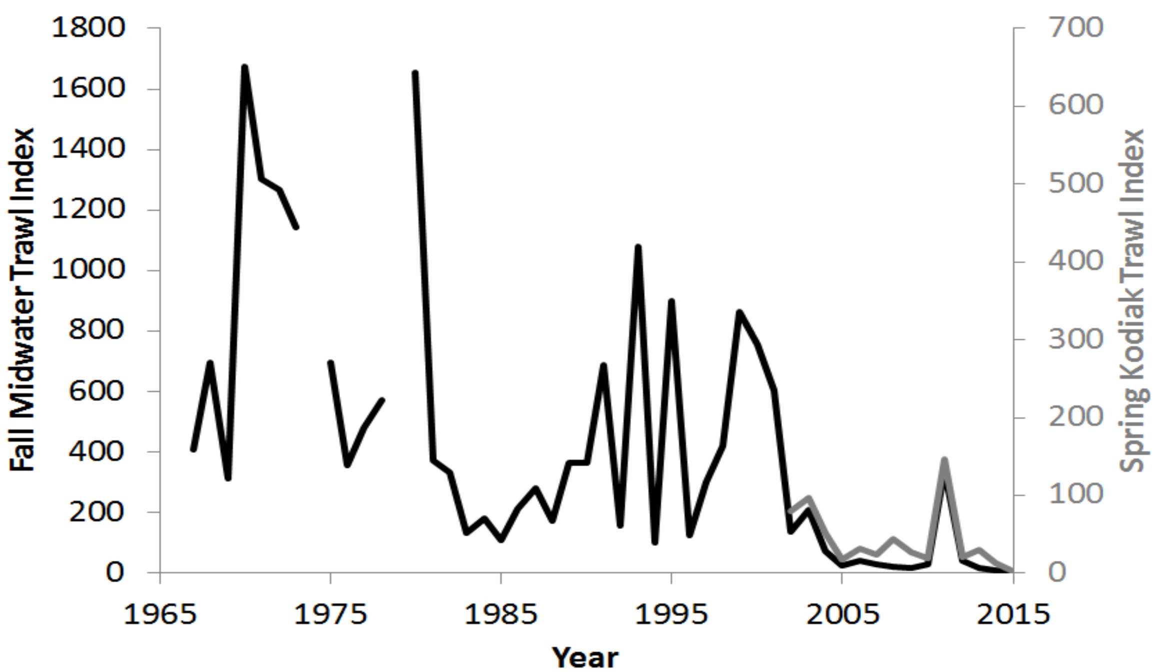


Figure 2.14-3. Time Series of the CDFW's FMWT (black line; primary y-axis) and SKT (gray line; secondary y-axis) Abundance Indices for Delta Smelt

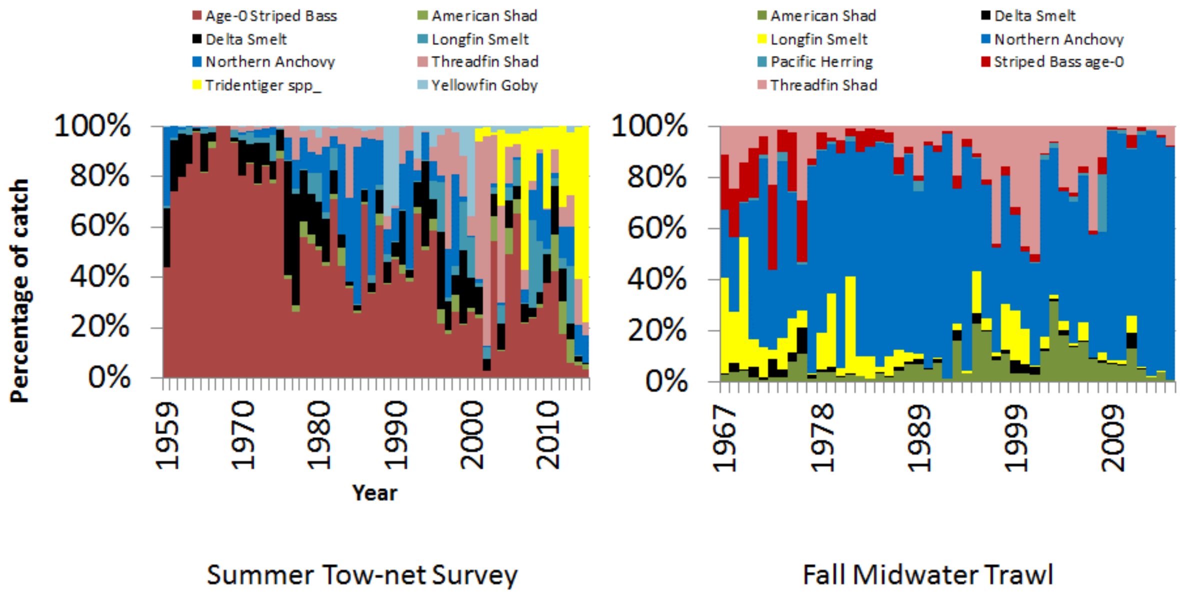


Figure 2.14-4. Fractional Compositions of the Eight Most Frequently Collected Fish Species in the CDFW's Summer TNS (1959–2015), and the Seven Most Frequently Collected Fish Species in the FMWT (1967–2015)

The general distribution of Delta Smelt is well known partly due to its limited geographic distribution (Moyle et al. 1992; Bennett 2005; Hobbs et al. 2006, 2007; Feyrer et al. 2007; Nobriga et al. 2008; Kimmerer et al. 2009; Merz et al. 2011; Murphy and Hamilton 2013; Sommer and Mejia 2013). The suitable habitat for Delta Smelt is a geographically limited area (e.g., one example is Sacramento River around Decker Island) and has low-salinity conditions. The additional seasonally suitable habitats utilized for spawning and migration are identified as occasional seasonal use habitats. Distribution extremes do not yield Delta Smelt in most sampling years.

Delta Smelt have been observed as far west as San Francisco Bay, as far north as Knights Landing on the Sacramento River, as far east as Woodbridge on the Mokelumne River and Stockton on the Calaveras River, and as far south as Mossdale on the San Joaquin River (Figure 2.14-5). This distribution represents a range of salinity from essentially 0 ppt to about 20 ppt, which includes brackish water exceeding 2 ppt salinity. However, most Delta Smelt that have been collected in the extensively surveyed San Francisco Estuary have been collected from locations within the defined ranges of the critical habitat rule. In addition, all habitats known to be occupied year-around by Delta Smelt occur within the conditions defined in the critical habitat rule.

Each year, the distribution of Delta Smelt seasonally expands when adults disperse in response to winter flow increases, increases in turbidity, and decreases in water temperature (Figure 2.13-1). The annual range expansion of adult Delta Smelt extends up the Sacramento River to about Garcia Bend in the Pocket neighborhood of Sacramento, up the San Joaquin River from Antioch to areas near Stockton, up the lower Mokelumne River system, and west throughout Suisun Bay and Suisun Marsh. Some Delta Smelt seasonally and transiently occupy Old and Middle River in the south Delta each year, but face a high risk of entrainment when they do (Grimaldo et al. 2009).

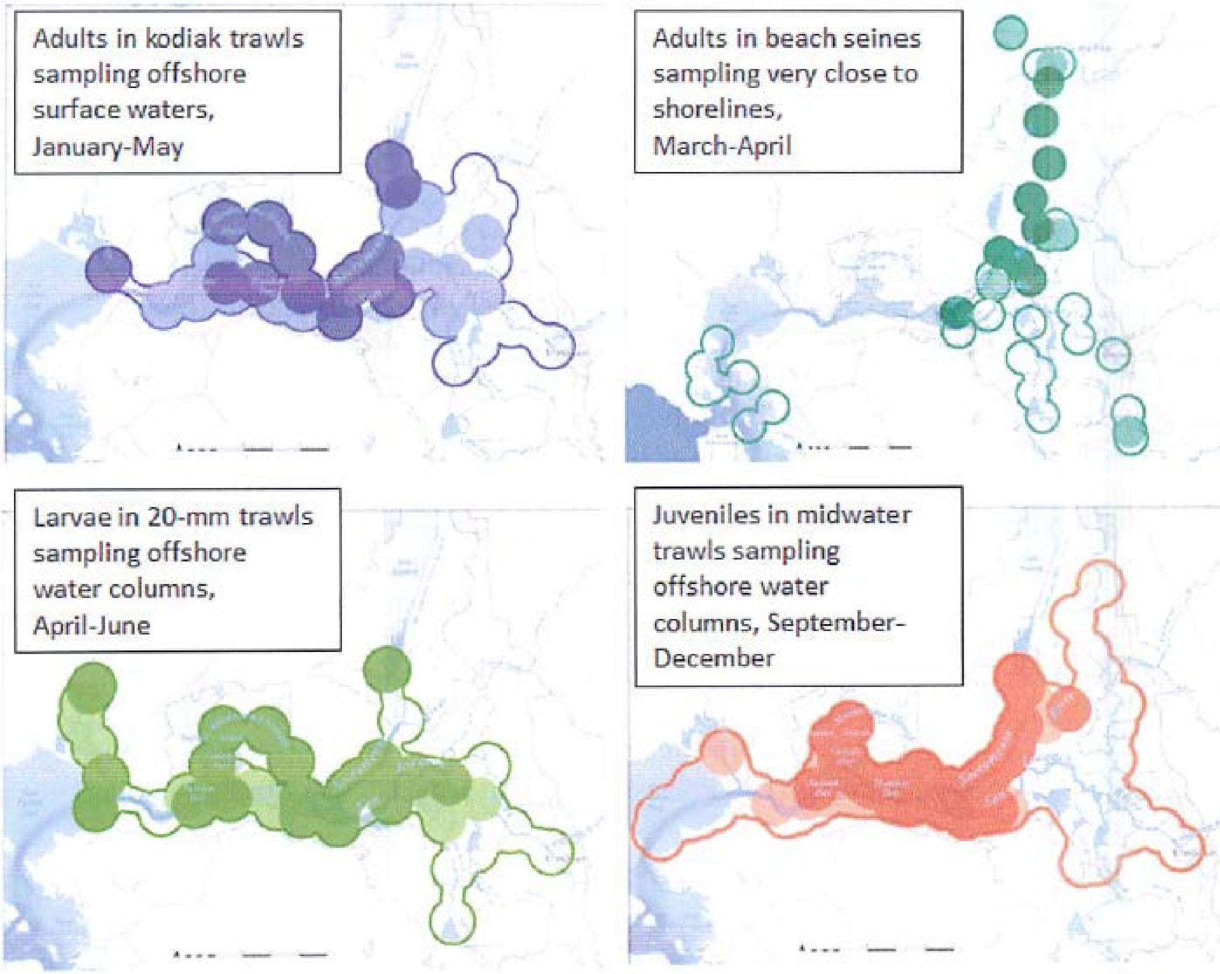


Figure 2.14-5. Maps of Multi-Year Average Distributions of Delta Smelt Collected in Four Monitoring Programs

The sampling regions covered by each survey are outlined. The areas with dark shading surround sampling stations in which 90 percent of the Delta Smelt collections occurred, the areas with light shading surround sampling stations in which the next 9 percent of Delta Smelt collections occurred (Murphy and Hamilton 2013).

The distribution of Delta Smelt occasionally expands beyond this area (Figure 2.14-5). For instance, during high outflow winters, adult Delta Smelt also disperse west into San Pablo Bay and up into the Napa River (Hobbs et al. 2007). Similarly, Delta Smelt have occasionally been reported from the Sacramento River north of Garcia Bend up to Knights Landing (Merz et al. 2011; Vincik and Julienne 2012).

The relative abundance of Delta Smelt has declined substantially for a small forage fish in an ecosystem the size of the San Francisco Estuary. The recent relative abundance reflects decades of habitat change and marginalization by nonnative species that prey on and outcompete Delta Smelt. The anticipated effects of climate change on the San Francisco Estuary and watershed, such as warmer water temperatures, greater salinity intrusion, lower snowpack contribution to spring outflows from the Delta, and the potential for frequent extreme drought, indicate challenges to maintaining a sustainable Delta

Smelt population. A rebound in relative abundance during the very wet and cool conditions during 2011 indicated that Delta Smelt retained some population resilience (IEP 2015). However, since 2012, declines to record low population estimates have been broadly associated with the 2012–2015 drought, and wetter conditions in 2017 and 2018 have not produced a rebound similar that seen in 2011.

2.14.4 Limiting Factors, Threats, and Stressors

Limiting factors for Delta Smelt are: SWP and CVP exports due to entrainment of larvae and juveniles and the effects of low flow on the location and function of the estuary mixing zone (now called the low-salinity zone) (Moyle et al. 1992; USFWS 1993; USFWS 2010); drought; in-Delta water diversions; reduction in food supplies by nonindigenous aquatic species, specifically overbite clam and nonnative copepods; toxicity due to agricultural and industrial chemicals; increasing water transparency; and Brazilian waterweed (*Egeria densa*). Predation was considered a low-level threat linked to increasing waterweed abundance and increasing water transparency. Additional threats considered potentially significant by the USFWS in 2010 were entrainment into power plant diversions, contaminants, and reproductive problems that can stem from small population sizes.

The long-term rarity of the Delta Smelt has had a consequence for understanding the reasons for their population decline, which adds challenges for implementing effective resource management strategies. Some pelagic fishes have shown long-term relationships between Delta inflow, Delta outflow, or X2 and abundance or survival (Stevens and Miller 1983; Jassby et al. 1995; Kimmerer 2002b; Kimmerer et al. 2009). A predictive correlation between freshwater flow conditions and relative abundance has not been established (Stevens and Miller 1983; Jassby et al. 1995; Kimmerer 2002b; Kimmerer et al. 2009). Since 2010, several conceptual models (Interagency Ecological Program [IEP] 2015) and empirical models (Thomson et al. 2010; Maunder and Deriso 2011; Miller et al. 2012; Rose et al. 2013a; Hamilton and Murphy 2018) have explored life cycle models for the Delta Smelt in an attempt to describe the reasons for the population decline. Some of these models have recreated the trend observed in abundance indices (Figure 2.14-6), but each model has applied different methodology and variables. Collectively, these modeling efforts generally support water temperature and changes in the estuary’s trophic dynamics as “universally supported” factors affecting Delta Smelt. However, they have varying conclusions regarding the effectiveness of alterations in water operations as management strategies to increase the likelihood of population increases for Delta Smelt.

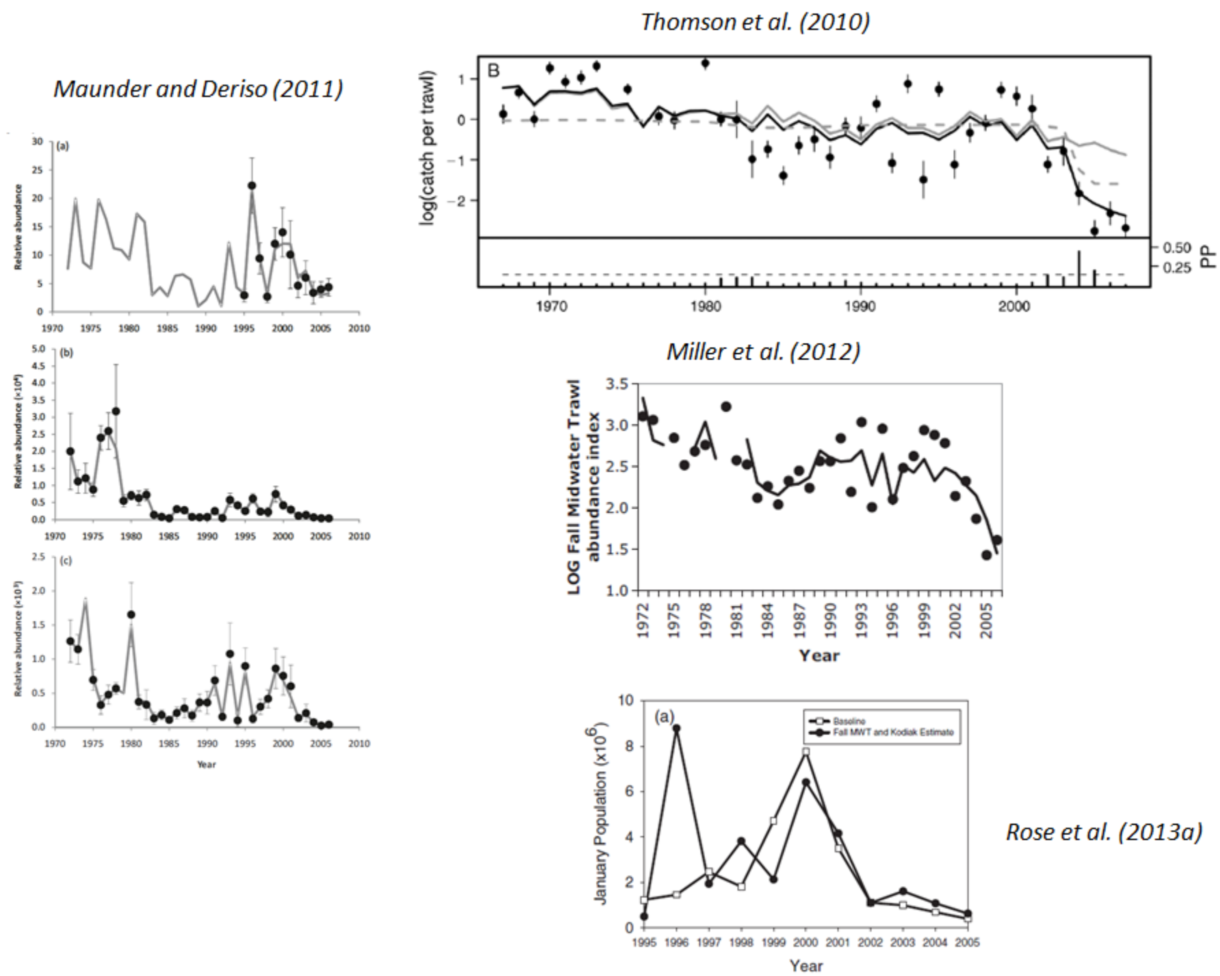


Figure 2.14-6. Examples of Recent Published Model Fits to Time Series of Delta Smelt Relative Abundance Data

The source of each is referenced above or alongside each time series. In each plot, observed catches are depicted as black dots and model predictions of the data as gray or black lines. Model predictions from Rose et al. (2013a) are a black line with open symbols. In Maunder and Deriso (2011), the three panels represent the 20-mm Survey, summer TNS, and FMWT Survey from top to bottom, respectively. The other three studies are fit to estimates of adult Delta Smelt relative abundance (Thomson et al. 2010; Miller et al. 2012) or absolute abundance (Rose et al. 2013a). See each study for further details on methods, results, and the authors' interpretations of their results.

The ecological function of the low-salinity zone can vary depending on Delta outflow (Jassby et al. 1995; Kimmerer 2002a; Kimmerer 2004). During the past four decades, the low-salinity zone ecosystem has undergone substantial changes in turbidity (Schoellhamer 2011) and foodweb function (Winder and Jassby 2011) that cannot be undone solely by increasing Delta outflow. These habitat changes, which extend into parts of the Delta where water is fresher than 0.5 ppt, are hypothesized to have also decreased the ability of the low-salinity zone and adjacent habitats to support the production of Delta Smelt (Thomson et al. 2010; Rose et al. 2013b; IEP 2015).

At all life stages, numerous small planktonic crustaceans, especially a group called calanoid copepods, make up most of the Delta Smelt diet (Nobriga 2002; Slater and Baxter 2014). Small crustaceans are ubiquitously distributed throughout the estuary, but the prey species present at particular times and locations has changed dramatically over time (Winder and Jassby 2011; Kratina et al. 2014). This has likely affected Delta Smelt feeding success, particularly during central California's warm summers.

Climate projections for the San Francisco Bay–Delta and its watershed indicate that temperature and precipitation changes would reduce snowpack in the Sierra Nevada, changing the timing and availability of natural water supplies (Knowles and Cayan 2002; Dettinger 2005). Temperature increases may result in more precipitation falling as rain and less water stored in spring snowpacks. Increased frequency of rain-on-snow events would increase winter runoff and an associated decrease in runoff for the remainder of the year (Hayhoe et al. 2004). Overall, these and other storm track changes may lead to increased frequency of flood and drought cycles during the 21st century (Dettinger et al. 2015).

Central California's warm summers are already a source of energetic stress for Delta Smelt and warm springs already compress the duration of their spawning season (Rose et al. 2013a, 2013b; Moyle et al. 2016). Central California's climate is anticipated to get warmer (Cayan et al. 2009). Warmer estuary temperatures to present a significant conservation challenge for Delta Smelt (Brown et al. 2013, 2016). Mean annual water temperatures within the Delta are expected to increase steadily during the second half of this century (Cloern et al. 2011). Warmer water temperatures could further reduce Delta Smelt spawning opportunities, decrease juvenile growth during the warmest months, and increase mortality via several foodweb pathways including: increased vulnerability to predators, increased vulnerability to toxins, and decreased capacity for Delta Smelt to successfully compete in an estuary that is energetically more optimal for warm-water tolerant fishes.

2.14.5 Water Operations Management

Currently, in addition to D-1641, Reclamation operates to reduce entrainment risk and for Delta Smelt fall habitat in wet and above normal water years through releases of water from storage for Fall X2.

2.14.6 Recovery and Management

The USFWS (2010) recommended the following conservation actions: establish Delta outflows proportionate to proposedproposed action flows to set outflow targets as fractions of runoff in the Central Valley watersheds; minimize net reverse flow in Old and Middle River; and, establish a genetic management plan with the goals of minimizing the loss of genetic diversity and limiting risk of extinction caused by unpredictable catastrophic events. The USFWS (2012b) added climate change to the list of threats to the Delta Smelt.

Continued protection of the Delta Smelt from excessive entrainment, improving the estuary's flow regime, suppressing nonnative species, increasing zooplankton abundance, and improving water quality are among the actions recommended to aid the recovery of Delta Smelt (USFWS 2010).

2.14.7 Monitoring and Research

The Enhanced Delta Smelt Monitoring (EDSM) program began in November 2016 to acquire finer temporal resolution information than existing surveys provided about the spatial distribution and abundance of Delta Smelt. EDSM is a year-round weekly sampling program that samples randomly selected locations using a probabilistic procedure aimed at providing a spatially dispersed sample. This is a significant improvement on existing surveys, which sample in the same locations again and again, and may find no fish. EDSM sampling is repeated until a fish is caught or an upper limit on the number of tows is reached. EDSM methodology attempts to lower the probability of a “False Zero,” that is, failing to catch fish when fish are present, while aiming to minimize the “take” of a threatened species. EDSM is the only survey that allowed agencies to measure where Delta Smelt are located in 2018, given their increasingly low abundance.

2.15 Delta Smelt Critical Habitat

The USFWS designated critical habitat for the Delta Smelt on December 19, 1994 (USFWS 1994). The geographic area encompassed by the designation includes all water and all 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; the Napa River; and the existing contiguous waters contained within the legal Delta, as defined in section 12220 of the California Water Code (USFWS 1994).

The primary objective in designating critical habitat was to identify the key components of Delta Smelt habitat that support successful completion of the life cycle, including spawning, larval and juvenile transport, rearing, and adult migration back to spawning sites. Delta Smelt are endemic to the San Francisco Bay/Sacramento–San Joaquin Delta (Bay-Delta) and the vast majority only live 1 year. Thus, regardless of annual hydrology, the estuary must provide suitable habitat all year, every year. The primary constituent elements essential to the conservation of the Delta Smelt are physical habitat, water, river flow, and salinity concentrations required to maintain Delta Smelt habitat for spawning, larval and juvenile transport, rearing, and adult migration (USFWS 1994). The USFWS recommended in its designation of critical habitat for the Delta Smelt that salinity in Suisun Bay should vary according to water year type. For the months of February through June, this element was codified by the State Water Resources Control Board’s “X2 standard” described in D-1641 and the Board’s current Water Quality Control Plan.

Table 2.15-1 compares the original descriptions of the primary constituent elements with current scientific understanding.

Table 2.15-1. Comparison of Delta Smelt Primary Constituent Elements of Critical Habitat between the 1994 Publication of the Rule and the Present

Primary Constituent Element	1994 Critical Habitat Rule	2018 State of Scientific Understanding
Spawning Habitat	Shallow fresh or slightly brackish edgewaters.	No change.
	Backwater sloughs.	Possible, never confirmed. Most likely spawning sites have sandy substrates and need not occur in sloughs. Backwater sloughs in particular tend to have silty substrates that would suffocate eggs.
	Low concentrations of pollutants.	No change.
	Submerged tree roots, branches, emergent vegetation (tules).	Not likely. Unpublished observations of spawning by captive Delta Smelt suggest spawning on substrates

Primary Constituent Element	1994 Critical Habitat Rule	2018 State of Scientific Understanding
		oriented horizontally and a preference for gravel or sand that is more consistent with observations of other osmerid fishes. (Bennett 2005, p.17).
	Suspected spawning locations: Sacramento River "in the Delta," Barker Slough, Lindsey Slough, Cache Slough, Prospect Slough, Georgiana Slough, Beaver Slough, Hog Slough, Sycamore Slough, Suisun Marsh.	All of the locations listed in 1994 may be suitable for spawning, but based on better monitoring from the Spring Kodiak Trawl Survey, most adult fish have since been observed to aggregate around Grizzly Island, Sherman Island, and in the Cache Slough complex, including the subsequently flooded Liberty Island, Sacramento River Deep Water Ship Channel (SRDWSC), and Montezuma Slough.
	Adults could spawn December–July.	Adults are virtually never fully ripe and ready to spawn before February and most spawning is completed by May (in warm years) or June (in cool years). However, new research confirms that Delta Smelt are capable of multiple batch spawning (Kurobe et al. 2016).
Larval and juvenile transport	Larvae require adequate river flows to transport them from spawning habitats in backwater sloughs to rearing habitats in the open waters of the low-salinity zone.	Not likely. Most Delta Smelt that survive to the juvenile life stage do eventually inhabit water that is in the 0.5 to 6 ppt range, due to either downstream movement or decreasing outflow, or both. However, Delta Smelt larvae can feed in the same habitats they were hatched in and juvenile fish can rear in water less than 0.5 ppt salinity.
	Larvae require adequate flow to prevent entrainment.	No change.
	Larval and juvenile transport needs to be protected from physical disturbances like sand and gravel mining, diking, dredging, riprapping.	No change, but these disturbances seem likely to have more impact on spawning habitat than larval transport.
	2 ppt isohaline (X2) must be west of the Sacramento–San Joaquin River confluence to support sufficient larval and juvenile transport.	X2 is generally west of the confluence during February–June due to State Water Resources Control Board X2 standard. Movement downstream of larval or other life stages is likely to have less of an energy cost with more outflow versus less.
	Maturation must not be impaired by pollutant concentrations.	Developmental contaminants are present at benchmark levels in the Delta (Fong et al. 2016; Jabusch et al. 2018).
	Additional flows might be required in the period July–August to protect Delta Smelt that were	July–August outflow augmentations may be helpful, but not to mitigate entrainment. Habitat changes in the central and south Delta have rendered it seasonally

Primary Constituent Element	1994 Critical Habitat Rule	2018 State of Scientific Understanding
	present in the south and central Delta from being entrained in export pumps.	unsuitable to Delta Smelt during the summer; entrainment is seldom observed past June.
Rearing habitat	2 ppt isohaline (X2) should remain between Carquinez Strait in the west, Three-Mile Slough on the Sacramento River and Big Break on the San Joaquin River in the east. This was determined to be a range for 2 ppt salinity (including its tidal time scale excursion into the Delta).	X2 is generally in this area during February–June due to State Water Resources Control Board X2 standard; however the standard does have a drought off-ramp. Most juvenile Delta Smelt still rear in this area but it is now recognized that a few remain in the Cache Slough complex as well. It has not been verified that the X2 isohaline must be between Carquinez and the confluence for biotic factors regarding Delta Smelt.
Adult migration	Adults require unrestricted access to spawning habitat from December–July.	Adults disperse faster than was recognized in 1994; most spawning is finished by the time Spring Kodiak Trawls start in January.
	Unrestricted access results from adequate flow, suitable water quality, and protection from physical disturbance.	Biotic factors can also restrict access.

2.15.1 Primary Constituent Element 1

Physical habitat is defined as the structural components of habitat (USFWS 1994). The ancestral Delta was a large tidal marsh–floodplain habitat totaling approximately 300,000 acres. During the late 1800s and early 1900s, most of the wetlands were diked and reclaimed for agriculture or other human use. The physical habitat modifications of the Delta and Suisun Bay were mostly due to land reclamation and urbanization. Water conveyance projects and river channelization have had some influence on the regional physical habitat by armoring levees with riprap, building conveyance channels like the DCC, storage reservoirs like CCF, and by building and operating temporary barriers in the south Delta and permanent gates and water distribution systems in Suisun Marsh.

Between the 1930s to 1960s, the shipping channels were dredged deeper (about 12 meters) to accommodate shipping traffic from the Pacific Ocean and San Francisco Bay to ports in Sacramento and Stockton. These changes left Suisun Bay and the Sacramento–San Joaquin River confluence region as the largest places with the greatest depth variation in the typical range of the low-salinity zone. This region remained a highly productive nursery for many decades (Stevens and Miller 1983; Moyle et al. 1992; Jassby et al. 1995). However, the deeper landscape created to support shipping and flood control requires more freshwater outflow to maintain the low-salinity zone in the large Suisun Bay/river confluence region than was once required. The shipping itself has historically provided a source of nonnative organisms, that, along with lower Delta outflow and deep channelization, have contributed to the changing ecology of the upper estuary (Winder and Jassby 2011; Kratina et al. 2014; Andrews et al. 2017).

Although the Delta Smelt is a generally pelagic or open-water fish, depth variation of open-water habitats is an important habitat attribute (Moyle et al. 1992; Hobbs et al. 2006). In the wild, Delta Smelt are most frequently collected in water that is somewhat shallow (4 to 15 feet deep) where turbidity is often elevated and tidal currents exist but are not excessive (Moyle et al. 1992; Bever et al. 2016). In Suisun Bay, the deep shipping channels are poor quality habitat because tidal velocity is very high (Bever et al. 2016), but in the north Delta where tidal velocity is slower, the Sacramento Deepwater Shipping Channel is used to a greater extent. Adult Delta Smelt also use edge habitats as tidal current refuges and corridors to spawning habitats (Bennett and Burau 2015).

2.15.2 Primary Constituent Element 2

Water is defined as water of suitable quality to support various Delta Smelt life stages that allow for survival and reproduction (USFWS 1994). Certain conditions of temperature, turbidity, and food availability characterize suitable pelagic habitat for Delta Smelt and are discussed in detail below. Contaminant exposure can degrade this primary constituent element even when the basic habitat components of water quality are otherwise suitable (Hammock et al. 2015).

Turbidity: Delta Smelt require turbidity. Even in captivity, clear water is a source of physiological stress (Lindberg et al. 2013; Hasenbein et al. 2016). The small plankton that Delta Smelt larvae eat are nearly invisible in clear water. The sediment (or algal) particles that make turbid water turbid, provide a dark background that helps Delta Smelt larvae see their translucent prey (Baskerville-Bridges et al. 2004). Older Delta Smelt are less reliant on turbidity to see their prey, but juvenile fish still feed more effectively in water of moderate turbidity (Hasenbein et al. 2016) and probably need turbid water to help disguise themselves from predators (Ferrari et al. 2014). The turbidity of the Delta and Suisun Bay has been declining for a long time due to dams and riprapped levees, both of which cut off sources of sediment from rivers flowing into the estuary (Arthur et al. 1996; Wright and Schoellhamer 2004), and due to the spread of Brazilian waterweed (Hestir et al. 2016) which filters the water, increasing clarity. Water exports from the south Delta may also have contributed to the trend toward clearer water by removing resuspended sediment in the exported water (Arthur et al. 1996). The primary turbid areas that remain in the upper estuary are the semi-shallow embayments in northern Suisun Bay (Bever et al. 2016) and the lower Yolo Bypass region that includes Liberty Island and the upper reach of the Sacramento Deepwater Shipping Channel (Morgan-King and Schoellhamer 2013). Both tidal and river flows, as well as wind speed, affect turbidity in these locations (Bever et al. 2018). Many of the estuary's deeper channels tend to have somewhat lower turbidity because water velocity and wind cannot resuspend sediment that sinks into deep water (Ruhl and Schoellhamer 2004).

Water temperature: Water temperature is the primary driver of the timing and duration of the Delta Smelt spawning season (Bennett 2005). Water temperature also affects Delta Smelt's growth rate which in turn can affect their readiness to spawn (Rose et al. 2013a). Water temperature is not strongly affected by variation in Delta outflow; the primary driver of water temperature variation in the Delta Smelt critical habitat is air temperature (Wagner et al. 2011). Very high flows can transiently cool the upper estuary (e.g., flows in the upper 10th percentile, Kimmerer 2004) during the early part of the year, but the system rapidly re-equilibrates once air temperatures begin to warm.

Older laboratory based research suggested an upper water temperature limit for Delta Smelt of about 25°C, or 77°F (Swanson et al. 2000). Newer laboratory research suggests Delta Smelt temperature tolerance decreases as the fish age, but is a little higher than previously reported, up to 28°C or 82°F in the juvenile life stage (Komoroske et al. 2014). It should be kept in mind that these are upper acute water temperature limits, meaning temperatures in this range will kill, on the average, one of every two fish.

In the laboratory and the wild, Delta Smelt appear to have a physiological optimum temperature near 20°C or 68°F (Nobriga et al. 2008; Rose et al. 2013a; Jeffries et al. 2016); most of the upper estuary exceeds this water temperature from June through September (Wagner et al. 2011). Thus, many parts of the estuary are energetically costly and stress Delta Smelt. Generally speaking, spring and summer water temperatures are cooler to the west and warmer to the east due to the differences in overlying air temperatures between the Bay Area and the warmer Central Valley (Kimmerer 2004). In addition, there is a strong water temperature gradient across the Delta with cooler water in the north and warmer water in the south. The higher flows from the Sacramento River probably explain this north-south gradient. Note that water temperatures in the north Delta near Liberty Island and the lower Yolo Bypass are also typically warmer than they are along the Sacramento River (Sommer et al. 2001; Nobriga et al. 2005).

Food: Food and water temperature are strongly interacting components of Delta Smelt health and habitat because the warmer the water, the more food Delta Smelt require (Rose et al. 2013a). If the water gets too warm, then no amount of food is sufficient. The more food Delta Smelt eat (or must try to eat) the more they will be exposed to predators and contaminants. Water exports can limit the flux of phytoplankton production from the Delta into Suisun Bay (Jassby and Cloern 2000), but the effect of water exports on phytoplankton production appears to be lower than grazing by clams (Jassby et al. 2002) and ammonium inhibition of phytoplankton growth from Sacramento's urban wastewater inputs (Dugdale et al. 2007).

Historically, prey production peaked when the low-salinity zone was positioned over the shoals of Suisun Bay during late spring through the summer, but this function has been depleted due to grazing by overbite clams (Kimmerer and Thompson 2014), high ammonium concentrations in critical habitat (Dugdale 2012; Dugdale et al. 2016), and water diversions (Jassby and Cloern 2000). Recent research suggests Delta Smelt occupying Suisun Bay may experience poor nutritional health (Hammock et al. 2015). Delta Smelt occupying the Cache Slough region in the north Delta are in better nutritional health, but have shown evidence of relatively high contaminant impacts. The southern Delta is among the more productive areas remaining in the upper estuary (Nobriga et al. 2005), but Delta Smelt cannot remain in this habitat during the warmer months of the year (Nobriga et al. 2008) and may face a high risk of entrainment when they occupy it during cooler months (Kimmerer 2008; Grimaldo et al. 2009). Extensive blooms of the toxin-producing cyanobacteria Microcystis in the central and southern Delta became abundant around 1999 and depending on flow, and temperature, blooms can extend westward into the low-salinity zone where Delta Smelt are rearing (Brooks et al. 2012). In one recent study, Delta Smelt that occupied Suisun Marsh fared better both in terms of nutrition and in experiencing a lower level of contaminant impacts (Hammock et al. 2015).

2.15.3 Primary Constituent Element 3

"River flow" was originally defined as transport flow to facilitate spawning migrations and transport offspring to low-salinity zone rearing habitats (USFWS 1994), currently called tidal surfing (Bennett and Burau 2015). Both the flood and ebb tide influence the Delta Smelt distribution and dispersal.

The spawning microhabitats of Delta Smelt are not known, but it is likely there is more available suitable spawning habitat when Delta outflow is high during spawning than when it is low because more of the estuary is covered in fresh- and low-salinity water when outflow is high (Jassby et al. 1995). An examination of the adults found that a majority were using fresh to low salinity water. Most spawning occurs between February and May. Delta outflow during February through May is mainly driven by the climatic effect on the amount and form of precipitation in the watershed, the storage and diversion of water upstream of the Delta, and CVP and SWP water operations in the Delta (Jassby et al. 1995; Kimmerer 2002a). Thus far, the 21st Century has tended to be pretty dry and warm and that could have resulted in some chronic reduction in spawning habitat availability or suitability.

2.15.4 Primary Constituent Element 4

Older laboratory research suggested that Delta Smelt have an upper acute salinity tolerance of about 20 ppt (Swanson et al. 2000) which is about 60 percent of seawater's salt concentration of 32 to 33 ppt. Newer laboratory-based research suggests that some individuals can acclimate to seawater, but that comes at a high energetic cost that is lethal to about one in four individuals (Komoroske et al. 2014, 2016). In the wild, Delta Smelt are nearly always collected at very low salinities, which recent laboratory research has confirmed is nearer to the physiological optimum (Komoroske et al. 2016). Few individuals are collected at salinities higher than 6 ppt (about 20 percent of seawater salt concentration) and very few are collected at salinities higher than 10 ppt (about 30 percent of seawater salt concentration) (Bennett 2005). This well documented association with fresh to low salinity water is a reason for the scientific emphasis on X2 as a Delta Smelt habitat indicator (Dege and Brown 2004; Feyrer et al. 2011). Recent research combining long-term monitoring data with three-dimensional hydrodynamic modeling shows that the spatial overlap of several of the key habitat attributes described above increases as Delta outflow increases (Bever et al. 2016). This means that higher outflow, which lowers the salinity of Suisun Bay and Suisun Marsh, increases the suitability of habitat in the estuary by increasing the overlap of some, but not necessarily all, needed elements.

2.16 Coho Salmon, Southern Oregon/Northern California Coastal ESU

2.16.1 ESA Listing Status

Southern Oregon/Northern California Coast (SONCC) Coho Salmon were listed as threatened under the ESA on May 6, 1997 (62 FR 24588). Subsequent to the Alsea Valley decsions (Alsea Valley Alliance v. Evans, 161 F. Supp. 2d 1154 (D. Or. 2001)), which provided guidance on the appropriate compositon of an ESU, this listing status was reaffirmed on June 28, 2005 (70 FR 37160). This ESU consists of populations from Cape Blanco, Oregon, south to Punta Gorda, California, including Coho Salmon in the Trinity River. NMFS designated critical habitat for SONCC Coho Salmon on May 5, 1999 (64 FR 24049) as accessible reaches of all rivers (including estuarine areas and tributaries) between the Elk River in Oregon and the Mattole River in California, inclusive).

2.16.2 General Life History and Habitat Requirements

Coho salmon exhibit a 3-year life cycle in the Trinity River and are dependent on freshwater habitat conditions year round because they spend a full year residing in freshwater. Most Coho Salmon enter rivers between August and January with some more northerly populations entering as early as June. Coho salmon river entry timing is influenced by a number of factors including genetics, stage of maturity, river discharge, and access past the river mouth. Spawning is concentrated in riffles or in gravel deposits at the downstream end of pools with suitable water depth, velocity, and substrate size. Spawning in the Trinity River occurs mostly in November and December.

Coho salmon eggs incubate from 35 to more than 100 days depending on water temperature, and emerge from the gravel 2 weeks to 7 weeks after hatching. Coho eggs hatch after an accumulation of 400 to 500 temperature units measured in degrees Celsius (°C) and emerge from the gravel after 700 to 800 temperature units. After emergence, fry move into areas out of the main current. As Coho grow they spread out from the areas where they were spawned.

During the summer, juvenile Coho prefer pools and riffles with adequate cover such as large woody debris with smaller branches, undercut banks, and overhanging vegetation and roots. Juvenile Coho overwinter in large mainstem pools, beaver ponds, backwater areas, and off-channel pools with cover such as woody debris and undercut banks. Most juvenile Coho Salmon spend a year in freshwater with some northerly populations spending 2 full years in freshwater. Coho in the Trinity River are thought be exclusively 3-year lifecycle fish (1 year in freshwater). Because juvenile Coho remain in their spawning stream for a full year after emerging from the gravel, they are exposed the full range of freshwater conditions. Most smolts migrate to the ocean between March and June with most leaving in April and May.

2.16.3 Historical and Current Distribution and Abundance

According to NMFS (2014), all nine Coho Salmon population units in the Klamath-Trinity Basin have declined dramatically in abundance relative to historical levels, including the three populations within the Trinity River Basin. These three populations are including (1) the Upper Trinity (North Fork Trinity River to Ramshorn Creek inclusive), (2) the Lower Trinity (Weitchpec to just below North Fork Trinity River confluence and tributaries excluding South Fork Trinity River), and (3) the South Fork Trinity sub-population (NMFS 2012). Coho Salmon were not likely the dominant species of salmon in the Klamath Trinity River before dam construction. They were, however, widespread in the Trinity Basin ranging as far upstream in the Trinity River as Stuarts Fork above Trinity Dam. Wild Coho in the Trinity River today are not abundant and the majority of the fish returning to the river are of hatchery origin. Returns to the Trinity River are monitored at the Willow Creek Weir, (typically sited within a few miles of the town of Willow Creek) (see figure 2.16-1 below). Run size estimates include Coho Salmon from all or part of the three Trinity River Coho Salmon populations. The proportion of Coho Salmon from each population is unknown, though most are thought to be of the Upper Trinity River Population Unit. Few juveniles or adults are observed in the Lower or South Fork Trinity Population Units. Adult return numbers to the TRH provide rough estimates of the hatchery-origin coho salmon return numbers.

Data from this monitoring program indicates the Trinity River portion of the Southern Oregon/Northern California Coast Coho Salmon ESU is predominately of hatchery origin (Figure 2-16.1). NMFS (2012) views such a high proportion of hatchery fish is a population to be a high level risk factor for continued existence of the populations in the Trinity Basin. NMFS, USBR, and CDFW are working to develop a Hatchery and Genetics Management Plan to mitigiate the adverse effects of the hatchery program on production of wild Coho Salmon in the Trinity River (NMFS 2017, USBR and CDFW 2017).

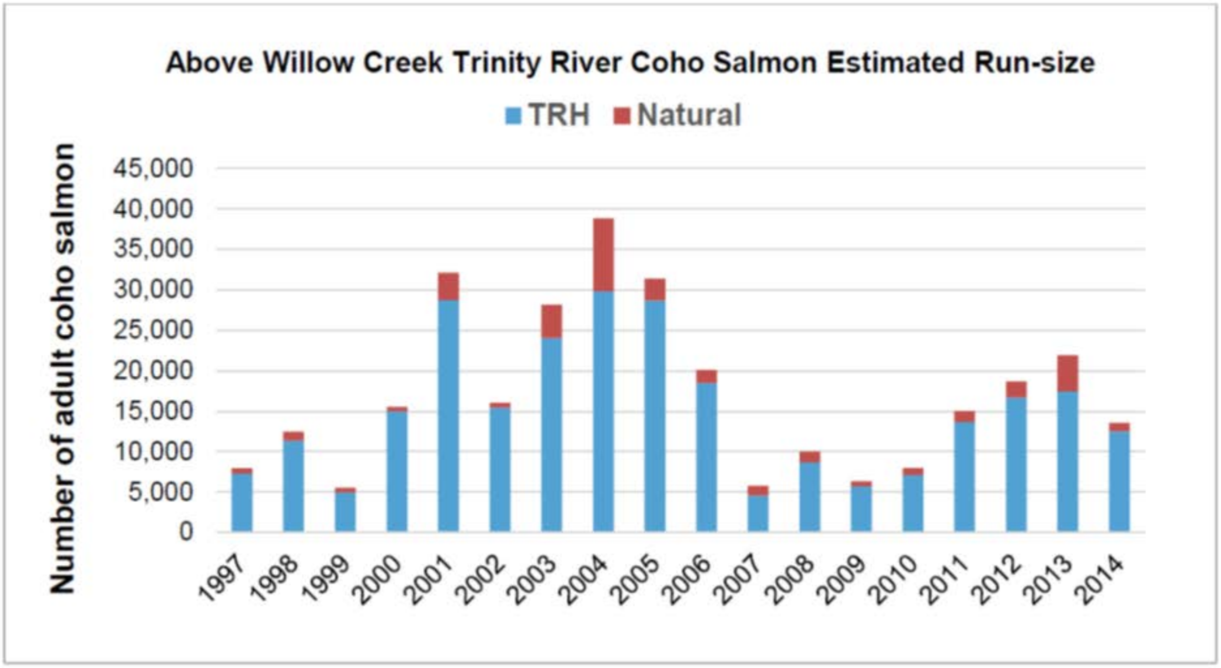


Figure 2.16-1. Estimated run-size of hatchery-origin and natural-origin Coho salmon in the Trinity River based on data collected at the Willow Creek weir (Reclamation and CDFW 2017).

2.16.4 Limiting Factors, Threats, Stressors

A number of interrelated factors affect Coho abundance and distribution in the Trinity River. These include water temperature, water flow, habitat suitability, habitat availability, hatcheries, predation, competition, disease, ocean conditions, and harvest. Current CVP operations affect primarily water temperature, water flow, and habitat suitability in the Trinity River. Climate change also affects water temperature, water flow, and habitat suitability in the Trinity River.

Juvenile Coho Salmon in the Trinity River spend up to a full year in freshwater before migrating to the ocean. Their habitat preferences change throughout the year and are highly influenced by water temperature. During the warmer summer months when Coho are most actively feeding and growing, they spend more time closer to main channel habitats. Coho tend to use slower water than Steelhead or Chinook Salmon. Coho juveniles are more oriented to submerged objects such as woody debris while Chinook and Steelhead tend to select habitats in the summer based largely on water movement and velocities, although the species are often intermixed in the same habitat. Juvenile Coho tend to use the same habitats as pikeminnows, a possible reason that Coho are not present in Central Valley watersheds. Juvenile Coho would be highly vulnerable to predation from larger pikeminnows during warm-water periods. Pikeminnow are limited to only a few SONCC Coho streams and they are not present in the Klamath River basin. When the water cools in the fall, juvenile Coho move further into backwater areas or into off-channel areas and beaver ponds if available. There is often no water velocity in the areas inhabited by Coho during the winter. These same off-channel habitats are often dry or unsuitable during summer because temperatures get too high.

Lewiston Dam blocks access to 109 miles of upstream habitat (U.S. Department of the Interior 2000). Trinity River Hatchery produces Coho Salmon with a production goal of 300,000 yearlings to mitigate for the upstream habitat loss. Habitat in the Trinity River has changed since flow regulation with the encroachment of riparian vegetation restricting channel movement and limiting fry rearing habitat (Trush et al. 2000). According to the Trinity River Restoration Plan, higher peak flows are needed to restore attributes of a more alluvial river such as alternate bar features and more off-channel habitats. These are projected in the restoration plan to provide better rearing habitat for Coho Salmon than the dense riparian vegetation currently present. Physical habitat manipulations have been implemented providing better juvenile rearing in selected sites along the river.

2.16.5 Water Operations

Reclamation makes releases from Lewiston Dam in accordance with the Trinity ROD, which considers requirements for Coho in the Trinity River. Increases in Trinity River releases in the late summer and fall result in lower storage in Trinity Reservoir at the end of the water year. The decreases in storage accumulate from water year to water year when the reservoir does not refill resulting in lower end-of-summer storages, negative impacts on cold water pool, and warmer stream temperatures for Coho and Fall-Run Chinook Salmon spawning in the Trinity River.

2.16.6 Recovery and Management

Reclamation is currently working on a Hatchery Genetics Management Plan for Trinity River Hatchery Coho.

2.17 Coho Critical Habitat

The critical habitat designation includes all waterways, substrate, and adjacent riparian zones, excluding: (1) areas above specific dams identified in the *Federal Register* notice (including Lewiston Dam); (2) areas above longstanding, natural impassable barriers (i.e., natural waterfalls in existence for at least several hundred years); and (3) Indian tribal lands.

2.18 Eulachon

2.18.1 ESA Listing Status

The southern DPS of Eulachon was listed as threatened under the ESA on March 18, 2010 (75 FR 13012) and the listing was reaffirmed on April 1, 2016. Critical habitat was designated on October 20, 2011 (76 FR 65324). The listing encompassed all spawning populations in rivers south of the Nass River in British Columbia to, and including, the Mad River in California (Gustafson et al. 2010).

2.18.2 General Life History and Habitat Requirements

Eulachon are an anadromous fish, meaning adults spend most of their life in the ocean but migrate into freshwater to spawn. Although they spend 95 to 98 percent of their lives at sea (Hay and McCarter 2000), current data only provides an incomplete picture concerning their saltwater existence. Their offspring hatch in freshwater but are carried to the estuary/ocean as larvae by the flow of the natal creek or river. The species is endemic to the northeastern Pacific Ocean, ranging from Northern California to the southeastern Bering Sea in Bristol Bay, Alaska (McAllister 1963; Scott and Crossman 1973; Willson et al. 2006). This distribution coincides closely with the distribution of the coastal temperate rainforest ecosystem on the west coast of North America (with the exception of populations spawning west of the Cook Inlet in Alaska).

Eulachon eggs can vary considerably in size but typically are approximately 1 mm (0.04 in) in diameter and average about 43 mg (0.002 oz) in weight (Hay and McCarter 2000). Eggs are enclosed in a double membrane; after fertilization in the water, the outer membrane breaks and turns inside out, creating a sticky stalk that acts to anchor the eggs to the substrate (Hart and McHugh 1944; Hay and McCarter 2000). Eulachon eggs hatch in 20–40 days with incubation time dependent on water temperature (Howell 2001). Shortly after hatching, the larvae are carried downstream and dispersed by estuarine, tidal, and ocean currents. It is not known how long larval Eulachon remain in the estuary before entering the ocean. Similar to salmon, juvenile Eulachon are thought to imprint on the chemical signature of their natal river basins. However, because juvenile Eulachon spend less time in freshwater environments than do juvenile salmon, researchers hypothesize that this short freshwater residence time may cause returning Eulachon to stray between spawning sites at higher rates than salmon (Hay and McCarter 2000).

Once juvenile Eulachon enter the ocean, they move from shallow nearshore areas to deeper areas over the continental shelf. Larvae and young juveniles become widely distributed in coastal waters, where they are typically found near the ocean bottom in 9 waters 20–150 m deep (66-292 ft) (Hay and McCarter 2000) and sometimes as deep as 182 m (597 ft) (Barraclough 1964). There is currently little information available about Eulachon movements in nearshore marine areas and the open ocean. However, Eulachon occur as bycatch in the pink shrimp fishery (Hay et al. 1999; Olsen et al. 2000; NWFSC 2008; Hannah and Jones 2009), which indicates that the distribution of these organisms overlaps in the ocean.

Eulachon typically spend several years in salt water before returning to fresh water to spawn from late winter through early summer. Spawning grounds are typically in the lower reaches of larger rivers fed by snowmelt (Hay and McCarter 2000). Willson et al. (2006) concluded that the age distribution of Eulachon in a spawning run varies considerably, but typically consists of fish that are 2-5 years old. Eulachon eggs commonly adhere to sand (Langer et al. 1977) or pea-sized gravel (Smith and Saalfeld 1955), though eggs have been found on a variety of substrates, including silt, gravel to cobble sized rock, and organic detritus (Smith and Saalfeld 1955; Langer et al. 1977; Lewis et al. 2002). Eggs found in areas of silt or organic debris reportedly suffer much higher mortality than those found in sand or gravel (Langer et al. 1977). The sexes must synchronize their activities closely, unlike some other group spawners such as herring, because Eulachon sperm remain viable for only a short time, perhaps only minutes (Hay and McCarter 2000). Eulachon are semelparous, meaning that they spawn once and then die. In many rivers, spawning is limited to the part of the river that is influenced by tides (Lewis et al. 2002), but some exceptions exist. In the Berners Bay system of Alaska, the greatest abundance of Eulachon is observed in tidally-influenced reaches, but some fish ascend well beyond the tidal influence (Willson et al. 2006). Eulachon once ascended more than 160 km (100 mi) in the Columbia River system (Smith and Saalfeld 1955). There is some evidence that water velocity greater than 0.4 meters/second (1.3 ft/second) begins to limit the upstream movements of Eulachon (Lewis et al. 2002).

Entry into the spawning rivers appears to be related to water temperature and the occurrence of high tides (Ricker et al. 1954; Smith and Saalfeld 1955; Spangler 2002). Spawning generally occurs in January, February, and March in the Columbia River, the Klamath River, and the coastal rivers of Washington and Oregon, and April and May in the Fraser River. Eulachon runs in central and northern British Columbia typically occur in late February and March or late March and early April. Eulachon typically spawn when water levels are lower and prior to spring freshets (Lewis et al. 2002). Rivers that experience Eulachon spawning generally have the characteristics of spring freshets caused by melting snow packs or glaciers (Hay and McCarter 2000). However, attempts to characterize Eulachon run timing are complicated by marked annual variation in timing. Willson et al. (2006) give several examples of spawning run timing varying by a month or more in rivers in British Columbia and Alaska. Water temperature at the time of spawning varies across the distribution of the species. Although spawning generally occurs at temperatures from 4 to 7°C (39 to 45º F) in the Cowlitz River (Smith and Saalfeld 1955), and at a mean temperature of 3.1°C (37.6º F) in the Kemano and Wahoo Rivers, peak Eulachon runs occur at noticeably colder temperatures (between 0 and 2°C [32 and 36º F]) in the Nass River. The Nass River run is also earlier than the Eulachon run that occurs in the Fraser River, which typically has warmer temperatures than the Nass River (Langer et al. 1977). Water temperatures between 4 and 10°C is preferred for adults entering the Columbia River (WDFW and ODFW, 2001). Sudden increases in temperatures above this range can lead to adult mortality and spawning failure (Blahm and McConnell 1971).

Eulachon larvae and juveniles eat a variety of prey items, including phytoplankton, copepods, copepod eggs, mysids, barnacle larvae, and worm larvae (Barraclough 1967, Barraclough and Fulton 1967, Robinson et al. 1968a, 1968b). Eulachon adults feed on zooplankton, chiefly eating crustaceans such as copepods and euphausiids (Hart 1973; Scott and Crossman 1973; Hay 2002; Yang et al. 2006), unidentified malacostracans (Sturdevant 1999), and cumaceans (Smith and Saalfeld 1955). Adults and juveniles commonly forage at moderate depths (20 to 150 m [66 to 292 ft]) in nearshore marine waters (Hay and McCarter 2000). Eulachon adults do not feed during spawning (McHugh 1939; Hart and McHugh 1944).

2.18.3 Historical and Current Abundance

Eulachon spawn in rivers from southwestern Alaska to Northern California. The southern DPS encompasses spawning populations in rivers south of the Nass River in British Columbia to, and including, the Mad River in California (Gustafson et al. 2010). Historically, the only large river basins in the contiguous United States with large, consistent spawning runs were the Klamath River in Northern California and the Umpqua River in Oregon. However, Eulachon have been found both frequently and infrequently in other coastal rivers within this range, including the Mad River, Redwood Creek, and Humboldt Bay in California (Monaco et al. 1990; Willson et al. 2006, as cited in Gustafson et al. 2010).

There are no reliable historical abundance estimates for Eulachon. Available information (based largely on commercial fishery records) indicates that, starting in 1994, the southern DPS of Eulachon experienced an abrupt decline in abundance throughout its range (Gustafson et al. 2010). Since the 2010 listing, improved monitoring of Eulachon in several rivers detected general increases in adult spawning abundance, especially in 2013-2015 (NMFS 2016). However, sharp declines in Eulachon abundance occurred in 2016 and 2017 likely in response to poor conditions in the north east Pacific Ocean (NMFS 2017). The likelihood that these conditions will persist into the near future suggest that declines may again be widespread in upcoming years (NMFS 2017).

2.18.4 Limiting Factors, Threats, and Stressors

Factors that have been identified as major threats to southern DPS Eulachon include climate change impacts on marine and freshwater habitat, bycatch in offshore shrimp and groundfish fisheries, changes in flow quantity due to dams or water diversions, and predation (Gustafson et al. 2010). Because of similar trends in abundance across their range, large-scale oceanic and atmospheric patterns in the northeast Pacific Ocean associated with both natural climate variability and anthropogenic-forced climate change is likely the principal threat to Eulachon (NMFS 2017). The relationship between ocean conditions and population dynamics of Eulachon suggests that marine survival, most likely during the first weeks or month in the ocean, may have a large influence on overall survival and adult recruitment (NMFS 2016). Consequently, anomalously warm marine and freshwater conditions combined with below average precipitation may have contributed to poor returns of spawning adults in recent years (NMFS 2017). In 2010, an analysis of these threats, together with large declines in abundance, indicated that the southern DPS of Eulachon was at moderate risk of extinction throughout its range (Gustafson et al. 2010, 2012). NMFS's recent threats analysis indicated that the collective risk to the persistence of Eulachon has not changed significantly since the listing determination (NMFS 2016).

2.18.5 Water Operations Management

Reclamation currently does not manage for Eulachon, although they benefit from TRRP ROD flows and other releases in the Trinity River.

2.18.6 Recovery and Management

The Recovery Plan for Southern DPS of Eulachon (NMFS 2017) established recovery goals, objectives, and delisting criteria that NMFS will use in future ESA status reviews. The recovery goals for Eulachon are to (1) increase abundance and productivity of Eulachon, and (2) protect and enhance the genetic, life history, and spatial diversity of Eulachon throughout its geographical range, and reduce existing threats to warrant delisting of the species. Conservation actions that have been implemented in the U.S. and Canada to support recovery efforts include state regulations requiring the use of bycatch reduction devices in ocean shrimp fisheries, commercial and recreational fishery closures and catch prohibitions, seasonal dredging restrictions, dam removal, and Salmon and Steelhead habitat restoration projects (NMFS 2017). In recent years, the states of Oregon and Washington opened a limited-opportunity Eulachon fishery to better understand trends and variability in Eulachon abundance, fill critical information gaps on species biology and distribution, support cultural traditions of Northwest tribes, and provide limited public and commercial opportunities for Eulachon harvest to promote public engagement in Eulachon conservation and recovery (NMFS 2107).

2.18.7 Monitoring and Research

NMFS proposes to advance the conservation of Eulachon by working with stakeholders to continue to implement actions that further reduce the severity of threats to Eulachon, as well as develop a comprehensive research program to improve understanding of Eulachon population abundance and demographics, and understanding of large-scale threats (e.g., climate change) on Eulachon productivity, recruitment, and persistence (NMFS 2017). Specific research and monitoring needs include implementation of annual in-river spawning stock surveys and distribution surveys (e.g., environmental DNA), and identification of data and assessment needs to monitor annual variability and long-term trends in abundance, productivity, and viability of Eulachon across their range.

2.19 Eulachon Critical Habitat

Critical habitat was designated under the ESA for southern DPS Eulachon on October 20, 2011 (76 FR 65324). Critical habitat extends from the Elwha River in Washington to the Mad River in California. In California, designated critical habitat includes the Klamath River, Redwood Creek and Mad River. NMFS identified the following physical or biological features as essential for conservation of the southern DPS of Eulachon:

1. Freshwater spawning and incubation sites with water flow, quality and temperature conditions and substrate supporting spawning and incubation.

2. Freshwater and estuarine migration corridors 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.
3. Nearshore and offshore marine foraging habitat with water quality and available prey, supporting juveniles and adult survival.

Critical habitat does not include any Indian lands of the following federally-recognized tribes in the States of California, Oregon, and Washington: Lower Elwha Tribe, Washington; Quinault Tribe, Washington; Yurok Tribe, California; and Resighini Rancheria, California.

2.20 Riparian Brush Rabbit

2.20.1 ESA Listing Status

The USFWS listed riparian brush rabbit (*Sylvilagus bachmani riparius*) as an endangered species under the Endangered Species Act (ESA) on February 23, 2000 (65 FR 8881).

2.20.2 Critical Habitat Designation

No critical habitat rules have been published for the riparian brush rabbit.

2.20.3 General Life-History and Habitat Requirements

Riparian brush rabbits prefer dense, brushy areas of valley riparian forests, marked by extensive thickets of wild rose (*Rosa* spp.), blackberries (*Rubus* spp.), and willows (*Salix* spp.). Riparian brush rabbits prefer to remain hidden under protective shrub cover and seldom venture more than a few feet from cover. A typical response to danger is to retreat back into cover rather than to be pursued in open areas (USFWS 1998).

Riparian brush rabbits feed at the edges of shrub cover rather than in large openings (e.g., along trails, fire breaks, edges of thickets). Their diet consists of herbaceous vegetation such as grasses, sedges, clover, forbs, buds, bark and leaves of woody plants, and vines (USFWS 1998).

The approximate breeding season of riparian brush rabbits is from January to May. In favorable years, females may produce three or four litters. The young are born in a shallow burrow or cavity lined with grasses and fur and covered by a plug of dried vegetation. Although these rabbits have a high reproductive rate, five out of six rabbits typically do not survive to the next breeding season (USFWS 1998).

2.20.4 Historical and Current Distribution and Abundance

One of eight subspecies of brush rabbit in California, the riparian brush rabbit occupies a range that is disjunct from other brush rabbits, near sea level on the northwestern floor of the San Joaquin Valley (USFWS 1998). Populations are known to have historically occurred in riparian forests on the valley floor along the San Joaquin and Stanislaus Rivers and some tributaries of the San Joaquin River (USFWS 1998).

Remaining populations of riparian brush rabbits occur in only two locations in San Joaquin County. One population is at an approximately 258-acre (104-hectare) patch in Caswell Memorial State Park on the Stanislaus River. The other population is located at several small, isolated or semi-isolated patches immediately west and southwest of Lathrop, totaling approximately 270 acres (109 hectares) along Paradise Cut and Tom Paine Slough and channels of the San Joaquin River in the south Delta (Kelly 2015; Kelly et al. 2011; Williams et al. 2002). In addition, a captive breeding program has established a population on the Faith Ranch, which is owned by the wine-making Gallo family (USFWS 2007).

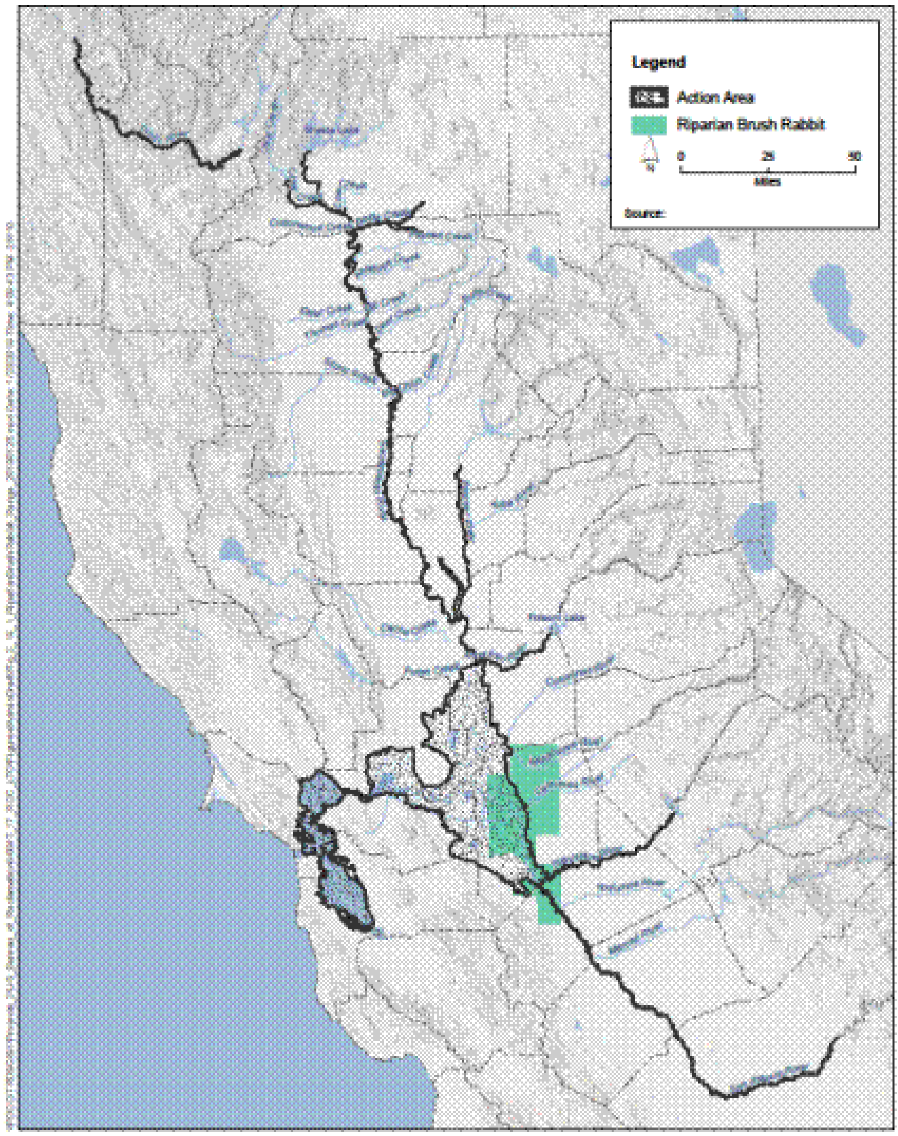


Figure 2.20-1. Riparian Brush Rabbit Range

2.20.5 Limiting Factors, Threats, and Stressors

The primary threats to the survival of riparian brush rabbit are the limited extent of its existing habitat, extremely low numbers of individual animals, and few extant populations. The small sizes of its remaining populations, the localization of the behavior of the subspecies, and the highly limited and fragmented nature of remaining habitat restrict natural dispersal and put the species at risk from a variety of environmental factors.

Flooding is a key issue for riparian brush rabbits and thought to be responsible for major population declines. Riparian brush rabbits are closely tied to brushy cover and will generally not cross large, open areas. Thus, they are unable to disperse beyond the dense brush, making them susceptible to mortality during flood events (Williams 1988; USFWS 1998). Climate change likely to increase the severity of flooding, impacting riparian brush rabbit.

Periodic flooding still occurs along all major rivers in the Central Valley (Kindel 1984). With behavioral restrictions on its freedom of movement (low mobility) and the shortage of habitat that is suitably protected from frequent floods downstream of Caswell Memorial State Park, there is little chance that individuals escaping drowning or predation will be able to meet mates or reproduce (USFWS 1998).

Wildfire also pose a major threat. Long-term fire suppression combined with prolonged drought conditions can result in the buildup of high fuel loads from dead leaves, woody debris, and senescent flammable shrubs. The dense, brushy habitat to which the rabbits are restricted is thus highly susceptible to catastrophic wildfire that would cause both high mortality and destruction of habitat.

Like most rabbits, the riparian brush rabbit is subject to a variety of common contagious, and generally fatal, diseases that could be transmitted easily to riparian brush rabbits from neighboring populations of desert cottontails. For these small remnant brush rabbit populations, this kind of epidemic could quickly eliminate the entire population (Williams 1988; USFWS 1998).

A wide variety of aerial and terrestrial predators prey on riparian brush rabbit, including various raptors, coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), bobcat (*Lynx rufus*), long-tailed weasel (*Mustela frenata*), mink (*Neovison vison*), raccoon (*Procyon lotor*), snakes, feral dogs (*Canis lupus familiaris*), and feral cats (*Felis catus*) (Kelly et al. 2011). A robust population of the riparian brush rabbit should be able to withstand predation, but habitat adjacent to residential properties or along public roads or waterways, or subject to human disturbance, can exacerbate predation risk (Kelly et al. 2011). The black rat (*Rattus rattus*) is an exotic invasive species that may be a threat to riparian brush rabbit populations by preying on offspring and competing for resources.

2.20.6 Recovery Considerations

The USFWS finalized the recovery plan for upland species of the San Joaquin Valley in 1998, which includes the riparian brush rabbit. Additionally, the riparian brush rabbit has limited coverage under the *San Joaquin County Multi-Species Habitat Conservation and Open Space Plan* (SJMSCP 2000).

The following are important components of riparian brush rabbit habitat when considering recovery actions:

- Large patches of dense brush composed of riparian vegetation such as blackberry (*Rubus* spp.), California wild rose (*Rosa californica*), and low-growing willows (*Salix* spp.), or other dense shrub species.

- Ecotonal edges of brushy species to grasses and herbaceous forbs.
- Scaffolding plants (dead or alive) for blackberry and rose to grow tall enough to withstand flood events.
- A tree overstory that is not closed, if present.
- High-ground refugia from flooding.

2.20.7 Monitoring and Research Programs

The San Joaquin River National Wildlife Refuge encompasses approximately 7,000 acres located where the Tuolumne, Stanislaus, and San Joaquin Rivers join, creating a mix of habitats for terrestrial wildlife and plant species. Initially established to protect and manage habitat for the Aleutian Cackling Goose, the refuge is currently managed to provide habitat for migratory birds and endangered wildlife species (USFWS 2012). River Partners have been working on increasing riparian brush rabbit population size; their restoration actions continue today and are expected to be completed in 2025. Over 500,000 native trees and shrubs such as willow, cottonwood, oak, blackberry, and rose have been planted across 2,200 acres of river floodplain within the San Joaquin River National Wildlife Refuge, creating the largest block of contiguous riparian woodland in the San Joaquin Valley. Endangered riparian brush rabbits have been reintroduced to this restored habitat from captive-reared populations. The goal is to have increased the available habitat for the riparian brush rabbit by more than 30 times its 1997 extent. The restored habitat will protect the population from nearing extinction in inevitable future flood events.

In 2015, Reclamation provided additional funds to the River Partners to restore 175 acres of historic floodplain forest that are now degraded back to riparian floodplain habitat at Dos Rios Ranch to benefit riparian brush rabbit, riparian woodrat, valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), least Bell's vireo, and western yellow-billed cuckoo in Stanislaus County. After successful pilot studies, two berms were strategically notched and removed from the landscape in 2018, which reconnected the endangered riparian brush rabbit and nine other endangered species to seasonally flooded land (River Partners 2018).

2.21 Riparian Woodrat

2.21.1 ESA Listing Status and Critical Habitat Designation

The USFWS listed riparian woodrat (*Neotoma fuscipes riparia*) as an endangered species under the ESA on February 23, 2000 (65 FR 8881).

2.21.2 Critical Habitat Designation

No critical habitat rules have been published for the riparian woodrat.

2.21.3 General Life-History and Habitat Requirements

Riparian woodrats are most numerous where shrub cover is dense and least abundant in open areas. In riparian areas, highest densities of riparian woodrats and their houses are often encountered in willow thickets with an oak overstory. They are common where there are deciduous valley oaks, but few live oaks. Mostly active at night, the riparian woodrat's diet is diverse and principally herbivorous. Their diet consists of leaves, fruits, terminal shoots of twigs, flowers, nuts, and fungi (USFWS 2000).

Riparian woodrats are well known for their large terrestrial stick houses some of which can last for 20 or more years after being abandoned. At Caswell Memorial State Park, riparian woodrats construct houses of sticks and other litter. Houses are typically placed on the ground or against/straddling a log or exposed roots of a standing tree and are often located in dense brush. Nests also are placed in the crotches and cavities of trees and in hollow logs. Sometimes arboreal nests are constructed, but this behavior seems to be more common in habitat with evergreen trees such as live oak. With their general dependence on terrestrial stick houses, riparian woodrats can be vulnerable to flooding.

Riparian woodrats live in loosely cooperative societies and have a matrilineal (mother-offspring associations; through the maternal line) social structure. Unlike males, adjacent females are usually closely related and, unlike females, males disperse away from their birth den and are highly territorial and aggressive, especially during the breeding season. Consequently, populations are typically female-biased and, because of pronounced polygyny (mating pattern in which a male mates with more than one female in a single breeding season), the effective population size (i.e., successful breeders) is generally much smaller than the actual population size. This breeding system in combination with the small size of the only known extant population suggests that the riparian woodrat could be at an increased risk of extinction because of inbreeding depression.

2.21.4 Historical and Current Distribution and Abundance

Historical records for the riparian woodrat are similarly distributed along the San Joaquin, Stanislaus, and Tuolumne Rivers, and Corral Hollow, in San Joaquin, Stanislaus, and Merced Counties (Hooper 1938; Williams 1986). Thus, prior to the statewide reduction of riparian communities by nearly 90 percent (Katibah 1984), the riparian woodrat probably ranged throughout the extensive riparian forests along major streams flowing onto the floor of the northern San Joaquin Valley.

The range of the riparian woodrat is far more restricted today than it was in 1938 (Williams 1986). The only population that has been verified is the single, known extant population restricted to about 100 ha (250 acres) of riparian forest on the Stanislaus River in Caswell Memorial State Park. Williams (1993) estimated the size of this population at 437 individuals. Analysis of California Department of Water Resources land use maps indicate that there were approximately 50 acres (20 hectares) of “natural vegetation” present along the San Joaquin River near the type locality in 1988, though no woodrats have been seen in that area. Today there is no habitat for woodrats around El Nido, which is located about 5.5.miles (8.9 kilometers) east of the San Joaquin River, the closest possible riparian habitat.

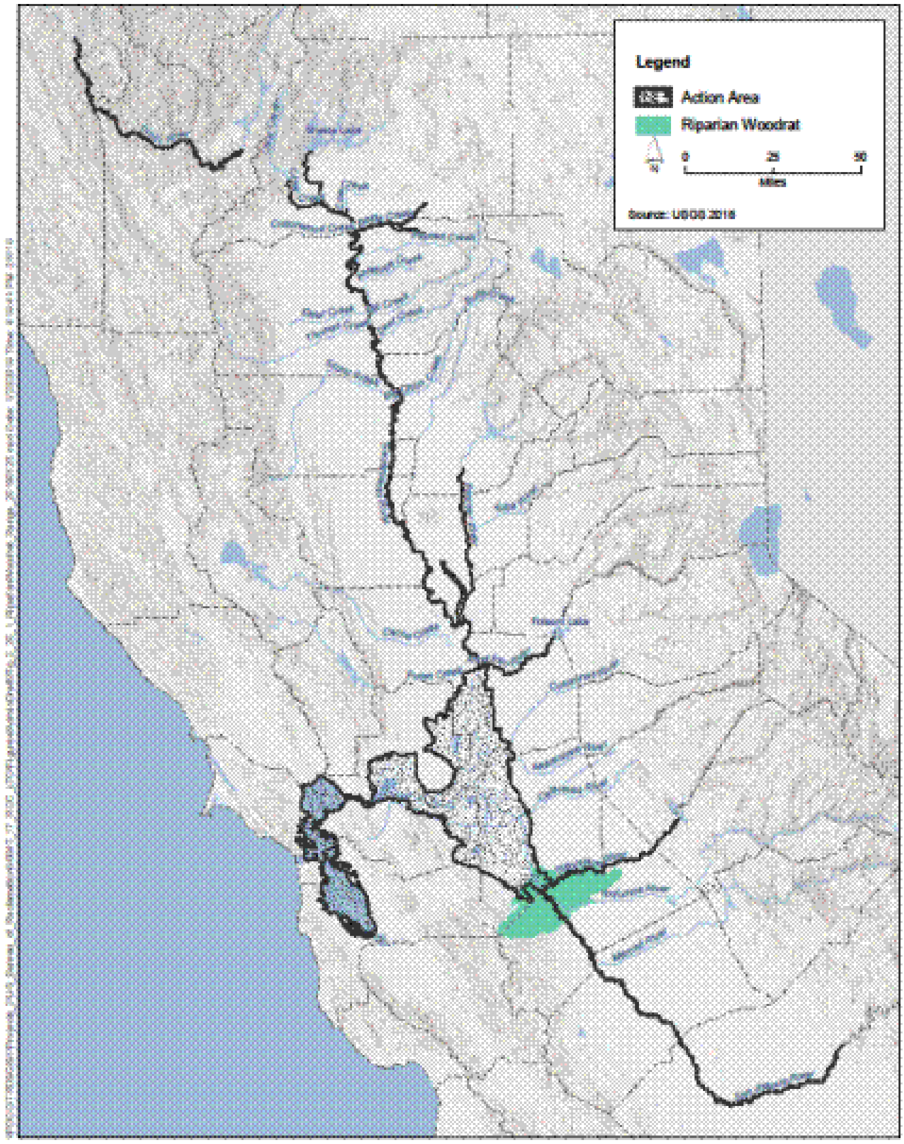


Figure 2.21-1. Riparian Woodrat Range

2.21.5 Limiting Factors, Threats, and Stressors

Loss, fragmentation, and degradation of habitat are the principal reasons for the decline of the riparian woodrat (USFWS 2000).

The most immediate threats to the single, small population of the species include naturally occurring events, such as drought, flooding of Caswell Memorial State Park lands, and wildfires. All of these environmental stressors are likely to increase in severity with climate change as California's snowpack decreases and watersheds move toward more precipitation driven hydrology (i.e., more variable). In addition, riparian woodrats are threatened by disease, predation, competition, clearing of riparian vegetation, use of rodenticide, and loss of genetic variability.

2.21.6 Recovery Considerations

The USFWS finalized the recovery plan for upland species of the San Joaquin Valley in 1998, which includes the riparian woodrat.

No specific conservation measures for the riparian woodrat are in place, but the species does receive some protection through the management plan for the riparian brush rabbit at the Caswell Memorial State Park.

2.21.7 Monitoring and Research Programs

The California Department of Parks and Recreation has supported some general small-mammal studies and woodrat population studies at the Caswell Memorial State Park (Cook 1992; Williams 1993).

In 2000, San Joaquin County developed a multispecies habitat conservation plan that considers habitat for the riparian woodrat. Some of the measures suggested under the plan may benefit or minimize negative impacts on the woodrat. A fire management plan has also been initiated for the Caswell Memorial State Park to protect habitat, but fires from outside sources still pose a threat.

In 2015, Reclamation provided additional funds to the River Partners to restore 175 acres of historic floodplain forest that are now degraded back to riparian floodplain habitat at Dos Rios Ranch to benefit riparian brush rabbit, riparian woodrat, valley elderberry longhorn beetle, least Bell's vireo, and western yellow-billed cuckoo in Stanislaus County. After successful pilot studies, two berms were strategically notched and removed from the landscape in 2018, which reconnected the endangered riparian brush rabbit and nine other endangered species to seasonally flooded land (River Partners 2018).

Section 4(c)(2)(A) of the ESA requires that the USFWS conduct a review of listed species at least once every 5 years. The USFWS announced review of 34 species in California and Nevada on May 21, 2010 which included review of the riparian woodrat (75 FR 28636).

2.22 Salt Marsh Harvest Mouse

2.22.1 ESA Listing Status and Critical Habitat Designation

The USFWS listed salt marsh harvest mouse (*Reithrodontomys raviventris*) as an endangered species under the ESA on October 13, 1970 (35 FR 16047).

2.22.2 Critical Habitat Designation

Critical habitat has not been designated for the salt marsh harvest mouse.

2.22.3 General Life-History and Habitat Requirements

Salt marsh harvest mice are critically dependent on dense cover and their preferred habitat is pickleweed (*Salicornia virginica*). However, harvest mice can use a broader source of food and cover, including salt grass (*Distichlis spicata*) and other vegetation typically found in the salt and brackish marshes of the region. Salt marsh harvest mice are seldom found in cordgrass or alkali bulrush (*Scirpus americanus* and *S. maritimus*). In marshes with an upper zone of peripheral halophytes (salt-tolerant plants), they use this vegetation to escape the higher tides, and may even spend a considerable portion of their lives there. They also move into the adjoining grasslands during the highest winter tides. During the spring and summer months, some individuals will move from pickleweed marsh to bordering grasslands.

Breeding occurs from March through November. The salt marsh harvest mouse does little nest building, and nest structures are generally composed of a loose arrangement of grass. One or two litters may be produced annually with three to four young per litter.

2.22.4 Historical and Current Distribution and Abundance

The salt marsh harvest mouse is endemic to the marshes of the San Francisco Bay. There are two subspecies: the southern subspecies (*R. raviventris*) is found in the South San Francisco Bay (South Bay), the Corte Madera area, and Richmond area in the Central Bay; and the northern subspecies (*R. halicoetes*) is found in the Marin Peninsula, as well as in the tidal and brackish marshes of San Pablo and Suisun Bays (USFWS 2013).

In most of its range, the salt marsh harvest mouse is found in the upper half of tidal salt marshes, where shallow flooding, high tide cover, and escape habitat are available (Shellhammer and Barthman-Thompson 2015; USFWS 2013). They species also occurs in some of the South Bay brackish marshes (Shellhammer et al. 2010).

Differences in population sizes for the two subspecies can likely be attributed to differences in available marsh habitat and ecotones throughout the species' range (Shellhammer and Barthman-Thompson 2015; USFWS 2013). For example, due to loss of marsh habitat, population numbers are low throughout the range of the southern subspecies (Shellhammer et al. 2010). Conversely, population numbers are higher in the brackish marshes of northern and western Suisun Marsh, where there is both a higher quantity and quality of available habitat. A study conducted by Sustaita et al. (2011) found a positive correlation between the density and height of mixed vegetation and salt marsh harvest mouse numbers. Sustaita and colleagues (2011) reported large populations in both pickleweed-dominant (*Salicornia virginica*) areas and areas with mixed halophytes, such as fat hen (*Atriplex triangularis*), alkali heath (*Frankenia salina*), Baltic rush (*Juncus balticus*), Olney's threesquare bulrush (*Schoenoplectus americanus*) and other halophytic species. Additionally, the results showed that areas with mixed vegetation that were not dominated by pickleweed were often as productive as the pickleweed-dominant areas (Sustaita el al. 2011).

CDFW and DWR conducted a 2-year mark-recapture study to investigate demographic performance and habitat use of the northern subspecies of the endangered salt marsh harvest mouse in the Suisun Marsh. The studies examined the effects of different wetland types and microhabitats on three demographic variables: density, reproductive potential, and persistence. The results indicate that microhabitats dominated by mixed vegetation or pickleweed supported similar salt marsh harvest mouse densities, reproductive potential, and persistence throughout much of the year. The studies showed that densities were higher in diked wetlands, whereas post-winter persistence was higher in tidal wetlands. The results emphasize the importance of mixed vegetation, where at least some vegetation is taller, and suggests that both diked and tidal wetlands support salt marsh harvest mouse populations by promoting different demographic attributes as well as adequate habitat. The southern subspecies, *R. raviventris*, occupies South San Francisco Bay marshes. Marshes in the South Bay generally lack the attributes that contribute to relatively high densities of mice in Suisun. South Bay marshes have lost most of their high marsh and upland ecotones to development, so mice have little escape cover during high tides.

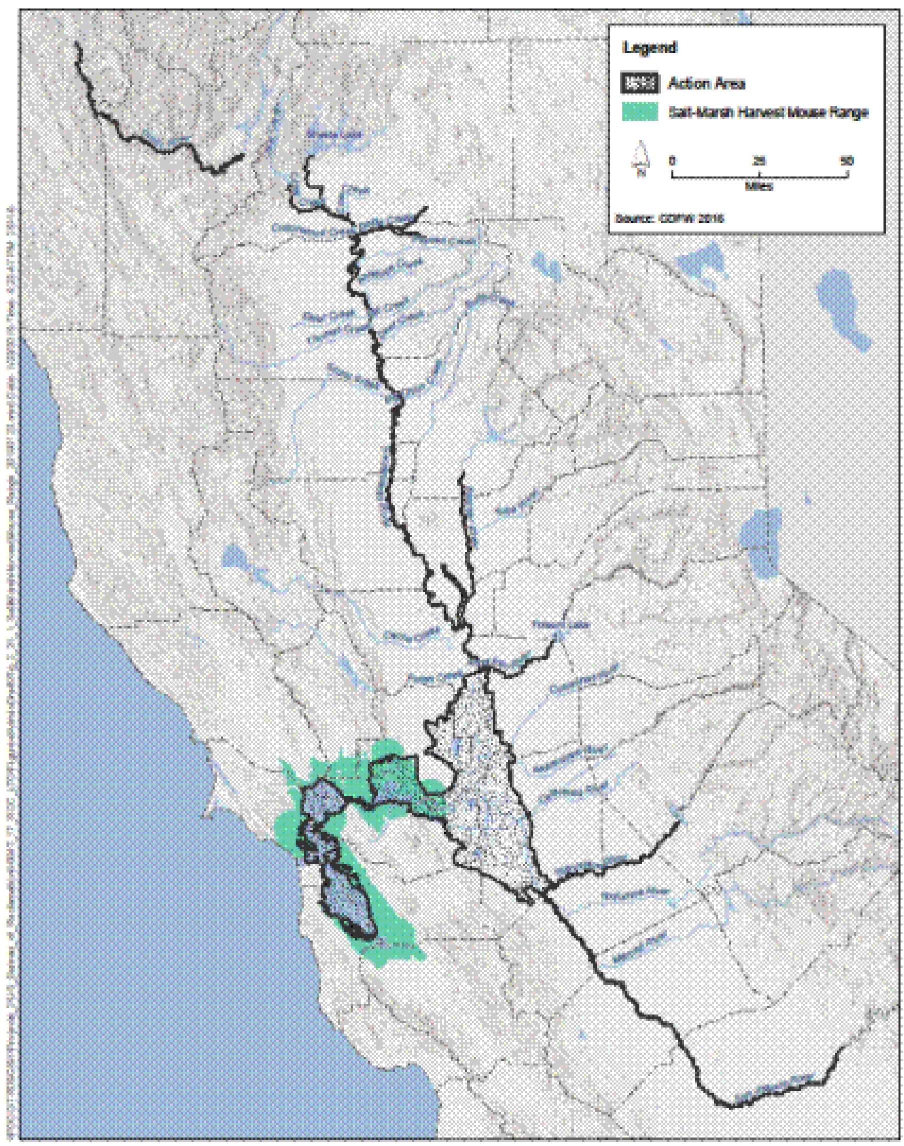


Figure 2.22-1. Salt Marsh Harvest Mouse Range

2.22.5 Limiting Factors, Threats, and Stressors

Salt marsh harvest mouse habitat loss can be ascribed to extensive urban and industrial development, particularly in the South Bay (USFWS 2013). Tidal marshes in the San Francisco Bay have lost the upper half of their mid-marsh zones, most of the high marsh zones, as well as most of the marsh/upland ecotones (Shellhammer and Barthman-Thompson 2015). Loss of the two latter areas means loss of escape cover during high tides. Many of the remaining South Bay marshes are very narrow, have poor vegetative cover, and reduce or prevent the movement of the salt marsh harvest mouse (Shellhammer and Duke 2010). Decreased sediment loads will likely result in narrowing of marshes (Cloern and Jassby 2012). The results are more and smaller populations that experience higher random genetic drift (Shellhammer and Duke 2010).

Climate change, particularly sea level rise due to climate change, will have a significant and negative impact on this species, especially in the South Bay where marshes are already narrow. For most of the mouse's range, marshes are bordered by developed land. Areas of undeveloped upland available as habitat and ecotone still exist, including the Coyote Hills in the South Bay and the Sears Point area in the San Pablo Bay. There are also protected areas along the eastern side of the Marin Peninsula, but unfortunately, they are vulnerable to steeply-rising waters. The Suisun Marsh, which is further inland, is not subjected to the same high tides as the San Francisco Bay. With less intense flooding, development, and infrastructure, Suisun Marsh provides better migration and survival rates (Shellhammer and Barthman-Thompson 2015).

Increased salinity from sea level rise coupled with lower precipitation from climate change could lead to vegetation loss, specifically pickleweed, and changes to vegetation composition (Padgett-Flohr and Isakson 2003; Shellhammer and Barthman-Thompson 2015). Intense flooding and storm events could eliminate cover and refugia, thereby increasing predation (Johnston 1957) and destroying nests (Hadaway and Newman 1971).

2.22.6 Recovery and Management

The *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* covers five endangered species, including the salt marsh harvest mouse. The overall goal of the recovery plan is comprehensive restoration and management of tidal marsh ecosystems. (USFWS 2013)

Population resilience can be increased in tidal salt marshes by acquiring existing, historic, and restorable tidal marsh in order to increase marsh size, connectivity, and expand high marsh and ecotone areas (Shellhammer and Barthman-Thompson 2015; USFWS 2013). One significant and successful endeavor for the southern subspecies is the South Bay Salt Pond Restoration Project, which began in 2003. Projects in San Pablo Bay and Suisun Marsh, where tidal action was restored, have benefited the northern subspecies. Improving marsh connectivity increases genetic exchange and avoids inbreeding depression (Shellhammer and Barthman-Thompson 2015). Increased marsh size, complexity, and the possibility for extension landward are critical to the species' survival.

Benefits to recreating large marshes include the development of raised overflow berms along their intermediate channels, which provide areas for marsh gumplant (*Grindelia robusta* var. *angustifolia*) to grow and offer escape cover from high tides (Shellhammer and Barthman-Thompson 2015). Restored marshes should have sloping upper edges where high marsh and transition zone vegetation can develop, even though the slopes will be narrow. One recurring dilemma with tidal restoration is that some areas to be diked have existing salt marsh harvest mouse populations (USFWS 2013). Because of this, unoccupied or unsuitable habitats have higher priority for tidal marsh restoration.

Salt marsh harvest mouse use of managed wetlands has been documented to be as high, or higher than, tidal wetland use (Sustaita et al. 2011). Downlisting of the salt marsh harvest mouse in the Suisun Bay Recovery Unit is achievable through 1,000 or more acres of muted or tidal marsh in the Western Suisun/Hill Slough Marsh Complex, 1,000 or more acres of muted or tidal marsh in the Suisun Slough/Cutoff Slough Marsh Complex, 1,500 or more acres of diked or tidal marsh in the Grizzly Island Marsh Complex, 1,000 or more acres of muted or tidal marsh in the Nurse Slough/Denverton Slough Marsh Complex, and 500 or more acres of muted or tidal marsh in the Contra Costa County Marsh Complex.

It is recommended that habitat management, restoration, and enhancement efforts include areas containing mixed vegetation, pickleweed in both diked and tidal wetlands, and areas that will accommodate sea level rise.

2.23 California Clapper Rail

2.23.1 ESA Listing Status

The USFWS listed California Ridgway's rail (*Rallus obsoletus obsoletus*), formerly California clapper rail (*Rallus longirostris obsoletus*), as an endangered species under the ESA on October 13, 1970 (35 FR 16047). Recent genetic analyses of rail species resulted in a change in the common name and taxonomy of the large, "clapper-type" rails (Rallus longirostris) of the west coast of North America to Ridgway's rail (Rallus obsoletus) (Maley and Brumfield 2013; Chesser et al. 2014). However, the change does not change the current listing status of the species. The USFWS will continue to recognize the species as the California clapper rail until the change in common name and taxonomy of the California clapper rail to Ridgway's rail is officially entered into the Federal Register.

2.23.2 Critical Habitat Designation

No critical habitat rules have been published for the species.

2.23.3 General Life-History and Habitat Requirements

The California Ridgway's rail is a year-round resident of tidally influenced salt and brackish marshes in the San Francisco Estuary. Areas used by California Ridgway's rails are dominated by pickleweed, Pacific cordgrass (*Spartina foliosa*), and salt grass in the lower tidal zone and taller pickleweed, gumplant, and wrack (the area where debris is deposited) in the upper tidal zone. They also can occupy habitats with other vegetative components, including bulrush, cattails (*Typha* spp.), and Baltic rush. Shrubby areas adjacent to or within the marsh may be important for predator avoidance during high tides. Nesting also occurs in this habitat.

California Ridgway's rails are most active in early morning and late evening, when they forage in marsh vegetation in and along creeks and mudflat edges. They are highly opportunistic feeders; principal food items include crabs, mussels, spiders, clams, snails, aquatic insects, isopods, pickleweed and Pacific cordgrass vegetation, seeds, and small fish. They often roost at high tide during the day.

The breeding season begins by February. Nesting starts in late March and extends into August. The end of the breeding season is typically defined as the end of August, which corresponds with the time when eggs laid during re-nesting attempts have hatched and young are mobile. Clutch sizes range from 5 to 14 eggs.

Both parents share in incubation and rearing. Nests are placed to avoid flooding by tides, yet in dense enough cover to be hidden from predators, generally on raised ground near tidal sloughs in low marsh habitats. The young are semiprecocial, incapable of moving from the nest for at least 1 hour after hatching and are brooded by the adults for several days. The young follow the adults during foraging and are able to forage independently on small prey soon after hatching.

2.23.4 Historical and Current Distribution and Abundance

The California Ridgway's rail is endemic to tidally influenced salt and brackish marshes of California. Historically, the California Ridgway's rail occurred in tidal marshes along California's coast from Morro Bay, in San Luis Obispo County, to Humboldt Bay, in Humboldt County. Thousands of California Ridgway's rails were eliminated by market hunters from the time of the Gold Rush until the passage of the Weeks-McLean Law in 1913, which was a precursor to the Migratory Bird Treaty Act of 1918 and was designed to stop commercial market hunting and illegal shipment of migratory birds from one state to another. Since that time, diking and filling for conversion to agriculture, urban development, and salt production have reduced the San Francisco Bay tidal marshes by 84 percent or more.

Currently, California Ridgway's rails are known to occur in tidal marshes in the San Francisco Estuary (estuary) (San Francisco, San Pablo, Grizzly, and Suisun Bays) (Olofson Environmental, Inc. 2011; CDFG 2011). California Ridgway's rails are typically found in the intertidal zone and sloughs of salt and brackish marshes dominated by pickleweed, Pacific cordgrass, Grindelia, saltgrass, jaumea, and adjacent upland refugia. They may also occupy habitats with other vegetative components, which include, but are not limited to, bulrush, cattails, and Baltic rush. In northern San Francisco Bay, California Ridgway's rails also occur in tidal brackish marshes that vary significantly in vegetation structure and composition, ranging from salt-brackish marsh to fresh-brackish marsh transitions (USFWS 2010a). Use of brackish marshes by California Ridgway's rails is largely restricted to major sloughs and rivers of San Pablo Bay and western Suisun Marsh, and along portions of Coyote Creek in the South Bay (USFWS 2010a). California Ridgway's rails were also found in nearly pure stands of alkali bulrush along Guadalupe Slough in 1990 and 1991 (H. T. Harvey & Associates 1990a, l990b and 1991). On rare occasions, California Ridgway's rails have been recorded even farther upstream, in brackish/freshwater transition marshes, particularly during the non-breeding season.

The California Ridgway's rail population was first estimated (between 1971-1975) at 4,200 to 6,000 birds, of which 55 percent occurred in the South Bay and 38 percent in the Napa Marshes (Gill 1979). Although the population was estimated at only 1,500 between 1981–1987 (Harvey 1988), the difference between these two estimates is believed to be partially due to survey intensity. Breeding season density data indicate that populations remained stable during the 1970s (Gill 1979; Harvey 1988), but reached an estimated all-time historical low of about 500 birds in 1991, with about 300 California Ridgway's rails in the South Bay (Harding et al. 1998). California Ridgway's rail numbers have rebounded between the 1990s and 2007. However, substantial increases in population may be difficult to achieve due to the current disjunct distribution of their habitat (Albertson and Evens 2000). Bay-wide California Ridgway's rail numbers in the estuary have been declining overall since 2007, and the decline is highly correlated with efforts to eradicate invasive Spartina in the estuary. U.S. Geological Survey (USGS) data suggest that Bay-wide California Ridgway's rail call count numbers declined by as much as 50 percent between 2007 and 2011.

Point Blue Conservation Science (formerly PRBO Conservation Science) conducted estuary-wide surveys of the San Francisco Bay for California Ridgway's rail between 2005 and 2010. Results of the 2008 survey indicated only 543 rails, compared to 938 rails detected in 2007 (PRBO Conservation Science

2009a). In both years, the South Bay accounted for the majority of California Ridgway's rails. Between 2005 and 2008, the estimated estuary-wide total population of California Ridgway's rails decreased by about 21 percent (Liu et al. 2009). The South Bay population of California Ridgway's rails decreased by 54 percent between 2007 and 2008 (Liu et al. 2009). Invasive Spartina Project (ISP) California Ridgway's rail survey data collected at 30 sites from 2004 to 2010 also shows an overall decline in California Ridgway's rails. The population increased by 25 percent between 2005 and 2006 and by 25 percent again between 2006 and 2007. Then count numbers decreased by 35 percent between 2007 and 2008, by 32 percent from 2008 to 2009 and by 13 percent from 2009 to 2010.

Data collected by ISP from 2004 to 2010 at 30 sites within the San Leandro Bay, the Hayward region, the San Francisco Peninsula, and the Newark region showed a decline in California Ridgway's rail numbers from 519 in 2007 to 202 in 2010. USGS data suggest that, estuary-wide California Ridgway's rail call count numbers declined by approximately 50 percent between 2007 and 2011. According to the California Ridgway's Rail Population Monitoring Report: 2005–2008, the estuary-wide California Ridgway's rail population showed an overall negative trend (-20.6 percent, $P<0.0001$) from 2005 to 2008, which can be mostly attributed to the 57 percent decline seen in the South Bay from 2007 to 2008 (PRBO Conservation Science 2009b). This decrease in the population of California Ridgway's rails in 2008 is highly correlated with large scale Spartina eradication during this period which resulted in the loss of cover. No new cover was created or enhanced for California Ridgway's rail to offset this loss.

In 20l0, Point Blue Conservation Science detected an increase of California Ridgway's rails in San Pablo Bay and South San Francisco Bay, while ISP detected a decline at other locations. This difference suggests that mature marshes (surveyed by Point Blue Conservation Science) which received a high degree of hybrid Spartina control still provided enough native habitat to support stable California Ridgway's rail population, while young marshes (surveyed by ISP), where hybrid Spartina was a more significant component of marsh vegetation cover, no longer provided habitat for California Ridgway's rails because California Ridgway's rails in these marshes were dependent on the hybrid Spartina for cover. It is unknown if the increased number of California Ridgway's rails detected at some locations is due to high breeding success or is a result of immigration from marshes where Spartina treatment resulted in a loss of high tide refugia habitat. In addition, high tide surveys conducted by East Bay Regional Parks District showed decreases in California Ridgway's rail numbers in San Leandro Bay since 2007. An extreme decline on East Bay Regional Parks District land occurred at Arrowhead Marsh which decreased from 112 California Ridgway's rails in 2007 to 35 in 2010.

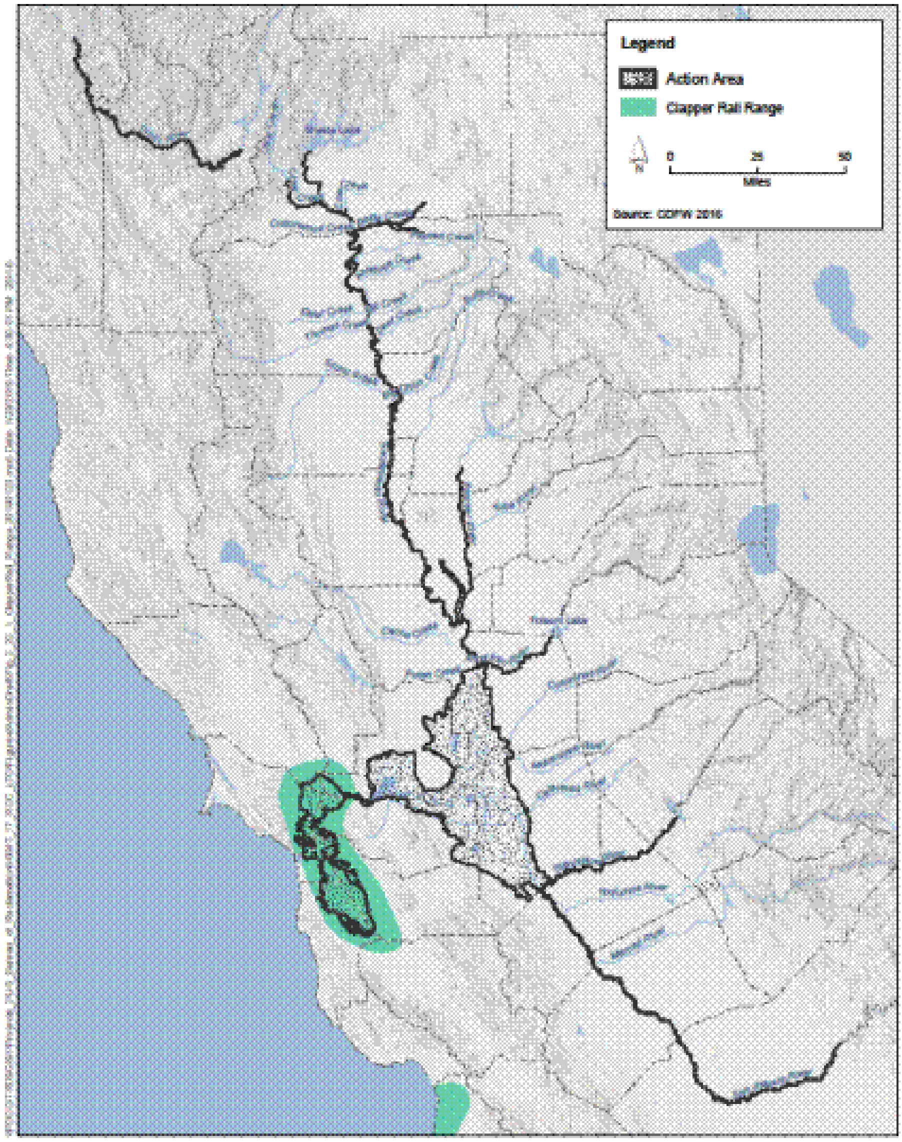


Figure 2.23-1. California Clapper Rail Range

2.23.5 Limiting Factors, Threats, and Stressors

California Ridgway's rail populations are limited by their small size, habitat fragmentation, and lack of tidal channel systems and other micro-habitat features. These limitations render much of the remaining tidal marsh acreage unsuitable or of low value for the species. Habitat loss has dramatically slowed since the California Ridgway's rail was listed in 1970, but ongoing disturbance and degradation precludes or reduces occupation of much of the remaining potential habitat by California Ridgway's rails. Remaining habitat has been fragmented by levee systems that reduce and isolate patches of habitat, reduce or eliminate high marsh and refugial habitat, and make habitat accessible to predators and human disturbance. Habitat has been filled, subjected to many contaminants, converted to less suitable vegetation conditions by fresh wastewater discharges, and submerged by land subsidence caused by agricultural practices and groundwater overexploitation. Loss of upper marsh vegetation has greatly reduced available habitat throughout the range of the California Ridgway's rail.

In addition to the problems associated with landscape alteration caused by development, California coastal wetlands are expected to be subject to the effects of global sea level rise and climate change due to global warming. The effects of past subsidence of marsh plain relative to mean tidal level, particularly in the South Bay (Atwater et al. 1979), are likely to be amplified by rising tidal levels.

California Ridgway's rails vary in their sensitivity to human disturbance, both individually and between marshes. California Ridgway's rails have been documented nesting in areas with high levels of disturbance, including areas adjacent to trails, dikes, and roads heavily used by pedestrian and vehicular traffic (USFWS 2013; Baye in litt. 2008). In contrast, Albertson (1995) documented a California Ridgway's rail abandoning its territory in the Laumeister Tract shortly after a repair crew worked on a nearby transmission tower. California Ridgway's rail reactions to disturbance may vary with season; however, both breeding and non-breeding seasons are critical times. Public trails that run along a narrow marsh transition zone may be particularly hazardous to California Ridgway's rails that depend on this habitat for refuge during high tides.

Throughout the estuary, the remaining California Ridgway's rail population is impacted by a suite of mammalian and avian predators and is exacerbated by at least 12 native and 3 nonnative predator species known to prey on various life stages of the California Ridgway's rail (Albertson 1995).

Mercury accumulation in eggs is perhaps the most significant contaminant problem affecting California Ridgway's rails in the estuary, with the South Bay containing the highest mercury levels. Mercury is extremely toxic to embryos and has a long biological half-life. Schwarzbach and colleagues (2006) found high mercury levels and low hatching success (due both to predation and, presumably, mercury) in California Ridgway's rail eggs throughout the estuary. California Ridgway's rail habitat is also at risk of contamination due to oil spills (Cosco Busan Oil Spill Trustees 2012).

2.23.6 Recovery and Management

The Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California (Recovery Plan; USFWS 2013) is an expansion and revision of the California Clapper Rail and Salt Marsh Harvest Mouse Recovery Plan (USFWS 1984). The Recovery Plan features the California Ridgway's rail (formerly California clapper rail) along with four other endangered species. The Recovery Plan identifies high priority areas for tidal marsh and ecotone restoration including restoring tidal action to many of the salt ponds and other diked baylands along San Francisco Bay. Thousands of acres of former salt ponds and other diked baylands along San Francisco Bay have been restored or are proposed to be restored to tidal action (Service file number 81420-2008-F-0621; USFWS 2008b); however, it may take decades before many of the heavily subsided areas within the former salt ponds accumulate enough sediment to become suitable tidal marsh habitat for California Ridgway's rails.The USFWS, on June 18, 2018 initiated 5-year status reviews for 50 species in California, Nevada, and the Klamath Basin of Oregon under the Endangered Species Act of 1973, as amended. A 5-year review is based on the best scientific and commercial data available at the time of the review; therefore, the USFWS is requesting submission of any new information on species that has become available since the last review.

2.23.7 Monitoring and Research Programs

The Don Edwards San Francisco Bay National Wildlife Refuge with assistance from the U.S. Department of Agriculture Wildlife Services currently manages mammalian and avian predators within California clapper rail habitat on its refuge lands in the South Bay and on DFW lands; however, the Predator Management Program is underfunded.

Although it has been suggested that habitat quality may be lower in brackish marshes than in salt marshes (Shuford 1993), further studies comparing reproductive success in different marsh types are necessary to determine the value of brackish marshes to California clapper rails.

2.24 Least Bell's Vireo

2.24.1 ESA Listing Status and Critical Habitat Designation

The least Bell's vireo (*Vireo bellii pusillus*) was listed as an endangered species by the USFWS on May 2, 1986 (51 FR 16474).

2.24.2 Critical Habitat Designation

Critical habitat, designated on February 2, 1994 (59 FR 4845 4867), is located in Santa Barbara, Ventura, Los Angeles, Riverside, San Bernardino, and San Diego Counties. No critical habitat for least Bell's vireo is present in the project Action Area or vicinity.

2.24.3 General Life-History and Habitat Requirements

Least Bell's vireo is an obligate riparian species during the breeding season, inhabiting structurally diverse woodlands along watercourses, including cottonwood-willow forests, oak woodlands, and mule fat (*Baccharis salicifolia*) scrub (USFWS 1998). Preferred breeding habitat generally consists of early successional, dense, low, shrubby vegetation in riparian areas, or young second-growth forest or woodland. This vireo is a subtropical migrant, typically arriving at breeding grounds in California from mid-March to early April. It can be highly territorial, and individuals have been known to return to the same breeding site, drainage, territory, and even nest tree each year, but birds may also disperse to new breeding sites (USFWS 1998). Birds may leave their breeding grounds as early as late July but are generally present until late September. Least Bell's vireos winter on the Baja California peninsula, where they occupy a variety of habitats, including mesquite scrub within arroyos, palm groves, and hedgerows bordering agricultural and residential areas (USFWS 1998).

Least Bell's vireos build their nest in dense cover in and along the edges of riparian habitat 3 to 6 feet off the ground, and within a dense, stratified canopy for foraging. Plant species composition and age are not important factors in nest site selection. Although least Bell's vireos nest in riparian habitat, they have also been observed foraging in adjacent upland habitats (USFWS 1998). Within a few days after pair formation, least Bell's vireos begin building a nest, with both parents constructing the cup-shaped nest composed of leaves, bark, willow catkins, spider webs, and other materials. Both parents incubate the eggs, which usually takes 14 days. Clutch size is typically three to four eggs, but may be as few as two or, rarely, up to five eggs. Fledging occurs approximately 10 to 12 days after the eggs hatch, with the adults continuing to care for the fledglings for 2 weeks. Pairs may attempt as many as five nests in a breeding season, but typically do not start nests after mid-July (USFWS 1998). Least Bell's vireos average between 1.1 and 2.4 young fledged per year (USFWS 1998).

2.24.4 Historical and Current Distribution and Abundance

The least Bell's vireo is a small, insectivorous bird of the southwestern United States. Historically, least Bell's vireo was widespread and abundant, ranging from the interior of Northern California near Red Bluff in Tehama County southward through the Sacramento and San Joaquin Valleys and Sierra Nevada Foothills, and in the Coast Ranges from Santa Clara County south to San Fernando, Baja California, Mexico.

By the early 1980s, least Bell's vireo was extirpated from the Sacramento and San Joaquin Valleys, with the species restricted to two locations in the Salinas River Valley in Monterey and San Benito Counties, one location along the Amargosa River in Inyo County, and numerous small populations in southern California south of the Tehachapi Mountains and in northwestern Baja California, Mexico (USFWS 1998). At the time of listing in 1986, over 99 percent of the least Bell's vireo population was found south of Santa Barbara County (USFWS 2006a). Since 1986, there has been a tenfold increase in the recorded least Bell's vireo population, largely due to efforts to control brown-headed cowbird (*Molothrus ater*) (USFWS 2006a). Breeding pairs have been observed in Monterey, San Benito, Inyo, Santa Barbara, San Bernardino, Ventura, Los Angeles, Orange, Riverside, and San Diego Counties, with the highest concentration of birds in San Diego County along the Santa Margarita River (USFWS 2006a). Pairs have also been observed exhibiting nesting behaviors in 2010 and 2011 in Yolo County within the Action Area (CDFW 2018). Although the breeding records do not yet support that least Bell's vireo has recolonized its historical breeding range in the San Joaquin and Sacramento Valleys (USFWS 2006a), the USFWS is including the small area around the 2010–2011 Yolo County unsuccessful nesting in the current range of the species (USFWS 2018).

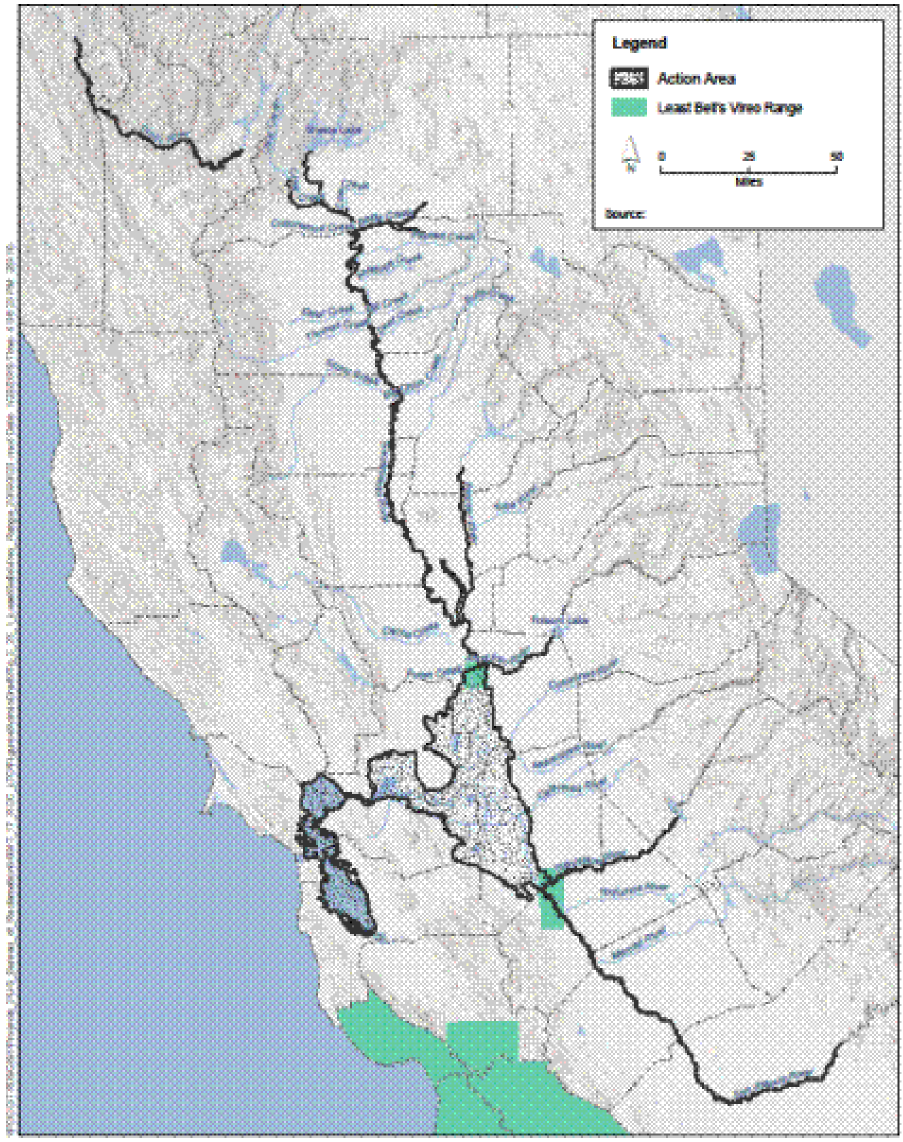


Figure 2.24-1. Least Bell's Vireo Range

2.24.5 Limiting Factors, Threats, and Stressors

The leading causes of least Bell's vireo decline include habitat loss and fragmentation resulting from stream channelization, flood control, water impoundment, water diversion, intensive recreation, agricultural conversion, livestock grazing, and urban development (Riparian Habitat Joint Venture [RHJV] 2004). Alteration of riparian landscapes can narrow or eliminate important population dispersal corridors. In addition, the degradation of riparian habitat resulting from construction of dams, levees, and diversions, clearing associated with farming and development, overgrazing, and invasion by exotic species can lead to disruption of natural hydrological conditions. Some of these factors may be exacerbated by climate change.

Another major threat to least Bell's vireo populations is the expansion of the range of the brown-headed cowbird, which acts as a brood parasite. Agricultural and livestock grazing areas located near riparian zones provide brown-headed cowbirds with ample foraging habitat close to songbird breeding grounds. Cowbird parasitism contributes to lowered productivity in host species through direct destruction of host eggs, competition between cowbirds and host chicks resulting in increased mortality, and nest abandonment in some species, all of which lower overall fecundity within a season (RHJV 2004). In addition, agricultural expansion and urbanization tend to reduce favorable conditions for top predators through habitat fragmentation and increased mortality from roadkill. The elimination of top predators, such as mountain lions (*Puma concolor*) and coyotes (*Canis latrans*), often results in an increased population of mid-level predators, such as raccoons, skunks, and domestic and feral cats, which are well documented nest predators (RHJV 2004).

2.24.6 Recovery and Management

Since its federal listing in 1986, along with intensive cowbird removal programs and riparian habitat protection, the population of Least Bell's Vireo has increased in the southern portion of its historic range, particularly in San Diego and Ventura counties, and is expanding northward (USFWS 1998). The USFWS prepared a Draft Recovery Plan for the Least Bell's Vireo in 1998. This plan details the importance of habitat conservation for Least Bell's Vireo recovery (USFWS 1998). Habitat features that are essential to Least Bell's Vireo conservation include riparian woodland vegetation that contains both canopy and shrub layers as well as associated upland habitat. Current threats to the remaining Least Bell's Vireo habitat that limit the ability for expansion of this habitat beyond its protected critical habitat core areas include stream channelization, water impoundment and extraction, water diversion, intensive recreation, and urbanization. Riparian areas are increasingly bordered by urban areas, whereas historically they were bordered by native upland plant communities. Vireo territories bordering agricultural and urban areas have been demonstrated to be less successful in producing young than territories bordering native upland plant communities (Kus 2002; USFWS 2006a).

2.25 Western Yellow-Billed Cuckoo

2.25.1 ESA Listing Status

The USFWS listed the western DPS of the yellow-billed cuckoo (*Coccyzus americanus*) as threatened on October 3, 2014 (79 FR 59992).

2.25.2 Critical Habitat Designation

Critical habitat, proposed on August 15, 2014 (79 FR 48547), includes sections of the Action Area along the Sacramento River from south of Red Bluff in Tehama County to Colusa, California. No final critical habitat has been designated for this species.

2.25.3 General Life-History and Habitat Requirements

The western yellow-billed cuckoo is a riparian obligate species, using riparian areas along low gradient rivers and streams and in valleys that provide floodplain conditions. Preferred habitat for this species consists of willow-cottonwood (*Salix-Populus*) riparian forest, but other tree species such as white alder (*Alnus rhombifolia*) and box elder (*Acer negundo*) may be important habitat components in some areas, including occupied sites along the Sacramento River (Laymon 1998).Potential habitat may also include valley marshland with willow riparian corridors, such as that found in the Llano Seco area of Butte County. Nesting habitat requires large expanses of willow-cottonwood forests (RHJV 2004). Along the Sacramento River, orchards of English walnut (*Juglans regia*), prune, and almond trees have also reportedly been used for nesting (Laymon 1980).

In western North America, yellow-billed cuckoos begin arriving from their wintering grounds in South America in mid- to late May (Hughes 1999). Nests usually consist of loose platforms of twigs lined with leaves or finer materials and, in the west, are often placed in willows, cottonwoods, and shrubs (Gaines and Laymon 1984). Clutch size ranges from one to five eggs, but is typically two to three (Hughes 1999). The entire period from egg laying to fledgling is one of the shortest among all bird species, lasting only 17 to 18 days, with incubation extending 9 to 11 days and nestlings fledging at 17 to 19 days of age (Hughes 1999). Young can typically fly at about 3 weeks of age. In years with a good food supply, yellow-billed cuckoos may lay two clutches of eggs. Although yellow-billed cuckoos usually raise their own young, they are facultative brood parasites, meaning they occasionally lay their eggs in nests of other yellow-billed cuckoos or of other bird species (Hughes 1999). They depart breeding grounds by early fall.

Yellow-billed cuckoos feed on katydids, caterpillars, cicadas, and other large insects. They forage in areas that are similar to breeding sites, but these areas may be smaller, narrower, and lack understory vegetation. Riparian vegetation is used by adults and young as a movement corridor between foraging sites and post-breeding dispersal areas. Western yellow-billed cuckoo may be found in a variety of vegetation communities during migration, including coastal scrub, secondary growth woodland, hedgerows, humid lowland forests, and forest edges below 8,125 feet above mean sea level, suggesting that the habitat needs of this species during migration are not as restricted as their habitat needs when nesting (Hughes 1999).

2.25.4 Historical and Current Distribution and Abundance

The yellow-billed cuckoo is a neotropical migrant bird that winters in South America and breeds in North America. The breeding range of the entire species formerly included most of North America, extending from southeastern and western Canada to the Greater Antilles in the Caribbean Sea and northern Mexico. At the time of the proposed listing, western yellow-billed cuckoo was not recognized as a separate sub-species and the USFWS determined that the western population segment, which nests in the portion of the United States west of the Continental Divide, is a DPS under the ESA.

The western DPS range has experienced significant reductions over the past 90 years. The northern limit of this species' breeding range along the west coast of the United States is now the Sacramento Valley. A small, potential breeding population exists in coastal Northern California along the Eel River (USFWS

2014b). In California, the yellow-billed cuckoo breeding range once extended from the Mexican border northward along the southern coast, and through the entire Central Valley (Grinnell and Miller 1944). However, its range is now generally restricted to the Sacramento Valley, the Kern River, and the lower Colorado River, with individuals occasionally reported in other areas (Laymon and Halterman 1987). The Sacramento Valley is believed to be a major population center for this species and the Sacramento River represents an area where yellow-billed cuckoo habitat has potentially increased over the last 30 years (Dettling and Howell 2011). The estimated breeding population in California is currently 40 to 50 pairs (78 FR 61639; October 3, 2013).

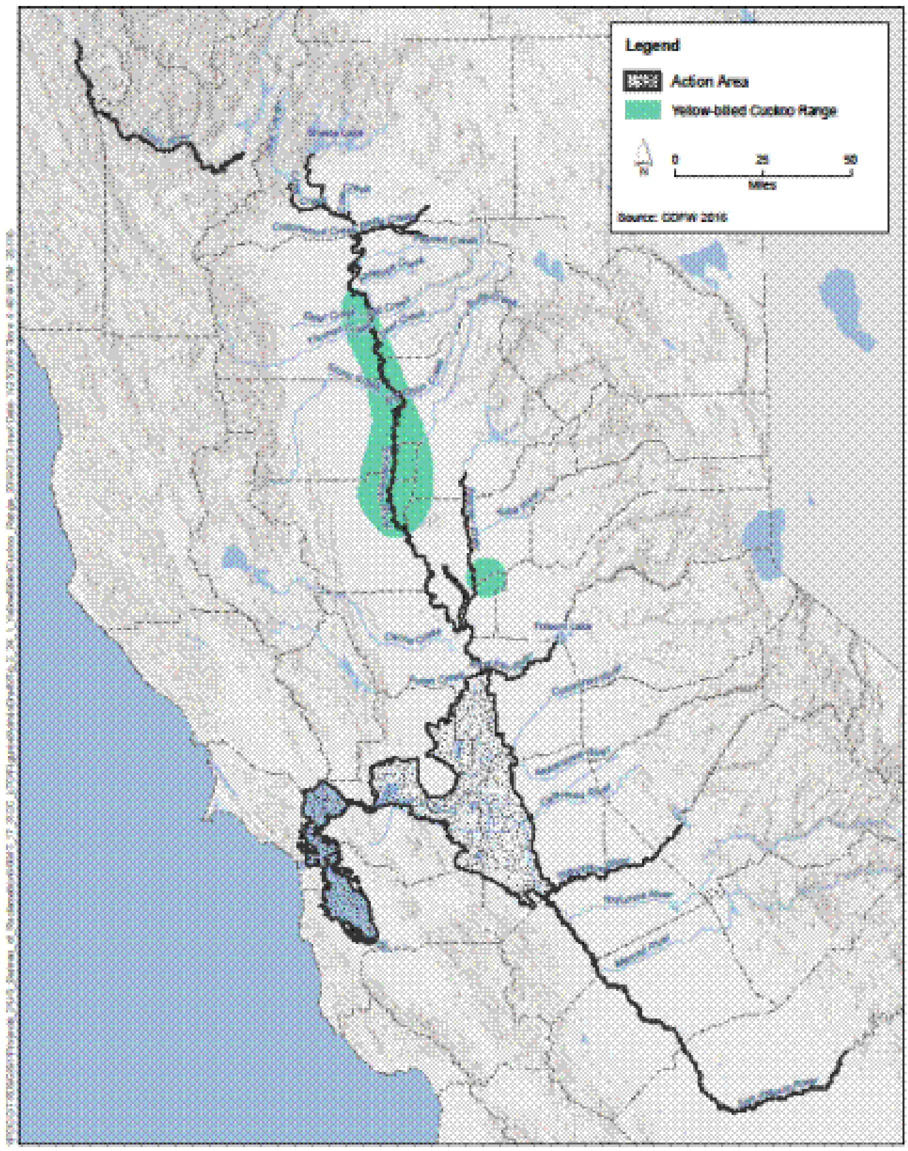


Figure 2.25-1. Western Yellow-Billed Cuckoo Range

2.25.5 Limiting Factors, Threats, and Stressors

Over the past 150 years, land use changes and alterations of river flow regimes have drastically reduced the amount of riparian forest in California and, therefore, the availability of breeding habitat for this neotropical migrant (Laymon and Halterman 1987). Because yellow-billed cuckoo is a riparian obligate, the range of this species in the western United States has become restricted to remaining isolated riparian forest fragments. Similarly, the number of western yellow-billed cuckoos in the western United States has declined substantially. The western population of cuckoos once ranged from northern Mexico to the Canadian border; however, they currently only breed in significant numbers in California, Arizona, New Mexico, and Texas (Gaines and Laymon 1984; Hughes 1999; USFWS 2014b).

Current threats to the yellow-billed cuckoo include habitat loss from flood control projects (including from ongoing maintenance), alterations to hydrology, development of urban and agricultural areas, climate change, and invasive species. The application of pesticides in riparian habitats and adjacent agricultural areas may affect the reproductive success of this species. In addition, a reduction in the availability of suitably sized prey may lead to the abandonment of nesting areas.

2.25.6 Recovery and Management

A recovery plan has not yet been developed for this species, so recovery efforts are based on general conservation needs. For a species like the Western Yellow-billed Cuckoo that has lost much of its former known occupied habitat, recovery would begin with the conservation of much of the remaining occupied and suitable habitat and restoration of suitable habitat that has been disturbed.

2.26 Giant Garter Snake

2.26.1 ESA Listing Status

The USFWS listed the giant garter snake (*Thamnophis gigas*) as a threatened species on October 20, 1993 (58 FR 54053) under the ESA.

2.26.2 Critical Habitat Designation

Critical habitat has not been designated for the giant garter snake.

2.26.3 General Life-History and Habitat Requirements

Endemic to the wetlands of the Sacramento and San Joaquin Valleys of California, giant garter snake historically inhabited tule marshes and seasonal wetlands created by overbank flooding of rivers and streams in the Central Valley. Present populations of giant garter snake inhabit agricultural wetlands and other waterways such as irrigation and drainage canals, sloughs, ponds, small lakes, low-gradient streams, and adjacent uplands. Because of the direct loss of natural perennial wetland habitat, the giant garter snake relies heavily on rice fields in the Sacramento Valley, but also uses managed marsh areas in federal National Wildlife Refuges and state Wildlife Areas.

The giant garter snake is approximately 15 times more active in aquatic habitats (Halstead et al. 2016), but at the same time Halstead et al. (2015) found high frequency use of terrestrial underground habitats to escape hot weather and for brumation. Giant garter snakes have been observed in uplands during the active spring and summer season up to hundreds of meters (hundreds of yards) from water bodies

(USFWS 2017c). The giant garter snake feeds primarily on aquatic prey, including small fish, frogs, and tadpoles.

Habitat requirements consist of adequate water during the active season (typically March through November) to provide food and cover; emergent, herbaceous wetland vegetation, such as cattails and bulrushes, for escape cover from predators and foraging habitat during the active season. Essential habitat components consist of 1) freshwater aquatic habitat with protective emergent vegetation cover where snakes can forage; 2) upland habitat near the aquatic habitat that can be used for thermoregulation and summer shelter (i.e., burrows), and 3) upland refugia outside flood waters that can serve as winter hibernacula (U.S. Fish and Wildlife Service 2017).

Ideal giant garter snake aquatic habitat exhibits the following characteristics.

- Water present from March through November.
- Slow moving or static water flow with mud substrate.
- Presence of emergent and bankside vegetation that provides cover from predators and may serve in thermoregulation.
- Absence of a continuous canopy of riparian vegetation.
- Available prey in the form of small amphibians and small fish.
- Thermoregulation (basking) sites with supportive vegetation such as folded tule clumps immediately adjacent to escape cover.
- Absence of large predatory fish.
- Absence of recurrent flooding, or, where flooding is probable, the presence of upland refugia.

Because of the historic loss of natural wetlands, the preferred aquatic habitat for giant garter snake, rice fields and more importantly their associated canals and drainage ditches have become important habitat for giant garter snakes within agricultural areas. While giant garter snakes are known to use rice fields seasonally, the species is strongly associated with the canals that supply water to and drain water from rice fields; these canals provide much more stable habitat than rice fields because they maintain water longer and support marsh-like conditions for most of the giant garter snake active season (Reyes et. al. 2017). The giant garter snake active season extends approximately April through September. While flooded rice fields provide a component of aquatic habitat for giant garter snakes that occupy rice-growing regions, rice fields only provide adequate cover for the species for approximately one-third of their active season (Halstead et. al. 2016). In the Sacramento Valley, cultivated rice generally emerges from flooded fields in late May or early June, but sufficient growth that provides cover for snakes does not occur until approximately late June. Water is then drawn off the fields to allow them to dry in late August or early September.

In addition to providing foraging and refuge habitat, canals and ditches provide connectivity between occupied habitats. Giant garter snakes rely on canals and ditches as movement corridors through agricultural landscapes. These corridors provide important habitat, and are used during daily movement within a home range. Studies of marked snakes indicated that individuals typically move about 0.25 to 0.5 miles per day and individuals have been documented to move up to 5 miles over the course of a few days. (Wylie et al. 2002).

Throughout the winter dormancy period, giant garter snakes inhabit small mammal burrows and other soil or rock crevices above flood elevations, often as far as 656 to 820 feet (200 to 250 meters) from the edge of summer aquatic habitat. They typically select burrows with sunny exposures along south- and west-facing slopes along canal banks, marshes, or even riprap. The breeding season extends from March into May, with females giving birth to live young from late July through early September (USFWS 2017). Brood size averages 17 to 23 young, but can range from 10 to 46 young. Newborn snakes immediately scatter into dense cover and soon begin feeding on their own. Giant garter snake growth rates are variable, with size typically doubling within a year. Sexual maturity averages 3 years for males and 5 years for females (USFWS 2017).

2.26.4 Historical and Current Distribution and Abundance

Historically, giant garter snake inhabited the Sacramento and San Joaquin Valleys—bounded by the Coast Range to the west and the Sierra Nevada to the east—from the vicinity of Chico in Butte County in the north to Buena Vista Lake in Kern County in the south. Currently, less than 5 percent of the historical 4.5 million acres (1.8 million hectares) of wetlands remain (USFWS 2017). Giant garter snake has been extirpated from the southern one-third of its range in former wetlands associated with the historical Buena Vista, Tulare, and Kern lakebeds. This species now occupies what remains of high-quality fragmented wetlands, including marshes, ponds, small lakes, and low-gradient streams with silt substrates, as well as managed waterways, including irrigation ditches, drainage canals, rice fields, and their adjacent uplands (USFWS 2017).

Occurrence records coincide with the historical distribution of large flood basins, freshwater wetlands, and tributaries of the Central Valley’s Sacramento and San Joaquin watersheds. Recent genetic studies indicate that giant garter snake populations should be grouped by watershed basin. The current population groupings that are genetically and geographically distinct are: Butte Basin, Colusa Basin, Sutter Basin, American Basin, Yolo Basin, Cosumnes-Mokelumne Watershed, Delta Basin, San Joaquin Basin, and Tulare Basin. The Yolo Basin—the Liberty Farms, Burell, and Lanare populations are presumed extirpated (USFWS 2017).

Giant garter snake abundance has decreased throughout its range. The distribution of giant garter snake in the northern part of the range may still reflect its historic distribution; however, distribution in the San Joaquin Valley has been substantially reduced, with only a few recent sightings (USFWS 2017). In the Central Valley, giant garter snake relies heavily on rice fields, but also uses managed marsh areas in National Wildlife Refuges and state Wildlife Areas.

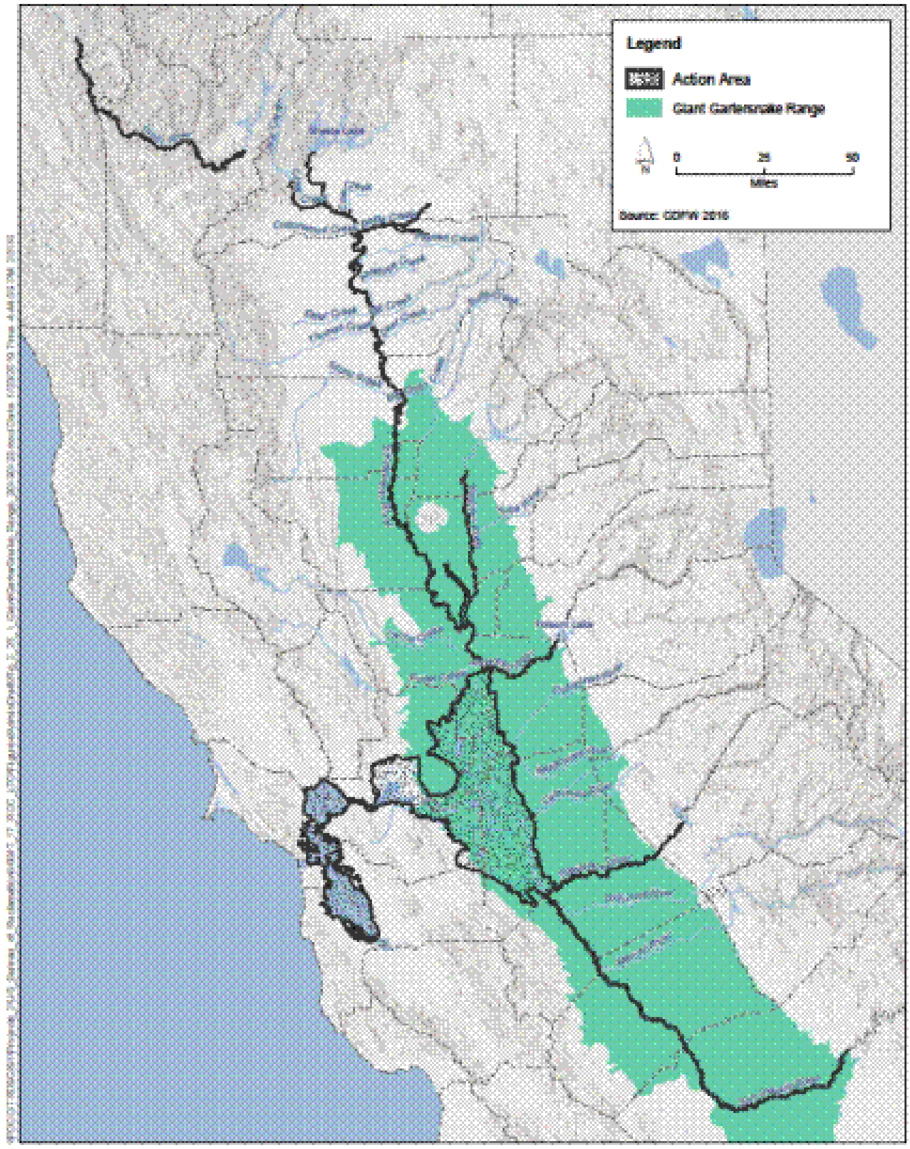


Figure 2.26-1. Giant Garter Snake Range

2.26.5 Limiting Factors, Threats, and Stressors

Habitat loss and fragmentation resulting from urbanization, agricultural conversion, and flood control activities are the main factors that have contributed to the decline of giant garter snake (USFWS 2017). Flood control activities, agricultural practices, and land and water management practices, such as wetland management for waterfowl, nonnative plant management, and water transfers, can alter the availability of summer water, thereby reducing habitat quality for giant garter snake. The loss of wetland ecosystems and suitable habitat has also resulted in giant garter snake using highly modified and degraded habitats among cultivated farm lands, including irrigation ditches, drainage canals, rice fields, and adjacent uplands. Current threats to giant garter snake include habitat loss and fragmentation due to urbanization; changes in the levels and methods of rice production; changes in water availability; levee and canal maintenance, water management, and water deliveries that do not take into account the requirements of the giant garter snake; water transfers (resulting from cropland idling/shifting, reservoir releases, conservation measures, or groundwater substitution); small population sizes; and invasive aquatic species (USFWS 2017).

Flood control and canal maintenance activities can subject snakes to ongoing risks of mortality and injury and can also lead to habitat fragmentation and dispersal barriers. Although giant garter snakes have been observed using rock riprap for thermoregulation, the flood control practice of lining streams and canals with large and extensive quantities of rock can be detrimental to wetland ecosystems and snakes by eliminating a natural thermal mosaic. Flood maintenance activities often include weed management, which destroys surface cover, and rodent eradication, which eliminates the occurrence and abundance of burrows and retreats that are used by giant garter snake for thermoregulation, for cover during shedding, and for over-wintering (USFWS 2012). Additional threats include predation, drought, climate change, roads (resulting in habitat fragmentation and vehicular threats), impaired water quality, selenium contamination, and mosquito abatement (USFWS 2017c).

A “mosaic of cover and water is likely beneficial” to snakes during the active season (Halstead et al. 2016). One study found that a lack of rice production adjacent to occupied canals appears detrimental to giant garter snake survival rates and populations. The study surmises that lower survival rates could be related to lower prey populations, increased predator presence, and a less secure water supply. This study supports the importance of maintaining water in canals adjacent to fallowed rice fields (Reyes et al. 2017). Research results indicate that there is a strong positive association between giant garter snake occupancy, soil classification, elevation, canal density, and the proportion of rice croplands (Hansen et al. 2017).

2.26.6 Recovery and Management

The USFWS finalized its giant garter snake recovery plan in 2017, with the recovery strategy focused on protecting existing, occupied habitat and identifying and protecting areas for habitat restoration, enhancement, or creation, including areas that are needed to provide connectivity between populations (USFWS 2017c). The three habitat components that are important for the giant garter snake include a freshwater aquatic component with protective emergent vegetation cover, nearby uplands that can be used for thermoregulation and summer shelter, and upland winter hibernacula (USFWS 2017c).

Protected waterfowl habitats in wildlife refuges are an important source of habitat for giant garter snake, but do not necessarily provide good habitat when they are flooded in winter and drained in summer. Rice fields and irrigation ditches, which are both flooded in summer, provide good habitat for this species.

2.26.7 Monitoring and Research Programs

In 2009, the California Department of Water Resources (DWR) developed a giant garter snake Baseline Monitoring and Research Strategy to help quantify and evaluate the response of the giant garter snake to rice land idling (USFWS 2015). DWR is working with the USGS Western Ecological Research Center (WERC) on the study of giant garter snake in the Sacramento Valley. The broad objective of this research effort is to provide scientific information to USFWS in support of identifying the effects of rice land idling for the purpose of water transfers on the species. Ultimately, the goal is to design conservation measures that will avoid and minimize effects on giant garter snake from rice land idling for water transfers. Once rice was emergent in the rice fields, giant garter snake used rice fields 39 to 60 percent of the time and canals 40 to 61 percent of the time. These results support that both rice fields and canals are important habitats for the species (Wylie and Casazza 2000a, 2000b).

Restored areas providing summer water were more effective in meeting the habitat needs of giant garter snake in the 2000-2001 study periods; therefore, giant garter snake did not have to venture as far as in previous years to find aquatic habitat during their active period. This was also found to be true for monitoring conducted during 2005. Sampling of the restored areas in Colusa NWR during the summers of 2002 and 2003 continued to document use of the restored wetland area as the habitat quality improves (USFWS 1999; Wylie and Casazza 2000a; Wylie et al. 2002).

The occurrence of rice agriculture, its supporting network of irrigation and drainage canals, and the restoration of marsh habitats currently provide suitable giant garter snake habitat. Research demonstrates, however, giant garter snake have not been able to disperse into all suitable habitats, and are largely restricted to areas near locations at which they were likely historically abundant (Halstead et al. 2016).

Central Valley Project Conservation Program (CVPCP) and Central Valley Project Improvement Act Habitat Restoration Program (HRP)

Developed during the Section 7 consultation process for the CVPIA and renewal of CVP water service contracts, the Central Valley Project Conservation Program (CVPCP) implements actions to protect, restore, and enhance special-status species populations and habitat, especially federally-listed species (USFWS 2015). Since the mid-1990s, the CVPCP and HRP have routinely identified and funded giant garter snake research and habitat improvement as top Priority Actions (USFWS 2015).

2.27 Soft Bird’s Beak

2.27.1 ESA Listing

U.S. Fish and Wildlife Service (USFWS) listed soft bird’s beak as an endangered species under ESA on November 20, 1997 (62 FR 61925).

2.27.2 Critical Habitat Designation

Critical habitat for soft bird's beak was designated in 2007 (72 FR 18536). The designated critical habitat areas contain physical and biological features (primary constituent elements [PCEs]) that are considered essential to the conservation of the species and that may require special management considerations and protection. The PCEs identified for soft bird's beak are: (1) persistent emergent, intertidal, estuarine wetland at or above the mean high-water line (as extended directly across any intersecting channels); (2)

rarity or absence of plants that naturally die in late spring (winter annuals); and (3) partially open spring canopy cover at ground level, with many small openings to facilitate seedling germination. In total, five critical habitat units covering approximately 2,276 acres (921 hectares) were designated. The critical habitat is located within Contra Costa, Napa, and Solano Counties at Fagan Slough Marsh, Hill Slough Marsh, Point Pinole Shoreline, Rush Ranch/ Grizzly Island Wildlife Area, and Southampton Marsh.

2.27.3 General Life-History and Habitat Requirements

Soft bird's beak is an annual herb of the snapdragon family (Scrophulariaceae). It grows 10 to 16 inches tall, branching sparingly from the middle and above. A floral bract (modified leaf) with two to three pairs of lobes occurs immediately below each inconspicuous white or yellowish-white flower. Flowers appear between May and September. Like other members of *Cordylanthus* and related genera, soft bird's beak is partially parasitic on the roots of other plants. Soft bird's beak is found predominantly in the upper reaches of salt grass/pickleweed marshes of the San Francisco Estuary at or near the limits of tidal action. It is associated with pickleweed (*Salicornia pacifica*), saltgrass (*Distichlis spicata*), fleshy or marsh jaumea (*Jaumea carnosa*), alkali seaheath (*Frankenia salina*) and seaside arrowgrass (*Triglochin maritima*).

2.27.4 Historical and Current Distribution and Abundance

Soft bird’s beak grows at the upper margin of tidal brackish high marshes in the San Francisco Estuary, often near the upper marsh–upland boundary (Grewell 2005; Grewell et al. 2007, p. 140). Where the topography is relatively uniform, soft bird’s beak is distributed in bands at the upper margin of the brackish high marsh. In Suisun Marsh, these bands are not correlated with elevation, but with soil pore water salinity during the dry season, which is determined by distance to channel and varies from season to season depending on freshwater flows from creeks draining into the marsh (Culberson 2001). Where the topography is more complex, such as areas with ridges or mounds and on levee banks, soft bird’s beak can be found in a variety of patch shapes (Grewell 2005; Grewell et al. 2007, p. 140). Plant distribution is influenced by a number of factors, including the existence of a persistent seed bank, the dispersal and germination dynamics of its floating seed, the extent of bare soil where seedlings can establish, the presence of appropriate long-lived annual or perennial host species, and the absence of dense populations of large, perennial, nonnative plant species (Grewell et al. 2003; Grewell 2005; Grewell et al. 2007, p. 143–144). The presence of a natural tidal inundation pattern is important, and the more muted the tidal influence is, such as tidal creeks with salt water exclusion gates or marshes with extensive levee systems, the less suitable the habitat is for soft bird’s beak (Grewell et al. 2003; Grewell 2005; Grewell et al. 2007, p. 140). A number of hypotheses have been suggested to explain the effects of the muted tidal influence, including increased rates of seed predation and herbivory by native insects, high densities of inappropriate host species, such as nonnative annual plants, and invasion and displacement by large nonnative plant species, such as perennial pepperweed (*Lepidium latifolium*) (Grewell 2005).

2.27.5 Limiting Factors, Threats, and Stressors

Threats to the subspecies include the destruction of habitat, erosion, the elimination or muting of tidal regimes, overgrazing and trampling by livestock, rooting by feral pigs, invasion of habitat by nonnative annual plants that are inappropriate hosts, recent invasion of its habitat by perennial pepperweed, alteration of salinity regimes, mosquito abatement, and oil spills (Fiedler et al. 2007; Grewell et al. 2003; Grewell 2005). Trampling and disturbance by cattle, feral pigs, and human foot traffic can directly damage plants and also damage the fragile root connections between soft bird’s beak and the host plants (U.S. Fish and Wildlife Service 2009a). Seed predation by moth larvae may be an important factor in population declines at sites in Suisun Marsh (Grewell et al. 2003; Fiedler et al. 2007). Climate change and sea level rise may change tidal regimes faster than species can react, leading to increased pressure on the soft bird’s beak.

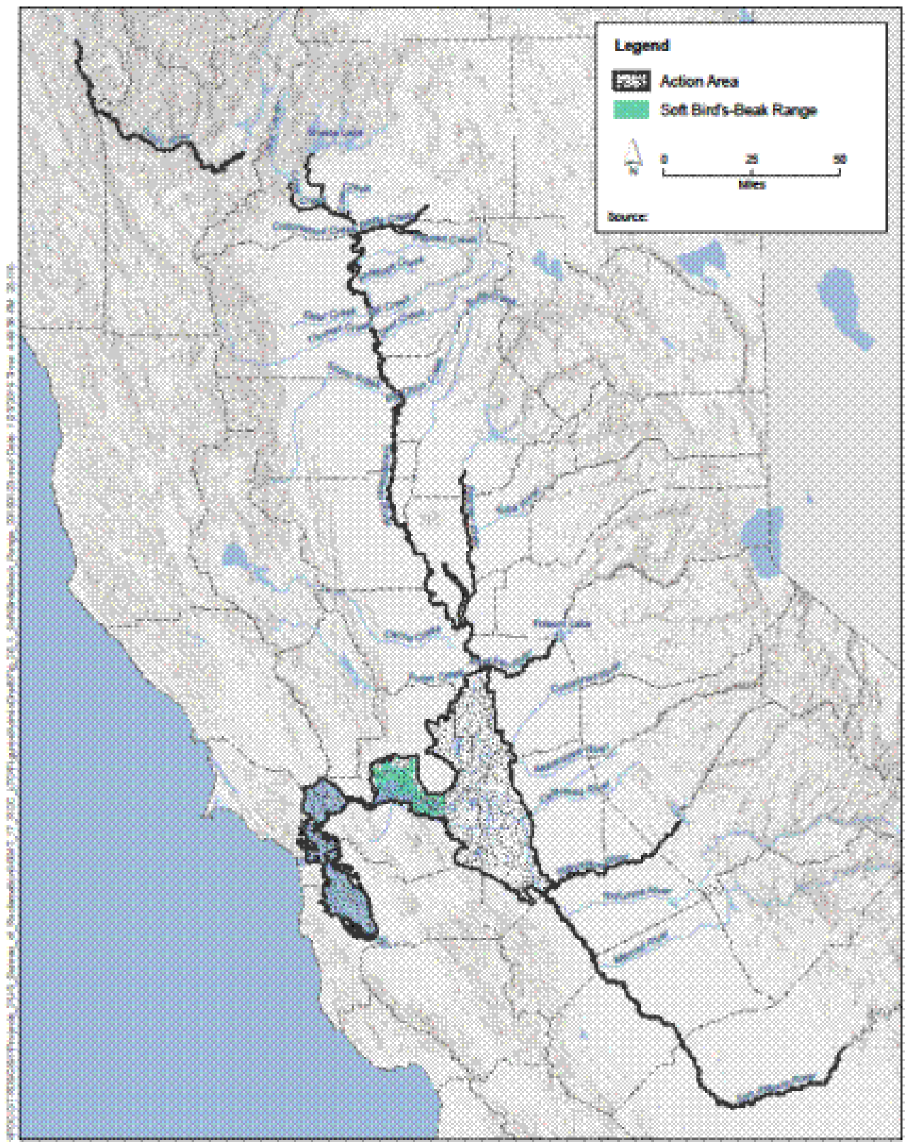


Figure 2.27-1. Soft Bird’s Beak Range

2.27.6 Recovery and Management

The status of soft bird's beak and information about its biology, ecology, distribution, and current threats is available in the *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (U. S. Fish and Wildlife Service 2013). The plan features soft bird's beak, along with four other endangered species.

There are two recovery units for this species, the Suisun Recovery Unit and the San Pablo Bay Recovery Unit. Downlisting of soft bird's beak would be achieved if the minimum area inhabited by the species in the Suisun Bay Area Recovery Unit is at least 3,000 acres and at least 1,000 acres in the San Pablo Bay Recovery Unit, over a period of 5 years. A minimum of 5,000 acres of suitable habitat in both recovery units must be permanently established. This must include existing or successfully restored tidal marsh areas with suitable habitat for the species and encompass a minimum of 80 percent of the species. Perennial pepperweed populations must be reduced to less than 10 percent cover in Suisun Marsh for 5 years, natural tidal cycles must be restored at Hill Slough, and the ponded area at Rush Ranch must be returned to periodic tidal flooding. There must be less than 10 percent total cover of other nonnative, invasive perennial or nonnative winter annual grass species.

2.28 Suisun Thistle

2.28.1 ESA Listing Status

USFWS listed Suisun thistle as an endangered species under ESA on November 20, 1997 (62 FR 61925).

2.28.2 Critical Habitat Designation

Critical habitat for Suisun thistle was designated in 2007 (72 FR 18536). The designated critical habitat areas contain physical and biological features (PCEs) that are considered essential to the conservation of the species, and that may require special management considerations and protection. The PCEs identified for Suisun thistle are: (1) persistent emergent, intertidal, estuarine wetland at or above the mean high-water line (as extended directly across any intersecting channels); (2) open channels that periodically contain moving water with ocean-derived salts in excess of 0.5 percent; and (3) gaps in surrounding vegetation to allow for seed germination and growth. In total, three critical habitat units covering approximately 2,052 acres (830 hectares) were designated. The critical habitat is located within Solano County at Hill Slough Marsh, Peytonia Slough Marsh, and Rush Ranch/ Grizzly Island Wildlife Area.

2.28.3 General Life-History and Habitat Requirements

Suisun thistle is a perennial herb in the aster family (Asteraceae). It has slender, erect stems that are 3.0 to 4.5 feet tall and well branched above. Pale, lavender-rose flower heads, 1 inch long, grow singly or in loose groups. Flowers appear between July and September. Suisun thistle grows in the upper reaches of tidal marshes of the San Francisco Estuary, where it is associated with narrowleaf cattail (*Typha angustifolia*), three-square or American bulrush (*Scirpus americanus*), Baltic rush (*Juncus balticus*), and saltgrass.

2.28.4 Historical and Current Distribution and Abundance

This species is known to exist only in Suisun Marsh and typically is found in the middle to high marsh zone along tidal channels and in irregularly flooded estuarine wetlands (Interagency Ecological Program 2001). One population occurs on California Department of Fish and Wildlife's (DFW's) Peytonia Slough Ecological Reserve. The remaining occurrences are associated with the Cutoff Slough tidal marshes and DFW's Joice Island Unit of the Grizzly Island Wildlife Management Area.

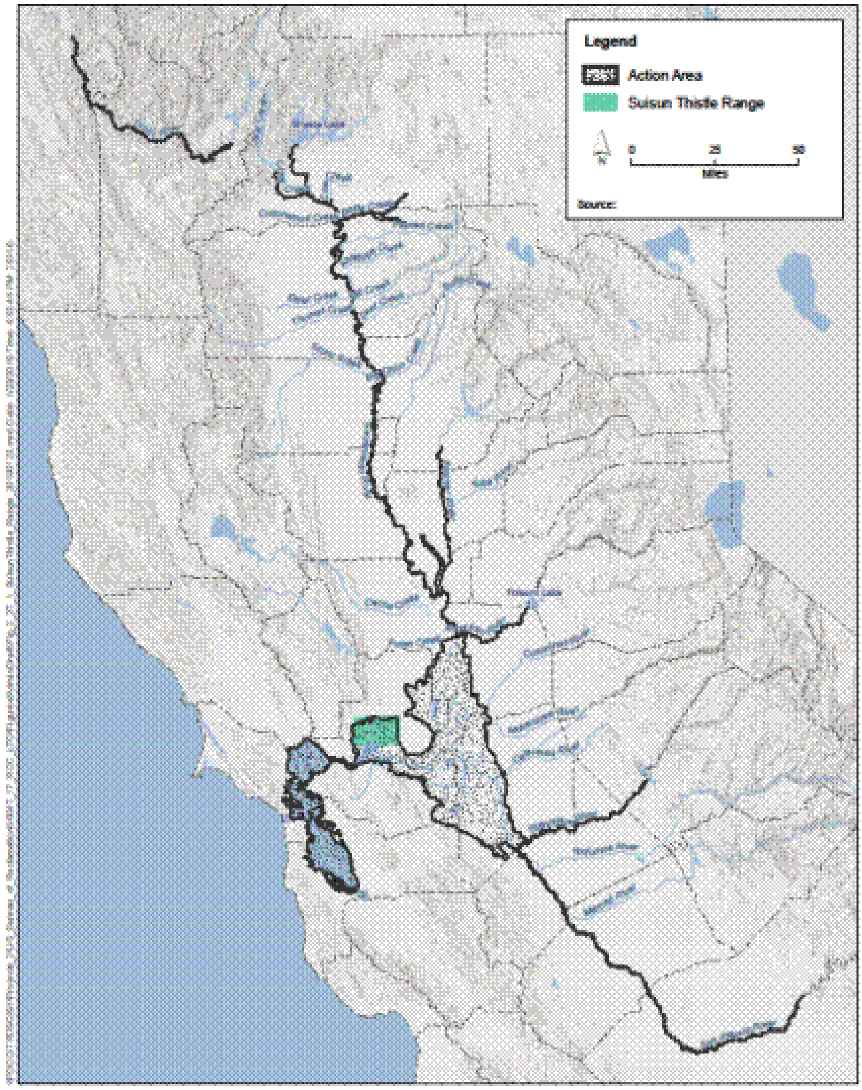


Figure 2.28-1. Suisun Thistle Range

2.28.5 Limiting Factors, Threats, and Stressors

Common threats that may require special management considerations or protections of the PCEs for Suisun thistle in all three critical habitat units include: (1) alterations to channel water salinity and tidal regimes from the operation of the Suisun Marsh Salinity Control Gates that could affect the depth, duration, and frequency of tidal events and the degree of salinity in the channel water column; (2) mosquito abatement activities (dredging, and chemical spray operations), which may damage the plants directly by trampling and soil disturbance, and indirectly by altering hydrologic processes and by providing relatively dry ground for additional foot and vehicular traffic; (3) rooting, wallowing, trampling, and grazing impacts from livestock and feral pigs that could result in damage or loss to Suisun thistle colonies, or in soil disturbance and compaction, leading to a disruption in natural marsh ecosystem processes; (4) the proliferation of nonnative invasive plants, especially perennial pepperweed, leading to the invasives outcompeting Suisun thistle; and (5) programs for the control or removal of nonnative invasive plants, which, if not conducted carefully, can damage Suisun thistle populations through the injudicious application of herbicides, by direct trampling, or through the accidental transport of invasive plant seeds to new areas. An additional threat that may require special management considerations or protection of the PCEs in Units 1 and 2 includes urban or residential encroachment from Suisun City to the north that could increase stormwater and wastewater runoff into these units. Alterations to channel water salinity and tidal regimes may also occur due to climate change and sea level rise.

2.28.6 Recovery and Management

The status of Suisun thistle and information about its biology, ecology, distribution, and current threats is available in the *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (U. S. Fish and Wildlife Service 2013). The plan features Suisun thistle along with four other endangered species. Supplemental or updated information is provided in USFWS's 2009 5-year review for Suisun thistle (U. S. Fish and Wildlife Service 2009b). In 2009, USFWS recommended no change in the classification of Suisun thistle.

USFWS intends to conserve the geographic areas containing the physical and biological features that are essential to the conservation of the species, through the identification of the appropriate quantity and spatial arrangement of the primary constituent elements sufficient to support the life-history functions of the species. Because not all life-history functions require all the primary constituent elements, not all areas designated as critical habitat will contain all the primary constituent elements.

Downlisting of Suisun thistle will be achieved if the median area inhabited by this species is 2,000 acres, a total of 4,000 acres or more is permanently preserved, perennial pepperweed populations are reduced to less than 10 percent cover in Suisun Marsh, natural tidal cycles are restored at Hill Slough, and the ponded area at Rush Ranch is returned to periodic tidal flooding.

2.29 Valley Elderberry Longhorn Beetle

2.29.1 ESA Listing Status

The valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) was listed as threatened by the USFWS in 1980 (45 FR 52803). A proposed rule to remove the species from federal listing was initiated in 2012 (77 FR 60237), and then withdrawn in 2014 due to habitat loss continuing to threaten the species (79 FR 55879).

2.29.2 Critical Habitat Designation

Critical habitat, designated at the time of listing in 1980 (45 FR 52803), includes two locations in Sacramento County along the American River where the densest known populations of the beetle occur. These areas are within the Action Area.

2.29.3 General Life-History and Habitat Requirements

The valley elderberry longhorn beetle is a small (0.5 to 0.8 inch) wood borer that depends on red or blue elderberry (*Sambucus* spp.) in every phase of its life cycle and is nearly always found on or close to its host plant along rivers and streams. Females are indistinguishable from the more widespread California elderberry longhorn beetle (*Desmocerus californicus californicus*). The elderberry is a common shrub component of riparian forests and adjacent nonriparian vegetation (valley oak and blue oak woodland, and annual grassland) along river corridors of the Central Valley.

Adult beetles feed on elderberry nectar, flowers, and foliage, and are generally active from March through June (77 FR 60237). As elderberry plants begin flowering in the spring, beetles begin to emerge from tunnels they bored as larvae through the shrub's pith, roaming the shrubs, eating foliage and possibly flowers, until they mate.

Adults live from a few days to a few weeks after emerging, during which time they mate and lay their eggs (Talley et al. 2006). The females lay eggs, singly or in small groups, on the leaves or stems of living elderberry shrubs (Barr 1991). The larvae hatch in a few days and bore into living stems that are at least 1 inch (2.5 cm) in diameter, where they remain within the elderberry stem, feeding on the pith until they complete their development (Talley et al. 2006). Larvae eventually cut an exit hole out of the stem, and then plug the hole up from within using wood shavings. This allows the beetle to eventually exit the stem after it becomes an adult, as adults are not wood borers. Within the stem, the larva becomes a pupa, and finally emerges from its single exit hole as an adult between mid-March and mid-June (77 FR 60237).

Shrub characteristics and other environmental factors appear to have an influence on use by the valley elderberry longhorn beetle, with more exit holes found in shrubs in riparian than in nonriparian habitat types (Talley et. al. 2006). Occupancy of elderberry shrubs varies based on elderberry condition, water availability, elderberry density, and the health of the riparian habitat, indicating that healthy riparian systems supporting dense elderberry clumps are the primary habitat of the beetle (Barr 1991; Talley et al. 2006; Talley et al. 2007). However, some studies have demonstrated that valley elderberry longhorn beetles prefer elderberry shrubs with low to moderate levels of damaged stems (USFWS 2014).

2.29.4 Historical and Current Distribution and Abundance

The valley elderberry longhorn beetle is endemic to the Central Valley of California in moist valley oak woodlands along the margins of rivers and streams in the lower Sacramento and San Joaquin Valleys where its obligate larval host plant, elderberry grows. At the time of listing in 1980, the beetle was known from less than 10 locations on the American River, Putah Creek, and Merced River (USFWS 2009). Subsequent surveys have documented a broader distribution of the species and now it is known to occur from southern Shasta County in the north to Fresno County in the south, including the valley floor and lower foothills, and is generally found below 500 feet (152 meters) above mean sea level (USFWS 2017).

Most of the approximately 270 CNDDB element occurrences are based on observations of exit holes in elderberry stems or branches rather than direct observation of individual beetles; many of these occurrences predate 1997, which was the most recent, comprehensive rangewide survey by observers known to be qualified to detect occupancy of valley elderberry longhorn beetle (CDFW 2018; USFWS 2014). There are approximately 130 known occurrences of valley elderberry longhorn beetle in the San Joaquin and Sacramento Valleys that have been documented since the 1997 comprehensive rangewide survey (CDFW 2018). These occurrences have been found within 18 watersheds at 36 geographic locations (USFWS 2014).

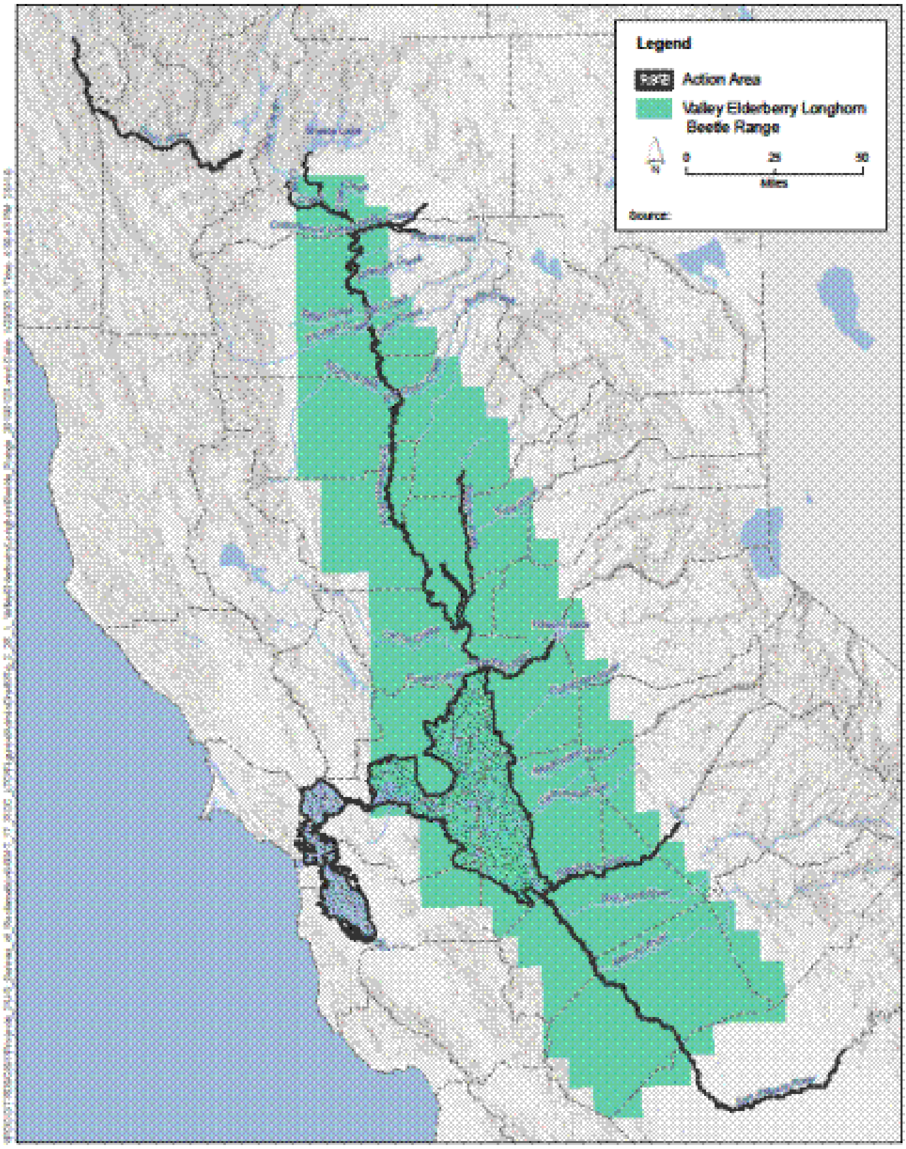


Figure 2.29-1. Valley Elderberry Longhorn Beetle Range

2.29.5 Limiting Factors, Threats, and Stressors

The valley elderberry longhorn beetle, though wide-ranging, is experiencing a long-term decline due to human activities that have resulted in widespread alteration and fragmentation of riparian habitats, and, to a lesser extent, upland habitats that support the beetle.

The primary threats to survival of the beetle include levee construction, stream and river channelization, removal of riparian vegetation, riprapping of shoreline, nonnative animals such as the Argentine ant (*Linepithema humile*), which may eat the early phases of the beetle, and recreational, industrial, and urban development. Insecticide and herbicide use in agricultural areas and along road right-of-ways may also be factors limiting the beetle's distribution.

Over the past 150 years, agricultural expansion and urbanization in the Central Valley increased. The need for water and flood protection spurred water development and reclamation projects, which reduced the expanse of riparian vegetation, including elderberry plants. Riparian vegetation was also removed for or impacted by the building of artificial levees and dams, river channelization, water diversion, and heavy groundwater pumping, thereby reducing these communities to small, isolated fragments.

Based on valley elderberry longhorn beetle research, this species occurs throughout the Central Valley in metapopulations, or discrete subpopulations that exchange individuals through dispersal or migration (Collinge et al. 2001). The subpopulations may shift spatially and temporally within riparian drainages, resulting in a patchwork of occupied and unoccupied habitat (USFWS 2017e). Valley elderberry longhorn beetles have limited dispersal capabilities, making it difficult to colonize unoccupied habitat areas. Therefore, the preservation of contiguous areas of suitable habitat is important for the longevity of this species. Climate change may change riparian flow regimes, which could remove valley elderberry longhorn beetle habitat and create it elsewhere, without the opportunity for the beetle to disperse to the new habitat.

Small population numbers of valley elderberry longhorn beetle host plants, and even lower numbers of occupied host plants, constitute a threat to the beetle at many locations, which, in turn, may result in small beetle population sizes. Additionally, low mobility, very small local populations, and isolation of habitat patches make beetle populations especially susceptible to extirpation with little chance of recolonization (Talley et al. 2006).

2.29.6 Recovery and Management

When the *Valley Elderberry Longhorn Beetle Recovery Plan* was developed (USFWS 1984), little information regarding the beetle's life history, distribution, and habitat requirements was available to develop specific recovery objectives. The recovery plan did not include recovery criteria, but did include primary interim objectives that have since been at least partially met and include increased surveys, management of additional areas where the beetles have been identified, and some protections afforded to habitat areas (USFWS 2012). The majority of the beetle's habitat along the Lower American River has been protected as part of the American River Parkway that includes both designated critical habitat and essential habitat (USFWS 2012).

Although riparian vegetation in the Central Valley has declined over time, a number of areas have been restored to accommodate the habitat needs and recovery of the valley elderberry longhorn beetle (that is, riparian vegetation that specifically contains elderberry shrubs). In the years since the time of listing, known locations of the beetle have increased through continued survey efforts, with a resultant significantly greater range size than was originally listed (USFWS 2012). In 2012, the USFWS proposed delisting the beetle from its threatened status under the ESA based on this increase, as well as past and ongoing riparian vegetation restoration and the persistence of elderberry shrubs in restored areas. However, the proposal was withdrawn in 2014 (79 FR 55879) because continued data acquisition indicated that threats to the species and its habitat have not been reduced to the point where the species no longer meets the statutory definition of a threatened species.

2.30 Vernal Pool Fairy Shrimp

2.30.1 ESA Listing Status and Critical Habitat Designation

Vernal pool fairy shrimp (*Branchinecta lynchi***)** is listed as threatened under the ESA throughout its range (59 FR 48136). In September 2007, the USFWS published a 5-year review recommending that the species remain listed as threatened. On May 25, 2011, USFWS initiated a new 5-year review to determine if the species should be listed as endangered.

The final rule designating critical habitat for vernal pool fairy shrimp was published in the *Federal Register* on February 10, 2006 (71 FR 7118–7316). There is no designated critical habitat for vernal pool fairy shrimp within the action area.

2.30.2 General Life History and Habitat Requirements

Vernal pool fairy shrimp is entirely dependent the temporary waters of natural vernal pool and playa pool ecosystems, as well as the artificial environments of ditches and tire ruts (King et al. 1996; Helm 1998; Eriksen and Belk 1999). The temporary waters fill directly from precipitation and from surface runoff and perched groundwater from their watersheds (Williamson et al. 2005; Rains et al. 2006, 2008; O'Geen et al. 2008). The watershed extent needed to maintain hydrological function of the temporary waters depends on the hydrologic conductivity of the surface soil horizons, the continuity and extent of hardpans and claypans underlying nonclay soils, the existence of a perched aquifer overlying the pans, slope, effects of vegetation on evapotranspiration rates, compaction of surface soils by grazing animals, and other factors (Marty 2005; Pyke and Marty 2005; Williamson et al. 2005; Rains et al. 2006, 2008; O'Geen et al. 2008). Temporary waters that are habitat for the vernal pool fairy shrimp range from low to moderate alkalinity (King et al. 1996; Eriksen and Belk 1999). Vernal pool fairy shrimp commonly co-occur with other fairy shrimp and vernal pool tadpole shrimp (*Lepidurus packardi*) (USFWS 2005).

Vernal pool fairy shrimp cysts can remain dormant in the soil when their habitats are dry. When the pools refill in the same or subsequent seasons, the cysts may hatch. The cyst bank in the soil may comprise cysts from several years of breeding (USFWS 2005, 2007). Beyond inundation of the habitat, the specific cues for hatching are unknown, although temperature and conductivity (solute concentration) are believed to play a large role (Helm 1998; Eriksen and Belk 1999).

In a study using large plastic pools to simulate natural vernal pools, Helm found that vernal pool fairy shrimp can reproduce in as early as 18 days following hatching, with the average being 40 days (Helm 1998). Site-specific conditions, primarily water temperature, have been shown to affect time to reach reproductive maturity (Helm 1998).

2.30.3 Historical and Current Distribution and Abundance

There is little information on the historical range of vernal pool fairy shrimp. The species currently occurs in a wide range of vernal pool habitats in the southern and Central Valley areas of California, and at two sites in Jackson County, Oregon (USFWS 2005). It is currently found at locations across the Central Valley from Shasta County to Tulare and Kings Counties, in the central and southern Coast Ranges from Napa County to Los Angeles County, and inland in western Riverside County, California (USFWS 2005, 2007; CDFW 2019). There are 191 CNDDB element occurrences for vernal pool fairy shrimp in the action area (CDFW 2019).

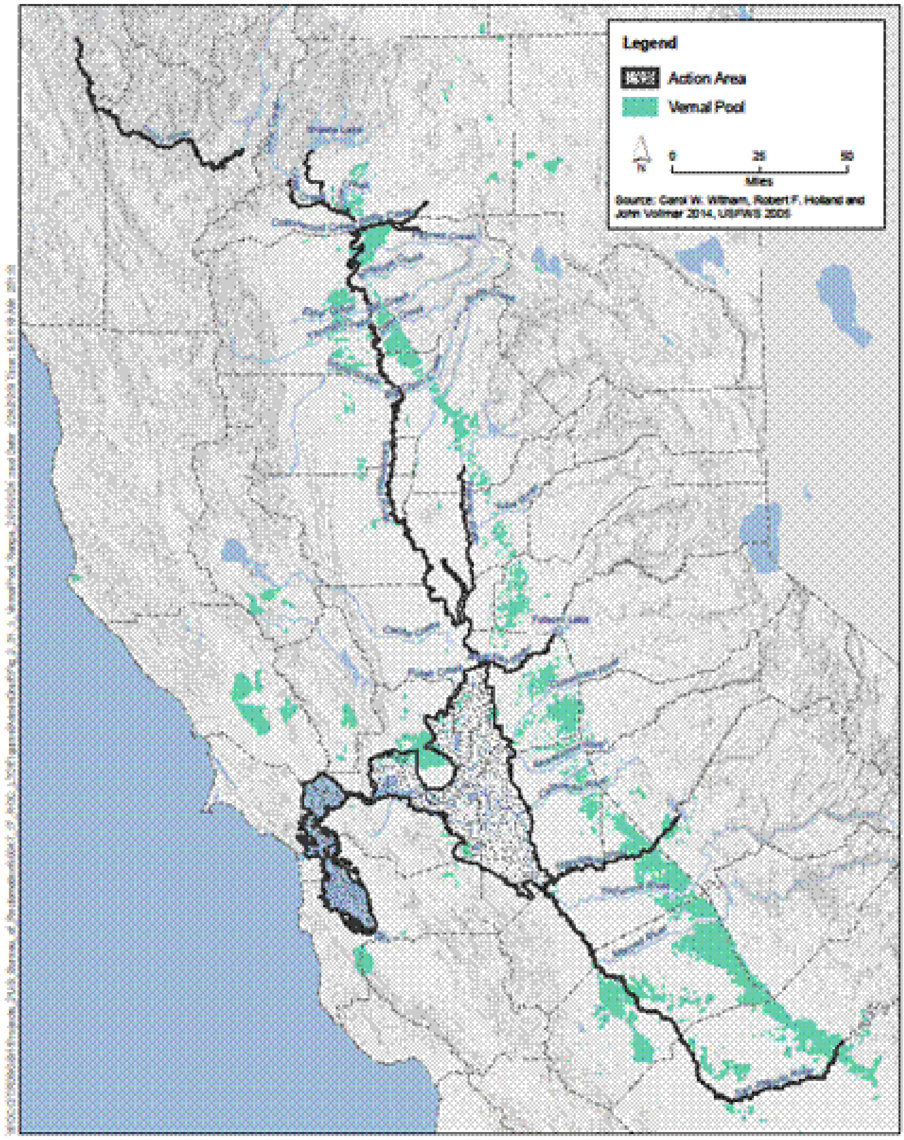


Figure 2.30-1. Vernal Pool Range

2.30.4 Limiting Factors, Threats, and Stressors

Threats to vernal pool habitat and vernal pool branchiopods in general, as well as specific threats to vernal pool fairy shrimp, are described in the *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon* (USFWS 2005, 2007). Habitat loss and fragmentation are the largest threats to the survival and recovery of vernal pool species. Habitat loss generally is a result of agricultural conversion from rangelands to more developed land uses, while habitat fragmentation results from activities such as road development and other infrastructure projects (USFWS 2005).

Within habitat, grazing practices affect habitat quality. Inappropriate grazing practices include complete elimination of grazing in areas where nonnative grasses dominate the uplands surrounding vernal pools, and inappropriate timing or intensity of grazing. Appropriate grazing regimes help control nonnative weed plants such as Italian ryegrass (*Lolium multiflorum*) and waxy mannagrass (*Glyceria declinata*), which, if unchecked, can increase thatch buildup, decrease ponding durations, and decrease the aquatic habitat available to the vernal pool fairy shrimp (USFWS 2007).

Human disturbances and changes in land use practices can alter the hydrology of temporary waters and result in a change in the timing, frequency, or duration of inundation in vernal pools, which can create conditions that render existing vernal pools unsuitable as habitat for vernal pool species (USFWS 2005).

Climate change affects vernal pool hydrology through changes in the amount and timing of precipitation inputs to vernal pools and the rate of loss through evaporation and evapotranspiration. It is unknown at this time if climate change in California is causing localized cooling and drying, or warming with higher precipitation. Either scenario might result in adverse effects on vernal pool invertebrate species. Cooling and drying trends could adversely affect vernal pool fairy shrimp through decreased inundation periods that do not allow the species sufficient time to complete its life cycle. A warming trend could increase inundation periods, but could also increase temperatures above levels needed for the species to hatch or reproduce (USFWS 2007).

Specific threats to vernal pool fairy shrimp habitat include the following (USFWS 2005).

- More than half of the known populations are threatened by development or agricultural conversion. Several populations are found on military bases, and although not an immediate threat, military activities can result in alteration of pool characteristics, including introduction of nonnative plant species (USFWS 2005, 2007).

- In the Livermore Vernal Pool Region, the vernal pool fairy shrimp is located primarily on private land, where it is threatened by development, including expansion of the Byron Airport.

- In the Northeastern Sacramento Valley Vernal Pool Region, most of the known occurrences are located on California Department of Transportation (Caltrans) rights-of-way and are thus threatened by various future road improvement projects in this region, particularly the future expansion of State Route 99. Additional populations are threatened by commercial and residential development projects.

- Some occurrences on private land in the Northwestern Sacramento Vernal Pool Region may be threatened by agricultural conversion or development.

- In the Southern Sacramento Vernal Pool Region, the vernal pool fairy shrimp is threatened by urban development. Both Sacramento and Placer Counties are currently developing habitat conservation plans to address growth in the region.

- In the San Joaquin Valley Region, the vernal pool fairy shrimp is found primarily on private land where it is threatened by direct habitat loss, including urban development and agricultural conversion.

- In the Solano-Colusa Region, the vernal pool fairy shrimp is threatened by development on the private property where it occurs.

2.30.5 Recovery and Management

The Collinsville, Altamont Hills, and Jepson Prairie core recovery areas, which were developed in part for the recovery of the vernal pool fairy shrimp, encompass both designated critical habitat and essential habitat (USFWS 2005). Other recovery areas include the Western Riverside County and Santa Barbara vernal pool regions. For both regions, the recovery and management strategies involve protecting and reestablishing vernal pool habitat (USFWS 2005).

2.31 Vernal Pool Tadpole Shrimp

2.31.1 ESA Listing Status and Critical Habitat Designation

Vernal pool tadpole shrimp (*Lepidurus packardi*) was listed as endangered throughout its range under the ESA on September 19, 1994 (59 FR 48136). In September 2007, USFWS published a 5-year review recommending that the species remain listed as endangered. On May 25, 2011, USFWS initiated a new 5-year review to determine if the species should remain listed as endangered.

Critical habitat for vernal pool tadpole shrimp was designated on February 10, 2006 (71 FR 7118–7316) and does not occur in the action area.

2.31.2 General Life History and Habitat Requirements

Vernal pool tadpole shrimp occur in a variety of seasonal habitats, including vernal pools, ponded clay flats, alkaline pools, ephemeral stock tanks, and roadside ditches. Habitats where vernal pool tadpole shrimp have been observed range in size from small (less than 25 square feet), clear, vegetated vernal pools to large (more than 100 acres) winter lakes (Helm 1998:134–138; Rogers 2001:1002–1005). These habitats must dry out and be inundated again for the vernal pool tadpole shrimp cysts to hatch. This species has not been reported in pools that contain high concentrations of sodium salts, but may occur in pools with high concentrations of calcium salts (Helm 1998:134–138; Rogers 2001:1002–1005).

Vernal pool tadpole shrimp commonly co-occur with other fairy shrimp (U.S. Fish and Wildlife Service 2005).

Vernal pool tadpole shrimp cysts can remain dormant in the soil when their vernal pool habitats are dry. When the pools refill in the same or subsequent seasons, the cysts may hatch. The cyst bank in the soil may comprise cysts from several years of breeding (U.S. Fish and Wildlife Service 2005, 2007). Beyond inundation of the habitat, the specific cues for hatching are unknown, although temperature and conductivity (solute concentration) are believed to play a large role (Helm 1998; Eriksen and Belk 1999).

In a study using large plastic pools to simulate natural vernal pools, Helm found that vernal pool tadpole shrimp can reproduce as early as 41 days following hatching with the average being 54 days (Helm 1998). Site-specific conditions, primarily water temperature, have been shown to affect time to reach reproductive maturity (Helm 1998).

Vernal pool tadpole shrimp have relatively high reproductive rates and may be hermaphroditic. Sex ratios can vary, perhaps in response to changes in water temperature (Ahl 1991). Genetic variation among vernal pool tadpole shrimp corresponds with differences between sites in physical and chemical aspects of the pool habitat (depth, surface area, solutes concentration, elevation, and biogeographic region), and species richness is positively correlated with both depth and surface area (King et al. 1996). Vernal pool crustaceans generally have low rates of gene flow between separated sites, which is probably a result of the spatial isolation of their habitats and their reliance on passive dispersal mechanisms. Gene flow between pools within the same vernal pool complex is much higher, indicating that vernal pool tadpole shrimp populations are defined by vernal pool complexes rather than by individual vernal pools (USFWS 2005).

2.31.3 Historical and Current Distribution and Abundance

Historically, vernal pool tadpole shrimp probably did not occur outside of the Central Valley and Central Coast regions (USFWSe 2005). Currently, vernal pool tadpole shrimp occur in the Central Valley of California and in the San Francisco Bay Area. The species has a patchy distribution across the Central Valley from Shasta County southward to northwestern Tulare County (USFWS 2007). In the Central Coast Vernal Pool Region, the vernal pool tadpole shrimp is found the San Francisco National Wildlife Refuge and on private land in Alameda County near Milpitas (USFWS 2007; CDFW 2019). The largest concentration of vernal pool tadpole shrimp occurrences is found in the Southeastern Sacramento Vernal Pool Region, where the species occurs on a number of public and private lands in Sacramento County (USFWS 2005, 2007). There are 136 occurrences of vernal pool tadpole shrimp in the action area (CDFW 2019).

2.31.4 Limiting Factors, Threats, and Stressors

Threats to vernal pool habitat and vernal pool branchiopods in general, as well as specific threats to vernal pool tadpole shrimp, are identified in the Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon (USFWS 2005). Habitat loss and fragmentation are the largest threats to the survival and recovery of vernal pool species. Habitat loss generally is a result of agricultural conversion from rangelands to more developed land uses, while habitat fragmentation results from activities such as road development and other infrastructure projects (USFWS 2005).

Within habitat, grazing practices affect habitat quality. Inappropriate grazing practices include complete elimination of grazing in areas where nonnative grasses dominate the uplands surrounding vernal pools, and inappropriate timing or intensity of grazing. Appropriate grazing regimes help control nonnative weed plants such as Italian ryegrass (*Lolium multiflorum*) and waxy mannagrass (*Glyceria declinata*), which if unchecked can increase thatch buildup and decrease ponding durations and decrease the aquatic habitat available to the vernal pool tadpole shrimp (USFWS 2007).

Human disturbances and changes in land use practices can alter the hydrology of temporary waters and result in a change in the timing, frequency, or duration of inundation in vernal pools, which can create conditions that render vernal pools unsuitable as habitat for vernal pool species (USFWS 2005).

Climate change affects vernal pool hydrology through changes in the amount and timing of precipitation inputs to vernal pools and the rate of loss through evaporation and evapotranspiration. It is unknown at this time if climate change in California is causing localized cooling and drying, or warming with higher precipitation. Either scenario might result in adverse effects on vernal pool invertebrate species. Cooling and drying trends could adversely affect vernal pool tadpole shrimp through decreased inundation periods that do not allow the species sufficient time to complete its life cycle. A warming trend could increase inundation periods, but could also increase temperatures above levels needed for the species to hatch or reproduce (USFWS 2007).

Specific threats to vernal pool tadpole shrimp habitat include the following (USFWS 2005).

- Encroachment of nonnative annual grasses on the San Francisco Bay National Wildlife Refuge in the Central Coast Region, and urban development on private land in Alameda County.
- In the Northeastern Sacramento Valley Region, most of the known occurrences of the vernal pool tadpole shrimp are on Caltrans rights-of-way, where they continue to be threatened by road improvement projects related to general urban growth.
- In the Northwestern Sacramento Valley Vernal Pool Region, the vernal pool tadpole shrimp is threatened by development on the few sites on private land where it is known to occur.
- In the Southeastern Sacramento Vernal Pool Region, extant populations of the vernal pool tadpole shrimp are threatened by continued extensive urban development.
- In the San Joaquin Vernal Pool Region, the species is threatened by development on private land.
- In the Solano-Colusa Region, the species is threatened by urbanization on private lands.
- In the Southern Sierra Foothills Vernal Pool Region, the species is threatened by development of the University of California, Merced campus, which will likely contribute to significant growth in the region. Populations on the Stone Corral Ecological Reserve may be threatened by pesticide drift from adjacent farmlands.

2.31.5 Recovery and Management

The Collinsville, Altamont Hills, and Jepson Prairie core recovery areas, which were developed in part for the recovery of the vernal pool tadpole shrimp, encompass both designated critical habitat and essential habitat (USFWS 2005).

2.32 California Tiger Salamander

2.32.1 ESA Listing Status and Critical Habitat Designation

The USFWS listed the Central California DPS of California tiger salamander (which overlaps with the proposed action) as threatened on August 4, 2004 (50 FR 47212–47248). California tiger salamander is also listed as threatened under the California Endangered Species Act (CESA). On August 23, 2005, the USFWS designated approximately 199,109 acres (80,576 hectares) of critical habitat for the Central Valley DPS. The critical habitat is located in 19 California counties (70 FR 49380). No critical habitat overlaps with the action area.

2.32.2 General Life-History and Habitat Requirements

California tiger salamander is found in annual grasslands and open woodland communities in lowland and foothill regions of central California, where aquatic sites are available for breeding (USFWS 2003). The species is typically found at elevations below 1,509 feet (68 FR 13498), although the known elevational range extends up to 3,455 feet (Jennings and Hayes 1994). Ecological characteristics of this area include dry soils, needlegrass grasslands, valley oaks, coast live oaks, and ephemerally flooded claypan vernal pools (USFWS 2003).

Adult California tiger salamanders are terrestrial and spend much of the year (6 to 9 months) in the underground burrows of small mammals, such as California ground squirrels (*Spermophilus beecheyi*) and Botta's pocket gopher (*Thomomys bottae*), in grassland and open woodland habitats (Storer 1925;

Loredo and van Vuren 1996; Petranka 1998). Active rodent burrow systems are considered an important component of California tiger salamander upland habitat (Loredo et al. 1996; USFWS 2013b). Active ground-burrowing rodent populations are probably necessary to sustain California tiger salamander populations because inactive burrow systems begin to deteriorate and collapse over time (Loredo et al. 1996). In a 2-year radiotelemetry project in Monterey County, Trenham (2001) found that salamanders preferentially used open grassland and isolated oaks; salamanders present in continuous woody vegetation were never more than 10 feet from open grassland, potentially because ground squirrels prefer to construct burrows in open habitats (Jameson and Peeters 1988, as cited in Trenham 2001).

Vernal pools and other seasonal rain pools are the primary breeding habitat of California tiger salamanders (Barry and Shaffer 1994; 68 FR 13498). Because the species requires at least 10 weeks of pool inundation to complete metamorphosis of larvae (Anderson 1968; East Contra Costa County Habitat Conservancy 2006), California tiger salamanders are usually only found in the largest vernal pools (Laabs et al. 2001). The species is also known to successfully reproduce in ponds (Barry and Shaffer 1994; 69 FR 47212). In the East Bay Regional Park District in Contra Costa and Alameda Counties, California tiger salamanders breed almost exclusively in seasonal and perennial stock ponds (Bobzien and DiDonato 2007). However, the presence of predatory fish and bullfrogs (*Rana catesbeiana*) can affect the habitat suitability of perennial ponds (Holomuzki 1986; Fitzpatrick and Shaffer 2004). Barry and Shaffer (1994) note that perennial stock ponds can be productive breeding sites as long as they are drained annually, which can prevent predatory species from establishing.

Adult California tiger salamanders move from subterranean refuge sites to breeding pools during relatively warm late winter and spring rains (Jennings and Hayes 1994:12). Breeding generally occurs from December through March (Stebbins 2003:154). Development through metamorphosis requires 3 to 6 months (69 FR 47215). Metamorphosed juveniles leave their ponds in the late spring or early summer and move to terrestrial refuge sites before seasonal ponds dry (Loredo et al. 1996:282).

The distance between occupied upland habitat and breeding sites depends on local topography and vegetation, and the distribution of California ground squirrel or other rodent burrows (WRA Environmental 2005; Cook et al. 2006). While juvenile California tiger salamanders have been observed to disperse up to 1.6 miles from breeding pools to upland areas (Austin and Shaffer 1992) and adults have been observed up to 1.2 miles from breeding ponds, most movements are closer to the breeding pond. Trenham et al. (2001) observed California tiger salamanders moving up to 0.42 mile between breeding ponds in Monterey County. Similarly, Shaffer and Trenham (2005) found that 95 percent of California tiger salamanders resided within 0.4 mile of their breeding pond at Jepson Prairie in Solano County.

Interconnectivity of breeding sites may be an important factor in long-term conservation of this species in order to sustain the species' metapopulation structure, where local extinction and recolonization by migrants of other subpopulations are probably common (69 FR 47212). Thus, providing movement corridors between potential breeding sites and avoiding isolation of these sites may counterbalance the effects of normal ecological processes (e.g., drought) that may result in local extinctions by allowing for movements to new sites and facilitating recolonization (Semlitsch et al. 1996).

2.32.3 Historical and Current Distribution and Abundance

Historically, California tiger salamander occurred throughout the grassland and woodland areas of the Sacramento and San Joaquin River Valleys and surrounding foothills, and in the lower elevations of the central Coast Ranges (Barry and Shaffer 1994). The species is found in a relatively dry landscapes where its range is limited by its aestivation and winter breeding habitat requirements, which are generally defined as open grassland landscapes with ephemeral pools and with ground squirrel and pocket gopher burrows (Barry and Shaffer 1994).

Within the coastal range, the species currently occurs from southern San Mateo County south to San Luis Obispo County, with isolated populations in Sonoma and northwestern Santa Barbara Counties (CDFW 2013). In the Central Valley and surrounding Sierra Nevada foothills, the species occurs from northern Yolo County southward to northwestern Kern County and northern Tulare and Kings Counties (CDFW 2013).

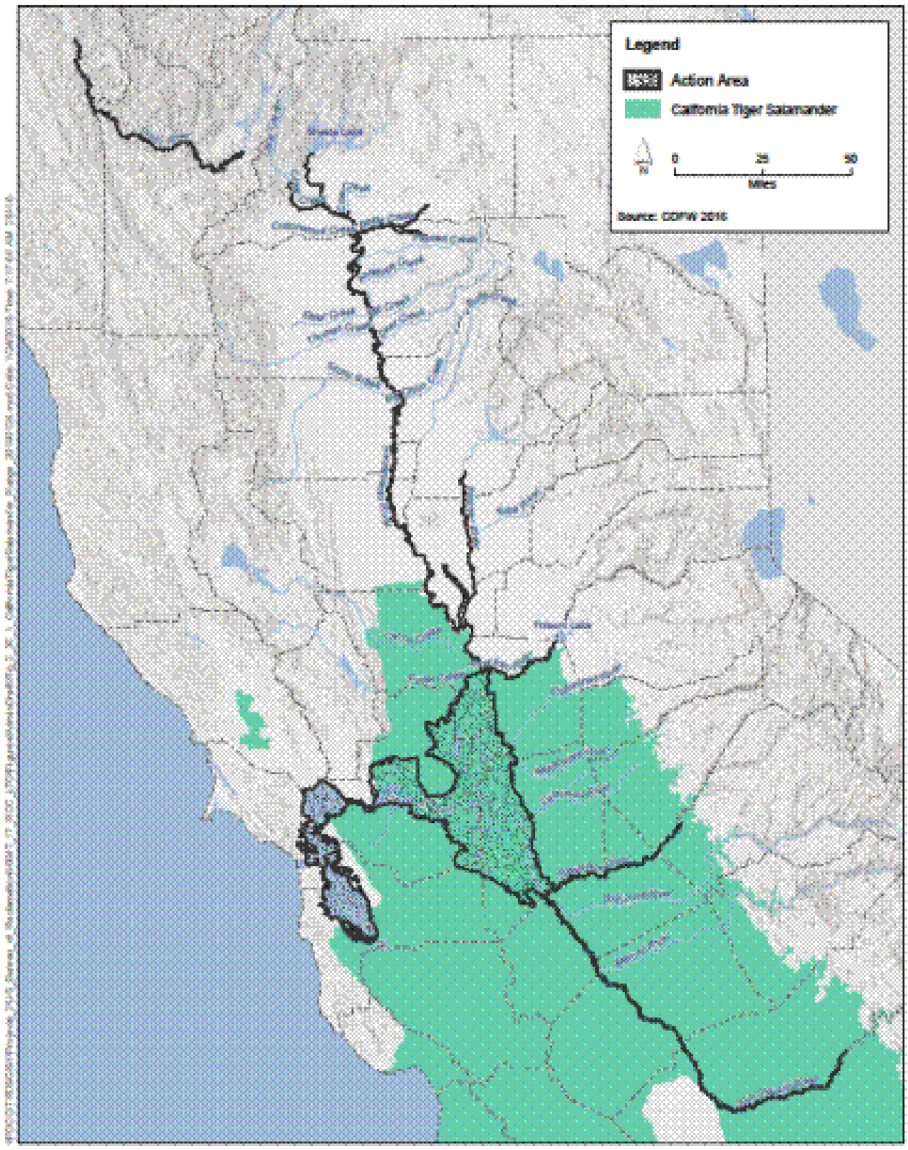


Figure 2.32-1. California Tiger Salamander Range

2.32.4 Limiting Factors, Threats, and Stressors

Conversion of land to residential, commercial, and agricultural activities is considered the most significant threat to California tiger salamanders, resulting in destruction and fragmentation of upland and/or aquatic breeding habitat and killing of individual California tiger salamanders (Twitty 1941; Shaffer et al. 1993; Jennings and Hayes 1994; Fisher and Shaffer 1996; Loredo et al. 1996; Davidson et al. 2002; CDFW 2010). Roads can fragment breeding habitats and dispersal routes in areas where they traverse occupied habitat. Features of road construction, such as solid road dividers, can further impede migration, as can other potential barriers such as berms, pipelines, and fences.

Exotic species, such as bullfrog, mosquitofish (*Gambusia affinis*), sunfish species (e.g., largemouth bass [*Micropterus salmoides*] and bluegill [*Lepomis macrochirus*]), catfish (*Ictalurus* spp.), and fathead minnows (*Pimephales promelas*), that live in perennial ponds such as stock ponds are considered to have negatively affected California tiger salamander populations by preying on larval salamanders (Anderson 1968; Shaffer et al. 1993; Fisher and Shaffer 1996; Lawler et al. 1999; Laabs et al. 2001; Leyse 2005; USFWS 2013b). Hybridization with the barred tiger salamander (*Ambystoma tigrinum mavortium*) is also a threat to this species, although it is unlikely that hybridization or nonnative alleles occur in California tiger salamander populations found in the action area, and hybridization does not appear to be a serious threat in this area (Reclamation and DWR 2013; Riley et al. 2003; Fitzpatrick et al. 2009).

Pesticides, hydrocarbons, and other pollutants are all thought to negatively affect breeding habitat, while rodenticides used in control of burrowing mammals (e.g., chlorophacinone, diphacinone, strychnine, aluminum phosphide, carbon monoxide, and methyl bromide) are considered toxic to adult salamanders (Salmon and Schmidt 1984). California ground squirrel and pocket gopher control operations may have the indirect effect of reducing the availability of upland burrows for use by California tiger salamanders (Loredo-Prendeville et al. 1994).

2.32.5 Recovery and Management

The strategy to recover the Central California tiger salamander focuses on alleviating the threat of habitat loss and fragmentation to increase population resiliency (ensure each population is sufficiently large to withstand stochastic events), redundancy (ensure a sufficient number of populations to provide a margin of safety for the species to withstand catastrophic events), and representation (conserve the breadth of the genetic makeup of the species to conserve its adaptive capabilities) (USFWS 2017). Recovery of this species can be achieved by addressing the conservation of remaining aquatic and upland habitat that provides essential connectivity, reduces fragmentation, and sufficiently buffers against encroaching development and intensive agricultural land uses. Appropriate management of these areas will also reduce mortality by addressing non-habitat related threats, including those from nonnative and hybrid tiger salamanders, other nonnative species, disease, and road mortality (USFWS 2017).

The range of the Central California tiger salamander has been classified into four recovery units: the Central Valley Unit, Southern San Joaquin Valley Unit, Bay Area Unit, and Central Coast Range Unit. The proposed action occurs within the Central Valley Unit, which comprises 12 Management Units across Yolo, Sacramento, Solano, eastern Contra Costa, northeast Alameda, San Joaquin, Stanislaus, Merced, western Amador, western Calaveras, and northwestern Madera Counties. The closest Management Unit to components of the proposed action is the Jepson Prairie Management Unit, located northeast of the Hills Slough Restoration project.

2.33 California Least Tern

2.33.1 ESA Listing Status and Critical Habitat Designation

The USFWS listed the California least tern as endangered on October 13, 1970 (35 FR 8491). California least tern is also listed as endangered under the CESA. On August 23, 2005, the USFWS designated approximately 199,109 acres (80,576 hectares) of critical habitat for the Central Valley DPS. Critical habitat has not been designated for this species.

2.33.2 General Life-History and Habitat Requirements

California least terns nest in loose colonies on barren or sparsely vegetated sandy or gravelly substrates above the high tide line along the coastline and in lagoons and bays of the California coast. Colonies are always near water that provides foraging opportunities. Foraging typically occurs in shallow estuaries or lagoons (Thompson et al. 1997; USFWS 2006d).

California least terns are migratory and are present at nesting areas from mid-April to late September (Anderson and Rigney 1980; Patton 2002). Courtship generally occurs during April and May and usually takes place away from the nesting area on exposed tidal flats or beaches. Nesting begins by mid-May (Massey 1981). Clutch size ranges from one to four eggs but usually consists of two or three eggs, with a single brood raised each year. Incubation is usually 20 to 25 days, and young are fledged by 28 days. The young continue to depend on adults for an additional 2 weeks (Rigney and Granholm 2005). Wintering areas are largely unknown, but are suspected to be along the Pacific Coast of Central and South America (Massey 1977). In the San Francisco Bay Area and Suisun Bay, nesting colonies are typically located in abandoned salt ponds and along estuarine shores, often using artificially or incidentally created habitat (Rigney and Granholm 2005; Marschalek 2008). Foraging occurs in the bay or large river estuaries.

California least terns select nesting colony sites that are free of human or predatory disturbance and are located in proximity to a foraging area. The availability of such sites is a limiting factor for the species. California least terns roost on the ground. Nest sites are shallow depressions without nesting material, typically in barren sandy or gravelly substrate. Prior to egg-laying, adults generally roost away from nest sites, from 0.25 mile at coastal sites to several miles at estuarine sites. This behavior is thought to be a form of predator avoidance (USFWS 2006d).

California least terns are very gregarious and nest, feed, roost, and migrate in colonies. They are highly sensitive to nest disturbance and will readily abandon nest sites if disturbed (Davis 1974, as cited in Rigney and Granholm 2005).

The California least tern feeds in shallow estuaries and lagoons for small fish, including anchovies (*Engraulis* spp.), silversides (*Atherinops* spp.), and shiner surfperch (*Cymatogaster aggregata*) (Rigney and Granholm 2005). It hovers above the water, then plunges but does not completely submerge. It will also forage in the shallow tidal zone of the open ocean and in bays (Rigney and Granholm 2005).

2.33.3 Historical and Current Distribution and Abundance

The historical breeding range of the California least tern extends along the Pacific Coast from approximately Moss Landing to the southern tip of Baja California (Grinnell and Miller 1944). However, since about 1970, colonies have been reported north to San Francisco Bay (USFWS 2006d). The nesting range in California is somewhat discontinuous as a result of the availability of suitable estuarine shorelines, where California least terns often establish breeding colonies. Marschalek (2006) identified six geographic population clusters along the Pacific Coast in California, including San Diego, Camp Pendleton, Los Angeles/Orange County, Ventura County, San Luis Obispo/Monterey County, and San Francisco Bay. The majority of the California population is concentrated in three counties: San Diego, Orange, and Los Angeles.

Statewide surveys in 2016 estimated 3,989 to 4,661 breeding pairs that established 4,746 nests and produced approximately 1,612 to 2,000 fledglings at 50 breeding sites across California (Frost 2017). Of these, only five breeding sites supporting a total of 570 nests (12 percent of the total) were reported from the San Francisco Bay Area (Frost 2017). Statewide, the growth of the breeding population has been dramatic since state and federal listing of the California least tern, from only several pairs in the late 1960s to a current minimum of 3,989 pairs in 2016 (Frost 2017), 4,202 in 2015 (Frost 2016), and 4,232 in 2014 (Frost 2015).

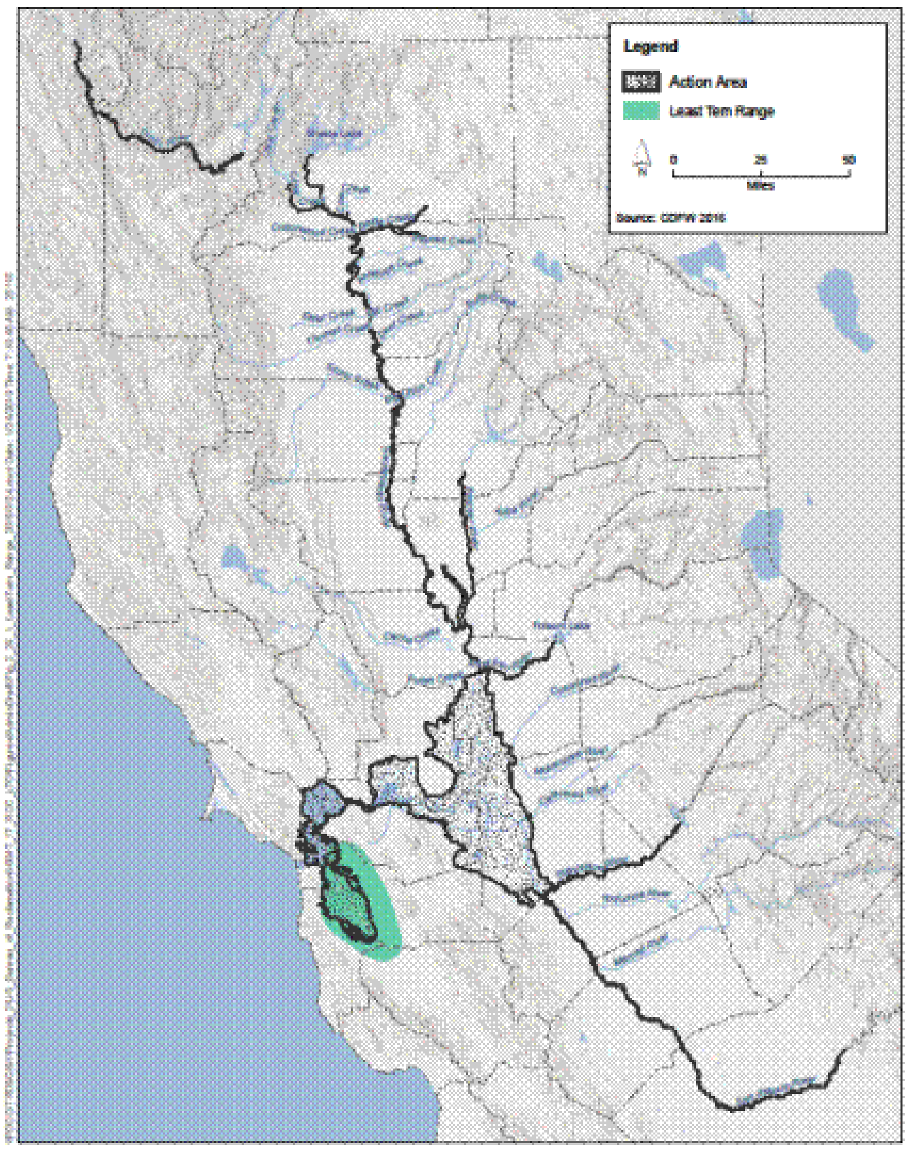


Figure 2.33-1. California Least Tern Range

2.33.4 Limiting Factors, Threats, and Stressors

The loss, degradation, and disturbance of suitable coastal strand and estuarine shoreline habitat is the primary reason for the historical reduction of California least tern populations. Most extant colonies occur on small patches of degraded nesting habitat surrounded on all sides by human activities. The majority of colony sites are in areas that were incidentally created during development projects. Further expansion and recovery of the California least tern population may require the creation or restoration of nesting habitat (USFWS 2006d).

Human disturbance was noted as early as the mid-1920s as a factor in causing colony abandonment and population declines (Rigney and Granholm 2005), and is still considered a major threat to remaining colonies (Garrett and Dunn 1981; Marschalek 2009). There is no suitable natural habitat in California that is free of development, military, or recreation-related human disturbances; thus, opportunities for the species to develop new breeding territories are mostly restricted to artificially or incidentally created habitat. Fencing has been used to prohibit entry into colony sites, but this also restricts the movement of birds. Lack of fencing or damage to existing fencing has led to nesting failures (USFWS 2006d).

Predation is regarded as the most significant threat to existing colonies. Marschalek (2011) reports 47 vertebrate and invertebrate predators or suspected predators of California least tern colonies in 2010. Most depredated tern chicks were taken by gull-billed terns (*Gelochelidon nilotica*, formerly *Sterna nilotica*). Common ravens (*Corvus corax*), coyotes (*Canis latrans*), and American crows (*Corvus brachyrhynchos*) had the highest depredation rate of eggs while peregrine falcons (*Falco peregrinus*) and unknown avian species had the highest depredation rate of fledglings and adults. Marschalek (2011) calculated that 1,007 eggs, 340 chicks, 161 fledglings, and 115 to 129 adults were lost to predation events in 2010.

2.33.5 Recovery and Management

The 1985 recovery plan recommended developing and implementing management plans and programs for “secure” nesting habitat in Alameda, San Mateo, Santa Barbara, Ventura, and Los Angeles, Orange, and San Diego Counties. Management plans created for long-term site ecological security would focus on reducing perturbation, destruction, or pollution of nesting or foraging habitat (USFWS 1985). No plans have been completed for any of these areas.

2.34 California Red-Legged Frog

2.34.1 ESA Listing and Critical Habitat

The USFWS listed the California red-legged frog as threatened in 1996 (61 FR 25813) and published a final rule to revise the designated critical habitat in 2010 (75 FR 12816). The designated critical habitat areas contain physical and biological features (primary constituent elements) that are considered essential to the conservation of the species, and that may require special management considerations and protection. The primary constituent elements identified for the California red-legged frog are:

1) Aquatic Breeding Habitat. Standing bodies of fresh water (with salinities less than 7.0 parts per thousand), including: natural and constructed (e.g., stock) ponds, slow-moving streams or pools within streams, and other ephemeral or permanent water bodies that typically become inundated during winter rains and hold water for a minimum of 20 weeks in all but the driest of years.

2) Non-Breeding Aquatic Habitat. Freshwater habitats, as described above, that may or may not hold water long enough for the subspecies to hatch and complete its aquatic life cycle but that do provide for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult California red-legged frogs. Other wetland habitats that would be considered to meet these elements include plunge pools within intermittent creeks, seeps, quiet water refugia during high water flows, and springs of sufficient flow to withstand the summer dry period.

3) Upland Habitat. Upland areas within 200 feet (60 meters) of the edge of the riparian vegetation or dripline surrounding aquatic and riparian habitat and comprised of various vegetational series such as grasslands, woodlands, and/or wetland/riparian plant species that provides the frog shelter, forage, and predator avoidance. Upland features are also essential in that they are needed to maintain the hydrologic, geographic, topographic, ecological, and edaphic features that support and surround the wetland or riparian habitat. These upland features contribute to the filling and drying of the wetland or riparian habitat and are responsible for maintaining suitable periods of pool inundation for larval frogs and their food sources, and provide breeding, non-breeding, feeding, and sheltering habitat for juvenile and adult frogs (e.g., shelter, shade, moisture, cooler temperatures, a prey base, foraging opportunities, and areas for predator avoidance). Upland habitat can include structural features such as boulders, rocks and organic debris (e.g. downed trees, logs), as well as small mammal burrows and moist leaf litter.

4) Dispersal Habitat. Accessible upland or riparian dispersal habitat within designated units and between occupied locations within 0.7 mile (1.2 kilometers) of each other that allows for movement between such sites. Dispersal habitat includes various natural habitats and altered habitats such as agricultural fields, which do not contain barriers to dispersal. (An example of a barrier to dispersal is a heavily traveled road constructed without bridges or culverts.) Dispersal habitat does not include moderate to high density urban or industrial developments with large expanses of asphalt or concrete, nor does it include large reservoirs over 50 acres (20 hectares) in size, or other areas that do not contain those features identified in primary constituent elements 1, 2, or 3 as essential to the conservation of the subspecies.

In total, 34 critical habitat units covering approximately 450,288 acres (182,225 hectares) were designated. The critical habitat is located in Alameda, Butte, Contra Costa, El Dorado, Kern, Los Angeles, Marin, Merced, Monterey, Napa, Nevada, San Benito, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Solano, Ventura and Yuba Counties.

2.34.2 General Life History and Habitat Requirements

The California red-legged frog is the largest native frog in the western United States. It is endemic to California and Baja California, Mexico. This species uses a variety of aquatic, riparian, and upland habitats, including ephemeral ponds, intermittent streams, seasonal wetlands, springs, seeps, permanent ponds, perennial creeks, constructed aquatic features, marshes, dune ponds, lagoons, riparian corridors, blackberry thickets, annual grasslands, and oak savannas. The common factor in all habitats used by California red-legged frogs is an association with a permanent water source.

Breeding sites have been documented in a wide variety of aquatic habitats. Larvae, juveniles, and adults have been observed inhabiting streams, creeks, ponds, marshes, sag ponds, deep pools and backwaters within streams and creeks, dune ponds, lagoons, estuaries, and artificial impoundments such as stock ponds. Breeding has been documented in these habitat types irrespective of vegetative cover. They often breed in artificial ponds with little or no emergent vegetation. The importance of riparian vegetation for this species is not well understood. It is thought that the riparian plant community may provide good foraging habitat and may facilitate dispersal in addition to providing pools and backwater aquatic areas for breeding.

California red-legged frogs disperse upstream and downstream of their breeding habitat to forage and seek shelter. Sheltering habitat for red-legged frogs potentially includes all aquatic, riparian, and upland areas within the range of the species and any landscape features that provide cover, such as existing animal burrows, boulders or rocks, organic debris such as downed trees and logs, and industrial debris. Agricultural features such as drains, watering troughs, spring boxes, abandoned sheds, or hay ricks may also be used. California red-legged frogs breed from November through March with earlier breeding records occurring in southern localities. Individuals occurring in coastal drainages are active year-round, whereas those found in interior sites are normally less active during the cold season. Females attach egg masses to emergent vegetation such as tule stalks, grasses, or willow roots just below the water surface. Larvae hatch 6 to 14 days following fertilization and spend most of their time concealed in submergent vegetation or detritus. Most larvae metamorphose into juvenile frogs 4 to 7 months after hatching, generally between July and September.

The diet of California red-legged frogs is highly variable. Similar to other frog species, larvae most likely consume diatoms, algae, and detritus (USFWS 2002). Invertebrates are the most common food items of adults. Vertebrates, such as Pacific tree frogs (*Hyla regilla*) and California mice (*Peromyscus californicus*), are frequently eaten by larger frogs. Feeding activity likely occurs along the shoreline and on the surface of the water.

2.34.3 Historical and Current Distribution and Abundance

The California red-legged frog has sustained a 70-percent reduction in its geographic range as a result of several factors acting singly or in combination (Jennings et al. 1992). Only a few drainages are currently known to support California red-legged frogs in the Sierra Nevada foothills, compared to more than 60 historical records. In southern California, the California red-legged frog has essentially disappeared from the Los Angeles area south to the Mexican border; the only known population in Los Angeles County is in San Francisquito Canyon on the Angeles National Forest (USFWS 2011).

Based on the best available information at the time of listing, the historic range of the California red-legged frog was described as extending along the coast from the vicinity of Point Reyes National Seashore in Marin County, and inland from the vicinity of Redding in Shasta County, southward to northwestern Baja California, Mexico (61 FR 25814). The listing rule described an intergrade zone between the California red-legged frog and the closely related (and nonlisted) northern red-legged frog (*Rana aurora*; formerly *Rana aurora aurora*) that extended approximately from the Walker Creek watershed in Marin County north to southern Mendocino County. Recent research on the genetics of red-legged frogs indicates that the intergrade zone between the California red-legged frog and the northern red-legged frog likely occurs within a narrower geographic area than previously known, and that the range of the California red-legged frog extends about 60 miles (100 kilometers) farther north (USFWS 2011). The California red-legged frog was probably extirpated from the floor of the Central Valley prior to 1960: the last record of a reproducing population on the valley floor is from the vicinity of Gray Lodge Wildlife Area (Butte County) around 1947, although this record is unverified (USFWS 2002). The species is therefore unlikely to occur in the action area. Reclamation has conducted surveys for California red-legged frog in the action area, and survey results were negative.

2.34.4 Limiting Factors, Threats and Stressors

Factors associated with declining populations of the California red-legged frog include degradation and loss of its habitat through agriculture, urbanization, mining, overgrazing, recreation, timber harvesting, nonnative plants, impoundments, water diversions, degraded water quality, use of pesticides, and introduced predators. The reason for decline and degree of threats vary by geographic location. California red-legged frog populations are threatened by more than one factor in most locations (USFWS 2011).

2.34.5 Recovery and Management

In 2002, USFWS published a recovery plan for the California red-legged frog (USFWS 2002). USFWS initiated a 5-year Status Review of California red-legged frog in June 2018 (USFWS 2018).

2.34.6 Monitoring and Research Programs

Monitoring of the California Red-legged Frog, Rana aurora draytonii, within Properties of the Los Baños Wildlife Area Complex, 2008, by CDFG December 2008

California Department of Fish and Wildlife has been conducting California red-legged frog surveys on the San Luis Reservoir and Upper Cottonwood Creek Wildlife Areas since 2001. Between January and July of 2008, they performed frog surveys on these properties, and additionally at Lower Cottonwood Creek Wildlife Area and Little Panoche Reservoir Wildlife Area at a total of 24 sites. Monitoring consisted primarily of daytime visual surveys and a limited number of night surveys. They were able to confirm frog presence and breeding activity at several sites on Upper Cottonwood Creek Wildlife Area, and observed frog calls during breeding season at Little Panoche Reservoir Wildlife Area. Habitat quality, restoration possibilities, future monitoring, and frog health continue to be key factors in CDFW's monitoring efforts.

One study documented only 20 Sierra Nevada localities and one Cascades Mountains locality where *R. draytonii* occurred between 1916 and 1975, extending from Tehama County southeast about 405 kilometers to Madera County. The elevation range of most of the historical localities was 200 to 900 meters (about 40 kilometers from lower to upper elevation), but three apparently extirpated populations that may have originated from deliberate translocations occurred at 1,500 to 1,536 meters elevation in Yosemite National Park. They surveyed directly or within 5 kilometers of 20 of the 21 historical Sierra Nevada/Cascades *R. draytonii* localities and found that at least one of these historical populations persists today, in large numbers. They also discovered or confirmed six new Sierra Nevada *R. draytonii* populations and individual frogs at three additional new sites, for a total of seven recent populations and three recent single-specimen occurrences extending from Butte County southeast about 275 kilometers to Mariposa County. Historically, *R. draytonii* in the Sierra Nevada probably bred in stream pools, which tend to be small with limited forage and thus may have constrained the historical size and number of Sierra Nevada *R. draytonii* populations. Since the 1850s, constructed ponds sometimes capable of supporting large *R. draytonii* populations have supplemented stream pool breeding habitat. Excluding the southernmost and Yosemite historical localities, the current range of Sierra Nevada *R. draytonii* differs little from the historical range, and further surveys may reveal additional surviving Sierra Nevada *R. draytonii* populations (Barry and Fellers 2013).

Chapter 3 Environmental Baseline

This section analyzes the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat (including designated critical habitat) and the ecosystem, within the action area. The environmental baseline includes the impacts of all federal, state, and private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR § 402.02). It does not include the effects of the action under review in the consultation; that is, the Long Term Coordinated Operations of the Central Valley Project and State Water Project.

As described below, the environmental baseline includes the effects of multiple physical, hydrological, and biological alterations that have negatively affected the species and habitat considered in this consultation. These baseline conditions include the past, present, and ongoing effects of the existence of the CVP structures. It is well established that the existence of dams and other structures, which may already be endangering species survival and recovery, is an existing human activity that is included in the environmental baseline and is not an effect of the action. The decisions of Congress and the state legislature to authorize the construction of those structures fundamentally altered the habitat and survival prospects of the species considered in this document. While those negative effects may continue to occur, they are not effects of the ongoing operation of the CVP and SWP.

Reclamation has discretion in aspects of its operations, such as the exercise of discretion in operational decision making, including deciding how to comply with the existing terms of respective existing water supply and settlement contracts, and legal obligations. However, Reclamation does not have discretion to remove any of the CVP or SWP structures. In contrast to other obligations, Reclamation has a fundamental, nondiscretionary obligation to ensure that its facilities do not present an unreasonable risk to people, property, and the environment. Reclamation Safety of Dams Act, P.L. 95-589, directs Reclamation to “preserve the structural safety of Bureau of Reclamation dams and related facilities...” (P.L. 95-578, as amended).

The environmental baseline projects the future “without-action” condition and the past, present, and ongoing impacts of human and natural factors, including the present and ongoing effects of current operations that were considered in prior consultations. These are included in the “Past and Present Impacts” section below.

By projecting the prospects for species survival and recovery without the action, the environmental baseline plays a necessary role in defining the effects of the action. That, in turn, allows for a determination of whether the action jeopardizes the continued existence of listed species or adversely modifies their critical habitat.

3.1 Past and Present Impacts

The baseline includes the past and present impacts of all federal, state, and private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process, including the past and present impacts of CVP and SWP operations under 2008 and 2009 biological opinions.

The CVP and SWP operate in an environment vastly different from the conditions under which native aquatic species evolved. Physical, hydrological, and biological alterations present novel conditions that result in stressors on California species and that pre-date the CVP. During the last 200 years, human activities have dramatically altered and reshaped the habitat upon which the species addressed in this consultation depend for survival. Those activities, as well as others, have reduced and continue to reduce significantly the species' likelihood of survival and recovery.

3.1.1 Physical Alteration

Since 1900, approximately 95 percent of historical freshwater wetland habitat in the Central Valley floodplain has been lost, typically through the construction of levees and draining for agriculture or residential uses (Hanak et al. 2011). Human expansion has occurred over vast areas in the Delta and Sacramento and San Joaquin Valleys between the 1850s and the early 1930s, completely transforming their physical structure (Thompson 1957, 1965; Suisun Ecological Workgroup 2001; Whipple et al. 2012; Whipple 2010). Levee ditches were built to drain land for agriculture, human habitation, mosquito control, and other human uses, while channels were straightened, widened, and dredged to improve shipping access to the Central Valley and to improve downstream water conveyance for flood management.

3.1.1.1 *Dams*

Water storage and diversion in California began in 1772, with a 12-foot high dam on the San Diego River. The water needs of mining, agriculture, communities, and electricity generation resulted in dams throughout the Sierra Nevada. In 1890, the California Fish and Game Commission first documented concerns with upstream passage and seasonal barriers for Chinook Salmon. Around the same time, the Folsom Powerhouse created a stone dam across the American River in 1893 (California Parks and Recreation 2018b). On the Sacramento River, the Anderson-Cottonwood Irrigation District constructed a dam near Redding in 1916. PG&E developed the Pit River in the 1920s for hydroelectricity (FERC 2011). On the Stanislaus River, the Oakdale and South San Joaquin Irrigation Districts constructed the original Melones Dam in 1926 to provide water for agriculture. On the San Joaquin River, Mendota Dam diverted irrigation water beginning in 1919 (CCID 2011). These early, non-CVP dams and diversions blocked fish passage and reduced downstream flows during the irrigation season. Since the 1850s, declining numbers of California's anadromous salmonids have been attributed, in large part, to dams (Yoshiyama et al. 1998).

On non-CVP and non-SWP streams, local districts have constructed dams and diversion facilities. Examples include Ward Dam on Mill Creek; Deer Creek Irrigation Diversion Dam on Deer Creek; Comanche Dam on the Mokelumne River; Durham Mutual Diversion on Butte Creek; La Grange Diversion Dam on the Tuolumne River; Crocker-Huffman Dam on the Merced River; and New Hogan Dam on the Calaveras River.

The primary negative effect of dams on salmonids is the elimination of access to a portion of spawning habitat, and for some species, the majority of spawning habitat. This effect started before the CVP, as early as 1918. Starting in the 1930s, the "rim dams" were constructed, which blocked higher elevation spawning habitat for salmonids. Construction of major CVP facilities began in 1938 with breaking of ground for Shasta Dam on the Sacramento River near Redding in Northern California. Over the next five decades, the CVP was expanded into a system of 20 dams and reservoirs that together can hold nearly 12

MAF of water. Currently, in California's Central Valley, dams block access to more than 80 percent of historical salmonid spawning areas (Yoshiyama et al. 1998; Lindley et al. 2006).

These CVP, SWP, and other dams prevent fish passage into cold upstream areas with more spawning habitat. Historical Winter-Run Chinook Salmon and Green Sturgeon spawning habitat may have extended up into the three major branches of the Upper Sacramento River above the current location of Shasta Dam; the Upper Sacramento River, the Pit River, and the McCloud River. In a 2014 habitat assessment, Reclamation found suitable and stable temperatures for Chinook Salmon during the warmest weeks of summer in portions of the McCloud and Upper Sacramento Rivers. For Central Valley Steelhead, it has been estimated that access to as much as 95 percent of all spawning habitat in the Central Valley has been lost (California Advisory Committee on Salmon and Steelhead Trout 1988). For several species, dams have resulted in a consolidation of spawning areas into one reach of one river. This increases the vulnerability of the species because a single catastrophic event could eliminate the population. Multiple reaches of spawning habitat in multiple rivers allows for greater resiliency of the population. Preventing access to the coldest water spawning habitat has greatly reduced the resiliency of Chinook Salmon to respond to stressors such as higher temperatures and extended drought.

Dams also trap sediment from upstream, which can lead to downstream streambeds becoming coarser or armored, hindering excavation of redds by spawning salmonids. Also, fine sediment from side channels that is normally flushed out by more frequent and larger flows can accumulate in gravel, reducing spawning success of salmonids.

3.1.1.2 *Disconnected Floodplains and Drained Tidal Wetlands*

Flooding has always been a regular occurrence along the Sacramento River (Thompson 1957) and the San Joaquin River. Floodplains are areas inundated by overbank flow, typically during the winter and spring peak flows. Inundation can last for up to several months. Floodplains can provide conditions that support higher biodiversity and productivity relative to conditions in river channels (Tockner and Stanford 2002; Jeffres et al. 2008). Floodplains also create important habitat for rearing and migrating fish; migratory waterfowl; and amphibians, reptiles, and mammals native to the Central Valley. Historically, Central Valley Chinook Salmon juveniles reared for up to three months on inundated floodplains, growing rapidly prior to ocean entry (Sommer et al. 2001).

Between the 1850s and 1930s over 300,000 acres of tidal marshes in the Delta were diked, drained, and converted to agriculture (Atwater et al. 1979). In addition, fill associated with past development has resulted in the loss of approximately 79 percent of tidal marsh habitat and approximately 90 percent of all tidal wetlands in the San Francisco Bay (California State Coastal Conservancy et al. 2010). Thus, the complex, shallow, and dendritic marshlands were replaced by simplified, deep, and less vegetated channels. This hydrogeomorphic modification fragmented aquatic and terrestrial habitats and decreased the value and quantity of available estuarine habitat (Herbold and Vendlinski 2012; Whipple et al. 2012). In the Central Valley, 95 percent of historical floodplain wetland has disappeared (Katz et al. 2017). The decline in, and disconnection from, floodplain habitat and the food it produces has been linked to native fish population declines (Jassby et al. 2003). The degradation and simplification of aquatic habitat in the Central Valley has also greatly reduced the resiliency of Chinook Salmon to respond to additional stressors (NMFS 2016b). Further, important ongoing development stressors (e.g., urban and agricultural development) continue to affect wetlands in California, and stream-associated salt marsh and wetland habitat have shown declining health and function due to urbanization effects (California Natural Resources Agency 2010).

3.1.1.3 *Levees*

The development of California's agricultural industry and water conveyance system has resulted in the construction of armored, riprap levees on more than 1,100 miles of channels and diversions to increase channel elevations and flow capacity of the channels (Mount 1995). As part of the Sacramento River Flood Control Project, the U.S. Army Corps of Engineers (USACE) constructed levees in the lower Sacramento River Basin. Revetments and bank armoring caused channel narrowing and incision and prevented natural channel migration. Levees have also isolated former floodplains from the river channel, preventing access for rearing for juvenile salmonids.

Many of these levees use riprap to armor the bank. Constructing and armoring levees changes bank configuration and reduces cover (Stillwater Sciences 2006). Constructed levees protected with rock revetment generally create nearshore hydraulic conditions characterized by greater depths and faster, more homogeneous water velocities than occur along natural banks. Higher water velocities typically reduce deposition and retention of sediment and woody debris. This reduces the shoreline variability, especially by eliminating the shallow, slow-velocity river margins used by juvenile fish as refuge and to escape from fast currents, deep water, and predators (Stillwater Sciences 2006).

In addition, the armoring and revetment of stream banks may narrow rivers, reducing the amount of habitat per unit channel length (Sweeney et al. 2004). As a result of river narrowing and deepening, benthic habitat decreases and the number of macroinvertebrates per unit channel length decreases, affecting salmonid food supply.

3.1.1.4 *Gold and Gravel Mining*

Significant gold and gravel mining in the Sacramento River watershed has further degraded aquatic habitats by decreasing the availability and recruitment of suitable spawning gravels. Hydraulic gold mining began in mid-1800, with an estimated 5,000 miles of mining canals and flumes established by 1859 (Lufkin 1996). Around 1.5 billion cubic yards of debris were sluiced into streams. For over 100 years, around 1.5 billion cubic yards of hydraulic mining debris moved through California's rivers and the Sacramento–San Joaquin Delta (Lufkin 1996). Fine sediments settle in between spawning gravels, reducing hyporheic flow and the movement of required dissolved oxygen to developing salmonid eggs. This contributed to decreased salmonid populations in the 1800s and early 1900s; however, the direct effect no longer occurs, as fine sediments from hydraulic mining are moving past the Golden Gate Bridge (James 2004). Persistent effects from the genetic bottlenecks and physical alterations remain.

3.1.1.5 *Gravel*

Coarse sediment from the upper watershed is prevented from being transported downstream by dams, resulting in an alluvial sediment deficit and reduction in fish habitat quality within the Sacramento River (Wright and Schoellhamer 2004). In addition to the reduction of sediment supply, recruitment of large woody material to the river channel and floodplain has also declined due to a reduction in bank erosion and blockage of wood transport by dams.

3.1.1.6 *Timber Production*

Timber production is a dominant land use within private timber holdings that operate in the mountains of Humboldt, Trinity, and Mendocino Counties. The effects of road building associated with timber harvest, and rural road construction in general, can destabilize hillsides and increase erosional processes that deliver fine sediment to streams and rivers. Poorly designed or constructed stream crossings can often preclude adult and juvenile fish from migrating upstream past the crossing, and can alter stream channel morphology and hydraulic characteristics within, and upstream and downstream, of the road crossing. High instream sediment loads and poor large woody debris recruitment associated with timber production can affect salmonid habitat for decades after logging has stopped (NMFS 2016).

3.1.1.7 *Marijuana Cultivation*

Changes in land use associated with growing marijuana can result in habitat fragmentation, agricultural water diversions from rivers and streams, and non-point pollutant discharge (i.e., sediment, pesticides, etc.). Illegal marijuana cultivation has grown into a leading threat to Salmon and Steelhead recovery on smaller creeks throughout California, including those that form part of the watersheds of the Trinity and Sacramento Rivers. Illegal growers often dam and dewater creek channels to irrigate their marijuana gardens, and commonly use pesticides, fertilizers and poisons without regard for their impacts on the environment. On January 16, 2019, the the Office of Administrative Law approved California Department of Food and Agriculture’s final cannabis cultivation regulations, which include requirements for diversions, fertilizers, and pesticides, and should reduce this effect.

3.1.1.8 *Large Woody Debris*

Prior to the 1970s, some streams were so clogged with logs that biologists believed they were total barriers to fish migration. As a result, in the early 1970s it was common practice for fisheries agencies to remove woody debris (Bisson et al. 1987). It is now recognized, however, that too much large woody debris was removed from the streams. Large quantities of downed trees are an important component of many streams in order to increase channel complexity, shade the channel, and provide nutrient inputs (Bisson et al. 1987).

3.1.1.9 *Alterations to Address Effects*

Reclamation, DWR, USFWS, NMFS, and CDFW as well as other agencies have worked to address the effects of these factors on listed species over the past decades as directed by Congress and state legislatures. The following sections describe beneficial physical alterations.

3.1.1.10 *Fish Passage*

Although agencies have reduced fish passage by damming rivers, they have also worked to provide fish passage over their dams. In the late 20th century, agencies including Reclamation and DWR have increasingly worked to increase fish passage above water infrastructure and reduce fish entrainment into diversions. Providing fish passage increases access to spawning habitats, decreasing density-dependent effects and allowing more variability in the population, thereby increasing resiliency.

For example, in August 2012, Reclamation completed the Red Bluff Pumping Plant and Fish Screen to improve fish passage conditions on the Sacramento River. The facility includes a 1,118-foot flat-plate fish screen, intake channel, 2,500-cfs capacity pumping plant, and discharge conduit to divert water from the Sacramento River into the Tehama-Colusa and Corning Canals. In 2011, the dam gates were permanently placed in the open position for free migration of fish while ensuring continued water deliveries by way of the Red Bluff Pumping Plant. Other examples of passage improvements include removal of the McCormack-Seltzer Dam on Clear Creek, passage at the ACID diversion dam, and tributary efforts under the CVPIA on Battle, Butte, Calaveras, Mill, Deer, and Antelope Creeks.

3.1.1.11 *Spawning and Rearing Habitat Augmentation*

Through CVPIA(b)(12), Reclamation has augmented spawning and rearing habitat for listed species in CVP tributaries. Between 1997 and 2008, over 195,000 tons of gravel have been placed in the Sacramento, Stanislaus, and American River tributaries. Since 2016, a number of spawning and rearing side channel restoration sites on the American and Sacramento Rivers have been implemented. In the Lower American River, roughly 24 acres have been devoted to gravel augmentation, while approximately 50 acres have focused on side channel creation. In the Sacramento River, roughly 4 acres have been devoted to ongoing gravel augmentation launching sites, while approximately 20 acres have been devoted to side channel creation. As a result of these actions, Reclamation has improved spawning and rearing habitat for ESA-listed salmonids in these tributaries.

3.1.1.12 *Tidal Marsh Restoration*

To repair some of the 300,000 acres of tidal wetlands that were drained starting in the 1800s, DWR is in the process of implementing 8,000 acres of tidal wetland habitat restoration in the Sacramento–-San Joaquin Delta and Suisun Marsh. DWR has completed 159 acres of tidal and subtidal restoration with another 2,020 acres in construction. As some projects are still being planned, Reclamation is programmatically consulting on tidal wetland habitat restoration in this biological assessment.

3.1.1.13 *Suisun Marsh Preservation Agreement*

Reclamation and DWR will address salinity in the Suisun Marsh related to operations through the 2015 Suisun Marsh Preservation Agreement (SMPA) and Suisun Marsh Habitat Management, Preservation, and Restoration Plan (Suisun Marsh Plan), which has separate NEPA and ESA compliance completed in 2014. Public Law 99-546 identifies that Reclamation and DWR will share the implementation cost of the 2015 SMPA. The 2015 SMPA was signed by DWR, CDFW, Suisun Resource Conservation District, and Reclamation. The Suisun Marsh Plan addresses concerns of operations of the CVP and SWP on the ecosystem, much of which is privately owned and home to waterfowl hunting clubs. As part of the Suisun Marsh Plan, Reclamation and DWR propose to work with the SMPA principals to: (1) Restore 5,000 to 7,000 acres of tidal marsh to contribute to the recovery of threatened and endangered species; (2) Protect and enhance 40,000 to 50,000 acres of managed wetlands to benefit waterfowl and other resident and migratory wildlife species; (3) Improve ecological processes and reduce stressors, such as invasive species and contaminants; (4) Maintain waterfowl hunting heritage and expand opportunities for hunting, fishing, bird watching, and other nature-oriented recreational activities; (5) Maintain and improve Marsh levee system integrity; and (6) Protect and, where possible, improve water quality for beneficial uses in the Marsh through operating the Suisun Marsh Salinity Control Gates and Roaring River distribution system.

3.1.1.14 *Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project*

To assist in recovering some of the hundreds of thousands of acres of floodplain that were disconnected from Central Valley streams starting in the 1800s, Reclamation and DWR will modify infrastructure at Fremont Weir to increase access to floodplain habitat in the Yolo Bypass for juvenile salmonids. The project will also increase the ability of adult salmon and sturgeon to migrate from the Yolo Bypass to the Sacramento River.

3.1.2 Hydrologic Alteration

3.1.2.1 *Dams*

Construction and operation of CVP and SWP dams, as well as other large dams in the California Central Valley, have changed streamflow downstream of the dams. Dams reduce downstream peak spring flows by storing snowmelt and precipitation inflows for industrial and domestic uses and agriculture. A large percentage of the natural historical inflow to Central Valley watersheds and the Delta is now diverted for human uses. Flows are increased in the summer and fall periods due to releases from storage for downstream agricultural, municipal, and industrial water supplies. Dams disrupt natural hydrologic patterns and impair sediment transport, channel morphology, substrate composition, and water quality (including temperature and turbidity) within downstream reaches (Spence et al. 2008). Operations at reservoir-related dams often affect downstream reaches by impairing flow timing and volume. These effects impair salmonid habitat and affect salmonid migration, spawning, and rearing within the affected reaches.

Reduced streamflows have contributed to decreased recruitment of gravel, decreased recruitment of large woody debris, and reduced geomorphic work. Stable year-round flows have resulted in diminished natural channel formation, altered foodweb processes, and slowed regeneration of riparian vegetation. These stable flow patterns have reduced bedload movement (Mount 1995), caused spawning gravels to become embedded, and decreased channel widths due to channel incision, all of which has decreased the available spawning and rearing habitat below dams. Dams have also trapped fine sediment which otherwise could have entered the Delta (Wright and Schoellhamer 2004), thus contributing—along with other factors such as increases in invasive aquatic vegetation (Hestir et al. 2016) and declining wind speed (Bever et al. 2018)—to a long-term reduction in turbidity for Delta Smelt (e.g., Nobriga et al. 2008).

The reduced flow variability has also shifted water temperatures. If warm surface water from the reservoir is released, dams may increase downstream water temperatures, particularly in summer, when flows are lowest. Lower base flows and warm-water releases can reduce the amount of available habitat, increase the metabolic demands of fishes, and disrupt fish migration patterns (Olden and Naiman 2010). Warm water can also facilitate the spread of disease (Okamura et al. 2011; Kocan et al. 2009).

Most large dams, however, release cold water from the bottom of reservoirs. Cold water releases that maintain or increase downstream base flows will usually reduce water temperatures in summer and fall (Huang et al. 2011; Yates et al. 2008), effectively shifting cold-water rearing habitat for juvenile anadromous salmonids from headwaters to below reservoirs (Ward and Stanford 1983). Cold water releases are often crucial for sustaining remnant salmonid populations. For example, endangered Winter-Run Chinook Salmon in the Sacramento River are maintained entirely by cold-water flows from Shasta Dam, which prevents access to their former habitats (Moyle 2002). However, reliance on cold-water releases to protect salmon can be a problem if there is insufficient cold water in the reservoir to keep temperatures cool during late summer or during periods of drought. Cooler temperatures can also delay juvenile migration cues and slow juvenile growth (Moyle and Cech 2004).

3.1.2.2 *Diversions*

A large number of water diversions were constructed in the Central Valley in the 1900s, for riparian water rights holders, water districts, and CVP and SWP water users. These diversions reduce the flow in California rivers, reducing available spawning area, dewatering redds, and stranding juvenile salmonids.

Water withdrawals, for agricultural and municipal purposes, have reduced river flows and increased temperatures during the critical summer months, and in some cases, have been of a sufficient magnitude to result in reverse flows in the Lower San Joaquin River (Reynolds et al. 1993). Direct relationships exist between water temperature, water flow, and juvenile salmonid survival in riverine sections of the Central Valley (Brandes and McLain 2001). Elevated water temperatures in the Sacramento River have limited the survival of young salmon in those waters. Juvenile Fall-Run Chinook Salmon survival in the Sacramento River is also directly related to June streamflow and June and July Delta outflow (Dettman et al. 1987). Diversions can also affect pelagic species, e.g., by influencing the extent of abiotic rearing habitat for juvenile and subadult Delta Smelt (Feyer et al. 2011).

Reclamation delivers water to the Sacramento and San Joaquin Valleys and the San Francisco Bay Area, and DWR delivers water to these areas as well as southern California cities. Effects in both CVP and SWP water delivery service areas have already been addressed in separate, completed ESA consultations. These effects have been previously analyzed and there is no new information that would change that analysis. The results remain valid and are incorporated by reference.

In addition to surface water diversion, groundwater withdrawals also impair stream habitat by lowering groundwater resources. This impairs volume, extent, timing, and temperature of surface flows.

3.1.2.3 *Entrainment*

Entrainment of fish into irrigation canals can be a major source of mortality (Carlson and Rahel 2007). Legislation requiring fish screens in the Western United States began as early as 1893 in Montana (Clothier 1953), and anadromous fish were being entrained by the millions in Oregon in 1928 (McMillan 1928). Fish entering unscreened water diversions undergo injury and mortality (Kimmerer 2008; Baumgartner et al. 2009; Grimaldo et al. 2009), reduced fitness (Bennett 2005; Kimmerer 2008) or habitat degradation (Drinkwater and Frank 1994; Kingsford 2000). Entrainment into water diversions can harm several fish species, including ESA-listed species, such as Delta Smelt (Bennet 2005) and Green Sturgeon (Mussen et al. 2014).

Entrainment at Jones and Banks Pumping Plants, as well as the effects of changed Delta hydrodynamics, is a significant source of mortality for listed species in the Delta. To minimize these effects, Reclamation currently operates in accordance with RPA actions from the 2008 and 2009 biological opinions that minimize and reduce the effects of entrainment, including salvaging fish and operating to OMR reverse flow criteria.

The 1992 passage of CVPIA included construction of new screens, rehabilitation and replacement of existing screens, and relocation of diversions. In 1997, there were at least 3,356 diversions taking water from the Sacramento and San Joaquin Rivers, their tributaries, and the Delta (Herren and Kawasaki 2001). Over 98 percent of these diversions were unscreened or inadequately screened (Herren and Kawasaki 2001). Since the start of CVPIA’s Anadromous Fish Screen Program through 2012, Reclamation and USFWS have provided funding for 35 fish screen projects, screening 5,412 cfs of diversions. Only one diversion greater than 100 cfs remains unscreened on the Sacramento River.

3.1.2.4 *Contaminants (Runoff, Waste Treatment, Etc.)*

As described above, historical activities, such as gold mining, have resulted in high concentrations of methylmercury in much of the Central Valley. Many of the more than 500 mercury mines in California have not been remediated and continue to release mercury to the environment (CDFW 2017). Methylmercury is formed from inorganic mercury by microscopic organisms that live in waterbodies and sediments. Inundation of sediments, such as on a floodplain, can increase the methylation of mercury. Methylmercury is a neurotoxin that bioaccumulates and biomagnifies in the aquatic foodweb (Davis et al. 2003). It can also impair the smoltification and subsequent outward migration behavior in juvenile salmon.

Current activities continue to contribute contaminants to Central Valley waterways. For example, from Fong et al 2016: “Monitoring entities and research studies have detected multiple contaminants occurring simultaneously in Delta water samples (Ensminger et al. 2013; Orlando et al. 2013, 2014). Multiple pesticides are continuously detected in the two primary tributaries to the Delta. For example, 27 pesticides or degradation products were detected in Sacramento River samples, and the average number of pesticides per sample was six. In San Joaquin River samples, 26 pesticides or degradation products were detected, and the average number detected per sample was 9.”

High levels of toxicity to aquatic invertebrates were found to originate from urban stormwater pyrethroid pesticide loading to San Francisco Estuary tributaries (Weston et al. 2014, 2015; Brander 2013; Connon et al. 2009; Amweg et al. 2006). Weston and Lydy (2010) detected pyrethroids in all but one of 33 urban runoff samples and observed toxicity over at least a 30 km reach of the American River, and at one site in the San Joaquin River. Pyrethroid pesticides have been identified as a factor possibly contributing to pelagic organism decline because of their increased use in recent years and their high toxicity to aquatic organisms (Fong et al 2016).

The discharge of contaminants into California waters from urban and agricultural sources is likely to continue into the future. The Central Valley is becoming more urbanized, which increases the likelihood of urban discharges entering waterways. Likewise, regional agriculture will continue to discharge agricultural return flows from irrigation practices into surrounding waterways.

3.1.2.5 *Pulse Flows*

As discussed above, operation of dams has reduced flow variability across California. To address this, Reclamation and DWR have implemented pulse flows on a variety of CVP and SWP streams due to the 2000 Trinity River ROD, CVPIA (b)(2), 1960 Memorandum of Agreement (MOA) with CDFG, 1987 CDFG agreement on the Stanislaus, SWRCB water rights orders, and 2009 NMFS Biological Opinion. Spring pulse flows have beneficial effects on salmonids by increasing Chinook Salmon smolt survival (Michel 2015) and subyearling Chinook Salmon smolt survival (Zeug et al. 2014).

3.1.2.6 *Management for Temperature*

Reclamation and DWR have managed for temperature on CVP and SWP tributaries as a result of SWRCB Water Rights Order 90-5 and ESA requirements. These temperature management actions have had generally beneficial effects on species. Reclamation and DWR’s temperature management has resulted in cooler flows during summer and fall periods than would occur without temperature management. Absent these temperature management actions, increased temperatures and therefore increased egg and juvenile salmonid mortality would occur.

3.1.2.7 *Temperature Control Devices*

Reclamation has constructed a TCD at Shasta Dam, a selective withdrawal device at Folsom Dam, and a selective withdrawal device on the Folsom Dam Urban Water Supply Pipeline for greater flexibility in managing the cold water reserves while enabling hydroelectric power generation to occur and to improve salmonid habitat conditions. Many reservoirs have a low-level outlet that accesses the coldest water in the reservoir. However, these outlets often are not routed through the hydroelectric powerplant at the dam. Therefore, a TCD allows several elevations of water to be withdrawn from the reservoir—warm from the surface or cold from the bottom—and routed through the powerplant. Temperature control devices allow Reclamation to release warmer water from the top of the reservoir in the springtime, when salmonid temperature requirements are warmer, without bypassing power generation. These devices also allow Reclamation to lower the reservoir elevation at which water is taken for river release, in accordance with changing fish temperature requirements throughout the year. As air temperatures and stratification result in a warming surface of the reservoir in the summer and fall, Reclamation uses the warmer surface water until fisheries requirements necessitate withdrawal of colder water from lower in the reservoir.

Without temperature control devices, Reclamation either would not be able to provide as much cold water in any given year for meeting fisheries temperature requirements, or would reduce the hydroelectricity generated from releases from its dams.

3.1.2.8 *Water Quality*

Although conditions in most streams, rivers, and estuaries throughout the State are much improved from 40 years ago, the rate of improvements have slowed over time (San Francisco Estuary Partnership 2015). Contaminants such as polybrominated diphenyl ethers (PBDEs), and copper have declined over time, however many potentially harmful chemicals and contaminants of emerging concern (pharmaceuticals) have yet to be addressed. Legacy pollutants such as mercury and PCBs limit consumption of most fish, and directly and indirectly affect endangered fish populations, as well as their designated critical habitat.

In particular, urban stormwater runoff is consistently toxic to fish and stream invertebrates (McIntyre et al. 2014, 2015). The array of toxicity is variously attributed to metals from motor vehicle brake pads; petroleum hydrocarbons from vehicle emissions of oil, grease, and exhaust; and residential pesticide use. Urban stormwater toxicity has been linked to pre-spawn mortality of Coho Salmon (*Oncorhynchus kisutch*) (Scholz et al. 2011). The degree of impervious surface (Feist et al. 2011) has also been linked to pre-spawn mortality of Coho Salmon, and both have been directly linked to effects at the population level (Spromber and Scholz 2011). Emphasis on wastewater treatment plant upgrades and new legislative requirements (SWRCB and EPA), development and implementation of total maximum daily load (TMDL) (i.e., pathogens, selenium, pesticides, pyrethroids, methylmercury, heavy metals, salts, nutrients) programs, and adoption of new water quality standards (i.e., Basin Plans), all aid in protecting beneficial uses for aquatic wildlife.

In recent years, NOAA scientists have investigated the direct and indirect effects of pesticides on individual ESA-listed species, the foodwebs on which they depend, and at the population level (Baldwin et al. 2009; Laetz et al. 2009; Macneale et al. 2010; Scholz et al. 2012). NMFS has consulted on seven batched pesticide ESA Section 7 consultations, and concluded that chlorpyrifos, diazinon, malathion, carbaryl, carbofuran, methomyl, bensulide, dimethoate, ethroprop, methidathion, naled, phorate, phosmet, 2,4-D, chlorothalonil, diuron, oryzalin, pendimethalin, and trifluralin jeopardize the continued existence of ESA-listed species and/or adversely modified critical habitat for salmonids across the West Coast Region (NMFS 2008b, 2010, 2011b, 2013).

3.1.3 Biological Alteration

3.1.3.1 *Commercial Harvest*

Commercial harvest of salmon began in the 1850s (CDFG 1929) and gill net salmon fisheries became well established in the Lower Sacramento and San Joaquin Rivers by 1860. In 1864, the first Pacific

Coast salmon cannery was constructed along the Sacramento River. By its peak in 1882, the Sacramento and San Joaquin Rivers had 20 salmon canneries and processed about 11 million pounds of catch (CDFG 1929). In 1910, there were 10 million pounds of commercial salmon catch; that declined to 4.5 million pounds by 1919 when the last inland cannery closed (CDFG 1929). An estimate of historical abundances of Chinook Salmon in the Central Valley is about 1 to 2 million annual spawners (Yoshiyama et al. 1998).

In 1916, ocean harvest at Monterey alone was over 5 million pounds (Yoshiyama et al. 1998). Between 2006 and 2017, the highest total commercial ocean harvest was 3.8 million pounds in 2013, averaging about 1.5 million pounds over that period (CDFW 2016). The ocean commercial harvest at Monterey in 2016 and 2017 was about 150,000 pounds, representing about 25 and 30 percent of the total ocean commercial harvest, respectively (CDFW 2016). NMFS recently revised harvest rules, which had the effect of increasing harvest pressures on Winter-Run Chinook Salmon at low abundances (NMFS 2018).

3.1.3.2 *Hatcheries*

Five hatcheries currently produce Chinook Salmon in the Central Valley, and four of these also produce Steelhead. Releasing large numbers of hatchery fish can have negative effects on wild populations through competition for space and food, direct predation, and loss of genetic diversity (Moyle 2002). Interbreeding between artificially propagated hatchery and wild individuals can reduce fitness of offspring (Araki et al. 2009). Barnett-Johnson et al. (2008) found that only 10 percent of Central Valley Fall-Run Chinook Salmon harvested in the ocean fishery were of natural origin. On the Mokelumne River, approximately 4 percent of returning adults in the 2004 escapement were found to be of natural origin (Johnson et al. 2012) and the work identified large-scale hatchery production as masking poor natural production and recruitment. These patterns appear throughout the Central Valley, with large proportions of returning adult salmon straying into watersheds without hatcheries (Palmer-Zwahlen and Kormos 2015).

In 1942, CNFH was established to mitigate the loss of spawning areas due to construction of the Shasta and Keswick Dams. Reclamation constructed the LSNFH, a sub-station to CNFH, in 1997 to assist in Winter-Run Chinook Salmon recovery. CDFW operates a number of hatcheries for Salmon and Steelhead, including on the Trinity, Feather, and American Rivers.

Hatchery practices as well as spatial and temporal overlaps of habitat use and spawning activity between Spring-Run and Fall-Run Chinook Salmon have led to the genetic hybridization of some subpopulations (CDFG 1998). Spring-Run from the Feather River Fish Hatchery have been straying throughout the Central Valley for many years (CDFG 1998), and in many cases have been recovered from the spawning grounds of Fall-Run, an indication that Feather River Fish Hatchery Spring-Run may have Fall-Run life history characteristics.

To start to address these interbreeding and hybridization concerns, modern hatcheries are required to develop a Hatchery Genetic Management Plan under Section 4 of ESA. A Hatchery Genetic Management Plan addresses long-range planning and management of the hatchery fish.

3.1.3.3 *Nonnative Predators*

Aquatic invasive species (both plants and animals) have been shown to have major negative effects on the receiving communities, where they often outcompete native species, reduce species diversity, change community structure, reduce productivity and disrupt foodweb function by altering energy flow among trophic levels (Cohen and Carlton 1995; Ruiz et al. 2000; Stachowicz and Byrnes 2006). Multiple mechanisms of impact affect salmonids directly, such as predation and infection (disease and parasitism), and indirectly, such as competition, hybridization, and habitat alterations (Mack et al. 2000; Simberloff et al. 2005). Based on the number of species, individuals and biomass, as well as high and accelerating rate of invasion, the Delta may be the most invaded estuary in the world (Cohen and Carlton 1998).

Striped Bass were introduced in 1880s to provide a commercial fishery. Now a recreational fishery, Striped Bass and other introduced species including Catfish prey upon listed species. A Striped Bass population of 1,000,000 could consume 9 percent of out-migrating Winter-Run Chinook Salmon based on Bayesian population dynamics modeling (Lindley and Mohr 2003). According to the Coalition for a Sustainable Delta's website, invasive species represent 95 percent of the total biomass in the Delta. Striped Bass are identified by Bennett (2005) as a low potential threat to Delta Smelt.

High rates of predation have been known to occur at diversions and locations where rock revetment has replaced natural river bank vegetation (Grossman et al. 2013). Young salmonids are more susceptible to predation at these locations because predators congregate in areas that provide refuge (Tucker et al. 1998; Williams 2006). Nonnative centrarchids, such as Largemouth Bass and Spotted Bass, will opportunistically feed on juvenile salmonids.

3.1.3.4 *Invasive Aquatic Weeds*

The Delta has changed as a result of the proliferation of invasive aquatic vegetation in recent years (Ta et al. 2017). These aquatic plants, largely comprised of invasive species, create highly productive microhabitats (Lucas et al. 2002; Nobriga et al. 2005; Grimaldo et al. 2009), but they degrade habitat quality for native species by increasing water transparency (Nobriga et al. 2008; Hestir et al. 2016) and harboring predatory fishes (Ferrari et al. 2014; Conrad et al 2016), increasing nonnative predator populations. Aquatic weeds have resulted in increased nonnative predator populations, while on their own they would likely be helpful for salmon by providing food and shelter.

3.1.3.5 *Foodweb Dynamics and Clams*

Diatoms are the group of phytoplankton that tend to be most important to open-water foodwebs in estuaries and coastal marine systems. Diatoms need three things to grow: sunlight, nutrients, and time. The primary historical limit on sunlight was turbidity so diatoms tended to grow best in shallow water. Suisun Bay and marsh were important locations for fish in the low-salinity zone because the Delta was already so channelized and deep (Cloern et al. 1983; Cole and Cloern 1984). Historically, the estuary was considered to have excess nutrients for diatom growth, so that nutrients were not limiting the base of the foodweb (Jassby et al. 2002). The third thing diatoms need to grow is time. Historical limits on this were water residence time and clam grazing rates (Cloern et al. 1983; Lopez et al. 2006).

There are two clam species that affect phyto- and zooplankton biomass. The freshwater *Corbicula fluminea*, which has been in the Delta and its tributaries since the 1940s, and the estuarine overbite clam *Potamocorbula amurensis*, which has been in the Bay and west Delta (but not tributaries) since 1986. Freshwater *Corbicula fluminea* can have foodweb impacts in shallow freshwater habitats with long water residence times (Lucas et al. 2002; Lopez et al. 2006).

Year to year variation in Delta outflow, especially during the spring and summer, led to year to year variation in plankton productivity because in wet years, outflow brought nutrients and organic carbon into the low-salinity zone, and in dry years, the elevated salinity let a marine clam (*Mya arenaria*) colonize Suisun Bay and eat the diatoms down to low levels (Knutson and Orsi 1983; Cloern et al. 1983). This lowered the production of opossum shrimp (*Neomysis*) that was a significant food source for native fish species at the time (Feyrer et al 2003). However, wet year plankton productivity did not extend to increases in Delta Smelt abundance (Stevens and Miller; Jassby et al. 1995). It was also shown through modeling and data analysis that water exports could affect foodweb productivity in the low-salinity zone by affecting rates of organic carbon/diatom subsidy from the Delta (Jassby and Cloern 2000).

By 1987, the overbite clam (*P. amurensis*) was established and resulted in a permanent source of loss to diatoms and copepod larvae. This resulted in rapid step-declines in the abundance of the most important historical foodweb components like diatoms, *Neomysis*, and *Eurytemora affinis* (Alpine and Cloern, 1992; Kimmerer and Orsi 1996). *Eurytemora affini*s was a major prey for both *Neomysis* and Delta Smelt (Knutson and Orsi).

Another hypothesis for the decline in foodweb components in the Delta is ammonium from wastewater treatment plants. Also around 1987, ammonium levels frequently rose above 4 micro-molar, which is a critical threshold that slows diatom growth (Wilkerson et al. 2006; Gilbert et al. 2011; Rev Fish Sci; Dugdale et al. 2016; Dugdale et al. 2007). Opponents of this hypothesis argue that but for the overbite clam, diatom populations would eventually build up enough biomass each year to use up the ammonium and then rapidly accelerate their growth by feeding on nitrate. The overbite clam recruitment increases in the late spring to early summer, and the clam population eats most of the diatom biomass so that there is no opportunity for sustaining enough diatoms long enough into the summer to consume the ammonium and reach the nitrate (Dugdale et al. 2012; Dugdale et al. 2016). Uncertainty exists in the scientific literature on this point, with Dugdale et al. (2016) stating that estimates of the overbite clam's grazing rates are too high, while Kimmerer and Thompson (2014) defend overbite clam grazing rates and further state that other microscopic organisms also contribute to the grazing rate calculation.

In addition to directly reducing fish food, the overbite clam changed the overall ecosystem of the Delta. By repressing the production of historically dominant diatoms and zooplankton, several invertebrates invaded the Delta, causing changes in plant communities (Kimmerer and Orsi 1996; Bouley and Kimmerer 2006; Winder and Jassby 2011). Drought is also thought to have contributed to the species changes (Winder and Jassby 2011). The reduction in diatoms reduced and changed the copepod community, which is the majority of the diet of younger Delta Smelt (Slater and Baxter 2014).

After the overbite clam invasion came the copepod invasions of the late 1980s and early 1990s, which actually helped stem (but not recover from) what had been a major decline in their abundance (Winder and Jassby 2011). Prior to the overbite clam, Delta Smelt mostly ate the native copepod *E. affinis* from the time the larvae started feeding into the following fall (Moyle et al. 1992). The overbite clam suppressed *E. affinis*, leading to several nonnative copepods including *Pseudodiaptomus forbesi* taking over *E. affinis*'s niche in the ecosystem. *P. forbesi* then became the new main prey of larval and juvenile Delta Smelt (Nobriga 2002; Hobbs et al. 2006; Slater and Baxter 2014; Hammock et al. 2017).

P. forbesi production originates in the freshwater parts of the Delta (Merz et al. 2016; Kayfetz et al. 2017), including the Cache Slough-Yolo Bypass complex (Kimmerer et al. 2018). *E. affinis* had peak abundance near X2 (Orsi and Mecum 1986). However, now, when either *E. affinis* or *P. forbesi* are in the low-salinity zone, they are consumed by both the overbite clam and a predatory nonnative copepod that appeared in the 1990s (Kayfetz et al. 2017). Therefore, Delta Smelt food in the low-salinity zone has to be constantly replenished or subsidized from the Delta where the overbite clam and the predatory copepod are less abundant. Delta outflow can provide this food subsidy (Kimmerer et al. 2018a and Kimmerer et al. 2018b).

3.2 Status of the Species in the Action Area

California native freshwater fishes have declined as a result of the aforementioned anthropogenic influences and climate change, and have benefited by anthropogenic improvements as also discussed above. These species will likely continue to suffer population declines in the future in the action area due to existing stressors as well as long-term meteorological variability, sea level rise, and extreme weather events. Moyle et al. (2010) found that 83 percent of California's native freshwater fishes are extinct, endangered, or in decline. Fishes requiring cold water (<22°C) are particularly likely to go extinct (Moyle et al. 2013). For this consultation, the action area encompasses most if not all of the range of the species. Therefore, please refer to Chapter 2, Aquatic and Terrestrial Status of the Species and Designated Critical Habitat, for more information on the status of the species in their entire range and the action area, as well as for the status of terrestrial species.

Winter-Run Chinook Salmon: Escapements have declined from the levels that occurred in the 1960s and 1970s, several decades after dam construction. The run size in 1969 was approximately 120,000, whereas run sizes averaged 600 fish from 1990 to 1997 (Moyle 2002). Escapement subsequently increased after Red Bluff Diversion Dam operations were modified and temperature control shutters were installed on Shasta Dam (Reclamation 2008a). Winter-Run Chinook Salmon adult escapement data for the Sacramento River Basin from 1974 to 2016 are included in Figure 2.1-2 (CDFW 2018). Preliminary data show a decline since 2012 corresponding to severe drought conditions.

Spring-Run Chinook Salmon: The Central Valley drainage as a whole is estimated to have supported annual runs of Spring-Run Chinook Salmon as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). The Central Valley Spring-Run Chinook Salmon ESU has displayed broad fluctuations in adult abundance. Estimates of Spring-Run Chinook Salmon in the Sacramento River and its tributaries (not including the lower Yuba and Feather Rivers because CDFW's GrandTab does not distinguish between Fall-Run and Spring-Run Chinook Salmon in-river spawners, and not including the FRFH) have ranged from 1,404 in 1993 to 25,890 in 1982. Adult Spring-Run Chinook Salmon are predominantly found in tributaries to the Upper Sacramento River with the bulk of adults found in Mill, Deer, and Butte Creeks. Clear and Battle Creeks also contain regular runs of Spring-Run Chinook. Butte Creek has produced an average of two-thirds of the total production over the past 10 years (DWR and Reclamation 2017; CDFW 2018b). During recent years, Spring-Run Chinook Salmon escapement estimates (excluding in-river spawners in the Yuba and Feather Rivers) have ranged from 23,696 in 2013 to 8,112 in 2016 throughout the tributaries to the Sacramento River surveyed (CDFW 2018b).

Central Valley Steelhead: In the 1950s, Central Valley Steelhead populations numbered approximately 40,000 fish, while during the mid-1960s, the Steelhead population was estimated at 27,000 (DFG 1965, as cited in McEwan and Jackson 1996). McEwan and Jackson (1996) estimated the annual run size for Central Valley Steelhead to be less than 10,000 fish by the early 1990s. Steelhead returns have been lower than average (n = 1,480) on the American River during recent years with a return of 756 adults in 2016, 1,032 in 2017, and 513 in 2018. Furthermore, Steelhead redd counts on the American River have been lower than average (n = 122) with 53 redds counted in 2015, 10 in 2017, and 63 counted in 2018. A total of 25 Steelhead have been counted migrating upstream on the Tuolumne River from 2009 to 2018, according to the counting weir operated by FishBio, with a high of 16 counted in 2011. On the Stanislaus River 82 Steelhead have been counted passing the FishBio weir from 2011 through 2017 with an annual low of 10 (2011) and a high of 82 (2017). The Mokelumne River regularly passes Steelhead through the Woodbridge fish ladder.

Central Coast Steelhead: CDFG (1965) estimated a total of 94,000 adult CCC Steelhead spawned in the rivers and streams of this DPS during the mid-1960s, including 50,000 fish in the Russian River—the largest population within the DPS. Near the end of the 20th Century, the Steelhead population in the Russian River was believed to have declined substantially and local CDFG biologists estimated the wild run population in the Russian River Watershed was between 1,700 and 7,000 fish (McEwan and Jackson 1996). Abundance estimates for smaller coastal streams indicate low but stable levels with individual run size estimates for several streams (Lagunitas, Waddell, Scott, San Vicente, Soquel, and Aptos Creeks) of approximately 500 fish or less (62 FR 43937).

Green Sturgeon: Based on surveys of sites where adult North American Green Sturgeon aggregated in the upper Sacramento River from 2010 to 2015, the total number of adults in the Southern DPS population was estimated to be 2,106 ± 860 (Mora 2016 as cited in NMFS 2018).

Killer Whale: The historical abundance of Southern Resident Killer Whales was estimated based on genetic data to have ranged from 140 to 200 individuals (Krahn et al. 2002; NMFS 2008c). As of September 13, 2018, the Southern Resident Killer Whale population comprised 74 individuals. J pod has 22 members; K pod has 18; and L pod has 34 (Orca Network 2019).

Delta Smelt: Fisheries surveys indicate that Delta Smelt abundance has declined substantially in the San Francisco Estuary since the 1970s and has been relatively low during most years since 2004 (CDFW 2018a). The 2018 Delta Smelt 20-millimeter, TNS, and Fall Midwater Trawl (FMWT) indices were all zero or unable to be calculated, the lowest in history, which began with the FMWT in 1967 (CDFW 2018a).

Coho Salmon: Wild Coho Salmon in the Trinity River today are not abundant and the majority of the fish returning to the river are of hatchery origin. Data from the monitoring program at the Willow Creek Weir indicates the Trinity River portion of the Southern Oregon/Northern California Coast Coho Salmon ESU is predominately of hatchery origin (NMFS 2014; Reclamation and CDFW 2017).

Eulachon: There are no reliable historical abundance estimates for Eulachon. Available information (based largely on commercial fishery records) indicates that, starting in 1994, the southern DPS of Eulachon experienced an abrupt decline in abundance throughout its range (Gustafson et al. 2010). Since the 2010 listing, improved monitoring of Eulachon in several rivers detected general increases in adult spawning abundance, especially in 2013 to 2015 (NMFS 2016d). However, sharp declines in Eulachon abundance occurred in 2016 and 2017, likely in response to poor conditions in the north east Pacific Ocean (NMFS 2017).

3.3 Without-Action Analysis

Environmental baseline is a concept that both courts and agencies have struggled to address for ongoing actions, but it is important in understanding the status of the species and factors affecting species environment within the action area but without the proposed action. In a consultation on a new action, where the status quo does not include the effects of the action under consultation because the action has not yet taken place, a simple projection of the status quo can often represent the without-action scenario. However, in a consultation on an ongoing action, the without-action scenario cannot be defined by simply projecting the status quo into the future, because doing so would improperly include in the baseline the continued effects of the action under consultation. Instead, in a consultation on an ongoing action, such as operation of the CVP and SWP, the baseline analysis must project a future condition without the action. This allows for isolation of the effects of the action from the without-action scenario and, in turn, a determination of whether the action is likely to jeopardize listed species and/or destroy or adversely modify critical habitat. Thus, to provide a snapshot of the species' survival and recovery prospects without the proposed action, Reclamation is analyzing a without-action scenario. The without-action scenario entails no future operations of the CVP and SWP: in other words, no discretionary regulation of flows through the system, including, for example, storing and releasing water from reservoirs and delivering water otherwise required by contract.

Reclamation reviewed consultations on other ongoing water project actions to inform this analytical approach. Recently, in the USACE (2014) consultation with NMFS on the ongoing operation of the Daguerre Point and Englebright Dams, the agencies recognized that "effects attributable to the existence of a dam over which the agency has no discretion," as well as "to non-discretionary operations and maintenance should be included in the environmental baseline rather than attributable to the proposed action" (NMFS 2014). The biological opinion utilized a predominantly qualitative analysis to represent the environmental baseline, explaining how the existence of the dams as a baseline condition had multiple effects on the action area.

With this and other examples and the foregoing principles in mind, in the without-action scenario, Reclamation and DWR would not operate to meet the CVP and SWP's water rights permit obligations, or any environmental or contractual obligations. The without-action scenario is consistent with Reclamation's mandatory obligation to preserve the integrity of the facilities (per the Reclamation Safety of Dams Act P.L. 95-589). Described in more detail below, this condition essentially entails each of the CVP facilities simply passing inflows with no pumping or flow routing operations.

Reclamation considered multiple types of structural configurations and gate positions to identify a configuration to protect the long-term integrity of the structures in a without-action scenario, regardless of hydrology. One option considered was to set conditions at continuous low flow releases. However, while setting river release valves at a low flow release condition would result in storing water and maintaining a regular high storage, it would eventually result in overtopping of the dams under high inflow conditions, thereby threatening the structural integrity of the dams.

Review of the hydrologic and operational record identified a historical example where Reclamation and the SWP operated most major facilities with gates essentially fully open to pass inflow for the purpose of preserving the integrity of structures pursuant to the National Dam Safety Program. Reclamation and DWR selected a day within the historical period of record with high inflow, February 19, 1986, that resulted in releases that were intended to preserve the integrity of the structures. February 19, 1986, was during a flood event during which Reclamation and DWR were dealing with massive inflows at all major reservoirs, and were operating most dams for the purpose of passing flows. Flows below Shasta Dam and Folsom Dam were 76,900 cfs and 134,000 cfs, respectively, and the configuration was that the projects passed through all the runoff, constrained only by the structural reservoir and gate capacities, for the purpose of protecting the structural integrity of the facilities. Gates and barriers that could be damaged under high flow events, such as the DCC, were closed on this date.

The purpose of this historical example is to provide an empirical precedent for how Reclamation and DWR would model passing flows in a situation where the infrastructure is operating "without action," for the purpose of preserving the existence of the structures. This is not a separate alternative, but a historical snapshot that provides the basis for isolating the causal effects of operations and, thus, determining whether the effects of operations would jeopardize the species. Consistent with this historical example, the existence of the dams as a component of the without-action scenario is represented by setting the outlet works on storage facilities to release inflows in a way that ensures the structural integrity of the facilities in any hydrologic condition over the period of the proposed action. Generally, the analysis assumes the gate positions as they were on February 19, 1986; however some configurations may differ from the exact conditions on that day. For example, this scenario assumes Jones and Banks Pumping Plants exist but are turned off, which preserves the integrity of the pumps.

To establish the species' conditions absent operations, Reclamation modeled the hydrograph without the agencies' discretionary reshaping of flows. This approach represents the absence of the action under consultation using both quantitative tools and the qualitative analytical method from the Daguerre Point consultation. Based on the information available, this approach provides the most reasonable representation of the without-action component of the environmental baseline in this consultation.

While all demands continue to exist, the without-action scenario assumes that the CVP and SWP will not be operated to meet demands. However, water right holders having rights that pre-date the CVP and SWP would reasonably be expected continue to divert available supplies. Sacramento River Settlement Contractor, Exchange Contractor, Feather River Settlement contractor, holding contracts, and other senior water rights holder demands are based on senior water rights claimed by the contractors, and this without-action scenario assumes they would continue to divert water off of the rivers under those rights, to the extent water is available and they use their own facilities. This is what these senior water rights holders did previously in the absence of operation of the CVP and SWP. Water district operations and diversions for non-CVP or non-SWP water rights are thus assumed to continue in the environmental baseline.

In addition to the aforementioned senior water rights holders, refuges having pre-CVP rights would be expected to continue to divert available supplies. Sutter National Wildlife Refuge, Los Banos Wildlife Area, San Luis Unit of the San Luis National Wildlife Refuge, and East Bear Creek Unit of the San Luis National Wildlife Refuge all have riparian water rights and non-CVP diversions. Several other refuges have water rights as landowners within non-CVP and non-SWP water districts.

No regulations or RPAs tied to operation of the CVP or SWP would occur. Operations of non-CVP and non-SWP facilities would still occur as they are occurring today.

The specific hydrology of the 1986 date is not relevant; the operational model (CalSim) was run using the standard hydrologic period of record (1922–2003) and projected climate, with facilities configured (i.e., spillways, valves, etc.) mostly as they were on February 19, 1986, to represent preservation of the existing structures.

The detailed assumptions regarding hydrology, demands, facilities, and other criteria in the without-action scenario are explained below.

3.3.1 Trinity

Under the without-action scenario, Trinity and Lewiston Dam gates would be open to the extent necessary to protect Trinity and Lewiston Dams without exports to the Sacramento River watershed. Trinity Reservoir storage is assumed at current capacity (2,400 TAF). No transbasin diversion would occur through the Carr Power Plant to Whiskeytown Lake or through Spring Creek Tunnel to Keswick Reservoir.

Because the CVP and SWP would not operate under the without-action scenario, the Trinity River Restoration Program would not be implemented.

Whiskeytown Dam would pass flows with the river release valves set fully open, approximately 1,200 cfs. Additional flows would pass through the Glory Hole spillway. No flows would be diverted from Whiskeytown Reservoir through Spring Creek Tunnel.

3.3.2 Sacramento

Lake Shasta is assumed at current capacity (4,552 TAF). Under this scenario, it is assumed that Shasta Dam spillway gates would be fully open and river release valves would be set at the static level to pass approximately 80,000 cfs, or the amount necessary to preserve the integrity of the dam under this baseline, consistent with Reclamation's operation on February 19, 1986. The Shasta TCD would not operate under this scenario. All gates are assumed to be open.

Keswick Dam spillway gates are assumed to be open and valves would be set to pass a flow of approximately 80,000 cfs, which is the amount necessary to preserve the integrity of the dam under this scenario.

Because the CVP would not operate to meet project demands under this scenario, there would be no diversions for CVP water service contracts off of the Sacramento River. Sacramento River Settlement Contractors would still divert water off of the Sacramento River under their water rights and using their facilities.

Flood control weirs along the Sacramento River are assumed to be left in place; however, facilities to increase the frequency of floodplain inundation in the bypasses would not be operated.

Freeport Regional Water Project (FRWP) is assumed to be in place; however, CVP diversions through FRWP for delivery would not take to place under this without-action scenario. Deliveries based on other water rights would occur under this scenario.

Water transfers that do not rely on CVP and SWP facilities (e.g., NOD) could still occur.

3.3.3 Feather River

Lake Oroville has a capacity of 3,553 TAF. Under this scenario, spillway gates are assumed to be open and valves set to pass a flow of approximately 180,000 cfs, or the amount necessary to preserve the integrity of the Oroville Dam.

Oroville has a FERC license which is non-CVP and non-SWP; however, as the SWP would not be operating in the without-action scenario, Oroville release valves would be set at fixed condition similar to the other reservoirs.

Table A allocations would not occur, nor would Article 21 deliveries. Feather River Service Area settlement contractors would be expected to divert off of the Feather River when there is water available in the Feather River because they have non-CVP and non-SWP water rights.

The CVP and SWP would not be operated for CALFED Agreements under this scenario, including the Lower Yuba River Accord transfers. Operations of non-CVP facilities (i.e., Yuba) would still occur as they are occurring today.

3.3.4 American River

Folsom Reservoir has a capacity of 977 TAF. Under this scenario spillway gates are assumed to be open and valves set to pass a flow of up to 134,000 cfs, or the amount necessary to preserve the integrity of the Folsom Dam. The temperature shutters would be set in the raised position, allowing water to be released from the lowest portions of the reservoir. Reclamation would not operate the M&I Intake. Water agencies along the American River downstream of the dam would be expected to continue to divert under their own water rights as long as adequate flow is in the river.

Because the CVP and SWP do not operate in the without-action scenario, the American River Flow Management Standard would not apply.

Folsom South Canal would not deliver CVP water, and the Folsom South Canal gate would be closed to protect the structural integrity of the canal. However, water rights holders would be able to divert water from Folsom Reservoir and the American River through their own facilities.

Nimbus Dam spillway gates are open and set to pass all incoming flow.

3.3.5 Delta

The Jones and Banks Pumping Plants are turned off under the without-action scenario. Because in this scenario Reclamation and DWR are operating for protection of the facilities, pumps would be turned off to avoid breakage and destruction of the facility due to lack of maintenance and power. Moreover, because Reclamation's hydropower facilities would not be generating hydroelectricity, Reclamation would not have the power to run Jones Pumping Plant. CCF gates are assumed to be closed. Without filling of CCF, DWR would not run Banks Pumping Plant. No south of Delta pumping would take place. Delta outflow would be the result of the hydrology minus the other non-CVP/SWP facilities throughout the Sacramento and San Joaquin Basins. No south of Delta exports would occur for CVP, SWP, or non-project use. This includes no pumping for health and safety purposes or the facilitation of transfers.

Reclamation and DWR would not pump water into San Luis Reservoir. O'Neill Forebay gates would be left open, and associated pumping plants would be off.

Similar to other non-CVP water rights holders, under this scenario, CCWD is assumed not to divert CVP water, but would divert water based on their water rights through their own facilities.

No Delta barriers would be installed or operated because they are part of SWP operations. The south Delta agricultural barriers would not be in place, nor would the Head of Old River Barrier. However, the current Delta channel configuration would remain intact. In-Delta water users would continue to divert water for use and discharge drainage water.

The DCC would be left closed to prevent scouring around the facility and thus to preserve structural integrity to represent the system without operation of the CVP.

Suisun Marsh Salinity Control Gates would be left open year-round and other Suisun Marsh facilities would not be operated.

Water right permits assigned to Reclamation and DWR would not be applicable because the CVP and SWP would not be diverting water in California. Therefore, all D-1641 requirements including X2 standards, Delta water quality standards, real-time DCC operation, and San Joaquin flow standards are assumed not to be implemented under the without-action scenario. Without project water diversions, exports, or requirements, it is likewise assumed that there would be no implementation of the Coordinated Operations Agreement under this scenario.

3.3.6 Stanislaus River

New Melones Reservoir has a capacity of 2,400 TAF. Under this scenario, the lower level river outlets would be closed to preserve the integrity of the gate structure and the Flood Control and Industrial gate would be set fully open to pass a flow of up to an assumed 8,000 cfs. Inflow exceeding this capacity would be stored in the reservoir until the releases capacity could physically evacuate the water. The spillway would prevent overtopping of the dam and accordingly protect the structural integrity of the dam and related facilities. This spillway is not gated and would naturally flow should the reservoir reach that height.

3.3.7 San Joaquin River

Millerton Lake has a capacity of 520 TAF. Under the without-action scenario, the river release valves are assumed to be set to pass a flow of up to 15,000 cfs and the spillway gates are assumed to be open to pass the amount necessary to preserve the integrity of the Friant Dam.

Friant-Kern and Madera Canal gates and valves would be closed to protect the structures. Riparian water right holders below Friant Dam would be expected to divert from the San Joaquin River when water is available in the San Joaquin River. San Joaquin River Exchange Contractors would likewise be expected to divert off of the San Joaquin River when water is available. Friant Dam releases for the SJRRP would not be implemented in the without-action scenario.

3.3.8 Non-Operational Actions

The without-action scenario assumes that Reclamation is not operating the CVP for water supply, fish and wildlife, or any other authorized purpose, including CVPIA. Activities intended to protect, restore, and mitigate the effects of CVP and SWP operations would not occur, including but not limited to:

- CVPIA. These actions are in part reimbursable by beneficiaries of project operations. Without the action, Reclamation would have no revenue from project beneficiaries to offset costs. None of CVPIA would occur, including but not limited to:
    - (b)(1) – Reasonable measures to double anadromous fish in the Central Valley and address other identified adverse environmental impacts
    - (b)(12) – Clear Creek Restoration Program
    - (b)(13) – Spawning and Rearing Habitat on CVP Streams
    - (b)(21) – Anadromous Fish Screen Program
- Conservation Hatcheries
    - Livingston Stone National Fish Hatchery
    - U.C. Davis Fish Culture Center
- Monitoring Programs under IEP and CVPIA
    - (b)(1) – Federal Science
    - (b)(16) – Comprehensive Assessment and Monitoring Program
    - Bay Studies – Reclamation would not exercise its water rights
    - Delta Juvenile Fish Monitoring Program (DJFMP)
    - Environmental Monitoring Program (EMP)

  - Delta Status and Trend Monitoring Trawls (SKT, STN, FMWT)
- Watershed-Specific Restoration Programs
  - San Joaquin River Restoration Program
  - Trinity River Restoration Program

Reclamation has ongoing activities that would continue, including fish hatchery programs at Coleman and Nimbus, because these facilities were intended as mitigation for the construction of CVP dams. Because CVP dams exist in the without-action scenario, activities tied to the existence of the dam would also occur. The Battle Creek Restoration Program is a nonreimbursable activity that Congress has directed Reclamation to perform that is not tied to operation of the CVP and SWP, which would continue under the without-action scenario.

Chapter 4 Proposed Action

Reclamation and DWR propose to continue the coordinated long-term operation of the CVP and SWP to maximize water supply delivery and optimize power generation consistent with applicable laws, contractual obligations, and agreements; and to increase operational flexibility by focusing on non- operational measures to avoid significant adverse effects based on the conditions estimated to occur through 2030. Reclamation and DWR propose to store, divert, and convey water in accordance with existing water contracts and agreements, including water service and repayment contracts, settlement contracts, exchange contracts, and refuge deliveries, consistent with water rights and applicable laws and regulations. The "Current Operation" shows the applicable criteria for operation of the CVP and SWP today. Although not part of the effects of operating the project into the future, the Current Operation provides a reference for the changes under the proposed action to assist in understanding the proposed action. Table 4-1 below identifies specific changes from current operations that are part of this proposed action. The proposed action includes habitat restoration that would not occur under the without action scenario and provides specific commitments for habitat restoration.

In preparing this Proposed Action, Reclamation and DWR considered conditions estimated to occur through 2030. If conditions past 2030 are similar to the analysis period, this BA can remain in effect. If, in accordance with the ESA, new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered or if the amount or extent of taking specified in the incidental take statement is exceeded, formal consultation will be reinitiated. Reclamation recognizes that the NEPA process is ongoing and that proposed action may change as a result of that process. If necessary, Reclamation may reinitiate consultation with the Services to address any significant modifications to the proposed action as considered in the BiOps.

Table 4-1. Comparison of Select Components Across Without Action, Current Operation, and Proposed Action

Without Action	Current Operation	Proposed Action
Sacramento		
No temperature management	NMFS RPA I.2.1-I.2.4: Shasta Temperature Management, WRO 90-5 downstream temperature targets	Temperature management based on use of Shasta cold water pool for Winter-Run survival, including WRO 90-5.
No managed spring pulses	No managed spring pulses	Spring pulses up to 150 TAF if projected May 1 storage > 4 MAF
No fall base flows	3,250 cfs minimum flow	Measures to reduce Fall-Run redd dewatering and rebuild cold water pool, e.g., when end-of-September storage is: ≤ 2.2 MAF, flow is 3,250 cfs; ≤ 2.8 MAF, flow is 4,000 cfs; ≤ 3.2 MAF, flow is 4,500 cfs; > 3.2 MAF, flow is 5,000 cfs.
No Winter-Run Conservation Hatchery	Livingston-Stone National Fish Hatchery	Increased use of Livingston-Stone National Fish Hatchery during droughts

Without Action	Current Operation	Proposed Action
Trinity		
No flow control	Trinity ROD Flows + Lower Klamath Augmentation Flows	Trinity ROD Flows + Lower Klamath Augmentation Flows
Clear Creek		
No base flows	Base flow of 50–100 cfs based on 1960 CDFG MOA	Base flow of 200 cfs October 1 through May 31, 150 cfs from June to September in all except critical years. In critical years, base flows may be reduced below 150 cfs based on the available water from Trinity Reservoir.
No channel maintenance flows	Channel maintenance flows when flood operations occur	10 TAF for channel maintenance, unless flood control operations provide similar releases, using the river release outlets, in all but dry and critical years
No managed pulse flows	Two managed pulse flows in Clear Creek in May and June of at least 600 cfs for at least 3 days for each pulse per year	10 TAF for pulse flows, using the river release, in all but critical years
No temperature management	Daily water temperature of: (1) 60^{o} F at the Igo gage from June 1 through September 15; and (2) 56^{o}F at the Igo gage from September 15 to October 31.	Daily water temperature in below normal and wetter years of: (1) 60^{o}F at the Igo gage from June 1 through September 15; and (2) 56^{o}F or less at the Igo gage from September 15 to October 31; operate as close as possible to these targets in dry and critical years.
Feather		
No minimum flow	FERC License flows	FERC License flows
American River		
No minimum flows	2006 Flow Management Standard	2017 Flow Management Standard: Flows range from 500 to 2,000 cfs based on time of year and annual hydrology, and “planning minimum”
No temperature management	Daily average water temperature of 65°F or lower at Watt Avenue Bridge from May 15 through October 31. 56°F temperature target November 1 through December 31.	May 15 through October 31 daily average water temperature of 65°F (or target temperature determined by temperature model) or lower at Watt Avenue Bridge. When the target temperature requirement cannot be met because of limited coldwater availability in Folsom Reservoir, then the target daily average water temperature at Watt Avenue may be increased incrementally (i.e., no more than 1°F every 12 hours) to as high as 68°F. November 1 through December 31 daily average water temperature of 56°F target if cold water pool allows. A temperature higher than 56°F may be targeted based on temperature modeling results.
Delta		
No exports	D-1641 requirements; and OMR requirements based on USFWS RPA	D-1641 requirements; and risk-based OMR management incorporating real-time monitoring and models

Without Action	Current Operation	Proposed Action
	Actions 1-3 and NMFS RPA Action IV.2.3	
DCC closed	DCC operations based on NMFS RPA that requires consultation to avoid exceeding water quality standards	DCC operations based on D-1641, closures for fish protections, and operations that avoid exceeding water quality standards
No Delta Outflow requirement	D-1641 requirements; and maintain average X2 for September and October no greater (more eastward) than 74 km in the fall following wet years and 81 km in the fall following above normal years	Delta outflow to meet D-1641 requirements; Suisun Marsh Salinity Control Gate operation for up to 60 additional days between June 1 – October 31, depending on year type; increased Delta outflow in wet and above normal year types in certain conditions.
No management of Old and Middle River tidal reverse flows	Old and Middle River Managed Reverse Flows based on calendar date and workgroups per USFWS RPA Actions 1-3 and NMFS RPA Action 1V.2.3.	Old and Middle River Managed Reverse flows based on species distribution, modeling, and risk analysis with provisions for capturing storm flows
No Head of Old River Barrier (HORB)	HORB installed between September 15 and November 30 of most years when flows at Vernalis is <5,000 cfs; occasionally also between April 15 and May 30 if Delta Smelt entrainment is not a concern	No HORB installed
No Delta Smelt conservation hatchery	U.C. Davis Fish Culture Center Refugial Population	Increased use of the U.C. Davis Fish Culture Center and a Delta Fish Species Conservation Hatchery for the introduction of propagated fish into the wild
No COA	1986 COA with 2018 Addendum	1986 COA with 2018 Addendum
Stanislaus		
No base flows	Appendix 2-E flows from NMFS RPA III.1.3	Stepped Release Plan
San Joaquin		
No base flows	San Joaquin River Restoration Program flows	San Joaquin River Restoration Program flows

4.1 Decreasing Operational Discretion

In the 1920s, farmers and municipalities relied upon intermittent surface flows and groundwater for water supply. Over time, as land in California was reclaimed and demand for water increased, over-pumping caused groundwater-level declines in the Sacramento and San Joaquin Valleys and associated aquifer- system compaction and land subsidence. The concept of a statewide water development project was first raised in 1919 by Lieutenant Robert B. Marshall of the U.S. Geological Survey, in large part to meet the demands of California's economy and prevent ongoing impacts resulting from water shortages, including land subsidence. He proposed transporting water from the Sacramento River system to the San Joaquin Valley then moving some of it over the Tehachapi Mountains into Southern California. His proposal led to the first plan for a state-operated water project.

In 1931, State Engineer Edward Hyatt introduced a report identifying the facilities required and the economic means to accomplish the north-to-south water transfer. Called the “State Water Plan,” the report took 9 years and $1 million to prepare. To implement the plan, the Legislature passed the Central Valley Act of 1933, which authorized the project. A $170 million bond act was subsequently approved by the voters of the State of California in a special election on December 19, 1933. During the Great Depression, revenue bonds were unmarketable, so the State was unable to secure funding to begin construction of the CVP. The State then sought the assistance of the federal government. Following the issuance of a feasibility report, President Franklin Roosevelt’s administration agreed to take over the CVP as a public works project.

In the Rivers and Harbors Act of 1935, Congress originally authorized the CVP and provided initial funding. The Rivers and Harbors Act of 1937 reauthorized the CVP for the purposes of “improving navigation, regulating the flow of the San Joaquin River and the Sacramento River, controlling floods, providing for storage and for the delivery of the stored waters thereof, for construction under the provisions of the Federal Reclamation Laws of such distribution systems as the Secretary of the Interior (Secretary) deems necessary in connection with lands for which said stored waters are to be delivered, for the reclamation of arid and semiarid lands and lands of Indian reservations, and other beneficial uses, and for the generation and sale of electric energy as a means of financially aiding and assisting such undertakings and in order to permit the full utilization of the works constructed.” Congress gave Reclamation broad authority to operate the dams and reservoirs of the CVP “first, for river regulation, improvement of navigation, and flood control; second, for irrigation and domestic uses; and, third, for power.” Reclamation had substantial flexibility in determining how to balance the three original project purposes.

Reclamation and DWR’s operation of the CVP and SWP changed significantly in 1978 with the issuance of the WQCP under the SWRCB Water Right Decision 1485 (D-1485). D-1485 imposed on the water rights for the CVP and SWP new terms and conditions that required Reclamation and DWR to meet certain standards for water quality protection for agricultural, M&I, and fish and wildlife purposes; incorporated a variety of Delta flow actions; and set salinity standards in the Delta while allowing the diversion of flows into the Delta during the winter/spring. Generally, during the time D-1485 was in effect, natural flows met water supply needs in normal and wetter years and reservoir releases generally served to meet export needs in drier years.

The D-1485 requirements applied jointly to both the CVP and SWP, requiring a joint understanding between the projects of how to share this new responsibility. To ensure operations of the CVP and SWP were coordinated, the COA was negotiated and approved by Congress in 1986, establishing terms and conditions by which Reclamation and DWR would coordinate operations of the CVP and SWP, respectively. The 1986 COA envisioned Delta salinity requirements but did not address export restrictions during excess conditions.

In 1992, the CVPIA amended previous authorizations of the CVP to include fish and wildlife protection, restoration, and mitigation as project purposes having equal priority with irrigation and domestic water supply uses, and fish and wildlife enhancement as having an equal priority with power generation. The CVPIA included several other provisions that represented additional Congressional direction for operation of the CVP and overlaid a more complex statutory framework. These overlapping and sometimes competing requirements create challenges in how to address and balance the myriad of obligations Reclamation has in operating the CVP, and how to coordinate with the SWP.

In 1995, the SWRCB issued an update to the WQCP for the Bay-Delta. In 1999 (revised in 2000) the SWRCB issued D-1641 to implement those elements of the 1995 WQCP that were to be implemented through water rights. The 1995 WQCP and D-1641 included a new export to total Delta inflow (E/I) ratio of 35 percent from February through June. The 35 percent E/I from February to June was a significant change from D-1485. The 1995 WQCP and D-1641 also imposed Spring X2, pumping limitations based on San Joaquin River flow, which in combination with the E/I ratio, reduced the availability of “unstored” flow for the CVP and SWP. February to June became an unreliable season for conveying water across the Delta. The effect of D-1641 was a shift in the export season, in part, to the summer, and the CVP and SWP entered the fall with lower reservoir levels and less need for flood releases in the fall and winter.

In addition, D-1641 imposed a flow requirement for the San Joaquin Basin at Vernalis which included both base flows and a large spring pulse flow. However, it did not address how the requirement would be shared between the three major San Joaquin tributaries. In lieu of the SWRCB assigning responsibility, several interested parties entered into the San Joaquin River Agreement, which included flow commitments from all three tributaries, funding commitments, transfers, and voluntary demand reductions. The agreement was initially set to expire in 2009 but was extended to 2012, when it expired and was not replaced.

In 2000, Reclamation signed the Trinity ROD. This defined a minimum flow regime of 369,000 acre-feet in critical dry years ranging to 816,000 acre-feet in wet years in the Trinity River. The ROD decreased the amount of water Reclamation could bring from the Trinity River over to the Sacramento River, reducing water supplies for Delta outflow and salinity and reducing the Shasta Reservoir cold water pool flexibility. This was intended to benefit Trinity River listed fish species, but has complicated Reclamation’s ability to meet requirements imposed for the protection of Sacramento River listed fish.

4.2 Operational Tradeoffs

Operation of the CVP and SWP involves a balancing of various laws, regulations, contracts, and agreements. The overlapping and often conflicting requirements necessitate tradeoffs among watersheds, among fish species, among authorized purposes, and among water users. The tradeoffs occur within a season, between seasons, and across water years. Summarized below are examples of these conflicts and resulting tradeoffs that inform this proposed action.

To help protect against drought, Reclamation traditionally operated the CVP to achieve higher end-of- water-year storage that provided for increased carryover into the next year. Over time, the CVP has come under increasing pressure to provide water for environmental purposes which has resulted in decreased water supply reliability (see Figure 4-1 below). To meet state permit conditions, contractual demands, and environmental obligations, more demand has been placed on storage, resulting in lower end-of-water-year storage than was typical in the past. Significant tradeoffs in operational decision making now arise due to overlapping and conflicting regulations that make it difficult to meet congressionally authorized CVP purposes, including those for fish and wildlife.

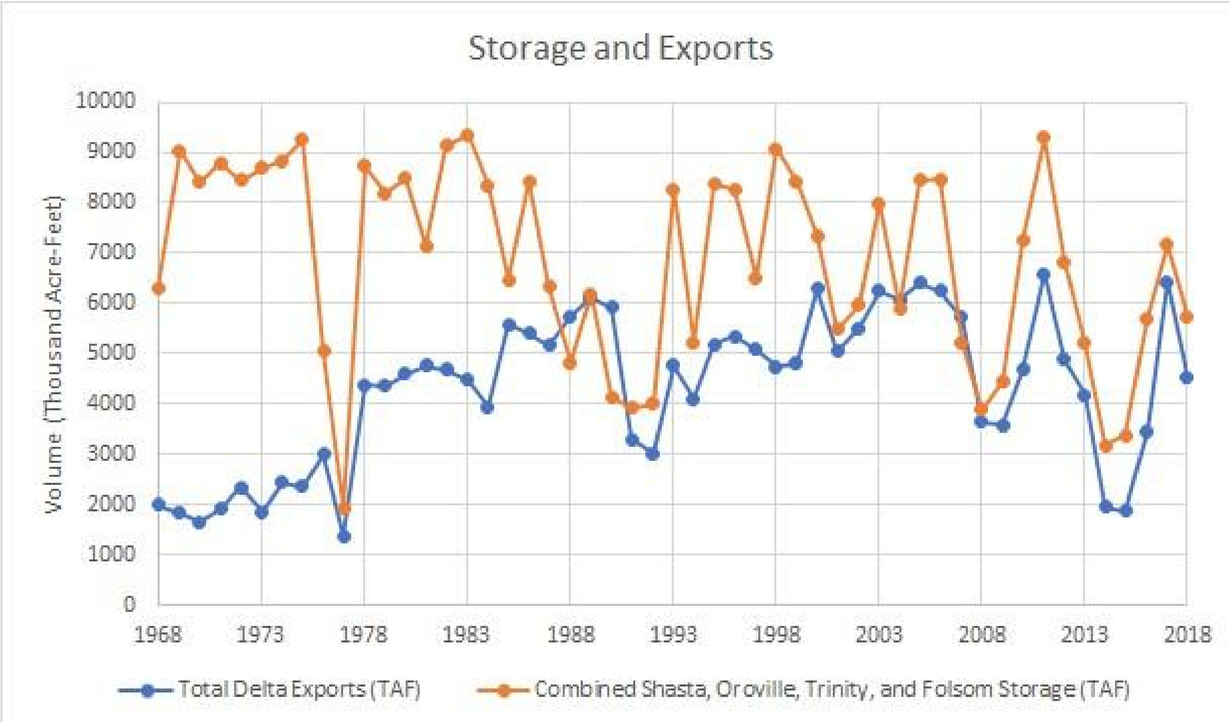


Figure 4-1. Delta Exports and Reservoir End-of-September Storage, 1968–2018

If releases are reduced during some timeframes to maintain higher storage levels in reservoirs, that has a corresponding effect of reducing inflows to the Delta, which then reduces Delta outflows. The benefit of increased reservoir storage should be weighed against the potential negative downstream impacts on fisheries. In addition, maintaining a higher carryover storage increases the risk of having to make flood control releases early in the season to draw down to the required maximum flood conservation space. Making flood control releases in October and November to draw down to the required maximum storage conflicts with needs to avoid redd dewatering.

At Shasta Reservoir, Reclamation seeks to build cold water pool for providing suitable temperatures for Winter-Run Chinook Salmon spawning and incubation in the summer. Releases earlier in the year may reduce this cold water pool. To avoid Winter-Run Chinook Salmon and Fall-Run Chinook Salmon redd dewatering, releases higher than what is needed for instream requirements or Delta requirements may occur. Increased releases may also occur to facilitate meeting Delta outflow or salinity requirements per D-1641. The Temperature Control Device (TCD) is operated to selectively withdraw cold water from specific elevations to maximize the use of the cold water pool. Water temperature management strategies that deplete cold water pool early in the year come at the expense of later season temperatures.

The Trinity ROD and lower Klamath fall augmentation flows limit Reclamation’s transbasin diversions and impact Reclamation’s temperature operations and CVP deliveries on the Sacramento River. Increases in Trinity River releases in the late summer and fall result in lower storage in Trinity Reservoir at the end of the water year. The decreases in storage accumulate from water year to water year when the reservoir does not refill. Hydrologic conditions that do not refill the reservoir result in lower end-of-summer storages, negative impacts on cold water pool, and potentially warmer stream temperatures for Fall-Run Chinook Salmon spawning in the Trinity River.

Reclamation and DWR coordinate regarding downstream requirements (Delta outflow, Delta salinity, etc.) through the COA. The amount of water released from each CVP reservoir depends upon reservoir storage, channel capacity, fishery concerns, projected inflows, and projected end-of-September storage. With its several upstream reservoirs, Reclamation balances releases so that no one reservoir bears the full burden of meeting the downstream requirements.

On the American River, temperature targets during the summer are intended to benefit Steelhead. Meeting this requirement typically uses nearly the full volume of cold water pool. As a result, there is typically a limited cold water pool remaining in the fall to provide suitable spawning and incubation temperatures for Fall-Run Chinook Salmon. There is rarely enough cold water to provide optimal conditions for both species. Water transfers through Folsom from upstream senior water right holders that occur after Folsom Reservoir has stratified (typically early June) also may have small negative impacts on the cold water pool.

Demands for higher outflow directly conflict with fishery agency requests to maintain substantial cold water pool storage in the reservoirs through the summer for temperature operations in the summer and fall. There are also tradeoffs between species; for example, spring pulse flows on the Sacramento River to benefit Spring-Run Chinook Salmon could negatively impact temperature operations for Winter-Run Chinook Salmon.

San Luis Reservoir is an off-stream storage facility primarily fed by water pumped from the Delta. This supply is used annually to meet south of Delta contractor demands. In the past (prior to major seasonal restrictions of Delta pumping), Delta exports were utilized heavily during the rainy season to capture excess flows in the Delta and store that additional water supply in San Luis Reservoir. The developed water supply (i.e., stored water) was then used during the summer months to provide water to the south of Delta contractors. Now, however, because of significant export restrictions during the precipitation season imposed by the 1995/2006 WQCP and the 2008/2009 biological opinions, the bulk of the joint CVP/SWP Delta export capability is timed during the summer months, resulting in a higher percentage of south of Delta deliveries relying on upstream storage. Ideally, San Luis Reservoir would be as full as possible by April 1 of each water year, then operated to meet south of Delta needs throughout the summer. San Luis Reservoir low point generally occurs the end of August of each water year. If San Luis low point is too low, there can be algae problems for users of water through the San Felipe Project, particularly Santa Clara Valley Water District. Those users have expressed a need to have a plan to prevent San Luis Reservoir from becoming so low that water supplies are negatively impacted by algal growth.

With respect to hydropower generation, the use of direct river release outlets to access colder water below the power penstock intakes for fishery purposes causes the releases to bypass hydropower production. This impacts power customers and represents a loss of revenue to Reclamation. In addition, increased requirements and regulations over the years have impacted the ability to deliver CVP water, resulting in lower allocations. The lower allocations result in increased power customer costs to ensure Restoration Fund revenues.

4.3 Coordinated Operation Agreement

Reclamation and DWR propose to operate their respective facilities in accordance with the COA. The COA defines the project facilities and their water supplies, sets forth procedures for coordinating operations, and identifies formulas for sharing joint responsibilities for meeting Delta standards and other legal uses of water. It further identifies how unstored flow will be shared, sets up a framework for exchange of water and services between the projects, and provides for periodic review of the agreement.

Through the COA, Reclamation and DWR share the obligation for meeting in-basin uses. In-basin uses are defined in the COA as legal uses of water in the Sacramento Basin, including the water required under the provisions of Exhibit A of the COA [SWRCB Delta standards]. Each project is obligated to ensure water is available for these uses. The respective degree of obligation is dependent on several factors, as described below.

Balanced water conditions are defined in the COA as periods when it is mutually agreed that releases from upstream reservoirs plus unregulated flows approximately equal the water supply needed to meet Sacramento Valley in-basin uses plus exports. Excess water conditions are periods when it is mutually agreed that releases from upstream reservoirs plus unregulated flow exceed Sacramento Valley in-basin uses plus exports. Reclamation's Central Valley Operations Office (CVO) and DWR's SWP Operations Control Office jointly decide when balanced or excess water conditions exist. During balanced water conditions, the projects share the responsibility in meeting in-basin uses.

During excess water conditions, sufficient water is available to meet all beneficial needs, and the CVP and SWP are not required to supplement the supply with water from reservoir storage. Under Article 6(g) of the COA, Reclamation and DWR have the responsibility (during excess water conditions) to store and export as much water as possible, within physical, legal, and contractual limits.

Implementation of the COA principles has continuously evolved since 1986 as changes have occurred to CVP and SWP facilities, to operating criteria, and to the overall physical and regulatory environment. For example, updated water quality and flow standards adopted by the SWRCB, CVPIA, and ESA responsibilities have affected both CVP and SWP operations. The 1986 COA incorporated D-1485 provisions regarding Delta salinity and outflow. It also envisioned and provided a methodology to incorporate future regulatory changes, like Delta salinity requirements, but did not explicitly envision (or explicitly address) sharing of export restrictions. Both D-1641 and the 2008 and 2009 biological opinions included various export restrictions that were not explicitly addressed in the 1986 COA; however, the available export capacity as a result of these export restrictions was shared between the projects in the absence of a formal update.

In 2018, Reclamation and DWR modified four key elements of the COA to address changes since COA was originally signed: (1) in-basin uses; (2) export restrictions; (3) CVP use of Banks Pumping Plant up to 195,000 acre-feet per year; and (4) the periodic review. COA sharing percentages for meeting Sacramento Valley in-basin uses now vary from 80 percent responsibility of the United States and 20 percent responsibility of the State of California in wet year types to 60 percent responsibility of the United States and 40 percent responsibility of the State of California in critical year types. In a dry or critical year following two dry or critical years, the United States and State will meet to discuss additional changes to the percentage sharing of responsibility to meet in-basin use. When exports are constrained, and the Delta is in balanced conditions, Reclamation may pump up to 65 percent of the allowable total exports with DWR pumping the remaining capacity. In excess conditions, these percentages change to 60/40.

4.4 CVP Water Contracts

Based on the provisions of federal reclamation law, the CVP delivers water pursuant to water service and water repayment contracts, as well as settlement, exchange, and refuge contracts. Reclamation also delivers water pursuant to temporary, not to exceed 1 year, “Section 215 Contracts,” when there are surplus flood flows. Pursuant to the Warren Act, Reclamation provides for the conveyance of non-CVP (which includes SWP water) when there is excess capacity available in CVP facilities. This consultation covers the operation of the CVP and SWP to deliver water under the terms of all existing contracts up to full contract amounts, which includes the impacts of maximum water deliveries and diversions under the terms of existing contracts and agreements, including timing and allocation. Reclamation is not proposing to execute any new contracts or amend any existing contracts as part of this consultation.

Reclamation proposes to operate the CVP to meet its obligations to deliver water to senior water right holders who received water prior to construction of the CVP, to wildlife refuge areas identified in the CVPIA, and to water service contractors.

Different water year type indices assist in determining flows and allocations in different regions. The table below shows these.

Table 4-2. Water Year Type Indices

Index	From	Formula	Use
Sacramento River Index (SRI)	D-1485 WQCP	Sum of the unimpaired runoff in the water year as published in the DWR Bulletin 120 for the following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total unimpaired inflow to Oroville Reservoir; Yuba River at Smartville; and American River, total unimpaired inflow to Folsom Reservoir.	
Sacramento Valley Index (SVI)	D-1641	(0.4) x Current Apr-Jul runoff forecast (in maf) + (0.3) x Current Oct-Mar runoff (in maf) + (0.3) x Previous Water Year’s Index	Used in determining Clear Creek for channel maintenance flows, Delta Smelt Summer-Fall habitat actions, transfer volumes
San Joaquin Index (SJI)	D-1641	0.6) x Current Apr-Jul runoff forecast (in maf) + (0.2) x Current Oct-Mar runoff (in maf) + (0.2) x Previous Water Year’s Index	Used in determining Stanislaus Stepped Release Plan releases,
Eight River Index (8RI)	D-1641	Sacramento River Runoff + San Joaquin River Runoff	
Shasta Critical	Reclamation	Shasta Critical years are if the forecasted unimpaired inflow for the water year is less than 3.2 MAF or the total accumulated deficiencies below 4 MAF in the immediately prior water year, or series of successive prior water years each of which had inflows of less than 4 MAF, together	Used in determining Settlement and Exchange Contractor delivery, refuge delivery

Index	From	Formula	Use
		with the forecasted deficiency for the current water year exceed 800 TAF	
Trinity River	Reclamation	Determined based on Trinity Inflow	Used in determining Trinity ROD releases

Many senior water right holders executed contracts with Reclamation, such as the Sacramento River Settlement Contractors and San Joaquin River Exchange Contractors. The terms of those contracts differ significantly from water service contracts. The pattern of diversion of water under a water service contract depends on the use of the water, with irrigation water typically diverted and used during the irrigation season (March through October), and M&I water diverted and used year-round. All water service contracts contain a shortage provision allowing Reclamation to reduce the amount of water made available for a variety of reasons, such as droughts. Table 4-3 summarizes the number of CVP water service and repayment contracts and the amount of water under contract.

Table 4-3. CVP Water Service and Repayment Contracts

CVP Division	Number of Contracts	Contract Quantity[1] (Acre-Feet)
Tehama-Colusa Canal, Corning Canal, Redding Area, and Trinity River Division	36	468,890
American River	9	328,750
New Melones/Eastside Contracts	2	155,000
South of Delta	44	2,112,898
Friant Division	27	2,249,475
Contra Costa Water District	1	195,000

Note: Contract quantities do not reflect actual deliveries due to system conditions.

This consultation covers Reclamation's operational actions to meet the terms of its existing CVP water supply contracts (i.e., water service contracts, and settlement, exchange, and refuge contract). Reclamation is not proposing to execute or amend any SRS Contracts. Rather, Reclamation proposes to operate the CVP in coordination with the SWP to deliver water for multiple authorized purposes, including the provision of water under the terms of the SRS Contracts and other water contracts as they currently exist.

CVP Water service and repayment contracts include shortage provisions as follows: Article 12, Constraints on the Availability of Water, provides for a Condition of Shortage, which is defined in Article 1(c) as "...a condition respecting the Project during any Year such that the Contracting Officer is unable to deliver sufficient water to meet the Contract Total." Article 12(c) provides "In any Year in which there may occur a shortage for any of the reasons specified in subdivision 12(b) above, the Contracting Officer shall apportion Project Water among the Contractor and others entitled, under existing contracts and future contracts (to the extent such future contracts are permitted under subsections (a) and (b) of Section 3404 of the CVPIA) and renewals thereof, to receive Irrigation Water consistent with the contractual obligations of the United States." Article 12(d) states, "Project Water furnished under this Contract will be allocated in accordance with the then-existing Project

M&I Water Shortage Policy. Such policy shall be amended, modified, or superseded only through a public notice and comment procedure."

The largest contracts belong to the Sacramento River Settlement Contractors (approximately 2.1 MAF) and the San Joaquin River Exchange contractors (approximately 840 TAF). In very dry years, Reclamation and DWR are often limited to operating the CVP and SWP solely to meet these, and other senior water right requirements, along with refuge water supply requirements and minimum instream and Delta flows, M&I deliveries pursuant to the CVP M&I Shortage Policy, and SWP exports for health and safety. In recent drought years, limited water supplies, dry hydrology, and regulatory restrictions made it difficult for Reclamation to make water available to satisfy contracts already reduced by 25 percent in those years. Reclamation delivers Level 2 refuge water primarily from the CVP and acquires Incremental Level 4 water from voluntary measures which include water conservation, conjunctive use, purchase, lease, donations, or similar activities, or a combination of such activities which do not require involuntary reallocations of project yield. This proposed action covers the operation to deliver up to full contract amounts, including full Level 4 refuge contract amounts. Table 4-4 summarizes senior CVP water rights holders and the amount of water under contract[1].

Table 4-4. CVP Settlement Agreements

Contractor	Number of Contracts	Contract Quantity (Acre-Feet)
Sacramento River Settlement (SRS)	132	2,112,194 (1,775,313 Base + 336,881 Project)
San Joaquin River Exchange	4	840,000
Oakdale/S. San Joaquin ID Agreement and Stipulation	1	≤ 600,000
American River Contracts	13	578,441
Friant Division Riparian Holding Contracts	n/a	5 cfs past each diversion

[1] Reclamation proposes to operate the CVP in coordination with the SWP to deliver water for multiple authorized purposes, including the provision of water under the terms of the SRS Contracts as they currently exist, which include a Schedule of Monthly Diversions of Water, which sets forth the quantities and allocations of water to be provided, and applicable reductions in Contract Totals during Critical Years. In the modeling for CVP operations, SRS Contractor water demands are based on SRS demands over the last 15 years, as limited by the of Schedule of Monthly Diversions of Water in each SRS Contract. Since 1981, implementation of a variety of water conservation measures has reduced the demand for water under the SRS Contracts. Accordingly, Reclamation does not expect SRS demands to increase above that modeled demand over the planning horizon for this consultation, and therefore has not conducted a quantitative analysis of the various mechanisms for which increased demand would be met. However, increased demand of diversions under the SRS contracts could be met through modifying the coordinated operation of the CVP and SWP facilities in accordance with the operating priorities and project purposes and obligations. Potential modifications may include reduced deliveries to water service contractors, changes to reservoir storage throughout the CVP and SWP and/or modifications to operations of the Shasta temperature control device.

Contractor	Number of Contracts	Contract Quantity (Acre-Feet)
South of Delta Settlement Contractors	9	35,623
North of Delta Refuges—Level 2 CVP	2	151,250
South of Delta Refuges—Level 2 CVP	3	244,994

Note: Contract quantities do not reflect actual deliveries due to system conditions.

The contracts referenced above usually include articles such as Article 5, Constraints on the Availability of Water, which states that “in a Critical Year, the Contractor's Base Supply and Project Water agreed to be diverted during the period April through October of the Year in which the principal portion of the Critical Year occurs and, each monthly quantity of said period shall be reduced by 25 percent.”

4.5 SWP Water Contracts

The SWP has signed long-term contracts with 29 water agencies statewide to deliver water supplies developed from the SWP system. These contracts are with both M&I water users and agricultural water users. The contracts specify the charges that will be made to the water agency for both: (1) Conservation of Water, and (2) Conveyance of Water. The foundational allocation of water to each contractor is based on their respective “Table A” entitlement, which is the maximum amount of water delivered to them by the SWP, on an annual basis. Typically, annual water deliveries to individual agencies are less than their maximum Table A amount, due to a wide variety of reasons.

DWR proposes to operate the SWP in accordance with contracts with senior water right holders in the Feather River Service Area (approximately 983 TAF). Further, under State Water Contracts, DWR allocates Table A water as an annual supply made available for scheduled delivery throughout the year. Table A contracts total 4,173 TAF, with over 3 MAF for San Joaquin Valley and Southern California water users.

Article 21 of the long-term SWP water supply contracts provides an interruptible water supply made available only when certain conditions exist: (1) the SWP share of San Luis Reservoir is physically full, or projected to be physically full; (2) other SWP reservoirs south of the Delta are at their storage targets or the conveyance capacity to fill these reservoirs is maximized; (3) the Delta is in excess condition; (4) current Table A demand is being fully met; and (5) Banks has export capacity beyond that which is needed to meet current Table A and other SWP operational demands.

4.5.1 SWP Settlement Agreements

DWR has water rights settlement agreements to provide water supplies with entities north of Oroville, along the Feather River, Bear River, and in the Delta. These agreements provide users with water supplies that they were entitled to prior to the construction of the SWP’s Oroville Complex. Collectively, these agreements provide over 1 MAF of water each year. DWR also has agreements with several (more than 60) riparian diverters along the Feather, Yuba, and Bear Rivers to provide water for diversion. Table 4-5 summarizes the volumes under the water rights settlement agreements.

Table 4-5. SWP Settlement Agreements

Location	Entity	Amount (Acre-Feet)
North of Oroville	Andrew Valberde	135
North of Oroville	Jane Ramelli	800
North of Oroville	Last Chance Creek WD	12,000
Feather River	Garden Highway Mutual Water	18,000
Feather River	Joint Water Districts Board	620,000
Feather River	South Feather Water & Power	17,555
Feather River	Oswald WD	3,000
Feather River	Plumas Mutual Water	14,000
Feather River	Thermalito Irrigation District	8,200
Feather River	Tudor Mutual Water	5,000
Feather River	Western Canal/PG&E	295,000
Bear River	South Sutter/Camp Far West	4,400
Delta	Byron-Bethany ID	50,000
Delta	East Contra Costa ID	50,000
Delta	Solano Co./Fairfield, Vacaville and Benicia	31,620

4.5.2 SWP Contracting Agencies

The SWP has signed contracts with 29 parties to provide water supplies developed by the SWP. Table 4-6 shows the maximum contracted annual water supply per DWR's most recent water supply reliability report.

Table 4-6. SWP Water Service Contracts

Contracting Agency	Maximum Supply (Acre-Feet)
Butte County	27,500
Plumas County	2,700
Yuba City	9,600
Napa County Flood Control and Water Conservation District	29,025
Solano County	47,756
Alameda County—Zone 7	80,619
Alameda County Water District	42,000
Santa Clara Valley Water District	100,000
Oak Flat Water District	5,700
Kings County	9,305
Dudley Ridge Water District	45,350
Empire West Side Irrigation District	3,000
Kern County Water Agency	982,730
Tulare Lake Water Storage District	87,471
San Luis Obispo County	25,000
Santa Barbara County	45,486

Contracting Agency	Maximum Supply (Acre-Feet)
Antelope Valley-East Kern Water Agency	144,844
Santa Clarita Valley Water Agency	95,200
Coachella Valley Water District	138,350
Crestline-Lake Arrowhead Water Agency	5,800
Desert Water Agency	55,750
Littlerock Creek Irrigation District	2,300
Metropolitan Water District of Southern California	1,911,500
Mojave Water Agency	85,800
Palmdale Water District	21,300
San Bernardino Valley Municipal Water District	102,600
San Gabriel Valley Municipal Water District	28,800
San Gorgonio Pass Water Agency	17,300
Ventura County Watershed Protection District	20,000

4.6 D-1641

Reclamation and DWR propose to operate in accordance with obligations under D-1641, which provides protection for fish and wildlife, M&I water quality, agricultural water quality, and Suisun Marsh salinity. D-1641 granted Reclamation and DWR the ability to use or exchange each project's diversion capacity capabilities to maximize the beneficial uses of the CVP and SWP. The SWRCB conditioned the use of Joint Point of Diversion capabilities based on staged implementation and conditional requirements for each stage of implementation.

4.7 CVPIA

Reclamation proposes to operate in accordance with its obligations under the CVPIA, including but not limited to CVPIA 3406 (b)(2). DOI accounts for the following actions in meeting the 3406 (b)(2) requirement:

1. Primary Purposes: Any fish action (export reduction or upstream release) that predominantly contributes to one of the enumerated 3406(b) programs identified by the courts, including 3406(b)(1), (4), (5), (8), (9), (12), (18) and (19), must be counted against the up to 800 TAF of (b)(2) water. Thus, any upstream release or export reduction that predominantly contributes to one of those purposes will be deducted from the 3406(b)(2) account.
2. Secondary Purposes: Water operations in accordance with ESA and fish and wildlife objectives of D-1641 water quality actions may also be included in (b)(2) accounting. Upstream releases mandated by ESA Biological Opinions may also count towards 3406 (b)(2). Export reductions in ESA Biological Opinions or specified under D-1641 for fish and wildlife objectives may also count towards 3406 (b)(2). Releases for other water quality actions (i.e., net delta outflow) under D-1641 may also count towards 3406 (b)(2).

Pursuant to section 3406(b)(2)(C) the Secretary of the Interior may temporarily reduce deliveries of the quantity of water dedicated under this paragraph up to 25 percent of such total whenever reductions due to hydrologic circumstances are imposed upon agricultural deliveries of Central Valley Project water. The Secretary may make water available for other purposes if the Secretary determines that the 800,000 acre-feet identified in section 3406(b)(2) is not needed to fulfill the purposes of section 3406.

4.8 Allocation and Forecasts

Reclamation proposes to allocate CVP water on an annual basis in accordance with contracts. Reclamation bases north of Delta allocations primarily on available water supply within the north of Delta system along with expected controlling regulations throughout the year. For south of Delta allocations, Reclamation relies on upstream water supply, previously stored water south of the Delta (in San Luis Reservoir) and conveyance capability through the Delta. Flows on the San Joaquin River often limit conveyance under current compliance requirements, influence flow direction within the Delta and through their influence on Old and Middle net reverse flow, can affect entrainment levels at the State and federal pumps.

The water allocation process for the CVP begins in the fall when Reclamation makes preliminary assessments of the next year's water supply possibilities, given current storage conditions combined with a range of hydrologic conditions. Reclamation may refine these preliminary assessments as the water year progresses. Beginning February 1, Reclamation prepares forecasts of water year runoff using precipitation to date, snow water content accumulation, and runoff to date. All the CVP's Sacramento River Settlement water rights contracts and San Joaquin River Exchange contracts require that contractors be informed no later than February 15 of any possible deficiency in their supplies. Reclamation targets February 20 as the date for the first announcement of all CVP contractors' forecasted water allocations for the upcoming contract year. Reclamation updates forecasts of runoff and operations plans at least monthly between February and May.

Reclamation intends to use a conservative forecast for seasonal planning of reservoir releases (including developing initial and updated allocations) and temperature management planning. Starting in January, Reclamation reviews various exceedances of inflow forecasts to determine a conservative monthly operations outlook. In many cases, Reclamation develops monthly release forecasts and associated allocations based on a 90% exceedance inflow forecast through September. Reclamation may deviate from relying on the 90% exceedance inflow forecast in order to develop a conservative outlook. Such instances include scenarios when a wetter hydrology produces a more conservative outlook, due to, for example, more strenuous regulatory or contract requirements, or the actual conditions are significantly drier than the existing forecast such that a more conservative forecast is appropriate. This conservative approach is intended to minimize the frequency where real-time management results in a drier or warmer (water temperature) condition than forecasted.

Reclamation performs operations forecasting on a 12-month ahead cycle each month to determine how the available water resources can best be used to meet project objectives and requirements, which include considerations for health and safety, fishery, water quality, other environmental requirements, and water contracts. Reclamation bases forecasts on the 12-month projected runoff volumes that would occur naturally and considers potential upstream operations where relevant. For October and November, projected runoff is based entirely on historical hydrology as no snowpack data are available yet. In December and January, inflow forecasts may include snow pillow information and precipitation as well as historical hydrology. For the February through May period, the runoff volume estimates are based on the observed inflow to date and current snowpack measurements made at the end of each preceding month, projections through September, and historical hydrology for the next water year. These forecasts represent the uncertainty inherent in making runoff predictions. This uncertainty may include sources such as unknown future weather conditions, the various prediction methodologies, and the spatial coverage of the data network in a given basin.

While Reclamation does not operate to specific end of water year storage targets in its reservoirs, carryover is a key consideration when making operational decisions. Many conditions are considered which factor into end of water year carryover storage in its facilities. These considerations include (but are not limited to): the previous years' hydrology, previous years' end of water year south of Delta storage, current water year hydrology and current south-of-Delta storage, as well as looking at next years' potential hydrology and impacts resulting from various end-of-water year storage conditions. These factors are all considered when developing operations outlooks and actual real time operational decisions.

In most years, the combination of carryover storage and runoff into CVP reservoirs and the Central Valley is not enough to provide sufficient water to meet all CVP contractors' contractual demands. Multiple legislative, contractual, and settlement obligations have created an increased tension in Reclamation's ability to make contractual deliveries of water to water users and to meet other legal obligations. As provided in Section 9 of the Reclamation Projects Act of 1939, Section 215 of the Reclamation Reform Act of 1982, and Section 3404(b) of CVPIA, Reclamation is authorized to enter into temporary contracts, not to exceed 1 year, for delivery of surplus flood flows.

4.8.1 SWP Allocation and Forecasting

At the beginning of each new water year, there is significant uncertainty as to the hydrologic conditions that will exist in the future several months, and hence, the water supplies that will be allocated by the SWP to its water contractors. In recognition of this, DWR utilizes a forecasting-water supply allocation process that is updated monthly, incorporates known conditions in the Central Valley watershed to-date, and forecasts future hydrologic conditions in a conservative manner to provide an accurate estimate of SWP water supplies that can be delivered to SWP contractors as the water year progresses.

There are many factors considered in the forecast-supply process. Some of these factors are the following:

- Water storage in Lake Oroville (both updated and end-of-water-year (September 30))
- Water storage in San Luis Reservoir (both updated and end-of-calendar-year)
- Flood operations constraints at Lake Oroville
- Snowpack surveys (updated monthly from February through May)
- Forecasted runoff in the Central Valley (reflects both snowpack and precipitation)
- Feather River settlement agreement obligations
- Feather River fishery flows and temperature obligations
- Anticipated depletions in the Sacramento and Delta basins
- Anticipated Delta standards and conditions

- Anticipated CVP operations for joint responsibilities
- Contractor supply requests and delivery patterns

Staff from both the Operations Control Office (OCO) and the State Water Projects Analysis Office (SWPAO) coordinate their efforts to determine the current water supply allocations. OCO primarily focuses on runoff/operations models to determine allocations. SWPAO requests updated information from the contractors on supply requests and delivery patterns to determine allocations. Both OCO and SWPAO staff meet at least once a month with the DWR Director to make final decisions on staff's proposed allocations.

The Initial Allocation for SWP Deliveries is made by December 1 of each year with a conservative assumption of future precipitation to avoid over-allocating water before the hydrologic conditions are well defined for the year. As the water year unfolds, Central Valley hydrology and water supply delivery estimates are updated using measured/known information and conservative forecasts of future hydrology. Monthly briefings are held with the DWR Director to determine formal approvals of delivery commitments announced by DWR.

Another water supply consideration is the contractual ability of SWP contractors to "carry over" allocated (but undelivered) Table A from 1 year to the next if space is available in San Luis Reservoir. The carryover storage is often used to supplement an individual contractor's current year Table A allocations if conditions are dry. Carryover supplies left in San Luis Reservoir by SWP contractors can result in higher storage levels in San Luis Reservoir. As project pumping fills San Luis Reservoir, the contractors are notified to take, or lose, their carryover supplies. Carryover water not taken, after notice is given to remove it, then becomes project water available for reallocation to all contractors in a given year.

Article 21 (surplus to Table A) water which is delivered early in the calendar year may be reclassified as Table A later in the year depending on final allocations, hydrology, and contractor requests.

Reclassification does not affect the amount of water carried over in San Luis Reservoir, nor does it alter pumping volumes or schedules.

4.8.2 Daily Operations

After the allocations and forecasting process, Reclamation and DWR coordinate their operations on a daily basis. Some factors which Reclamation and DWR consider when coordinating their joint operations include required in-Delta flows, Delta outflow, water quality, schedules for the joint use facilities, pumping/wheeling arrangements, and any facility limitations. Both projects must meet the flood obligations of individual reservoirs. CVP operations must also consider flows at Wilkins Slough and associated pump intake elevations (see Upper Sacramento River for additional details).

During balanced water conditions, Reclamation and DWR maintain a daily water accounting of CVP and SWP obligations. This accounting allows for flexible operations and avoids the need to change reservoir releases made several days in advance (due to travel time from the Delta). Therefore, adjustments can be made "after the fact," using actual observed data rather than by prediction for the variables of reservoir inflow, storage withdrawals, and in-basin uses. This iterative process of observation and adjustment results in a continuous truing up of the running COA account. The project that is "owed" water (i.e., the project that provided more or exported less than its COA-defined share) may request the other project adjust its operations to reduce or eliminate the accumulated account within a reasonable time.

The COA provides the mechanism for determining each project's responsibility for meeting in-basin use, but real-time conditions dictate real-time actions. Conditions in the Delta can change rapidly. For example, weather conditions combined with tidal action can quickly affect Delta salinity conditions and, therefore, the Delta outflow required to maintain joint salinity standards under D-1641.

Increasing or decreasing project exports can achieve changes to Delta outflow immediately. Imbalances in meeting each project's initial shared obligations are captured by the COA accounting and balanced out later.

When more reaction time is available, reservoir release changes are used to adjust to changing in-basin conditions. If Reclamation decides the reasonable course of action is to increase upstream reservoir releases, then the response may be to increase Folsom Reservoir releases first because the released water will reach the Delta before flows released from other CVP and SWP reservoirs. DWR's Lake Oroville water releases require about 3 days to reach the Delta, while water released from Reclamation's Shasta Reservoir requires 5 days to travel from Keswick Reservoir to the Delta. As water from another reservoir arrives in the Delta, Reclamation can adjust Folsom Reservoir releases downward. Alternatively, if sufficient time exists for water to reach the Delta, Reclamation may choose to make initial releases from Shasta Reservoir. Each occurrence is evaluated on an individual basis, and appropriate action is taken based on multiple factors. Again, the COA accounting captures imbalances in meeting each project's initial shared obligation.

One of the principal considerations when determining which reservoir to make releases from is the reservoir refill potential, i.e., the probability that a reservoir will, over the course of a year's inflow and releases, return to a desirable carryover storage. The refill potential is approximated by the average annual runoff divided by the total reservoir storage. Reservoirs that are large compared to the average runoff of their watershed, such as New Melones, have a small refill potential (0.5). Reservoirs that are small compared to the average runoff of their watershed, such as Folsom, have a large refill potential (2.5).

Folsom Reservoir generally has the best refill potential of the CVP reservoirs. Refill potential also is a consideration when evaluating how much water to move from Trinity Reservoir (0.5) to the Sacramento River side. Shasta Reservoir currently has an average annual runoff of approximately 8,476 TAF, with 4,500 TAF of storage, meaning an approximate refill potential of 2, so releases from Shasta Reservoir are more likely to be replaced with new inflow and bring storage back up than releases from Trinity Reservoir.

The duration of balanced water conditions varies from year to year. Balanced conditions never occur in some very wet years, while very dry years may have long continuous periods of balanced conditions, and still other years may have had several periods of balanced conditions interspersed with excess water conditions. Account balances continue from one balanced water condition through the excess water condition and into the next balanced water condition. When the project that is owed water enters into flood control operations, which could be Shasta Reservoir for the CVP or Lake Oroville for the SWP, the accounting is zeroed out for that project.

Reclamation and DWR staff meet daily to discuss and coordinate CVP and SWP system operations. Several items are discussed at this daily meeting, including:

- Current reservoir conditions
- Pumping status and current outages (for both the CVP and the SWP and how they are affecting project operations)
- Upcoming planned outages (CVP and SWP) and what that means for future operations
- Current reservoir releases and what changes may be planned
- Current regulatory requirements and compliance status
- Delta conditions to determine if CVP and SWP pumping make use of all available water

Reclamation and DWR also coordinate with Hydrosystem Controllers and Area Offices to ensure that, if necessary, personnel are available to make the desired changes. Once Reclamation and DWR each decide on a plan for that day and complete all coordination, each issue change orders to effectuate the decisions, if necessary.

Reclamation and DWR are co-located in the Joint Operations Center. Additionally, the California Data Exchange Center, California-Nevada River Forecast Center and the DWR Flood Management Group are also co-located in the Joint Operations Center. This enables efficient and timely communication, particularly during flood events.

4.9 New Science

Reclamation reinitiated consultation on the coordinated long-term operation of the CVP and SWP, in part because of new information. A substantial amount of new information and science has occurred since the 2008 and 2009 biological opinions. The following selected studies particularly inform the proposed action described in this biological assessment, but do not form a comprehensive list:

- Martin, 2017: A phenomenological assessment of temperature-related Chinook Salmon egg mortality modeling, calibrated to fry survival to Red Bluff, Martin et al. concluded the ideal incubation temperature for eggs in the river was 53.6°F. Below 53.6°F, there is no mortality due to temperature according to Martin. Biophysical models of oxygen transfer across the egg membrane corroborated the difference between temperature-dependent egg mortality predicted in the laboratory versus fry survival to Red Bluff. The 2017 LOBO review (Gore 2018), stated that the Martin approach represents a powerful predictive model for salmon vulnerability to temperature exposure but that the predictions of the oxygen diffusion model should be tested under field conditions because of the model’s apparent sensitivity to extremely small changes in flow velocity, and it may be problematic to apply a density dependent model that lacks any mechanistic basis or site-specific information. Additionally, new laboratory studies from UC Davis (Del Rio et al. In Press) affirm earlier findings (USFWS 1999) that embryo survival is not appreciably impaired at daily mean water temperatures at or near 56°F.
- Anderson 2018: Anderson reviewed Martin 2017 and found that for Chinook Salmon egg incubation shifting the focus of management from meeting a compliance temperature of 53.6°F on the Sacramento River all season long to releasing cold water for just the life stage specific requirements of eggs yields efficiencies for when cold water from Shasta Reservoir is needed and when water from Shasta Reservoir can be saved.
- Grimaldo 2017: Models of Delta Smelt and salmonids at both CVP and SWP showed salvage of adult Delta Smelt increased at OMR more negative than -5,000 cfs, when all other variables were held at their averages. While OMR flow was an important predictor of CVP salvage, more

important than even CVP exports, the OMR threshold of -5,000 cfs was most notable in SWP salvage.

- Perry 2018: Statistical modeling revealed that survival was positively related to inflow only in reaches that transitioned from bidirectional tidal flows to unidirectional flow with increasing inflows. Bidirectional to unidirectional transitions occurred in Sutter, Steamboat, and Georgiana Sloughs, and in the Sacramento River from the DCC to Rio Vista, and in the Mokelumne Rivers between the DCC and the San Joaquin River.
- SST 2017: Neither Coded Wire Tag (CWT) nor acoustic tag (AT) data for juvenile Fall-Run Chinook Salmon show a strong and consistent relationship between survival of fish from the San Joaquin River and exports at Jones and Banks Pumping Plants. The evidence of relationship between exports and through-Delta survival is inconclusive, however, the authors stated that their basis of knowledge is low. “It is unknown whether equivocal findings regarding the existence and nature of a relationship between exports and through-Delta survival is due to the lack of a relationship, the concurrent and confounding influence of other variables, or the effect of low overall survival in recent years.”
- Six-Year Acoustic Telemetry Study: The Six-Year Steelhead Acoustic Telemetry Study monitored yearling Steelhead migrating through the San Joaquin River and Old River during 2011 to 2016. Estimated survival was no different between the two routes in 2011, 2012, and 2014, but was greater for Steelhead that migrated through the San Joaquin River route in 2015 (average for all release groups was 0.30 [range, 0.19–0.46]), and 2016 (average was 0.45 for all release groups [range, 0.23–0.61]) (statistically significant for 2015 and 2016 survival estimates at alpha = 0.05; Reclamation 2018a,b,c; Buchanan 2018a,b,c).
- Buchanan 2018. Buchanan et al. summarized results of the Fall-Run Chinook acoustic tag studies in the San Joaquin River from 2010 through 2015. The results were survival of Fall-Run Chinook Salmon has been low since 2002, ranging between 0 and 0.05. Even in the high flow year of 2011, survival was only 0.02, suggesting increased flows alone are not enough to resolve low survival. Over half of the Fall-Run Chinook Salmon that made it through the San Joaquin part of the Delta to Chipps Island were salvaged at the CVP and transported to Chipps.
- Hammock 2017 and Kimmerer and Rose 2018: These studies have used field research and modeling respectively to improve the scientific understanding of food limitation in Delta Smelt. Hammock et al. (2015, 2017) showed that feeding success is variable in space and time. Kimmerer and Rose (2018) used an individual-based life cycle model to show that if it were possible to achieve, a return to pre-overbite clam historical prey densities might increase the Delta Smelt’s population growth rate by 14 percent to 81 percent.
- MAST / FLaSH Reports: “According to the FLaSH conceptual model, conditions are supposed to be favorable for Delta Smelt when fall X2 is approximately 74 km or less, unfavorable when X2 is approximately 85 km or greater, and intermediate in between (Reclamation 2011, 2012). The data generally supported the idea that lower X2 and greater area of the LSZ would support more subadult Delta Smelt. The greatest LSZ area and lowest X2 occurred in September and October 2011 and were associated with a high FMWT index which was followed by the highest SKT index on record, although survival from subadults to adults was lower in 2011 than in 2010 and 2006. There was little separation between the other years based on X2, LSZ area, or FMWT index. The position and area of the LSZ is a key factor determining the quantity and quality of low salinity rearing habitat available to Delta Smelt and other estuarine species…” Any perceived benefit to the Delta Smelt population of having X2 in the ‘favorable area’ throughout most of 2017 due to high outflows remains unclear, with the Delta Smelt Fall Midwater Trawl index showing a decrease from that in 2016 and remaining near all-time lows.

- Bush 2017: Using isotopic analysis of otoliths from over a thousand Delta Smelt, Bush (2017) found the species exhibits partial migration through three different life history phenotypes, which include a freshwater resident fish, a brackish water resident fish, and a migratory phenotype, hatching in fresh water then occurring in brackish water during the juvenile and sub-adult stage. The relative abundance of each life history phenotype varied inter-annually with the latter most abundant, but not always dominant, in all years studied. The yearly contributions from each phenotype were found to vary with freshwater flows and temperature.
- CAMT Delta Smelt Entrainment Studies: New research shows that when Delta Smelt salvage is analyzed independently for SWP and CVP fish facility data, OMR flow has smaller explanatory influence on salvage than some other variables (Grimaldo et al. 2017). Population abundance, as indexed by the CDFW FMWT program, and turbidity have high explanatory power for adult Delta Smelt salvage at the SWP and CVP, particularly during the era of OMR management per the 2008 USFWS Biological Opinion. The basis for OMR flow management partially stems for earlier work showing that adult Delta Smelt salvage (Grimaldo et al. 2009) and proportional losses (Kimmerer 2008) increased as net OMR flow increased southward towards the Projects. New statistical techniques suggest several factors to minimize salvage or entrainment risk. However, given the correlation of OMR and SWP and CVP models, salvage and entrainment risk could be achieved through management of either indexes of the hydrodynamic influence from Project exports. It is worth noting that the ultimate objective for managing Delta Smelt entrainment should not focus on observed salvage. Rather, the management objective should be to target entrainment losses, in a traditional fisheries sense, to sustainable levels that do not compromise population growth rates (Maunder and Deriso 2011; Rose et al. 2013). New research performed under CAMT, can help scientists and resource managers identify circumstances when those large entrainment losses are likely to occur, which can ultimately be used to develop population risk assessment models (Grimaldo et al. 2017; Gross et al. 2018; Korman et al. 2018; Smith et al. 2018). The question about whether the Delta Smelt population can rebound from record-low abundances, even with improved entrainment management during the winter, remains outstanding given the importance of other factors at play (i.e., poor food supply, growth, water temperatures; see Maunder and Deriso 2011; Rose et al. 2013).

4.10 Proposed Action by Basin

Table 4-7 shows each of the components of the proposed action for this consultation, including operational changes, non-flow habitat, and facility improvements. The table also shows whether each action is covered at a site-specific or a programmatic level in this biological assessment and the proposed implementation approach. The three proposed implementation approaches are generally described as follows (further details are provided in section 4.12 and Appendix C):

- “Core” – the action is part of the Core Water Operations of the CVP and SWP.
- “Scheduling” – agencies and water users provide recommendations to Reclamation on scheduling and shaping specific flow actions.
- “Collaborative Planning” – agencies and water users work collaboratively to define, plan, and implement an action.

Completed consultations with existing biological opinions that address the effects of long-term operations, and do not trigger reinitiation under this consultation are identified by “NCO” (Not Consulted On).

Table 4-7. Components of the Proposed Action

Title	Site Specific or Programmatic	Implementation Approach
CVP/SWP Wide		
Divert and store water consistent with obligations under water rights and decisions by the State Water Resources Control Board	Site-specific	Core
Shasta Critical Determinations and Allocations to Water Service and Water Repayment Contractors	Site-specific	Core
Upper Sacramento		
Seasonal Operations	Site-specific	Core
Spring Pulse Flows	Site-specific	Scheduling
Shasta Cold Water Pool Management	Site-specific	Core
Fall and Winter Refill and Redd Maintenance	Site-specific	Core
Operation of a Shasta Dam Raise	Site-specific	Core
Rice Decomposition Smoothing	Site-specific	Core
Spring Management of Spawning Locations	Site-specific	Collaborative Planning
Temperature Modeling Platform	Programmatic	Collaborative Planning
Shasta Temperature Control Device Performance Evaluation	Programmatic	Collaborative Planning
Battle Creek Salmon and Steelhead Restoration Project and Battle Creek Reintroduction Plan	Programmatic	Collaborative Planning
Lower Intakes Near Wilkins Slough	Programmatic	Collaborative Planning
Spawning and Rearing Habitat Restoration	Programmatic	Collaborative Planning
Small Screen Program	Programmatic	Collaborative Planning
Knights Landing Outfall Gates	Programmatic	Collaborative Planning
Winter-Run Chinook Salmon Conservation Hatchery Production	Programmatic	Collaborative Planning
Adult Rescue	Programmatic	Collaborative Planning
Juvenile Trap and Haul	Programmatic	Collaborative Planning
Directors Meeting	Programmatic	Collaborative Planning
Yellow-billed Cuckoo Surveys	Programmatic	Collaborative Planning
Trinity		
Seasonal Operations	Site-specific	Core
Trinity River Record of Decision	NCO	NCO
Long-Term Plan to Protect Adult Salmon in the Lower Klamath River	NCO	NCO

Title	Site Specific or Programmatic	Implementation Approach
Whiskeytown Reservoir Operations	Site-specific	Core
Clear Creek Minimum Flows	Site-specific	Core
Clear Creek Geomorphic and Spring Attraction Pulse Flows	Site-specific	Scheduling
Spring Creek Debris Dam	Site-specific	Core
Yellow-billed Cuckoo Surveys	Programmatic	Collaborative Planning
Feather		
FERC Project #2100-134	NCO	NCO
American		
Seasonal Operations	Site-specific	Core
2017 Flow Management Standard Releases and “Planning Minimum”	Site-specific	Core
American River Pulse Flows	Site-specific	Scheduling
Spawning and Rearing Habitat Restoration	Programmatic	Collaborative Planning
Nimbus Hatchery Genetic Management Plans	Programmatic	Collaborative Planning
Drought Temperature Management	Programmatic	Core
Yellow-billed Cuckoo Surveys	Programmatic	Collaborative Planning
Stanislaus		
Seasonal Operations	Site-specific	Core
Stanislaus River Stepped Release Plan (including pulse flows)	Site-specific	Scheduling
Alteration of Stanislaus DO Requirement	Site-specific	Core
Spawning and Rearing Habitat Restoration	Programmatic	Collaborative Planning
Temperature Management Study	Programmatic	Core
Yellow-billed Cuckoo Surveys	Programmatic	Collaborative Planning
San Joaquin		
San Joaquin River Restoration Program	NCO	NCO
Lower San Joaquin River Habitat	Programmatic	Collaborative Planning
Yellow-billed Cuckoo Surveys	Programmatic	Collaborative Planning
Delta		
Seasonal Operations	Site-specific	Core
Minimum Export Rate	Site-specific	Core
Delta Cross Channel Operations	Site-specific	Core
Agricultural Barriers	Site-specific	Core
North Bay Aqueduct	Site-specific	Core
Contra Costa Water District Rock Slough Operations	Site-specific	Core

Title	Site Specific or Programmatic	Implementation Approach
Water Transfers	Site-specific	Core
Clifton Court Aquatic Weed and Algal Bloom Management	Site-specific	Core
Suisun Marsh Preservation Agreement	NCO	NCO
OMR Management	Site-specific	Core
Tracy Fish Collection Facility Operations	Site-specific	Core
Skinner Fish Facility Operations	Site-specific	Core
Delta Smelt Summer-Fall Habitat	Site-specific	Collaborative Planning
Delta Smelt Summer-Fall SMSCG Operation	Site-specific	Core
Delta Smelt Summer-Fall Habitat Flow Action	Site-specific	Core
Clifton Court Predator Management	Site-specific	Core
San Joaquin Basin Steelhead Telemetry Study	Site-specific	Collaborative Planning
Steelhead Lifecycle Monitoring Program	Programmatic	Collaborative Planning
San Joaquin Basin Steelhead Collaborative	Programmatic	Collaborative Planning
Sacramento Deepwater Ship Channel Food Study	Programmatic	Collaborative Planning
North Delta Food Subsidies/Colusa Basin Drain Study	Programmatic	Collaborative Planning
Suisun Marsh and Roaring River Distribution System Food Subsidies Study	Programmatic	Collaborative Planning
San Joaquin River Scour Hole Predation Reduction	Programmatic	Collaborative Planning
Tidal Habitat Restoration (Complete 8,000 acres from 2008 biological opinion)	Programmatic	Collaborative Planning
Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project	NCO	NCO
Predator Hot Spot Removal	Programmatic	Collaborative Planning
Delta Cross Channel Gate Improvements	Programmatic	Core
Tracy Fish Facility Improvements	Programmatic	Core
Clifton Court Forebay Mortality Reduction	Site-Specific	Core
Skinner Fish Facility Performance Improvements	Programmatic	Collaborative Planning
Salvage Release Sites	Site-Specific	Core
Small Screen Program	Programmatic	Collaborative Planning
Reintroduction efforts from Fish Conservation and Culture Laboratory	Site-specific	Collaborative Planning
Delta Fish Species Conservation Hatchery	Programmatic	Collaborative Planning
Sediment Supplementation Feasibility Study	Programmatic	Collaborative Planning

The proposed action for each basin is described in more detail below. These sections give some background for context along with a description of the proposed seasonal operations and proposed action.

4.10.1 Upper Sacramento River (Shasta and Sacramento Divisions)

Reclamation operates the CVP Shasta Division for flood control, agricultural water supplies, M&I water supplies, fish and wildlife, hydroelectric power generation, Delta water quality, and water quality in the upper Sacramento River. The CVP Shasta Division is also authorized for navigation. Water rights, contracts, and agreements specific to the Upper Sacramento include SWRCB Decisions 990, 90-5, 91-1, and 1641, Settlement Contracts, Exchange Contract, and Water Service Contracts. Facilities include the Shasta Dam, Lake (4.552 MAF capacity), and Power Plant; Keswick Dam, Reservoir, and Power Plant, and the Shasta TCD. The Sacramento Division includes the Red Bluff Pumping Plant, the Corning Pumping Plant, and the Corning and Tehama-Colusa Canals, for the irrigation of over 150,000 acres of land in Tehama, Glenn Colusa, and Yolo Counties.

Flood control limits releases to less than 79,000 cfs at the tailwater of Keswick Dam and a stage of 39.2 feet in the Sacramento River at Bend Bridge gauging station (~100,000 cfs) to avoid inundating populated areas downstream. Flood control operations are based on regulating criteria developed by the USACE pursuant to the provisions of the Flood Control Act of 1944. Flood control may reserve up to 1.3 MAF of storage behind Shasta, leaving 3.2 MAF for storage management.

Historical commerce on the Sacramento River resulted in a CVP authorization to maintain minimum flows of 5,000 cfs at Chico Landing to support navigation in accordance with the River and Harbors Acts of 1935 and 1937. Although no commercial traffic persists, long-time water users diverting from the river have set their pump intakes based on minimum navigation flows; therefore, the CVP operates to approximately 5,000 cfs at the Wilkins Slough gage during periods when the intakes are being operated. This flow is often a challenge to meet under critical water supply conditions due to both water supply and cold water pool limitations, in which cases Reclamation has operated to approximately 4,000 cfs although impacts on senior diverters occur.

The intake for the Tehama-Colusa Canal and the Corning Canal is located on the Sacramento River approximately 2 miles southeast of Red Bluff. Water is diverted from the Sacramento River through a 2,000 cfs pumping plant (with ability to expand to 2,500 cfs) into a settling basin for continued conveyance in the Tehama-Colusa Canal and the Corning Canal.

The ACID holds senior water rights and has a settlement contract with Reclamation. Water is diverted to its main canal (on the right bank of the river) from a diversion dam located in Redding about 5 miles downstream from Keswick Dam. Reclamation will coordinate with ACID to ensure safe operation of the diversion dam during the irrigation season, from April through October.

In 1990 and 1991, SWRCB issued Water Rights Orders 90-05 and 91-01 modifying Reclamation's water rights for the Sacramento River. The orders stated that Reclamation shall operate Keswick and Shasta Dams and the Spring Creek Power Plant to meet a daily average water temperature of 56°F as far downstream in the Sacramento River as practicable during periods when higher temperature would be harmful to Winter-Run Chinook Salmon. Under the orders, the water temperature compliance point may be modified to an upstream location when the objective cannot be met at Red Bluff Pumping Plant. In addition, Order 90-05 modified the minimum flow requirements initially established in the 1960 MOA for the Sacramento River below Keswick Dam. The water right orders also recommended the construction of a Shasta TCD to improve the management of the limited cold water resources, monitoring, and coordination.

As a result, Shasta Dam is equipped with a TCD that allows temperature operations without impacting power generation. The TCD allows Reclamation to control the temperature of the water released from Shasta Dam. The TCD has four levels of gates from which water can be drawn, upper gates, middle gates, PRG gates (e.g., lower gates) and the Side Gates (coldest configuration). The last tool to reduce temperatures is to operate the TCD in the full side gate position, drawing the lowest (and coldest) possible water from the reservoir. Reclamation must balance the objectives of pulse flows or water supply releases early in the season which can conflict with the goal of maintaining a cold water pool sufficient to meet species' needs toward end of spawning and incubation season in the fall.

To operate the Shasta TCD, a defined amount of reservoir elevation above each set of gates is required to ensure safe operation. This requirement is reflected in Table 4-8 as 35 feet of submergence above the top of the gates.

Table 4-8. Shasta Temperature Control Device Gates with Elevation and Storage

TCD Gates	Shasta Elevation with 35 feet of Submergence of the TCD Gates (feet)	Shasta Storage (MAF)
Upper Gates	1,035	~3.66
Middle Gates	935	~1.64
Pressure Relief Gates	840	~0.59
Side Gates	720[1]	~0.08

[1]Low level intake bottom

4.10.1.1 *Seasonal Operations*

Reclamation operates in the winter for flood control, including both the channel capacity within the Sacramento River and Shasta Reservoir flood conservation space. The USACE is responsible for developing and maintaining the Water Control Manual (WCM) for Shasta Reservoir. The WCM provides that the top of conservation pool (TOC) will set the storage amount that Reclamation is not to exceed on a given date. Releases for flood control will vary dependent upon the current storage, the forecasted inflow, and the flow in the mainstem Sacramento River at Bend Bridge. Reclamation operates Shasta Dam releases to keep flows at Bend Bridge below 100,000 cfs, and therefore reservoir elevations may temporarily exceed the TOC storage to protect downstream populated areas. During the winter period, there can be significant flow fluctuations from Keswick Dam due to the flood control operations. When not operating for flood control, Shasta Dam is operated primarily to conserve storage while meeting minimum flows both down the Sacramento River and in the Delta. These minimum flows are held until irrigation demands require increased releases.

During the winter to spring period there are accretions (flows from unregulated creeks) into the Sacramento River below Shasta Dam. These local accretions help to meet both instream demands and outflow requirements, minimizing the need for additional releases from Shasta and Folsom Reservoirs. In wetter year types, Reclamation may be able to operate mostly for flood control and minimum instream requirements because of the large volumes of accretions to the Sacramento River. In drier years, these accretions may be lower and, therefore, require Reclamation to release a higher level of releases from the upstream reservoirs to meet state permit requirements as well as project exports in the Delta.

In the spring, releases are fairly stable (unless Shasta Reservoir is in flood control operations) until flows are needed to support instream demands on the mainstem Sacramento River and Delta Outflow requirements. When spring regulatory constraints are relaxed, exports can increase during excess flow periods and Reclamation can build additional storage in San Luis without increasing releases from upstream reservoirs. This provides more flexibility later in the year for meeting late season demands. Releases for Delta Outflow requirements are balanced between Shasta Reservoir and Folsom Reservoir. Both reservoirs have substantial temperature control requirements, and both need to substantially fill to be able to fully meet their temperature control requirements. Therefore, releases must be carefully balanced to allow each reservoir to fill without negatively impacting the other. An overarching goal for Reclamation when operating the CVP is to fill the reservoirs as much as possible by the end of the flood control season (end of May), while still meeting all other authorized project purposes. In wetter hydrology, during the March through May period, downstream demands are minimal and are generally met through unstored accretions to the system. Under these conditions, Reclamation will aim to reduce Keswick flows below those proposed for the fall-winter period. Operations under these conditions helps build storage in those types of years.

Currently, the seasonal operation of the TCD is generally as follows: during mid-winter and early spring the highest possible elevation gates are utilized to draw from the upper portions of the lake to conserve deeper colder resources. During late spring and summer, the operators begin the seasonal progression of opening deeper gates as Shasta Reservoir elevation decreases and cold water resources are utilized. In late summer and fall, the TCD side gates are opened to utilize the remaining cold water resource.

During the summer, operational considerations are mainly flows required for Delta outflows, instream demands, temperature control, and exports. In river temperatures below Shasta Dam can be controlled via two methods. First is changing release volume or shifting releases between Trinity and Sacramento reservoirs, and the second is selective withdrawal through the TCD. Determination of which method to use is made on a daily basis as operators balance releases from multiple reservoirs to meet downstream needs.

Fall operations are dominated by temperature control and provision of fish spawning habitat. By late fall, the remaining cold water pool in Shasta Reservoir is usually limited. This can be a delicate balancing act in that if the early fall flows are too high then the fish may make their redds higher up on the edge of the river, and they become subject to the possibility of dewatering when the flows are reduced later in the fall. Sacramento River releases cannot be too low early in the fall as there are still significant instream diversion demands on the mainstem of the Sacramento River between Keswick Dam and Wilkins Slough, and depending on conditions, SWRCB Delta requirements may require upstream reservoir releases. This necessitates maintaining higher releases to support the instream demands until they fall off later in the season. At that time, Reclamation’s objective is to drop Keswick releases to a lower level to conserve storage.

In addition to the requirements under 90-5, ramping rates for Keswick Dam between July 1 – March 31 would be reduced between sunset and sunrise:

- Keswick releases > 6,000 cfs, reductions in releases may not exceed 15% per night, and no more than 2.5% per hour.

- Keswick releases 4,000 cfs to 5,999 cfs reductions in releases may not exceed 200 cfs per night, or 100 cfs per hour.
- Keswick releases between 3,250 cfs and 3,999 cfs; reductions in releases may not exceed 100 cfs per night.

Ramping rates do not apply during flood control or if needed for facility operational concerns. The working groups may also determine a need for a variance.

4.10.1.2 *Spring Pulse Flows*

Under the Core Water Operation, Reclamation would release spring pulse flows of up to 150 TAF in coordination with the Upper Sacramento Scheduling Team when the projected total May 1 Shasta Reservoir storage indicates a likelihood of sufficient cold water to support summer cold water pool management, and the pulse does not interfere with the ability to meet performance objectives or other anticipated operations of the reservoir. Total storage provides a surrogate for the likely cold water pool prior to stratification of the reservoir, and would inform the decision, in addition to monthly winter reservoir temperature measurements and climate forecasts. Reclamation would evaluate the projected May 1 Shasta Reservoir storage at the time of the February forecast to determine whether a spring pulse would be allowed in March and would evaluate the projected May 1 Shasta Reservoir storage at the time of the March forecast to determine whether a spring pulse would be allowed in April. Reclamation anticipates that a projected May 1 storage greater than 4 MAF provides sufficient cold water pool management for Tier 1 and may release the spring pulse if it does not impact the ability to meet project objectives. Reclamation could also determine, in coordination with the Upper Sacramento scheduling team, that while the reservoir is less than 4 MAF, there is sufficient water to do a pulse of up to 150 TAF. The Upper Sacramento scheduling team could also determine that the benefits of a spring pulse flow do not outweigh the potential negative impacts on the system, in which case Reclamation would not release one. Reclamation would also not make a spring pulse release if the release would cause Reclamation to drop into a Tier 4 Shasta summer cold water pool management (i.e., the additional flow releases would decrease cold water pool such that summer Shasta temperature management drops in Tier 4), would interfere with meeting performance objectives, or would interfere with the ability to meet other anticipated demands on the reservoir. The Upper Sacramento Scheduling Team would determine the timing, duration, and frequency of the spring pulse within the 150 TAF volume. Wet hydrology downstream of Keswick Dam may meet the need for pulse flows without increased releases.

Based on current science, which may be updated through the Upper Sacramento Scheduling Team, the spring pulse could be 0 to 2 pulses of 10,000 cfs at Wilkins Slough for 3 days each, in a time when Wilkins Slough flows are less than 9,000 cfs. Following the initial three-day pulse targeting 10,000 cfs at Wilkins, Keswick flows could reduce by no more than 15% per night for flows greater than 6,000 cfs, and no more than 200 cfs per night for flows between 4,000 and 5,999 cfs.

4.10.1.3 *Summary of PA Items to Improve Shasta Storage*

As described in the sections below, the PA includes several operational components, that are intended to contribute to increased spring Shasta storage levels as compared to recent years. These include (1) Fall and Winter Refill and Redd Maintenance, which sets minimum late fall and winter flows, including modification of rice decomposition operations compared to the Current Operations Scenario (COS); (2) modified fall outflow requirements compared to the COS; (3) flexibility in export operations (especially in April and May) compared to the COS; and (4) December 2018 changes to COA (which are also included in COS). These operations, as well as real-time operations, are expected to result in increased end of September carryover storage, which Reclamation expects to benefit the following May 1 storage in years without flood control releases.

4.10.1.4 *Cold Water Pool Management*

The closer Shasta Reservoir is to full by the end of May, the greater the likelihood of being able to meet the Winter Run Chinook Salmon temperature targets throughout the entire temperature control season. If Shasta Reservoir storage is high enough to use the Shasta TCD upper shutters by the end of May, Reclamation can maximize the cold water pool potential. Storage of 3.66 MAF allows water to pass through the upper gates of the Shasta TCD, but historical relationships suggest that a storage of 4 MAF on May 1st generally provides enough storage to continue operating through the upper gates and develop a sufficient cold water pool to meet 53.5°F on the Sacramento River above Clear Creek (at the CCR gaging station) for Winter-Run Chinook Salmon spawning and egg incubation with minimal risks of higher temperatures in the late summer and fall. Figure 4-2 provides an approximate estimate of the relationship between temperature compliance, total storage in Shasta Reservoir, and cold water pool in Shasta Reservoir.

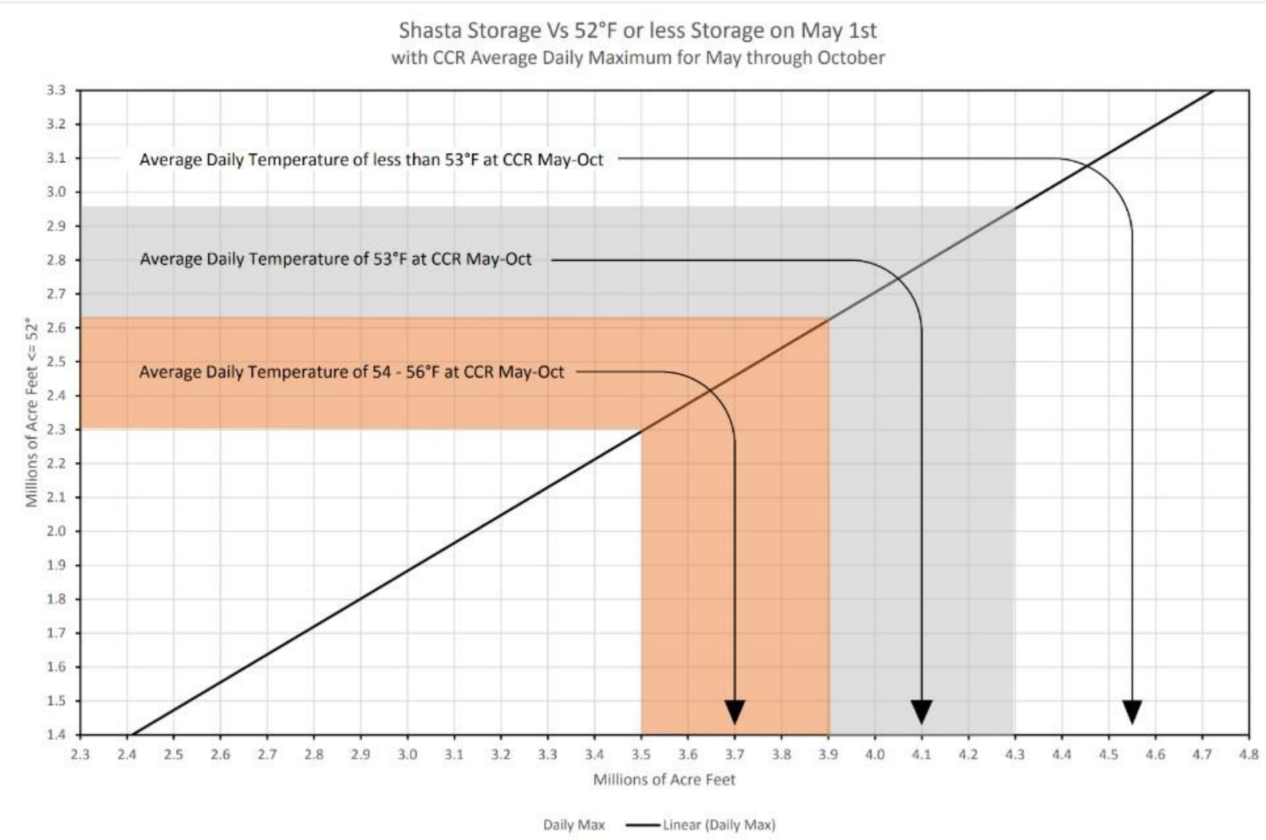


Figure 4-2. Relationship between Temperature Compliance, Total Storage in Shasta Reservoir, and Cold Water Pool in Shasta Reservoir

4.10.1.4.1 Summer Cold Water Pool Management

Reclamation proposes to operate the TCD at Shasta Dam to continue providing temperature management in accordance with CVPIA 3406(b)(6) while minimizing impacts on power generation. Cold water pool is defined as the volume of water in Shasta Reservoir that is less than 52°F, which Reclamation would determine based on monthly (or more frequent) reservoir temperature profiles. The Sacramento River above Clear Creek (CCR) gage is a surrogate for the downstream extent of most Winter-Run Chinook Salmon redds. Temperature management would start on May 15, or when the SRTTG determines, based on real-time information, that Winter-Run Chinook Salmon have spawned, whichever is later. Temperature management would end October 31, or when the SRTTG determines based on real-time monitoring that 95 percent of Winter-Run Chinook Salmon eggs have hatched, and alevin have emerged, whichever is earlier. Real-time information will continue to be considered in this process, which includes redd, carcass, and juvenile surveys.

Reclamation proposes to address cold water management utilizing a tiered strategy that allows for strategically selected temperature objectives, based on projected total storage and cold water pool, meteorology, Delta conditions, and habitat suitability for incoming fish population size and location. The tiered strategy recognizes that cold water is a scarce resource that can be managed to achieve desired water temperatures for fisheries objectives. Figure 4-3 below shows examples of water temperatures at CCR under the four tiers, with arrows indicating how temperatures would change in different years with less May 1 forecasted cold water pool. The proposed tiers are described below, along with storage levels that are likely to provide for cold water management within the tier. Actual operations will depend upon the available cold water and modeling. In any given year, cold water pool and storage could result in Reclamation switching between tiers within the year if needed to optimally use the cold water pool. Coldwater pool management is proposed to start as early as May 15th, however temperatures at the start of the temperature management season are often lower than the target temperatures.

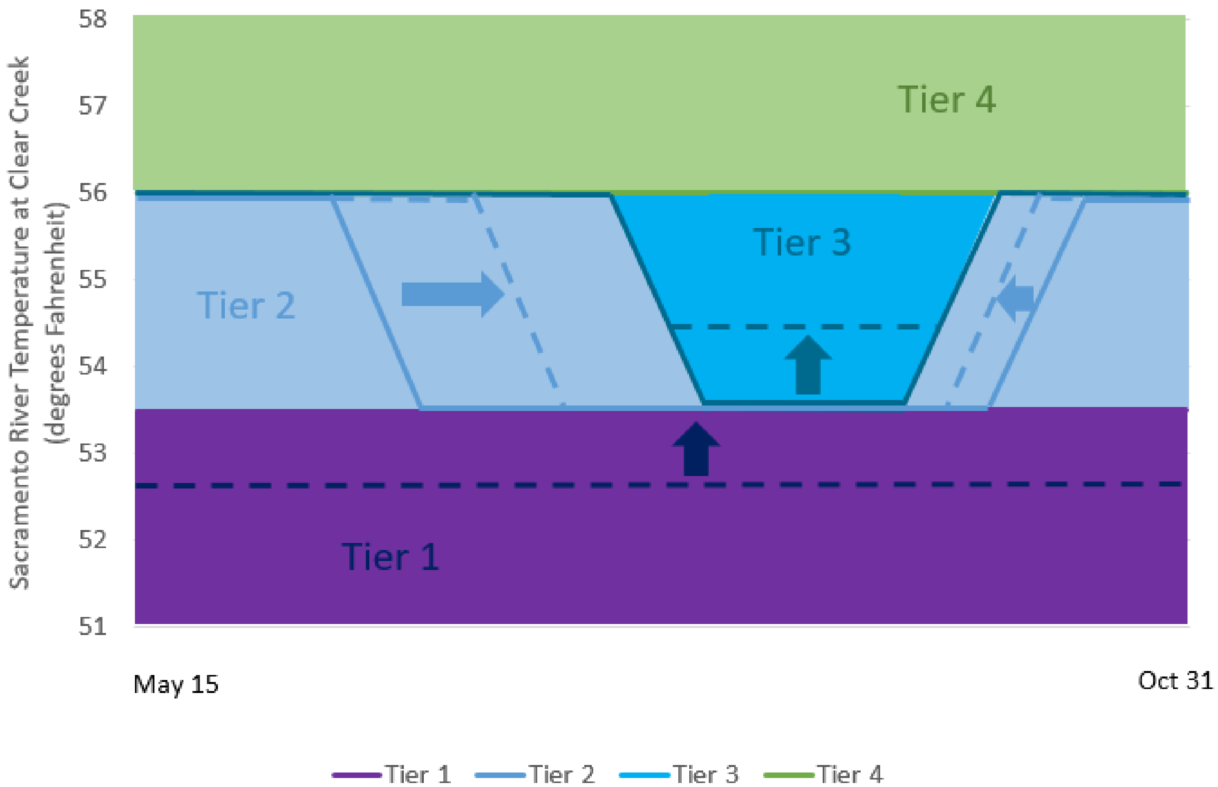


Figure 4-3. Tiered Temperature Management Strategy

- **Tier 1**. In years when Reclamation determines that cold water pool is sufficient (e.g., more than 2.8 MAF of cold water pool in Shasta Reservoir at the beginning of May or modeling suggests that a daily average temperature of 53.5°F at CCR can be maintained from May 15 to October 31), Reclamation proposes to operate to a daily average temperature of 53.5°F at the CCR gaging station to minimize temperature dependent mortality. Although Tier 1 years generally have sufficient cold water to maintain 53.5°F through October 31, the unknown meteorology continues to present a risk of temperatures rising above 53.5°F, particularly towards the end of the summer in September and October. Reclamation can generally manage these risks through real time operations of the TCD, although temporary exceedances may occur, and thus allowable tolerances will be identified in the annual temperature management plan through coordination with SRTTG.
- **Tier 2.** In years when cold water pool is insufficient to allow Tier 1 (e.g., less than 2.8 MAF of cold water pool in Shasta Reservoir at the beginning of May or modeling suggests that the 53.5°F at CCR cannot be maintained from May 15 to October 31), Reclamation would optimize use of cold water for Winter-Run Chinook Salmon eggs based on life-stage-specific requirements, reducing the duration of time of operating to 53.5°F target temperatures. Water temperatures at CCR would vary based on real-time monitoring of redd timing and lifestage-specific temperature

dependent mortality models, for example, Anderson (2017). The period of temperature management with 53.5°F at CCR would be centered on the projected time when the Winter-Run eggs have the highest dissolved oxygen requirement (37–67 days post fertilization). At 2.79 MAF of cold water pool, Reclamation would operate to 53.5°F from 37 days after the first observed redd to 67 days after the last observed redd, if this is earlier than October 31. The duration of the 53.5°F protection will decrease in proportion to the available cold water pool on May 1. Reclamation will determine this time period by running different temperature scenarios through the latest egg mortality model(s) and real-time monitoring of redds. Reclamation would operate to daily average temperatures at CCR during the temperature management season outside of the stage- specific critical window no warmer than 56°F Although Tier 2 years generally have sufficient cold water to maintain 56°F after the last observed red through October 31, the unknown meteorology continues to present a risk of temperatures rising above 56°F, particularly towards the end of the summer in September and October. Reclamation can generally manage these risks through real time operations of the TCD, although temporary exceedances may occur and thus allowable tolerances will be identified in the annual temperature management plan through coordination with the SRTTG.

- **Tier 3.** When Reclamation determines that life-stage-specific temperature targets cannot be met per (2) above (e.g., less than 2.3 MAF of cold water pool in Shasta Reservoir at the beginning of May or modeling suggests that cold water pool management at colder tiers would cause loss of temperature control late in the season), Reclamation proposes to use cold water pool releases to maximize Winter- Run Chinook Salmon redd survival by increasing the coldest water temperature target (see Figure 4-4 below). In Tier 3, the targeted temperature at CCR during the early and late periods of cold water pool management will not exceed a daily average of 56°F. Based on latest egg mortality models, real-time monitoring, and expected and current cold water availability, Reclamation would decrease the temperatures during the period of greatest temperature stress on early life stages to minimize adverse effects to the greatest extent possible. During this critical period, temperatures will be targeted between 53.5°F and 56°F. Tier 3 will be selected if Reclamation's temperature management plan indicates that temperatures can be maintained to at least 56°F at CCR, otherwise Reclamation would operate to Tier 4. Although Tier 3 years generally have sufficient cold water to maintain 56°F through October 31, the unknown meteorology continues to present a risk of temperatures rising above 56°F, particularly towards the end of the summer in September and October. Reclamation can generally manage these risks through real time operations of the TCD, although temporary exceedances may occur, and thus allowable tolerances will be identified in the annual temperature management plan through coordination with the SRTTG. If the temperature management plan indicates a higher risk of exceeding 56°F before October 1st, this is an indication that the cold water pool may not support a warm early fall and will therefore be treated as a Tier 4 year for the purposes of intervention measures and early season discussions and coordination.
- **Tier 4.** If there is less than 2.5 MAF of total storage (note the use of "total" storage as opposed to the "cold water pool" used in the previous criteria) in Shasta Reservoir at the beginning of May, or if Reclamation cannot meet 56°F at CCR, Reclamation will attempt to operate to a less than optimal temperature target and period that is determined in real-time with technical assistance from NMFS and USFWS. Reclamation will explore improved coordination of downstream diversions, and the potential for demand shifting. In addition, Reclamation proposes to implement intervention measures (e.g., increasing hatchery intake and trap and haul, as described below).

At the March forecast (mid-March), if the forecasted Shasta Reservoir total storage is projected to be below 2.5 MAF at the beginning of May, Reclamation would initiate discussions with USFWS and NMFS on potential intervention measures should this low storage condition continue into April and

May, as described in Tier 4. Reclamation proposes to perform the first temperature model run in April after the DWR Bulletin 120 has been received and the operations forecast completed and would provide this forecast to USFWS and NMFS if it is projected to be a Tier 4 year. This is the first month that a temperature model run is feasible based on temperature profiles. Prior to April, there is insufficient stratification in Shasta Reservoir to allow a temperature model to provide meaningful results. The April temperature model scenario is used to develop an initial temperature plan for submittal to the SWRCB. This temperature plan may be updated as Reclamation has improved data on reservoir storage and cold water pool via the reservoir profiles at the end of May, and throughout the temperature control season. Figure 4-4 provides a decision tree explaining the decision points for Shasta Reservoir temperature management.

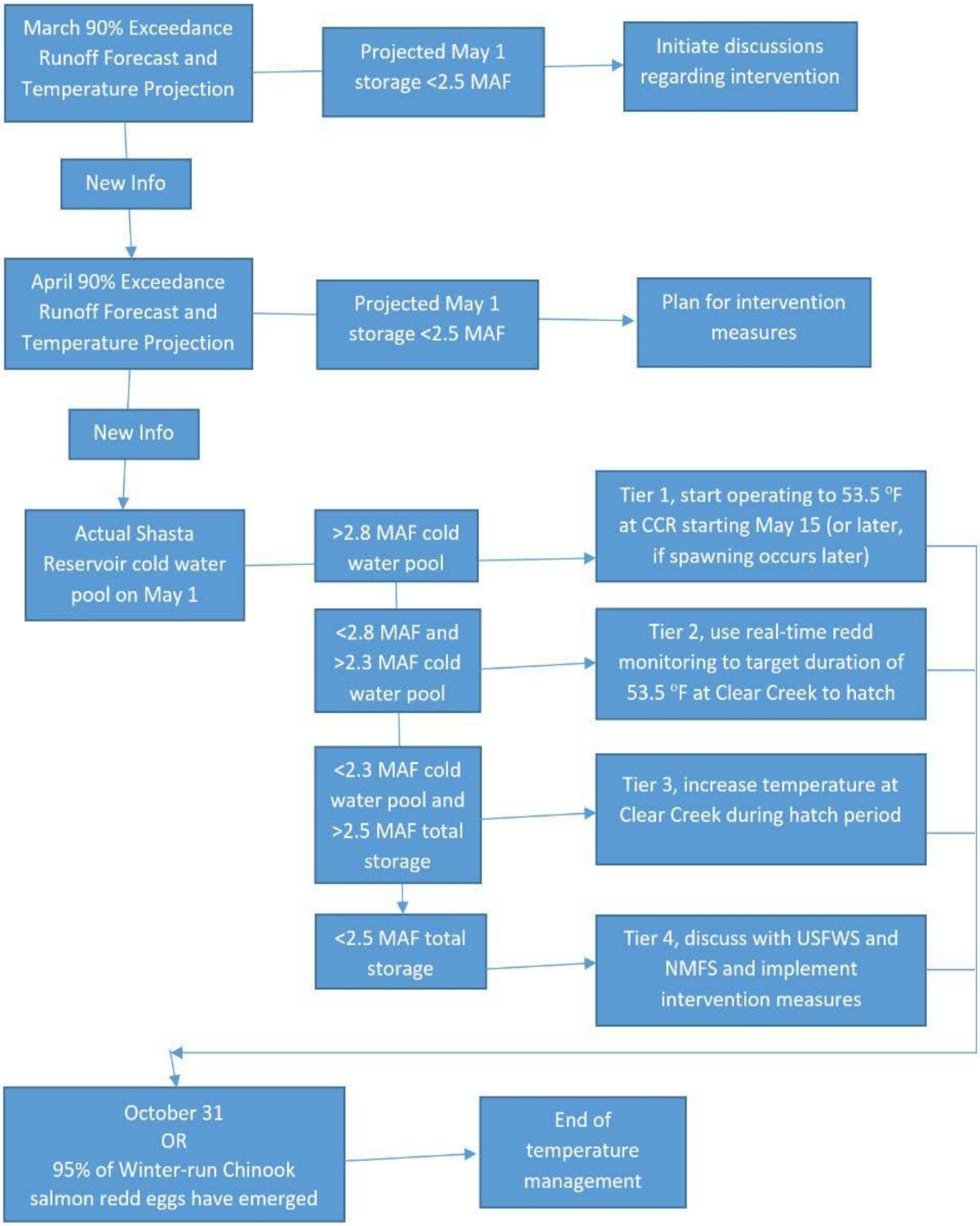


Figure 4-4. Decision Tree for Shasta Reservoir Temperature Management

Reclamation intends to collect temperature profile measurements for Shasta, Whiskeytown, and Trinity Reservoirs on the schedule shown in Table 4-9 and provide these to USFWS and NMFS if it is projected to be a Tier 4 year.

Table 4-9. Temperature Profile Measurements for Shasta, Whiskeytown, and Trinity Reservoirs

Reservoir	Every Month	Every 2 Weeks	Every Week	Comment
Shasta	01/01–03/01 12/1–12/31	03/01–05/01 11/15–12/01	05/01–11/15	25 ft intervals for “Every Month,” otherwise 5 ft intervals
Whiskeytown	01/01–12/31			25 ft intervals
Trinity	01/01–12/31			25 ft intervals

Reclamation proposes to provide a draft temperature management plan to the SRTTG in April for its review and comment, consistent with WRO 90-5. The draft temperature management plan will describe which of the four tiers Reclamation forecasts for that year’s summer temperature management season, along with a temperature modeling scenario and the operations forecast. The scenario shall include projected reservoir releases, assumed meteorological conditions, and anticipated water temperatures and target locations for the planned water temperature targets. For the final temperature management plan, Reclamation will use conservative assumptions for determining the Shasta Cold Water Management Plan including relying on the actual May 1st storage, a conservative inflow forecast for inflow May through September, proposed releases based on a conservative forecast and a conservative historical meteorology. Reclamation will utilize a forecast with 90% exceedance in the aggregate (when jointly considering multiple significant known uncertainties such as hydrology and meteorology) to develop conservative water temperature forecasts, although certain circumstances may lead Reclamation to use different exceedance levels to incorporate an appropriately more conservative approach. Reclamation shall share forecast assumptions with NMFS through the SRTTG. Reclamation anticipates NMFS will provide technical assistance through the SRTTG.

Consistent with the Shasta Cold Water Management Plan, Reclamation shall operate the Temperature Control Device at Shasta Dam to manage water temperatures below Keswick Dam and monitor the results. If monitored water temperatures exceed the target temperature (with allowable tolerances) in the Shasta Cold Water Management Plan for longer than 3 consecutive days, Reclamation shall notify NMFS of what actions, if any, are being taken to address the exceedances and will arrange for a follow-up on day 5 if the actions do not resolve the issue.

4.10.1.4.2 Commitment to Cold Water Management Tiers

The temperature tier will be forecasted in April of each water year based on forecasted cold water pool volume and temperature modeling results indicating the feasibility of meeting a particular tier. This tier will be finalized in May when there is additional confidence in the hydrologic forecast. If, as the water year progresses, it is determined that additional cold water is available for temperature control purposes, then the tier may be upgraded to a more beneficial tier. Given the use of conservative forecasts, additional cold water pool would be expected more frequently than less cold water pool, although this would only lead to a change in tiers when the conditions are close to the tier boundaries. Reasons for a mid-season change in tier include (but are not necessarily limited to) changes in hydrology, unusual climate conditions that vary from the climate assumptions in the temperature model, changes in water service delivery patterns and changes in assumptions on water needs for regulatory requirement. Temporary exceedances of target temperatures that are within the allowable tolerances identified in the temperature management plan will not be considered a shift into a different tier. In many cases, these can be corrected with real-time operational adjustments and do not indicate a deficit in cold water pool that would lead to a warmer temperature target. Reclamation will operate to the most protective temperature tier that is achievable.

Once the initial tier is selected by May 15th, Reclamation will not cause a shift into a warmer tier during real-time implementation of the Shasta Cold Water Management Plan except in the event of responding to emergency and/or unforeseen conditions. Examples of emergency and/or unforeseen conditions, may include, but are not limited to, higher water quality control plan compliance requirements, warmer meteorology, changes in forecasted inflow quantities and temperatures to Shasta, facility malfunctions, and higher than expected non-project water diversions (e.g., diverters other than those exercising water service and repayment contracts with Reclamation such as in-Delta diversions, riparian diversions, etc.).

Reclamation intends to check the temperature management plan (and associated tier) at least monthly and will notify NMFS within 2 business days of determining a potential change to the plan or tier is necessary. Reclamation may be able to adjust operations to overcome unexpected events without changing to a lower tier. Should Reclamation be unable to remain within the same or cooler tier identified by the Shasta Cold Water Management Plan, and require a mid-season change in tier, Reclamation will coordinate with NMFS on the need to charter an independent panel, at the end of the temperature management season, consistent “Chartering of Independent Panels” under the “Governance” section of this Proposed Action. The purpose of the independent review will be to evaluate the conditions experienced during the years under review, the success of the implementation of the tiered strategy, the effect of the implementation on the species, and, if needed, to develop recommendations to improve implementation and performance.

4.10.1.4.3 Upper Sacramento Performance Metrics

Reclamation proposes performance objectives for assessing cold water management under the different tiers. The objective is to ensure that the performance falls within the modeled range and shows a tendency towards performing at least as well as the distribution produced by the simulation modeling of the Proposed Action. Reclamation reviewed the modeled temperature dependent mortality over the CalSim-II period of record (1922-2002) with their modeled tier associated with each year. Reclamation’s objective, as described in this proposed action, will be to meet the temperature criteria associated with each tier and expects the associated biological performance will fall within the full range of modeled performance. The summary of modeled results is listed below with the median, average, maximum and minimum, and standard deviation values within the years. Reclamation intends for an independent panel to review and refine potential alternative steps if the objectives are not occurring.

Future downstream temperature performance is estimated using a numeric model and assumed future hydrologic, operations, and meteorological conditions. The temperature model makes decisions to select a TCD configuration based on user defined Shasta Dam tail-bay target temperatures. This model representation is more coarse than actual operational flexibility and sometimes does not capture daily adjustments which can be managed in real-time to avoid downstream temperature exceedances. Historical performance compared to model results confirms real-time adjustment capabilities using short-term forecasts and operational adjustments, however, this does not alleviate actual short-term forecast uncertainty. In the spring, simulated storm events will accurately predict unavoidable downstream temperature exceedances due to warm side-flows that dominate the upper Sacramento River system. Summary of modeled temperature dependent mortality:

- Tier 1 – Maximum (39%); Average (6%); Median (2%); Minimum (0.4%); Std. Dev (+/-9%)
- Tier 2 - Maximum (46%); Average (15%); Median (9%); Minimum (1%); Std. Dev (+/-16%)
- Tier 3 - Maximum (77%); Average (34%); Median (24%); Minimum (6%); Std. Dev (+/-31%)

- Tier 4 – Appropriate performance metrics will be addressed under “Drought and Dry Year Actions” consistent with the “Governance” section of this Proposed Action.

Reclamation reviewed the observed egg-to-fry survival over the past 21 years, excluding years with atypical temperature conditions (2015). Reclamation’s objective in undertaking habitat restoration and facility improvements, as described in this proposed action, will be to improve the egg to fry survival associated with each tier and expects the associated biological performance to increase over time. The summary of results is listed below with the average, maximum and minimum values within the years analyzed. Reclamation intends for an independent panel to review and refine potential alternative steps if the objectives are not occurring.

Summary of historical egg to fry survival:

- Tier 1 - Average (29%); Maximum (49%); Minimum (15%); Median (28%); Std. Dev (10%)
- Tier 2/3 - Average (21%); Maximum (34%); Minimum (15%); Median (20%); Std. Dev (6%)
- Tier 4 - Appropriate performance metrics will be addressed under “Drought and Dry Year Actions” consistent with the “Governance” section of this Proposed Action.

The 75th percentile values of the historical egg to fry survival will be included as a surrogate for expected improvements in ETF survival for each tier from the habitat restoration projects recently completed, currently underway, or proposed to be completed within the proposed action. These values are: Tier 1 – 32%; and Tiers 2/3 – 27%. These values will be updated with the appropriate metrics once modeled results are available on the expected improvements from these projects.

In the course of developing “Drought and Dry Year” actions, Reclamation and DWR will develop a range of alternative strategies for temperature management. The SRTTG may consider alternative strategies to the approach described in this PA during development of plans for Tier 3 years. In acknowledging that Tier 3 years are expected to produce a range of outcomes that increase the threat of viability to salmonid species, Reclamation will work to limit those effects through the SRTTG. These alternative strategies may be based on new or evolving science on the key biological drivers of temperature dependent mortality. These strategies may require additional analytical methods and monitoring specific to the hydrologic and temperature conditions. Reclamation would evaluate and report upon the effectiveness of strategies. These strategies would be coordinated with the conservation measure that addresses two successive years with total egg-to-fry survival less than 15% in each year.

Reclamation will measure upper Sacramento River fisheries populations, in collaboration with federal, state, and local partners, to estimate the total survival from egg incubation to juvenile migration to Red Bluff Diversion Dam, consistent with the monitoring described in Appendix C. Reclamation will estimate and report on the direct mortality and sublethal effects to egg incubation associated with water temperatures below Keswick Dam (temperature dependent mortality) using, at a minimum, the Martin et al. (2017) approach unless superseded by mutual agreement with NMFS. Reclamation will report annually on total survival and temperature dependent mortality consistent with Appendix C. The Annual Reporting will include a technical team (e.g., SRTTG) hindcast evaluation of whether either the total egg to fry survival or the temperature dependent mortality exceeded the Tier objective. This evaluation will consider the central tendency of modeled expected survival results and will contribute to determining whether an independent review of the year is required. The annual accomplishments in each year will be compared to the metrics by the review panels in 2024 and 2028, consistent with “Four Year Reviews” under the “Governance” section of this PA, to review whether there is a tendency or trajectory that will not lead to matching or exceeding the distribution of the modeled results over the long-term.

If the actual temperature dependent mortality or egg to fry survival fall outside the range described above in any single year, Reclamation will convene with NMFS to determine if an independent panel is necessary. If a panel is determined necessary, Reclamation will charter an independent panel consistent with “Chartering of Independent Panels” under the “Governance” section of this Proposed Action. If the actual results are within the ranges described above, Reclamation will still convene an independent panel consistent with “Four Year Review” under the “Governance” section of this Proposed Action and described above. The purpose of either panel will be to:

1. Review the drivers behind the management of cold water within the tiers including reservoir storage, releases, meteorology, hydrology, and other conditions affecting building and use of cold water (e.g. emergency, uncertainty, etc.).
2. Review the performance objectives, including the methods for determining temperature dependent mortality and methods for determining total survival.
3. Review the Tier types that have occurred during the performance periods of the Proposed Action and the performance within each tier as compared to expected performance. The selected metrics are the average, median, standard deviation, min, and max of the base dataset. Additional higher-order time series statistics may be used at the request of the review panel. The objective is to ensure that the performance falls within the modeled range and shows a tendency towards performing at least as well as the distribution produced by the simulation modeling of the Proposed Action.
4. Recommend potential modifications to CVP and SWP operations that would improve cold water management that are within the agencies’ authorities.
5. Review the effectiveness of habitat restoration, facility improvements, intervention, and research measures.

The panel will prepare a report incorporating discussion of the above items and recommendations, including alternative strategies. NMFS and Reclamation shall meet and confer to discuss the report and any response.

Prior to the initial Four Year Review independent panel, Reclamation shall refine performance objectives for temperature dependent mortality and the total survival of winter-run Chinook salmon from egg incubation to juvenile migration at Red Bluff Diversion Dam. Reclamation expects to participate in an effort by NMFS to establish early life stage survival rates that are required for a positive cohort replacement rate. Reclamation expects NMFS will submit for independent review temperature dependent mortality and egg to fry survival values that, as the species experts and with support from separate analyses, it expects will provide continued support of a viable population. Reclamation expects to participate in the panel and offer technical assistance regarding operations, understanding that these values, or any that result from addressing recommendations from the independent panel, could be adopted with mutual agreement as revised performance metrics for operations.

4.10.1.5 *Fall and Winter Refill and Redd Maintenance*

Reclamation proposes to rebuild storage and cold water pool for the subsequent year. Maintaining releases to keep late spawning Winter-Run Chinook Salmon redds underwater may drawdown storage necessary for temperature management in a subsequent year. Reclamation will minimize effects with a risk analysis of the remaining Winter-Run Chinook Salmon redds, the probability of sufficient cold water in a subsequent year, and a conservative distribution and timing of subsequent Winter-Run Chinook Salmon redds. If the combined productivity of the remaining redds plus a conservative scenario for the following year is less than the productivity of maintaining, Reclamation will reduce releases to rebuild storage. Real-time fish monitoring data, operational conditions, and modeling will be shared through SRTTG. Reclamation anticipates NMFS will provide technical assistance through the SRTTG.

The conservative scenario for the following year would include a 75% (dry) hydrology; 75% (warm) climate; a median distribution for the timing of redds, and the ability to remain within Tier 3 or higher (colder) tiers.

If, based on the above analysis, Reclamation determines reduced releases are needed to rebuild storage, targets for winter base flows (December 1 through the end of February) from Keswick would be set in October based on Shasta Reservoir end-of-September storage. These targets would be set based on end-of-September storage and the current hydrology, after accounting for winter-run red stranding. Base flows would be set based on historic performance to accomplish improved refill capabilities for Shasta Reservoir to build cold water pool for the following year. Table 4-10 shows the initial schedule for Keswick Releases based on Shasta Reservoir storage condition; these would be refined through future modeling efforts as part of the seasonal operations planning.

Table 4-10. Keswick Dam Release Schedule for End-of-September Storage

Keswick Release (cfs)	Shasta End-of-September Storage
3,250	≤ 2.2 MAF
4,000	≤ 2.8 MAF
4,500	≤ 3.2
5,000	> 3.2 MAF

High storage years are not necessarily correlated with a following wetter fall and winter. As a result, Reclamation will manage the real time releases based on conditions observed. In scenarios were higher storage exist at the end of September but the fall hydrology is dry (generally defined as below 90% exceedance of historical hydrology), Reclamation will coordinate with appropriate agencies, including NMFS and CDFW at a minimum, to reduce flows below those described in the table, if possible.

This approach to selecting fall, winter, and spring minimum flows allows Reclamation to build and conserve storage for supporting cold water management and summer demands. Due to the effort to build storage, this often results in flood control releases well over the minimum flows, typically in the December through May periods. The low flow in the fall and winter period directly increases the likelihood and magnitude of the flood control releases in the winter and spring months.

4.10.1.5.1 Operation of Shasta Dam Raise

There is a separate process and environmental impact statement for the Shasta Dam Raise, for which a Record of Decision and Biological Opinions have not been completed. Reclamation would not change operations described in the PA until the Shasta Dam Raise ROD and separate ESA consultations are completed. In the interim, Reclamation would operate the enlarged reservoir consistent with the operations and requirements of the proposed action. The additional storage created by the 18.5-foot dam raise could be used to improve the ability to meet water temperature objectives and habitat requirements for salmonids during drought years and increase water supply reliability.

4.10.1.5.2 Conservation Measures

Reclamation and DWR are proposing conservation measures to avoid and minimize or compensate for CVP and SWP project effects, including take, on the species under review in this biological assessment as well as contribute to the recovery and enhancement of species and their habitats. These conservation measures include non-flow actions that benefit listed species without impacting water supply or other beneficial uses. Actions could be implemented in part or fully through agreements and cost share with the State of California and potentially under the Voluntary Agreement alternative under the State Water Resources Control Board update to the Bay-Delta Water Quality Control Plan.

- Rice Decomposition Smoothing: Following the emergence of Winter-Run Chinook Salmon and prior to the majority of Fall-Run Chinook Salmon spawning, upstream Sacramento Valley CVP contractors and the Sacramento River Settlement Contractors propose to work to synchronize their diversions to lower peak rice decomposition demand. With lower late October and early November flows, Fall-Run Chinook Salmon are less likely to spawn in shallow areas that would be subject to dewatering during winter base flows. Early reductions (late October–early November) would balance the potential for dewatering late spawning Winter-Run Chinook Salmon redds and early Fall-Run Chinook Salmon dewatering.
- Spring Management of Spawning Locations: Reclamation will coordinate with NMFS to establish experiments to refine the state of the science and determine if keeping water colder earlier induces earlier spawning, or if keeping April/May Sacramento River temperatures warmer induces later spawning.
- Temperature Modeling Platform: Reclamation will continue as part of a collaborative model development effort to develop a new temperature model for the Upper Sacramento River (Shasta and Keswick reservoirs). NMFS Science Center, among others, is participating in the collaborative process. This new model will be on the CEQUAL-W-2 platform with the intention of developing similar platforms for all of Reclamation's major reservoirs.
- Shasta Temperature Control Device Performance Evaluation*:* Reclamation will coordinate with NMFS to study whether there are problems or limitations with the function of the TCD under low storage conditions, and, if necessary, identify potential actions and/or modification for improving operational efficiency of the TCD.
- Battle Creek Salmon and Steelhead Restoration Project and Battle Creek Reintroduction Plan: Reclamation will provide funding for ten years towards reintroduction of Winter-run Chinook Salmon to Battle Creek. Reclamation will accelerate implementation of the Battle Creek Salmon and Steelhead Restoration Project, which is intended to reestablish approximately 42 miles of prime salmon and Steelhead habitat on Battle Creek, and an additional 6 miles on its tributaries. The Battle Creek Restoration Project is a collaborative effort among several federal and state agencies and Pacific Gas & Electric Company. The partnership provides a framework for expanding Winter-Run Chinook Salmon spawning to cold water habitat not in the Sacramento River.

  In August 2016, the California Department of Fish and Wildlife released the Battle Creek Winter-run Chinook Salmon Reintroduction Plan. The U.S. Fish and Wildlife Service subsequently agreed to take responsibility for implementing the plan, and in 2018, approximately 200,000 juvenile Winter-tun Chinook salmon were reintroduced to Battle Creek to jumpstart the reintroduction effort. These fish have matured and started to return as adults in summer 2019. The jumpstart effort is intended to transition into implementation of the Reintroduction Plan with Reclamation support. Reclamation's support will go towards fish passage construction and reintroduction implementation activities. This includes ten years of annual Plan monitoring and implementation cost up to $1,400,000 annually. As the Reintroduction Plan continues additional funding will likely be needed to cover the annual costs.

- Lower Intakes near Wilkins Slough*:* Due to temperature requirements, Sacramento River flows at or near Wilkins Slough can drop below the 5,000 cfs minimum navigational flow set by Congress. As many of the fish screens at diversions in this region were designed to meet the 5,000 cfs minimum, they may not function properly at the lower flows and as a result, not meet state and federal fish screening requirements during the lower flows (NCWA 2014). This action would provide grants to senior water right holders within this area to install new diversions and screens that would operate at the lower flows, which would allow Reclamation to have greater flexibility in managing Sacramento River flows and temperatures for both water users and wildlife, including listed salmonids (NCWA 2014). The authority for this action is 3406(b)(21). One example project under this program is screening of Meridian Farms.
- Spawning Habitat Restoration: Reclamation proposes to create additional spawning habitat by injecting approximately 15,000 – 40,000 tons of gravel annually into the Sacramento River to 2030, using the following sites: Keswick Dam Gravel Injection Site, Market Street Injection Site, Redding Riffle, Turtle Bay, Tobiasson Island, Shea Levee sites, and Kapusta.
- Rearing Habitat Restoration: Reclamation, in coordination with the Sacramento River Settlement Contractors proposes to create 40–60 acres of side channel and floodplain habitat at 10 sites in the Sacramento River by 2030. The potential sites include Salt Creek, Turtle Bay Island, Kutras Lake Rearing Structures, Painter's Riffle maintenance, North Cypress maintenance, Cypress South, North Tobiasson Rearing Structures maintenance, Tobiasson Side Channel, Shea Side Channel, Kapusta Side Channel, Kapusta 1-A Side Channel maintenance, Kapusta 1-B Side Channel, Anderson River Park Side Channels, Cow Creek Side Channel, I-5 Side Channel, China Gardens, Rancheria Island Side Channel, Rancho Breisgau, Lake California Side Channel maintenance, Rio Vista Side Channel, East Sand Slough Side Channel, La Barranca Side Channel, Woodson Bridge Bank Rearing Improvement, Jellys Ferry, Dog Island, Altube Island, Blackberry Island, Oklahoma Avenue, Mooney Island, McClure Creek, Blethen Island, Wilsons Landing, McIntosh Island, Shaw, Larkins, Reilly Island, Hanson Island, and Broderick.
    - The Sacramento River Settlement Contractors approved *A Resolution Regarding Salmon Recovery Projects in the Sacramento River Watershed, Actions Related to Shasta Reservoir Annual Operations, and Engagement in the Ongoing Collaborative Sacramento River Science Partnership Effort*. Pursuant to the resolution, the SRS Contractors will continue to participate in, and act as project champions for future Sacramento Valley Salmon Recovery Program projects, subject to the availability of funding, regulatory approvals, acceptable regulatory assurances, and full performance of the SRS Contracts.
- Deer Creek Irrigation District Dam (DCID) Fish Passage: Reclamation will provide funding towards this collaborative fish passage project being completed by DCID, Trout Unlimited, California Department of Fish and Wildlife, and U.S Fish and Wildlife Service. The shovel-ready project will construct a natural like fishway downstream of the DCID's dam to provide spring-run Chinook salmon and Central Valley steelhead with unimpeded access to 25 miles of prime spawning habitat with no adverse effect on the DCID diversion. Improving fish passage at this site will improve upstream access to spawning, rearing and holding stream habitat. This will also

improve anadromous fish passage, downstream of the project sites, through fish screen and bypass pipe modifications.

- Small Screen Program: Reclamation and DWR propose to continue to work within existing authorities (e.g., Anadromous Fish Screen Program) to screen small diversions throughout Central Valley CVP/SWP streams and the Bay-Delta.
- Knights Landing Outfall Gates: Reclamation will provide funding towards reconstruction of the Knights Landing Outfall Gates to reduce the potential for fish straying into the Colusa Basin Drain. These funds will go towards repairing the positive fish barrier hoist system and electric controls.
- Winter-Run Chinook Salmon Conservation Hatchery Production: In a Tier 4 year, Reclamation proposes to increase production of Winter-Run Chinook Salmon. Increased production during drought could help populations continue over multiple years. Increased production would aim to offset temperature dependent mortality on the Sacramento River. Reclamation would consider New Zealand or Great Lake Winter-Run Chinook Salmon stock for augmenting conservation hatchery stock to improve heterozygosity. Reclamation would coordinate with USFWS and NMFS as part of the “Drought and Dry Year Actions” under the “Governance” section of this PA to determine the need to improve the facility and associate collection facilities. Improvements may include permanent chillers, additional tanks, and other features.
- Adult Rescue: Reclamation proposes to trap and haul adult salmonids and sturgeon from Yolo and Sutter bypasses during droughts and after periods of bypass flooding, when flows from the bypasses are most likely to attract upstream migrating adults and move them up the Sacramento River to spawning grounds. This trap and haul is in addition to weir fish passage projects that are part of the proposed action elsewhere. This would improve survival of the adults, leading to increased juvenile production in the following year and more flexibility with salvage.
- Trap and Haul: If Reclamation projects a Tier 4 year (less than 2.5 MAF of storage at the beginning of May), Reclamation proposes implementation of a downstream trap and haul strategy for the capture and transport of juvenile Chinook Salmon and Steelhead in the Sacramento River watershed in drought years when low flows and resulting high water temperatures are unsuitable for volitional downstream migration and survival. Reclamation proposes to place temporary juvenile salmon collection traps (e.g., rotary screw traps, fyke nets, floating juvenile collectors, weirs, trawls, seines), at key feasible locations, downstream of spawning areas in the Sacramento River. Reclamation would transport collected fish to a safe release location or locations in the Delta upstream of Chipps Island or in the bay. Juvenile trap and haul activities would occur from December 1 through May 31, consistent with the migration period for juvenile Chinook Salmon and Steelhead (NMFS 2014) depending on hydrologic conditions. In the event of high river flows or potential flooding, trapping operations would cease and traps would be removed, as appropriate.
- Directors Meeting: In the event of two successive years with total egg-to-fry survival less than 15% in each year, Reclamation will convene a meeting of the Regional Directors of the Department of Water Resources, National Marine Fisheries Service, Fish and Wildlife Service, and California Department of Fish and Wildlife no later than the end of November. The Directors will meet and confer to develop a list of actions to address the potential for a third year of low survival. The Directors will continue to meet monthly, or more often as appropriate, through the next operational season. The Directors will hold a similar meeting in each of the two following Novembers to ensure that the years following the two-year emergency condition appropriately address the need to recover from the multi-year event.

- Yellow-billed Cuckoo Surveys: Reclamation will coordinate with the USFWS to develop a baseline survey for the Yellow-billed cuckoo. The survey for this action would focus on the critical habitat areas, associated project sites, and occupied habitat within the action area. In addition, the baseline survey would incorporate the efforts from the Yolo Restoration Project and other related projects when conducting protocol-level surveys for Yellow-billed Cuckoo in the over-lapping project areas. Results from Yellow-billed Cuckoo surveys conducted by other agencies and organizations within the Action Area will be analyzed by Reclamation when determining baseline conditions for the species and effects resulting from project activities. By reducing redundant survey efforts, Reclamation would be able to leverage their resources to cover areas not recently surveyed and develop a more comprehensive baseline survey. Reclamation would coordinate and discuss with USFWS on the potential need for additional surveys for specific project areas and surveys to monitor the effects of project activities over the project timeline. Information collected in the baseline surveys could be used to inform ecological surrogate models in the future, potentially replacing the need for follow-up presence/absence surveys. In addition, Reclamation will follow the nesting bird protocols during construction activities and consider the needs of Yellow-billed cuckoo when designing and implementing salmonid habitat restoration projects. Results of Yellow-billed cuckoo surveys and findings from ecological surrogate models shall be shared with the U.S. Fish and Wildlife Service Bay-Delta Fish and Wildlife Office no later than 120 days after completion.

4.10.2 Trinity River Division

Congress authorized the Trinity River Division in 1955 as an integrated component of the CVP in order to increase water supplies for irrigation and other beneficial uses in the Central Valley, recognizing that water “surplus” to the present and future needs of the Trinity and Klamath Basins could be diverted to the Central Valley “without detrimental effect to the [Klamath-Trinity Basin’s] fishery resources.” Accordingly, Reclamation operates the Trinity River Division both to export water to the Sacramento River system and to ensure necessary flow releases into the Trinity-Klamath Basin, such as through implementation of the Department of the Interior’s Trinity River Mainstem Fishery Restoration ROD (2000 ROD). Trans-basin exports transfer water from the Trinity River to the Sacramento River system through Lewiston Reservoir, Carr Tunnel, Whiskeytown Reservoir, and Spring Creek tunnel.

4.10.2.1 *Seasonal Operations*

Diversion of Trinity Basin water to the Sacramento Basin (transbasin diversion) provides water supply and major hydroelectric power generation for the CVP and plays a key role in water temperature control in the Trinity River and upper Sacramento River. Transbasin diversions are managed to support water supply and temperature objectives within the Sacramento system and are regulated by the ROD and Trinity Reservoir supply. The 2000 Trinity ROD strictly limits Reclamation’s transbasin diversions to 55 percent of annual inflow on a 10-year average basis to legal and trust mandates for the restoration and protection of the Trinity fishery which restrict the amount of water authorized for exportation to the Central Valley. Reducing transbasin diversions was intended to improve the cold water pool in Trinity Reservoir to improve conditions for fall spawning down the Trinity River. This limitation on transbasin diversions significantly impacts Reclamation’s temperature operations on the Sacramento River and Reclamation’s ability to satisfy senior water right holder and/or Settlement contractor commitments within the CVP system.

Trinity River exports are first conveyed through Carr Power Plant which flows directly into Whiskeytown Lake, a heavily used recreation facility. From Whiskeytown Lake, the exported water continues to flow into Spring Creek Power Plant, is discharged into Keswick Reservoir where it mixes with water from Shasta, and then outflows into the Sacramento River, or water is released from Whiskeytown to Clear Creek. Although Whiskeytown Lake is primarily used as conveyance system for transbasin transfers, operations at both Carr and Spring Power plants are done in a manner to maintain specified elevations for supporting recreation (based on season).

The amounts and timing of Trinity River basin exports into the Sacramento River basin are determined by subtracting Trinity River scheduled flow and targeted carryover storage from the forecasted Trinity water supply. Reclamation maintains at least 600 TAF in Trinity Reservoir, except during the 10–15 percent of water years when Shasta Reservoir is also drawn down. Reclamation proposes to address end-of-water- year carryover on a case-by-case basis in dry and critically dry water year types described in the Water Operations Governance process below.

The seasonal timing of Trinity River exports is a result of determining how to make best use of a limited volume of Trinity River export (in concert with releases from Shasta Reservoir) to help conserve cold water pools and meet water temperature objectives on the upper Sacramento and Trinity Rivers, as well as power production economics.

These exports support better Trinity River temperatures by maintaining cold water and reducing residence time within Lewiston Reservoir. Transbasin diversions also typically help meet Sacramento River temperatures by providing additional cold water resources to the Sacramento River. As a result, Trinity River export operations are completely integrated with Shasta Dam operations.

4.10.2.2 *Trinity River Record of Decision*

The 2000 ROD prescribed increase flows to meet federal statutory and other responsibilities to protect and restore the basin’s fishery resources, to be released from Lewiston Dam down the Trinity River. Specifically, it entails: (1) variable annual instream flows for the Trinity River from the Trinity River Division based on forecasted hydrology for the Trinity River Basin; (2) mechanical habitat rehabilitation projects along with sediment management and watershed restoration efforts; and (3) an adaptive management program. The 2000 ROD flow release schedules vary among water-year classes and were designed to address the environmental requirements of anadromous fish and fluvial geomorphic function. The following five water year classes and associated annual water volumes for release to the Trinity River are identified as: Critically Dry (369 TAF); Dry (453 TAF); Normal (636 TAF); Wet (701 TAF); and Extremely Wet (815 TAF).

Total river release can reach up to 11,000 cfs below Lewiston Dam (flood criteria) due to local high water concerns in the floodplain and local bridge flow capacities. Flood criteria provides seasonal storage targets and recommended releases November 1 to March 31.

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

In addition, in various years since 2003, and particularly since 2013, certain fishery agencies, together with the Tribal Governments, have requested additional late-season flows in the Trinity River above the 2000 ROD baseline flows (primarily in August and September) to prevent fish illness from instream crowding and warm waters in the lower Klamath River in drier years. In some cases, these releases were made in successive dry years and therefore had cumulative effects year to year, leading to lower storage in Trinity Reservoir and water supply and temperature impacts in the Sacramento and Trinity Rivers and Clear Creek.

Reclamation released a Record of Decision for the Long Term Plan to Protect Adult Salmon in the Lower Klamath River in 2017 (2017 ROD), which identified an adaptive management approach for Reclamation to determine if and when to release supplemental flows from mid-August to late September from Lewiston Dam to prevent an episodic disease outbreak in the lower Klamath River. These flows include a Preventative Base Flow component of a supplemental release of up to 40 TAF from Lewiston Dam over the course of approximately 30 days, beginning on or about August 23, with the intent of meeting and/or maintaining a target of up to 2,800 cfs in the lower Klamath River; a Preventative Pulse Flow component of up to 10 TAF release over 4 days to achieve a peak of 5,000 cfs in the lower Klamath River; and an Emergency Flow component which would be up to 34 TAF from Lewiston Dam over no more than 8 days, beginning on or about September 20 to meet a target of 5,000 cfs in the lower Klamath River. The 2017 ROD cited proviso 1 of Section 2 of the 1955 Act as authority for the releases.

4.10.2.3 *Whiskeytown Reservoir Operations*

Reclamation proposes to operate Whiskeytown Reservoir to: (1) regulate inflows for power generation and recreation; (2) support upper Sacramento River temperature objectives; and (3) provide for releases to Clear Creek, as proposed below. Two temperature curtains in Whiskeytown Reservoir were installed to pass cold water through the bottom layer of the reservoir and limit warming from Carr power plant to Clear Creek or Spring Creek Power Plant.

Whiskeytown Lake is annually drawn down by approximately 35 TAF of storage space during November through April to regulate flows for winter and spring flood management. Heavy rainfall events occasionally result in spillway discharges to Clear Creek. Operations at Whiskeytown Lake during flood conditions are complicated by its operational relationship with the Trinity River, Sacramento River, and Clear Creek. On occasion, imports of Trinity River water to Whiskeytown Reservoir may be suspended to avoid aggravating high flow conditions in the Sacramento Basin. Joint temperature control objectives also similarly interact among the Trinity River, Clear Creek, and Sacramento River.

4.10.2.4 *Clear Creek Flows*

Reclamation proposes to release Clear Creek flows in accordance with the 1960 MOA with CDFW, and the April 15, 2002 SWRCB permit, which established minimum flows to be released to Clear Creek at Whiskeytown Dam. Reclamation proposes a minimum base flow in Clear Creek of 200 cfs from October through May and 150 cfs from June to September in all year types except Critical year types. In Critical years, Clear Creek base flows may be reduced below 150 cfs based on available water from Trinity Reservoir. Additional flow may be required for temperature management during the fall. A ramping rate of no more than 25 cfs per hour during nocturnal hours will be used to reduce potential stranding risks to juvenile salmonids during Whiskeytown controlled flow reductions.

In addition, Reclamation proposes to create pulse flows for both channel maintenance and spring attraction flows. For spring attraction flows, Reclamation would release 10 TAF (measured at the release), with daily release up to the safe release capacity (approximately 900 cfs, depending on reservoir elevation and downstream capacity), in all year-types except for Critical year-types to be shaped by the Clear Creek Implementation Team in coordination with CVO. For channel maintenance flows, Reclamation would release 10 TAF from Whiskeytown, with a daily release up to the safe release capacity, in all year-types except for Dry and Critical year-types (based on the Sacramento Valley index) to be shaped by the Clear Creek Implementation Team in coordination with CVO. Pulses would be scheduled with CVO. No channel maintenance flows would be scheduled before January 1. For each storm event that results in a Whiskeytown Gloryhole spill of at least 3,000 cfs for 3 days, Reclamation will reduce the channel maintenance flow volume for this year or the following year by 5,000 acre-feet. If two Gloryhole spills occur that meet this criterion in a year, additional channel maintenance flows would not be released in that year. In Critical years, Reclamation would release one spring attraction flow of up to the safe release capacity (approximately 900 cfs) for up to 3 days and would not release any channel maintenance flows. Reclamation could instead, or in addition, use mechanical methods to mobilize gravel or shape the channel if needed to meet biological objectives.

The outlet from Whiskeytown Reservoir to Clear Creek is equipped with outlets at two different elevations. Releases can be made from either or both outlets to manage downstream temperature releases. Reclamation proposes to manage Whiskeytown releases to meet a daily average water temperature of: (1) 60°F at the Igo gage from June 1 through September 15; and (2) 56°F or less at the Igo gage from September 16 to October 31. Reclamation may not be able to meet these temperatures in Critical or Dry water year types. In these years, Reclamation will operate to as close to these temperatures to the extent possible.

4.10.2.5 *Spring Creek Debris Dam*

Runoff containing acid mine drainage from several inactive copper mines and exposed ore bodies at Iron Mountain Mine is stored in Spring Creek Reservoir. In January 1980, Reclamation, CDFW, and SWRCB executed a memorandum of understanding (MOU) to implement actions that protect the Sacramento River system from heavy metal pollution from Spring Creek and adjacent watersheds. However, since 1990, concentrations of toxic metals in acidic drainage from Iron Mountain Mine have progressively decreased due to several significant remedial actions by the EPA. The completion of:

- EPA's Minnesota Flats Iron Mountain Mine Acid Mine Drainage Treatment Plant (lime neutralization plant) in 1994,
- Slickrock Creek Retention Reservoir in 2004, and
- Dredging of approximately 180,000 cubic yards of contaminated sediments from the Spring Creek arm of Keswick Reservoir in 2009-10

have resulted in a reduction of approximately 95 percent of the toxic metals that historically emptied into the Sacramento River. Lower concentrations of copper and zinc resulting from controlled and uncontrolled Spring Creek Debris Dam releases are expected as compared to pre-1990. The extent of heavy metal influence is usually limited to regions immediately downstream of Keswick Dam.

As a result of dramatic changes to the water quality in the vicinity of the Iron Mountain Mine watershed, Reclamation CDFW, SWRGB and EPA are progressing towards a revision of the 1980 MOU to address the improvements and changed conditions. Operation of the Spring Creek Debris Dam and Shasta Dam have deviated from the 1980 MOU to accommodate for these changes. Reclamation expects a revised MOU with similar guidelines to the interim operation.

The interim operation Reclamation proposes to implement includes actions that will protect the Sacramento River system from heavy metal pollution (i.e., acid mine runoff) from Spring Creek Dam and adjacent watersheds. This includes water quality criteria at the point of compliance (Below Keswick) shown in Table 1 and based upon the criteria for protection of aquatic life in the upper Sacramento River described in the Water Quality Control Plan for the Sacramento River and San

Joaquin River Basins (Basin Plan) (Water Board, 1998) and the California Toxics Rule (CTR) (provided in Water Board, 2003).

Table 4-11: Water Quality Criteria for Surface Water Downstream of Keswick Dam

Analyte	Maximum Concentration for Acute Exposure (µg/L) a	Maximum Concentration for Chronic Exposure (µg/L) b
Dissolved copper	5.6 c,d	4.1 e,f
Dissolved zinc	16 c,d	54 e,f

a The maximum concentration for acute exposure of the 1-hour average concentration.

b The maximum chronic exposure is the continuous concentration (4-day average concentration).

c Based upon surface water with a hardness of 40 mg/L. Where deviations in water hardness from 40 mg/L occur, the criteria, in µg/L, shall be determined by using the following formulas:

Dissolved Copper = (e[0.905 x ln(hardness) - 1.612])

Dissolved Zinc = (e[0.830 x ln(hardness) – 0.289])

d Based upon Water Quality Control Plan for the Sacramento River and San Joaquin River Basins (Basin Plan) (Water Board, 1998)

e Based upon surface water with a hardness of 40 mg/L. Where deviations in water hardness from 40 mg/L occur, the criteria, in µg/L, shall be determined by using the following formulas:

Dissolved Copper = 0.96 x (e[0.8545 x ln(hardness) - 1.702])

Dissolved Zinc = 0.986 x (e[0.8473 x ln(hardness) – 0.884])

f Based upon the California Toxics Rule (CTR) (provided in Water Board, 2003)

Reclamation expects continued monitoring of the water quality of Spring Creek Debris Dam, Spring Creek Power Plan, Keswick, and Shasta and increased frequency of monitoring if Spring Creek Debris Dam releases water through the spillway or drops below the minimum elevation threshold. The operation described herein is also dependent on the water treatment capabilities afforded by EPA.

When storage within Spring Creek Reservoir is less than capacity at 795 feet (approximately 5 TAF) and above 720 feet (note Reclamation's operation is conservative and includes an operational factor of safety of 5 feet), Reclamation is able to make controlled undiluted releases that result in allowable concentrations of total copper and zinc in the Sacramento River below Keswick Dam. These undiluted releases from Spring Creek Debris Dam can occur throughout the year, typically December through June and less frequently in other months.

When Spring Creek Reservoir storage exceeds the capacity of the reservoir at 795 feet (approximately 5 TAF) water must be released through the spillway. In this situation Reclamation anticipates an "emergency" relaxation of the criteria, as consistent with past protocol, of: a 50 percent increase in the objective concentrations of copper and zinc. Although the general operational goal is to avoid use of the Spring Creek Debris Dam spillway, some storm events or series of events are unavoidable. The spillway operation typically occurs during a large storm or series of events, January through April, and are coincident with large flood management flows released from Keswick Dam. In recent years EPA, Reclamation, DFG, and the RWQCB have agreed not to use the emergency criteria until a spill is imminent. During significant rain events Spring Creek Debris Dam releases may target a dilution ratio with Keswick releases to achieve an acceptable water quality below Keswick Dam. Spring Creek Reservoir spillway dilution flows from Keswick are expected to be coincident with large flood management flows and are unlikely to impact water supply or cold water pool resources.

Reclamation does not plan to operate Spring Creek Reservoir below elevation 720 feet to avoid potentially significant degraded water quality when reservoir soils are exposed. However, if Spring Creek Reservoir is less than 720 feet then a minimum dilution flow of 250 cfs from Spring Creek Power Plant and increased water quality monitoring is expected.

At any time that dilution flows are necessary, Reclamation plans to minimize the build-up of toxic metals in the Spring Creek arm of Keswick Reservoir. To accomplish this, the releases from the debris dam are coordinated with releases from Spring Creek Powerplant (Spring Creek Power Plant draws water from Whiskeytown Reservoir) to keep the metals in circulation within the main body of Keswick Reservoir.

4.10.2.6 *Clear Creek Restoration Program*

Reclamation and DWR propose to continue channel maintenance under the Clear Creek Restoration Program.

4.10.2.7 *Yellow-billed Cuckoo Surveys*

Reclamation will coordinate with the USFWS to develop a baseline survey for the Yellow-billed cuckoo. The survey for this action would focus on the critical habitat areas, associated project sites, and occupied habitat within the action area. In addition, the baseline survey would incorporate the efforts from the Yolo Restoration Project and other related projects when conducting protocol-level surveys for Yellow-billed Cuckoo in the over-lapping project areas. Results from Yellow-billed Cuckoo surveys conducted by other agencies and organizations within the Action Area will be analyzed by Reclamation when determining baseline conditions for the species and effects resulting from project activities. By reducing redundant survey efforts, Reclamation would be able to leverage their resources to cover areas not recently surveyed and develop a more comprehensive baseline survey. Reclamation would coordinate and discuss with USFWS on the potential need for additional surveys for specific project areas and surveys to monitor the effects of project activities over the project timeline. Information collected in the baseline surveys could be used to inform ecological surrogate models in the future, potentially replacing the need for follow-up presence/absence surveys. In addition, Reclamation will follow the nesting bird protocols during construction activities and consider the needs of Yellow-billed cuckoo when designing and implementing salmonid habitat restoration projects. Results of Yellow-billed cuckoo surveys and findings from ecological surrogate models shall be shared with the U.S. Fish and Wildlife Service Bay-Delta Fish and Wildlife Office no later than 120 days after completion.

4.10.3 Feather River

DWR will operate Oroville Dam consistent with the NMFS, USFWS, and CDFW environmental requirements applicable for the current FERC License for the Oroville Complex (FERC Project #2100- 134). The downstream boundary of FERC's Oroville Project area is the Feather River above the city of Gridley. During the summer, DWR typically releases water from Lake Oroville to meet the requirements of instream flows and D-1641. Additional releases are made for local deliveries and exports at Banks Pumping Plant. DWR balances the cumulative storage between Lake Oroville and

San Luis Reservoirs so as to meet its flood control requirements, Sacramento–San Joaquin Delta requirements, and deliver water supplies to its contracted water agencies consistent with all environmental constraints. Lake Oroville may be operated to convey water through the Delta to San Luis Reservoir via Banks under different schedules depending on Delta conditions, reservoir storage volumes, storage targets and regulatory requirements.

Decisions as to when to move water from Lake Oroville to San Luis Reservoir are based on many real- time factors.

4.10.4 American River Division

Reclamation operates the CVP American River Division for flood control, M&I and agricultural water supplies, hydroelectric power generation, fish and wildlife protection, recreation, and Delta water quality. Facilities include the Folsom Dam, reservoir (977 TAF capacity), the temperature control shutters on the power plant intakes for Folsom Dam, power plant, urban water supply temperature control device, and the Joint Federal Project auxiliary spillway as well as the Nimbus Dam, Lake Natoma, Nimbus Power Plant, and Folsom South Canal.

Folsom Reservoir is the main storage and flood control reservoir on the American River. Numerous other smaller reservoirs in the upper basin provide hydroelectric generation and water supply without specific flood control responsibilities. The total upstream reservoir storage above Folsom Reservoir is approximately 820 TAF and these reservoirs are operated primarily for hydropower production. Ninety percent of this upstream storage is contained by five reservoirs: French Meadows (136 TAF); Hell Hole (208 TAF); Loon Lake (76 TAF); Union Valley (271 TAF); and Ice House (46 TAF). Reclamation coordinates with the operators of these reservoirs to aid in planning for Folsom Reservoir operations.

Releases from Folsom Dam are re-regulated approximately 7 miles downstream by Nimbus Dam. Nimbus Dam creates Lake Natoma, which serves as a forebay for diversions to the Folsom South Canal. Releases from Nimbus Dam to the American River pass through the Nimbus Power Plant, or the spillway gates at flows in excess of 5,000 cfs. Because Folsom Reservoir is the closest reservoir to the Delta, releases from Folsom can more quickly address Delta water quality requirements under D-1641.

Reclamation proposes to meet water rights, contracts and agreements that are both specific to the American River Division as well as those that apply to the entire CVP, including the Delta Division. For lower American River flows (below Nimbus Dam), Reclamation proposes to adopt the minimum flow schedule and approach proposed by the Water Forum in 2017 in the document titled “Lower American River – Standards for Minimum Flows” dated December 2018. Flows range from 500 to 2000 cfs based on time of year and annual hydrology. The flow schedule is intended to improve cold water pool and habitat conditions for Steelhead and Fall-Run Chinook Salmon. Specific flows are determined using an index intended to define the current and recent hydrology. Although Reclamation has assumed the index proposed by the Water Forum in 2017 for the purposes of modeling and analysis within this biological assessment, Reclamation intends to continue discussions with the Water Forum to ensure the index used for implementation is appropriate to meet the intended objectives under continuously changing hydrology.

Reclamation proposes to work together with the American River water agencies to define an appropriate amount of storage in Folsom Reservoir that represents the lower bound for typical forecasting processes at the end of calendar year (the “planning minimum”). The planning minimum brings Reclamation's forecasting process together with potential local actions that either increase Folsom storage or reduce demand out of Folsom Reservoir. The implementation of a planning minimum allows Reclamation to work with the American River Group to identify conditions when local water actions may be necessary to ensure storage is adequate for diversion from the municipal water intake at Folsom Dam and/or the extreme hydrology presents a risk that needs to be properly communicated to the public and surrounding communities. This planning minimum will be a single value (or potentially a series of values for different hydrologic year types) to be used for each year's forecasting process into the future. The objective of incorporating the planning minimum into the forecasting process is to provide releases of salmonid-suitable temperatures to the lower American River and reliable deliveries (using the existing water supply intakes and conveyance systems) to American River water agencies that are dependent on deliveries or releases from Folsom Reservoir. This planning minimum is expected to be initially defined in 2019; however, it will be continuously evaluated between Reclamation and the Water Forum throughout implementation.

Reclamation expects infrequent scenarios where the forecasted storage may fall below the "planning minimum" due to a variety of circumstances and causes. In those instances, Reclamation and the American River water agencies will develop a list of potential off-ramp actions that may be taken to either improve forecasted storage or decrease demand on Folsom Reservoir. In its forecasting process for guiding seasonal operations, Reclamation will plan to maintain or exceed the planning minimum at the end of the calendar year. Reclamation has no legal liability should it fall below the planning minimum. When Reclamation estimates, using the forecasting process, that it would not be able to maintain Folsom Reservoir storage at or above the planning minimum for that year type (such as in extreme hydrologic conditions) or unexpected events cause the storage level to be at risk, American River water agencies would coordinate with Reclamation to identify and implement appropriate actions to improve forecasted storage conditions, and the American River water agencies would work together to educate the public on the actions that have been agreed upon and implemented and the reasons and basis for them. If potential changes to Folsom Dam operations would have impacts on other aspects of the CVP and SWP or the entire integrated system, Reclamation will meet and discuss these potential changes and impacts with water contractors.

Reclamation will continue to work with the American River Group, a group that includes federal, state, and local agencies, water users, and NGOs, to coordinate spring pulse flow timing and communicate upcoming releases.

Reclamation would ramp down to the revised minimum flows from Folsom Reservoir as soon as possible in the fall and maintain these flows, where possible.

4.10.4.1 *Seasonal Operations*

In the winter and spring, flood control releases typically dominate the flow regime in the American River Division. Flood control operations occur to safely pass large storm events without exceeding the identified downstream levee capacity. This includes making dry-weather releases to ensure that the maximum storage adheres to the flood control elevation identified in the applicable Water Control Manual.

As part of implementing the 2017 Flow Management Standard, Reclamation proposes redd dewatering protective adjustments to limit potential redd dewatering due to reductions in the minimum release during the January through May period. Redd dewatering protective adjustments should limit the amount of dewatering due to a reduction of the minimum release, not the actual river release, and, as such, would not always minimize dewatering impacts to the same extent. In January and February, there is a Chinook Salmon redd dewatering protective adjustment, and in February through May there is a Steelhead redd dewatering protective adjustment.

During non-flood control operations within the fall and winter months, Reclamation proposes to operate to build storage by making minimum releases and capturing inflows, although drier conditions may also require releases for Delta requirements. To the extent possible, releases will be held relatively consistent to minimize potential redd dewatering.

Spring releases will be controlled by flood control requirements or, in drier hydrology, Delta requirements and water supply. Reclamation proposes to operate Folsom Dam in a manner designed to maximize capture of the spring runoff to fill as close to full as possible. Reclamation proposes to follow the 2017 Flow Management Standard, which includes a pulse flow event at some time during the period extending from March 15 to April 15 by supplementing normal operational releases from Folsom Dam under certain conditions when no such flow event has occurred between the preceding February 1 and March 1 timeframe. In addition to the pulse flow under the 2017 Flow Management Standard, to the extent feasible, Reclamation proposes to accommodate additional requests for spring pulse flows by re-shaping previously planned releases; however, these requests will not be accommodated in times when they may compromise temperature operations later in the year. This spring pulse flow provides a juvenile salmonid emigration cue before relatively low flow conditions and associated unsuitable thermal conditions later in the spring, and downstream in the lower Sacramento River.

Reclamation proposes to continue to make summer releases for instream temperature control, Delta outflow, and exports, typically above the planning minimum flows. By late October, it is typical for Folsom Reservoir to have depleted the cold water pool. The primary way to provide additional instream cooling is to release water from the lower outlet works. This operation bypasses the power penstocks and has a significant impact on power generation. In order to optimize power generation, Reclamation proposes to limit power bypass operations solely to respond to emergency or unexpected events or during extreme drought years when a drought emergency has been declared by the Governor of California.

Reclamation will ramp down releases in the American River below Nimbus Dam as follows in Table 4-12 below.

Table 4-12: American River Ramping Rates

Lower American River Daily Rate of Change (cfs)	Amount of decrease in 24 hrs (cfs)	Maximum change per step (cfs)
20,000 to 16,000	4,000	1,350
16,000 to 13,000	3,000	1,000
13,000 to 11,000	2,000	700
11,000 to 9,500	1,500	500
9,500 to 8,300	1,200	400
8,300 to 7,300	1,000	350
7,300 to 6,400	900	300
6,400 to 5,650	750	250
5,650 to 5,000	650	250
<5,000	500	100

Ramping rates do not apply during flood control or if needed for facility operational concerns. The working groups may also determine a need for a variance.

4.10.4.2 *Temperature Management*

Reclamation proposes to prepare a draft Temperature Management Plan by May 15 for the summer through fall temperature management season using the best available (as determined by Reclamation) decision support tools. The information provided by the Operations Forecast will be used in the development of the Temperature Plan. The draft plan will contain: (1) forecasts of hydrology and storage; and (2) a modeling run or runs, using these forecasts, demonstrating what temperature compliance schedule can be attained. Reclamation will use an iterative approach, varying shutter configurations, with the objective to attain the best possible temperature schedule for the compliance point at Watt Avenue Bridge. The draft plan will be shared with the American River Group before finalization and may be updated monthly based on system conditions.

Reclamation proposes to manage the Folsom/Nimbus Dam complex and the water temperature control shutters at Folsom Dam to maintain a daily average water temperature of 65°F (or other temperature as determined by the temperature modeling) or lower at Watt Avenue Bridge from May 15 through October 31, to provide suitable conditions for juvenile Steelhead rearing in the lower American River. If the temperature is exceeded for 3 consecutive days, Reclamation will notify NMFS and outline steps being taken to bring the water temperature back into compliance. During the May 15 to October 31 period, if the Temperature Plan defined temperature requirement cannot be met because of limited cold water availability in Folsom Reservoir, then the target daily average water temperature at Watt Avenue may be increased incrementally (i.e., no more than 1°F every 12 hours) to as high as 68°F. The priority for use of the lowest water temperature control shutters at Folsom Dam shall be to achieve the water temperature requirement for listed species (i.e., Steelhead), and thereafter may also be used to provide cold water for Fall-Run Chinook Salmon spawning.

4.10.4.3 *Conservation Measures*

Reclamation and DWR are proposing conservation measures to avoid and minimize or compensate for CVP and SWP project effects, including take, on the species under review in this biological assessment as well as contribute to the recovery and enhancement of species and their habitats. These conservation measures include non-flow actions that benefit listed species without impacting water supply or other beneficial uses. Actions could be implemented in part or fully through agreements and cost share with the State of California and potentially under the Voluntary Agreement alternative under the State Water Resources Control Board update to the Bay-Delta Water Quality Control Plan.

- Spawning and Rearing Habitat Restoration: Project activities include primarily side channel and floodplain creation, expansion, and grading, spawning gravel and large cobble additions, and woody material additions. Pursuant to CVPIA 3406(b)(13), Reclamation proposes to implement the following projects: Paradise Beach, Howe Avenue to Watt Avenue rearing habitat, William Pond Outlet, Upper River Bend, Ancil Hoffman, El Manto, Sacramento Bar North, Sacramento Bar South, Lower Sunrise, Sunrise, Upper Sunrise, Lower Sailor Bar, Upper Sailor Bar, Nimbus main channel and side channel, Discovery Park, Cordova Creek Phase II, Carmichael Creek Restoration and Sunrise Stranding Reduction. Reclamation proposes to continue maintenance activities at Nimbus Basin, Upper Sailor Bar, Lower Sailor Bar, Upper Sunrise, Lower Sunrise and River Bend restoration sites.
- Nimbus Hatchery: Reclamation will complete Hatchery Genetics Management Plans (HGMPs) for Central Valley Steelhead and Fall-run Chinook Salmon for use in Nimbus Fish Hatchery management. Reclamation intends to improve the status of CV steelhead and Fall-run Chinook salmon in the American River by developing these plans. The steelhead HGMP will describe hatchery operations and associated monitoring to reduce genetic introgression from the out-of-basin Nimbus Hatchery broodstock, implement practices to reduce straying and eliminate inter-basin transfers from Nimbus hatchery, and promote a CV steelhead DPS population in the American River. The fall-run Chinook Salmon HGMP will describe hatchery operations and associated monitoring to reduce impacts on hatchery Chinook salmon on natural fall-run Chinook salmon and minimize effects on the genetic diversity and run-timing of American River fall-run Chinook salmon. Within six months of completion of the consultation, Reclamation will work with CDFW and NMFS to establish a clear understanding on this conservation measure’s goals, appropriate time horizons, and reasonable cost estimates for this effort.
- Drought Temperature Management: In severe or worse droughts, Reclamation proposes to evaluate and implement alternative shutter configurations at Folsom Dam to allow temperature flexibility.
- Yellow-billed Cuckoo Surveys: Reclamation will coordinate with the USFWS to develop a baseline survey for the Yellow-billed cuckoo. The survey for this action would focus on the critical habitat areas, associated project sites, and occupied habitat within the action area. In addition, the baseline survey would incorporate the efforts from the Yolo Restoration Project and other related projects when conducting protocol-level surveys for Yellow-billed Cuckoo in the over-lapping project areas. Results from Yellow-billed Cuckoo surveys conducted by other agencies and organizations within the Action Area will be analyzed by Reclamation when determining baseline conditions for the species and effects resulting from project activities. By reducing redundant survey efforts, Reclamation would be able to leverage their resources to cover areas not recently surveyed and develop a more comprehensive baseline survey. Reclamation would coordinate and discuss with USFWS on the potential need for additional surveys for specific project areas and surveys to monitor the effects of project activities over the project timeline. Information collected in the baseline surveys could be used to inform ecological surrogate models in the future, potentially replacing the need for follow-up presence/absence surveys. In addition, Reclamation will follow the nesting bird protocols during construction activities and consider the needs of Yellow-billed cuckoo when designing and implementing salmonid habitat restoration projects. Results of Yellow-billed cuckoo surveys and findings from

ecological surrogate models shall be shared with the U.S. Fish and Wildlife Service Bay-Delta Fish and Wildlife Office no later than 120 days after completion.

4.10.5 Delta

CVP and SWP facilities in the Delta provide for delivery of water supply to areas within and immediately adjacent to the Delta, and to regions south of the Delta. The major CVP features are the DCC, Contra Costa Canal and Rock Slough Intake facilities, Jones Pumping Plant, and TFCF. The main SWP Delta features are Suisun Marsh facilities, Banks Pumping Plant, CCF, Skinner Fish Facility, and Barker Slough Pumping Plant. These facilities and their operation under the proposed action are described in subsequent sections.

The CVP Jones Pumping Plant, located about 5 miles north of Tracy, has six fixed-speed pumps. It has a permitted diversion capacity of 4,600 cfs and sits at the end of an earth-lined intake channel about 2.5 miles long. The Jones Pumping Plant discharges into the head of the Delta Mendota Canal (DMC). The upper portion of the DMC is heavily impacted by subsidence which limits the maximum pumping rates to less than the permitted capacity. The SWP Banks Pumping Plant, located near the Jones Pumping Plant, has 11 variable speed pumps that allow for more control over the diversion rate. Pumping is limited to a maximum permitted capacity of 10,300 cfs per day. The Banks Pumping Plant discharges into the California Aqueduct. The Delta Mendota Canal Intertie (capacity 467 cfs from DMC to California Aqueduct; Capacity 900 cfs from California Aqueduct to DMC) is used to move water between the California Aqueduct and the Delta Mendota Canal. This structure was built to help both projects more effectively move water from the Delta into the San Luis Reservoir. This helps both projects when there are system restrictions that may prevent one party from moving water.

Banks pumps water directly from storage in CCF. The CCF radial gates are closed during critical periods of the ebb/flood tidal cycle to protect water levels experienced by local agricultural water diverters in the south Delta area. As a practical matter, Banks pumping rates are constrained operationally by limits on Clifton Court diversions from the Delta. The maximum daily diversion limit from the Delta into CCF is 13,870 acre-feet per day (6,990 cfs/day) and the maximum averaged diversion limit over any 3 days is 13,250 acre-feet per day (6,680 cfs/day). In addition to these requirements, DWR may increase diversions from the Delta into CCF by one-third of the San Joaquin River flow at Vernalis from mid-December through mid-March when flows at Vernalis exceed 1,000 cfs. These limits are listed in the USACE Public Notice 5820A Amended (Oct. 13, 1981).

During July through September, the maximum daily diversion limit from the Delta into CCF is increased from 13,870 acre-feet per day (6,990 cfs/day) to 14,860 acre-feet per day (7,490 cfs/day) and the maximum averaged diversion limit over any 3 days is increased from 13,250 acre-feet per day (6,680 cfs/day) to 14,240 acre-feet per day (7,180 cfs/day). These increases are for the purpose of recovering water supply losses incurred earlier in the same year to protect ESA-listed fish species. Those increases are a separate action permitted for short-term time periods. Further, Banks Pumping Plant will pump 195,000 acre-feet to the CVP in accordance with the 2018 COA Addendum.

The Barker Slough Pumping Plant diverts water from Barker Slough into the North Bay Aqueduct for delivery to the Solano County Water Agency (SCWA) and the Napa County Flood Control and Water Conservation District (Napa County FC&WCD) (NBA entitlement holders).

4.10.5.1 *Seasonal Operations*

Winter and spring pumping operations generally maximize exports of excess, unregulated, unstored water to help meet project demands later in the season and for Delta water quality. In order to minimize and avoid adverse effects on listed species, actions have been taken or imposed in the past to protect fish migration and minimize fish entrainment at Jones and Banks Pumping Plants. These restrictions limit the projects' ability to export excess water in the winter and spring and place a higher reliance on exporting previously stored water in the summer and fall.

Summer is generally a period of higher export potential. During the summer the CVP and SWP typically operate to convey previously stored water across the Delta for exporting at the Project pumps or other Delta facilities. Delta concerns during the summer are typically focused on maintaining salinity and meeting outflow objectives while maximizing exports with the available water supply.

Fall Delta operations typically begin as demands decrease, accretions increase within the system, and reservoir releases are decreasing to start conserving water. Exports are typically maximized to export available water in the system and may decrease if the fall remains dry. As precipitation begins to fall within the Sacramento and San Joaquin Basins, the reservoirs focus on building storage and managing for flood control. The enactment of D-1641 required higher spring releases; as a result, reservoir storage levels were lower in the fall and Reclamation and DWR had less need for flood releases. The 2008 biological opinion included an adaptive management action requiring an increase in fall flows to manage salinity in years following wet and above-normal years. However, lower fall outflows would better mimic historical (pre-project) conditions, and analyses indicate that the CVP and SWP have had negligible effects on fall outflows measured using X2 as a proxy (Hutton et al. 2017).

4.10.5.2 *Minimum Export Rates*

Water rights, contracts, and agreements specific to the Delta include D-1641, COA and other related agreements pertaining to CVP and SWP operations and Delta watershed users. In order to meet health and safety needs, critical refuge supplies, and obligations to senior water rights holders, the combined CVP and SWP export rates at Jones Pumping Plant and Banks Pumping Plant will not be required to drop below 1,500 cfs. Reclamation and DWR propose to use the Sacramento River, San Joaquin River, and Delta channels to transport water to export pumping plants located in the south Delta.

4.10.5.3 *Delta Cross Channel*

The DCC is a controlled diversion channel between the Sacramento River and Snodgrass Slough. When DCC gates are open, water is diverted from the Sacramento River through a short excavated channel into Snodgrass Slough and then flows through natural channels for about 50 miles to the vicinity of Banks and Jones Pumping Plants.

Reclamation operates the DCC in the open position to (1) improve the movement of water from the Sacramento River to the export facilities at the Banks and Jones Pumping Plants; (2) improve water quality in the central and southern Delta; and (3) reduce salinity intrusion rates in the western Delta. During the late fall, winter, and spring, the gates are often periodically closed to protect out-migrating salmonids from entering the interior Delta and to facilitate meeting the D-1641 Rio Vista flow objectives for fish passage. In addition, whenever flows in the Sacramento River at Sacramento reach 20,000 to 25,000 cfs (on a sustained basis), the gates are closed to reduce potential scouring and flooding that might occur in the channels on the downstream side of the gates.

Reclamation proposes to operate the DCC gates to reduce juvenile salmonid entrainment risk beyond actions described in D-1641, consistent with Delta water quality requirements in D-1641. From October 1 to November 30 Reclamation proposes to operate the DCC gates consistent with past operations. If during this period Knights Landing Catch Index or Sacramento Catch Index are greater than three fish per day Reclamation proposes to operate in accordance with Table 4-13 and Table 4-14 to determine whether to close the DCC gates and for how long.

From December 1 to January 31, the DCC gates will be closed, except to prevent exceeding a D-1641 water quality threshold.

If drought conditions are observed (i.e. fall inflow conditions are less than 90% of historic flows) Reclamation and DWR will consider opening the DCC gates for up to 5 days for up to two events within this period to avoid D-1641 water quality exceedances. Reclamation and DWR will coordinate with USFWS, NMFS and the SWRCB on how to balance D-1641 water quality and ESA-listed fish requirements. Reclamation and DWR will conduct a risk assessment that will consider the Knights Landing RST, Delta juvenile fish monitoring program (Sacramento trawl, beach seines), Rio Vista flow standards, acoustic telemetered fish monitoring information as well as DSM2 modeling informed with recent hydrology, salinity, and tidal data. Reclamation will also consider the cumulative entrainment from prior years. Reclamation will share this information with WOMT to describe how fish responses may be altered by DCC operations. If the risk assessment determines that survival, route entrainment, or behavior change to create a new adverse effect, or a greater range of an adverse effect, not considered under this proposed action, Reclamation will not open the DCC. During a DCC gates opening between December 1 and January 31, the CVP and SWP will divert at Health and Safety pumping levels.

From February 1 to May 20, the DCC gates will be closed consistent with D-1641. From May 21 to June 15, Reclamation will close the DCC gates for a total of 14 days during this period consistent with D-1641. Reclamation and DWR's risk assessment will consider the Knights Landing RST, Delta juvenile fish monitoring program (Sacramento trawl, beach seines), Rio Vista flow standards, acoustic telemetered fish monitoring information as well as DSM2 modeling informed with recent hydrology, salinity, and tidal data. Reclamation will evaluate this information to determine timing and duration of the gate closure.

Table 4-13. Delta Cross Channel October 1–November 30 Action

Date	Action Triggers	Action Responses
October 1–November 30	Water quality criteria per D-1641 are met and either the Knights Landing Catch Index or Sacramento Catch Index is greater than 5.0fish per day	Within 48 hours, close the DCC gates and keep closed until the catch index is less than three fish per day at both the Knights Landing and Sacramento monitoring sites
	Water quality criteria per D-1641 are met, either Knights Landing Catch Index or the Sacramento Catch Index are greater than 3.0 fish per day but less than or equal to five fish per day	Within 48 hours of trigger, DCC gates are closed. Gates will remain closed for 3 days

Date	**Action Triggers**	**Action Responses**
	Water quality criteria per D-1641 are met, real-time hydrodynamic and salinity modeling shows water quality concern level targets are not exceeded during	Within 48 hours of start of LMR attraction flow release, close the DCC gates for up to 5 days
	28-day period following DCC closure and there is no observed deterioration of interior Delta water quality	(dependent upon continuity of favorable water quality conditions)
	Water quality criteria per D-1641 are met, real time hydrodynamic and salinity modeling shows water quality concern level targets are exceeded during 14- day period following DCC closure	No closure of DCC gates
	The KLCI or SCI triggers are met but water quality criteria are not met per D-1641 criteria	Monitoring groups review monitoring data and provide to Reclamation. Reclamation and DWR determine what to do with a risk assessment

Table 4-14. Water Quality Concern Level Targets

Water Quality Concern Level Targets (Water Quality Model simulated 14-day average Electrical Conductivity)	Water Quality Concern Level Targets (Water Quality Model simulated 14- day average Electrical Conductivity)
Jersey Point	1800 umhos/cm
Bethel Island	1000 umhos/cm
Holland Cut	800 umhos/cm
Bacon Island	700 umhos/cm

4.10.5.4 *Agricultural Barriers*

DWR proposes to continue to install three agricultural barriers at the Old River at Tracy, Middle River, and Grant Line Canal each year when necessary to improve quality and channel water levels in the south Delta area. The barriers are installed between May and July and removed in November. Barriers would include at least one culvert open to allow for fish migration when water temperatures are less than 71.6°F. The barriers provide an adequate agricultural water supply in terms of quantity, quality, and channel water levels to meet the needs of water users in the south Delta area.

4.10.5.5 *North Bay Aqueduct*

The North Bay Aqueduct and Barker Slough Pumping Plant will continue to operate under applicable regulatory requirements with an annual maximum diversion of 125 TAF. The maximum daily diversion rate for the Pumping Plant is 175 cfs.

Reclamation and DWR will work with the Service to develop Delta Smelt minimization measures by the end of the 2019 calendar year. These minimization measures will aim to protect larval delta smelt from entrainment through the BSPP and will consider reduction in diversion through the NBA at the appropriate spring period and appropriate water year types by using effective detection measures or an appropriate proxy.

4.10.5.5.1 Sediment Removal

Sediment accumulates in the concrete apron sediment trap in front of the BSPP fish screens and within the pump wells behind the fish screens. Sediment removal from the sediment trap and the pump wells will be removed as needed.

4.10.5.5.2 Aquatic Weed Removal

Aquatic weeds will be removed, as needed, from in front of the fish screens at BSPP. Aquatic weeds accumulate on the fish screens, blocking water flow, and causing water levels to drop behind the screens in the pump wells. The low water level inside of the pump wells causes the pumps to automatically shut off to protect the pumps from cavitation. Aquatic weed removal system consists of grappling hooks attached by chains to an aluminum frame. A boom truck, staged on the platform in front of the BSPP pumps, will lower the grappling system into the water to retrieve the accumulated aquatic vegetation. The removed aquatic weeds will be transported to two aggregate base spoil sites located near the pumping plant.

4.10.5.6 *Contra Costa Water District Operations*

The CCWD diverts water from the Delta for irrigation and M&I uses under its CVP contract, under its own water right permits and license issued by the SWRCB, and under East Contra Costa Irrigation District's pre-1914 water right. The CCWD water system includes the Mallard Slough, Rock Slough, Old River, and Middle River (on Victoria Canal) intakes; the Rock Slough Fish Screen (constructed in 2011 under the authority of CVPIA 3406(b)(5)); the Contra Costa Canal and shortcut pipeline; and the Los Vaqueros Reservoir. The Rock Slough Intake, Contra Costa Canal, and shortcut pipeline are owned by Reclamation, and operated and maintained by CCWD under contract with Reclamation. Mallard Slough Intake, Old River Intake, Middle River Intake, and Los Vaqueros Reservoir are owned and operated by CCWD. Federal legislation providing the authority for Reclamation to transfer title of the facilities was passed by Congress and signed by the President in March 2019. CCWD and Reclamation are beginning the title transfer process, which includes conducting the required environmental and property record review to execute the transfer.

Operations at CCWD's intakes and Los Vaqueros Reservoir are governed by biological opinions from NMFS (NMFS 1993, 2007, 2010, 2017) and USFWS (USFWS 1993a, 1993b, 2000; 2007, 2010, 2017), an MOU with CDFW (CDFG 1994), and an incidental take permit from CDFW (CDFW 2009), which are separate from the biological opinions for the coordinated long-term operation of the CVP and SWP. Reclamation is not consulting on the biological opinions that govern CCWD's intakes and Los Vaqueros Reservoir, nor will this consultation amend or supersede those separate biological opinions. For the proposed action in this consultation, CCWD's operations are consistent with the current implementation of the operational criteria specified in those separate biological opinions. Reclamation will work with CCWD to ensure that implementation of the proposed action will not restrict CCWD operations beyond the restrictions of the separate biological opinions, allowing CCWD to have opportunities to fill Los Vaqueros Reservoir that are at least comparable to the current conditions.

Rock Slough Intake is located on Rock Slough at the head of the Contra Costa Canal, approximately 3.5 miles west of the junction of Rock Slough and Old River. The Rock Slough Fish Screen (RSFS) was constructed in 2011 at the Rock Slough Intake for the protection of listed species, in accordance with provisions specified in the 1993 USFWS biological opinion for the Los Vaqueros Project (USFWS 1993).

The 2008 USFWS biological opinion for the coordinated long-term operation of the CVP and SWP (USFWS 2008) and the 2009 CDFW ITP for the CCWD operations (CDFG 2009) considered the effects of the diversion of water at Rock Slough intake before the RSFS was constructed. In accordance with the 2009 ITP, CCWD obtained 36 acres of aquatic species habitat mitigation credits intended to address all of CCWD's intakes, assuming that Rock Slough was unscreened. Aquatic species impacts are now less given that the RSFS has been constructed (Reclamation 2016).

USFWS 2008 quantified incidental take and exempted prohibitions associated with all CCWD diversions as all Delta Smelt inhabiting the water diverted in the assumed 195 thousand acre -feet (TAF) maximum diversion amount (USFWS 2008, 2017). In a 2009 letter from USFWS regarding the effects of the RSFS on Delta Smelt and its critical habitat, USFWS acknowledges that "[s]ince the Rock Slough diversion will now be screened, less entrainment will be expected than what was described in the 2008 biological opinion and the expected incidental take remains the same."

In the proposed action, CCWD's operations are consistent with the operational criteria specified in separate biological opinions and permits that govern operations at CCWD's intakes and Los

Vaqueros Reservoir (NMFS 1993, 2007, 2010, 2017; USFWS 1993a, 1993b, 2000, 2007, 2010, 2017; CDFG 1994, 2009) and remain unchanged from the current operations scenario.

Reclamation is not consulting on the NMFS 2017 biological opinion at this time and is not requesting any amendments to that biological opinion. However, the NMFS 2017 biological opinion indicates that the NMFS 2009 biological opinion on the long-term coordinated operations of the CVP and SWP, which is the subject of this consultation, analyzed the actual diversion of water through the Rock Slough Intake (NMFS 2017: 87). Consistent with the 2008 USFWS biological opinion, Reclamation is requesting incidental take coverage for all water diverted at the Rock Slough Intake up to the maximum capacity of the intake (350 cfs) for the maximum annual diversion of 195 TAF.

4.10.5.7 *Water Transfers*

Reclamation and DWR propose to transfer project and non-project water supplies through CVP and SWP facilities, including north-to-south transfers and Sacramento River north-to-north transfers. The quantity and timing of Keswick releases would be similar to those that would occur absent the transfer. Water transfers would occur through various methods, including, but not limited to, groundwater substitution, release from storage, and cropland idling, and would include individual and multi-year transfers. The effects of developing supplies for water transfers in any individual year or a multi-year transfer is evaluated outside of this proposed action. Water transfers would occur from July through November in total annual volumes up to those described in Table 4-15.

Table 4-15. Proposed Annual North to South Water Transfer Volume

Water Year Type	Maximum Transfer Amount (TAF)
Critical	Up to 600
Dry (following Critical)	Up to 600
Dry (following Dry)	Up to 600
All other years	Up to 360

As part of this proposed action, Reclamation and DWR will provide a transfer window from July 1 through November 30. Allowing fall transfers is expected to have water supply benefits and may provide flexibility to improve Sacramento River temperature operations during dry conditions, such as occurred during the 2014–2015 drought conditions. Real-time operations may restrict transfers within the transfer window so that Reclamation and DWR can meet other authorized project purposes, e.g., when pumping capacity is needed for CVP or SWP water.

4.10.5.8 *Clifton Court Aquatic Weed and Algal Bloom Management*

DWR will apply herbicides or will use mechanical harvesters on an as-needed basis to control aquatic weeds and algal blooms in CCF. Herbicides may include Aquathol K, a chelated copper herbicide (copper-ethylenediamine complex and copper sulfate pentahydrate) and, a copper carbonate compound, or other copper-based herbicides. Algaecides may include peroxygen-based algaecides (e.g.., PAK 27). These products are used to control algal blooms that can degrade drinking water quality through production of taste and odor compounds of algal toxins. Dense growth of submerged aquatic weeds can cause severe head loss and pump cavitation at Banks Pumping Plant when the stems of the rooted plant break free and drift into the trash racks. This mass of uprooted and broken vegetation essentially forms a watertight plug at the trash racks and vertical louver array. The resulting blockage necessitates a reduction in the pumping rate of water to prevent potential equipment damage through cavitation at the pumps and excessive weight on the louver array causing collapse of the structure. Cavitation creates excessive wear and deterioration of the pump impeller blades. Excessive floating weed mats also reduce the efficiency of fish salvage at the Skinner Fish Facility. Ultimately, this all results in a reduction in the volume of water diverted by the SWP. In addition, dense stands of aquatic weeds provide cover for unwanted predators that prey on listed species within the CCF. Aquatic weed control is included as a conservation measure to reduce mortality of ESA-listed fish species within the CCF (see section *4.95.11.3 Skinner Fish Facility Improvements*).

Mechanical methods are utilized to manually remove aquatic weeds. A debris boom and an automated weed rake system continuously remove weeds entrained on the trash racks. During high weed load periods such as late summer and fall when the plants senesce and fragment or during periods of hyacinth entrainment, boat-mounted harvesters are operated on an as-needed basis to remove aquatic weeds in the Forebay and the intake channel upstream of the trash racks and louvers. The objective is to decrease the weed load on the trash racks and to improve flows in the channel. Effectiveness is limited due to the sheer volume of aquatic weeds and the limited capacity and speed of the harvesters. Harvesting rate for a typical weed harvester ranges from 0.5 to 1.5 acres per hour or 4 to 12 acres per day. Actual harvest rates may be lower due to travel time to off-loading sites, unsafe field conditions such as high winds, and equipment maintenance.

Aquatic weed and algae treatments would occur on an as-needed basis depending upon the level of vegetation biomass, the cyanotoxin concentration from the harmful algal blooms (HAB), or concentration of taste and odor compounds. The frequency of aquatic herbicide applications to control aquatic weeds is not expected to occur more than twice per year, as demonstrated by the history of past applications. Aquatic herbicides are ideally applied early in the growing season when plants are susceptible to them during rapid growth and formation of plant tissues; or later in the season, when plants are mobilizing energy stores from their leaves towards their roots for overwintering senescence. The frequency of algaecide applications to control HABs is not expected to occur more than once every few years, as indicated by monitoring data and demonstrated by the history of past applications. Treatment areas are typically about 900 acres, and no more than 50% of the 2,180 total surface acres.

Aquatic weed assemblages change from year to year in the CCF from predominantly *Egeria densa* to one dominated by curly-leaf pondweed, sago pondweed, and southern naiad. To effectively treat a dynamic aquatic weed assemblage and harmful algal blooms, multiple aquatic pesticide compounds are required to control aquatic weeds and algal blooms in CCF. The preferred products are:

- Aquathol K, an endothall-based aquatic herbicide, that is effective on pondweeds;
- copper-based compounds that are effective on *E. densa*, cyanobacteria and green algae. The copper-based aquatic herbicides include copper sulfate pentahydrate and chelated copper herbicides; and
- peroxygen-based algaecides (e.g., PAK 27) that are effective on cyanobacteria.
- Aquathol K

The dipotassium salt of endothall is used for control of aquatic weeds and is the active ingredient in Aquathol® K (liquid formulation). Aquathol K is a widely used herbicide to control submerged weeds in lakes and ponds, and the short residual contact time (12-48 hours) makes it effective in both still and slow-moving water. Aquathol K is effective on many weeds, including hydrilla, milfoil, and curly-leaf pondweed, and begins working on contact to break down cell structure and inhibit protein synthesis. Without the ability to grow, the weed dies. Full kill takes place in 1 to 2 weeks. As weeds die, they sink to the bottom and decompose. Aquathol K is not effective at controlling E. densa.

Aquathol K is registered for use in California and has effectively controlled pondweeds and southern naiad in CCF and in other lakes. Endothall has low acute and chronic toxicity effects to fish. The LC50 for salmonids is 20-40 times greater than the maximum concentration allowed to treat aquatic weeds. The EPA maximum concentration allowed for Aquathol K is 5 ppm. A recent study (Courter et al. 2012) of the effect of Cascade® (same endothall formulation as Aquathol K) on salmon and steelhead smolts showed no sublethal effects until exposed to 9-12 ppm, that is, 2-3 times greater than the 5 ppm maximum concentration allowed by the EPA and about 4-6 times greater than the 2-3 ppm applied in past CCF treatments. In the study, steelhead and salmon smolts showed no statistical difference in mean survival between the control group and treatment groups, however, steelhead showed slightly lower survival after 9 days at 9-12 ppm. Based on the studies with salmonids, Aquathol K applied at or below the EPA maximum allowable concentration of 5 ppm poses a low to no toxicity risk to salmon, steelhead and other fish. No studies have assessed the exposure risk to green sturgeon.

When aquatic plant survey results indicate that pondweeds are the dominant species in CCF, Aquathol K will be selected due to its effectiveness in controlling these species. Aquathol K will be applied according to the label instructions, with a target concentration dependent upon plant biomass, water volume, and forebay depth. The target concentration of treatments is 2- to 3 ppm, which is well below the concentration of 9-12 ppm where sublethal effects have been observed (Courter et al. 2012). DWR monitors herbicide concentration levels during and after treatment to ensure levels do not exceed the Aquathol K application limit of 5 ppm. Additional water quality testing may occur following treatment for drinking water intake purposes. Samples are submitted to a laboratory for analysis. There is no “real time” field test for endothall. No more than 50% of the surface area of CCF will be treated at one time. A minimum contact time of 12 hours is needed for biological uptake and treatment effectiveness, but the contact time may be extended up to 24 hours to reduce the residual endothall concentration for NPDES compliance purposes.

4.10.5.8.1 Copper-based Aquatic Herbicides and Algaecides

Copper herbicides and algaecides include chelated copper products and copper sulfate pentahydrate crystals. When aquatic plant survey results indicate that E. densa is the dominant species, copper-based compounds will be selected due to their effectiveness in controlling this species. E. densa is not affected by application of Aquathol K. Copper-based algaecides are effective at controlling algal blooms (cyanobacteria) that produce cyanotoxins or taste and odor compounds.

Copper herbicides and algaecides will be applied in a manner consistent with the label instructions, with a target concentration dependent upon target species and biomass, water volume and the depth of the forebay. Applications of copper herbicides for aquatic weed control will be applied at a concentration of 1 ppm with an expected dilution to 0.75 ppm upon dispersal in the water column. Applications for algal control will be applied at a concentration of 0.2 to 1 ppm with expected dilution within the water column. DWR will monitor dissolved copper concentration levels during and after treatment to ensure levels do not exceed the application limit of 1 ppm, per NPDES permit required procedures. Treatment contact time will be up to 24 hours. If the dissolved copper concentration falls below 0.25 ppm during an aquatic weed treatment, DWR may opt to open the radial gates after 12 hours but before 24 hours to resume operations. Opening the radial gates prior to 24 hours would enable the rapid dilution of residual copper and thereby shorten the exposure duration of ESA-listed fish to the treatment. No more than 50% of the surface area of CCF will be treated at one time.

4.10.5.8.2 Peroxygen-Based Algaecides

PAK 27 algaecide active ingredient is sodium carbonate peroxyhydrate. An oxidation reaction occurs immediately upon contact with the water destroying algal cell membranes and chlorophyll. There is no contact or holding time requirement, as the oxidation reaction occurs immediately and the byproducts are hydrogen peroxide and oxygen. There are no fishing, drinking, swimming, or irrigation restrictions following the use of this product. PAK 27 has NSF/ANSI Standard 60 Certification for use in drinking water supplies at maximum-labeled rates and is certified for organic use by the Organic Materials Reviews Institute (OMRI).

PAK 27, or equivalent product, will be applied in a manner consistent with the label instructions, with permissible concentrations in the range of 0.3 to 10.2 ppm hydrogen peroxide. No more than 50% of the surface area of CCF will be treated at one time.

The following are operational procedures to minimize impacts on listed species during aquatic herbicide treatment for application of Aquathol K and copper-based products and algaecide treatment for application of peroxide-based algaecides in CCF:

- Apply Aquathol K and copper-based aquatic pesticides, as needed, from June 28 to August 31.
- Apply Aquathol K and copper-based aquatic pesticides, as needed, prior to June 28 or after August 31 if the average daily water temperatures within CCF is at or above 77°F and if Delta Smelt, salmonids, and green sturgeon are not at additional risk from the treatment as conferred by NMFS and USFWS.
    - Prior to treatment outside of the June 28 to August 31 timeframe, DWR will notify and confer with NMFS and USFWS on whether ESA-listed fish species are present and at risk from the proposed treatment.
- Apply Aquathol K and copper-based aquatic pesticides, as needed, during periods of activated Delta Smelt and salmonid protective measures and when average daily water temperature in CCF is below 77°F if the following conditions are met:
    - Prior to treatment outside of the June 28 to August 31 timeframe, DWR will notify and confer with NMFS and USFWS on whether ESA-listed fish species are present and at risk from the proposed treatment.
    - The herbicide application does not begin until after the radial gates have been closed for 24 hours or after the period of predicted Delta Smelt and salmonid survival within CCF (e.g. after predicted mortality has occurred due to predation or other factors) has been exceeded, and
    - The radial gates remain closed for 24 hours after the completion of the application, unless it is conferred that rapid dilution of the herbicide would be beneficial to reduce the exposure duration to listed fishes present within the CCF.
- Apply peroxygen-based aquatic algaecides, as needed, year-round.
- There are no anticipated impacts on fish with the use of peroxygen-based aquatic algaecides in CCF during or following treatment.

- Monitor the salvage of listed fish at the Skinner Fish Facility prior to the application of the aquatic herbicides and algaecides in CCF.
- For Aquathol K and copper compounds, the radial intake gates will be closed at the entrance to CCF prior to the application of pesticides to allow fish to move out of the targeted treatment areas and toward the salvage facility and to prevent any possibility of aquatic pesticide diffusing into the Delta.
- For Aquathol K and copper compounds, the radial gates will remain closed for a minimum of 12and up to 24 hours after treatment to allow for the recommended duration of contact time between the aquatic pesticide and the treated vegetation or cyanobacteria in the forebay, and to reduce residual endothall concentration for drinking water compliance purposes. (Contact time is dependent upon pesticide type, applied concentration, and weed or algae assemblage). Radial gates would be reopened after a minimum of 36 hours (24 hours pre-treatment closure plus 12 hours post-treatment closure).
- For peroxide-based algaecides, the radial gates will be closed prior to the application of the algaecide to prevent any possibility of the algaecide diffusing into the Delta. The radial gates may reopen immediately after the treatment as the required contact time is less than 1 minute and there is no residual by-product of concern.
- Application will be made by a licensed applicator under the supervision of a California Certified Pest Control Advisor.
- Aquatic herbicides and algaecides will be applied by boat or by aircraft.
    - Boat applications will be by subsurface injection system for liquid formulations and boat-mounted hopper dispensing system for granular formulations. Applications would start at the shoreline and move systematically farther offshore, enabling fish to move out of the treatment area.
    - Aerial applications of granular and liquid formulations will be by helicopter or aircraft. No aerial spray applications will occur during windspeeds above 15 mph to prevent spray drift.
- Application would be to the smallest area possible that provides relief to SWP operations or water quality. No more than 50% of CCF will be treated at one time.
- Water quality samples to monitor copper and endothall concentrations within or adjacent to the treatment area, per the NPDES permit requirements, will be collected before, during and after application. Additional water quality samples may be collected during the following treatment for drinking water compliance purposes. No monitoring of copper or endothall concentrations in the sediment or detritus is proposed.
- No monitoring of peroxide concentration in the water column will occur during and after application as the reaction is immediate and there is no residual. Dissolved oxygen concentration will be measured prior to and immediately following application within and adjacent to the treatment zone.
- A spill prevention plan will be implemented in the event of an accidental spill.

Aquatic weed and algae treatments would occur on an as-needed basis. The timing of application is an avoidance measure and is based on the life history of Chinook Salmon and Steelhead in the Central Valley's Delta region and of Delta Smelt. Green sturgeon are present in the area year-round. Migrations of juvenile Winter-Run Chinook Salmon and Spring-Run Chinook Salmon primarily occur outside of the summer period in the Delta. Central Valley Steelhead have a low probability of being in the south Delta during late June when temperatures exceed 77°F through the first rainfall flush event, which can occur as late at December in some years (Grimaldo 2009). Delta Smelt are not expected to be in CCF during this time period. Delta Smelt are not likely to survive when water temperatures reach a daily average of 77°F, and they are not expected to occur in the Delta prior to the first flush event. Therefore, the likelihood of herbicide exposure to Chinook Salmon, Central Valley Steelhead, and Delta Smelt during the proposed herbicide treatment timeframe in CCF is negligible.

Additional protective measures will be implemented to prevent or minimize adverse effects from herbicide applications. As described above, applications of aquatic herbicides and algaecides will be contained within CCF. The radial intake gates to CCF will be closed prior to, during, and following the application. The radial gates will remain closed during the recommended minimum contact time based on herbicide type, application rate, and aquatic weed or algae assemblage. Additionally, following the gate closure and prior to the applications of Aquathol K and copper-based pesticides, the water is drawn down in the CCF via the Banks Pumping Plant. This drawdown helps facilitate the movement of fish in the CCF toward the fish diversion screens and into the fish protection facility, lowers the water level in the CCF to decrease the total amount of herbicide needed to be applied, per volume of water, and aides in the dilution of any residual pesticide post-treatment. Following reopening of the gates and refilling of CCF, the rapid dilution of any residual pesticide and the downstream dispersal of the treated water into the California Aqueduct via Banks PP will reduce the exposure time of any ESA-listed fish species present in CCF.

4.10.5.9 *Suisun Marsh Preservation Agreement*

The SMPA among DWR, Reclamation, CDFW, and Suisun Resource Conservation District (SRCD) contains provisions for DWR and Reclamation to mitigate the effects on Suisun Marsh channel water salinity from SWP and CVP operations and other upstream diversions. The SMPA requires DWR and Reclamation to meet salinity standards in accordance with D-1641, sets a timeline for implementing the Plan of Protection, and delineates monitoring and mitigation requirements.

There are two primary physical mechanisms for meeting salinity standards set forth in D-1641 and the SMPA: (1) the implementation and operation of physical facilities in the Marsh; and (2) management of Delta outflow (i.e., facility operations are driven largely by salinity levels upstream of Montezuma Slough and salinity levels are highly sensitive to Delta outflow). Physical facilities (described below) have been operating since the 1980’s and have proven to be a highly reliable method for meeting standards.

The SMSCG are located on Montezuma Slough about 2 miles downstream from the confluence of the Sacramento and San Joaquin Rivers, near Collinsville. The objective of Suisun Marsh Salinity Control Gate operation is to decrease the salinity of the water in Montezuma Slough. The gates control salinity by restricting the flow of higher salinity water from Grizzly Bay into Montezuma Slough during incoming tides and retaining lower salinity Sacramento River water from the previous ebb tide. Operation of the gates in this fashion lowers salinity in Suisun Marsh channels and results in a net movement of water from east to west through Suisun Marsh.

The SMSCG are operated on an as needed basis to meet D-1641 water quality standards in Montezuma Slough. The water quality standard include the period between October through May. Operations are determined from data at D-1641 compliance stations, hydrologic conditions, weather, Delta outflow, tide, fishery considerations, and other factors. The duration of gate operation may range from no use to full use for the entire October through May period. Assuming no significant long-term changes in the operational data mentioned above, it is expected that gate operations (outside of additional actions described under Delta Smelt Summer-Fall Habitat Action) will remain at current levels (17-69 days) necessary to meet D-1641 standards. During drought conditions, gate operations are more likely to span the entire October through May period to meet D-1641 standards.

The SMSCG boat lock portion of the gate will be held partially open during SMSCG operation to allow for continuous salmon passage opportunity. After an engineering solution is implemented to prevent boaters from entering the boat lock prior to the operator closing it, the gate will be held open at all times. However, the boat lock gates may be closed temporarily to stabilize flows to facilitate safe passage of watercraft through the facility.

The Roaring River Distribution System (RRDS) was constructed to provide lower salinity water to 5,000 acres of private and 3,000 acres of CDFW managed wetlands on Simmons, Hammond, Van Sickle, Wheeler, and Grizzly Islands. The RRDS includes a 40-acre intake pond that supplies water to Roaring River Slough. Water is diverted through a bank of eight 60-inch-diameter culverts equipped with fish screens into the Roaring River intake pond on high tides to raise the water surface elevation in RRDS above the adjacent managed wetlands. The intake to the RRDS is screened to prevent entrainment of fish larger than approximately 25 mm. After the listing of Delta Smelt, RRDS diversion rates have been controlled to maintain a maximum approach velocity of 0.2 ft/second at the intake fish screen except during September 14 – October 20, when RRDS diversion rates are controlled to maintain a maximum approach velocity of 0.7 ft / s for fall flood up operations.

The Morrow Island Distribution System (MIDS) allows Reclamation and DWR to provide water to the ownerships so that lands may be managed according to approved local management plans. The system was constructed primarily to channel drainage water from the adjacent managed wetlands for discharge into Suisun Slough and Grizzly Bay. This approach increases circulation and reduces salinity in Goodyear Slough. The MIDS is used year-round, but most intensively from September through June. When managed wetlands are filling and circulating, water is tidally diverted from Goodyear Slough just south of Pierce Harbor.

The Goodyear Slough Outfall (GYSO) connects the south end of Goodyear Slough to Suisun Bay. Prior to construction of the outfall, Goodyear Slough was a dead-end run slough. The GYSO was designed to increase circulation and reduce salinity in Goodyear Slough so as to provide higher water quality to the wetland managers who flood their ponds with Goodyear Slough water. GYSO has a series of four passive intakes that drain to Suisun bay. The outfall is equipped with slide gates on the interior of the outfall structure to allow DWR to close the system as needed for maintenance or repairs. The intakes and outfall of GYSO are unscreened but are equipped with trash racks to prevent damage. Any fish that entered the system would be able to leave via the intake or the outfall, as GYSO is an open system.

4.10.5.10 *OMR Management*

Reclamation and DWR propose to operate the CVP and SWP in a manner that maximizes exports while minimizing entrainment of fish and protecting critical habitat. Net flow OMR provides a surrogate indicator for how export pumping at Banks and Jones Pumping Plants influence hydrodynamics in the south Delta. The management of OMR, in combination with other environmental variables, can minimize or avoid the entrainment of fish in the south Delta and at CVP and SWP salvage facilities. Reclamation and DWR propose to maximize exports by incorporating real-time monitoring of fish distribution, turbidity, temperature, hydrodynamic models, and entrainment models into the decision support for the management of OMR to focus protections for fish when necessary and provide flexibility where possible, consistent with the WIIN Act Sections

4002 and 4003, as described below. Estimates of species distribution will be described by multi-agency Delta-focused technical teams.

From the onset of OMR management to the end, Reclamation and DWR will operate to an OMR index no more negative than a 14-day moving average of -5,000 cfs unless a storm event occurs (described below). Grimaldo et al. (2017) indicate that -5,000 cfs is an inflection point in OMR for fish entrainment. OMR could be more positive than -5,000 cfs if additional real-time OMR restrictions are triggered (described below) or constraints other than OMR control exports. Reclamation and DWR propose to operate to an OMR index computed using an equation. An OMR index allows for shorter-term operational planning and real-time adjustments. Reclamation and DWR will make a change to exports within 3 days of the trigger when monitoring, modeling, and criteria indicate protection for fish is necessary. The 3-day trigger allows for efficient power scheduling.

4.10.5.10.1 Onset of OMR Management:

Reclamation and DWR shall start OMR management when one or more of the following conditions have occurred:

- Integrated Early Winter Pulse Protection ("First Flush" Turbidity Event): To minimize project influence on migration (or dispersal) of Delta Smelt, Reclamation and DWR proposes to reduce exports for 14 consecutive days so that the 14-day averaged OMR index for the period shall not be more negative than -2,000 cfs, in response to "First Flush" conditions in the Delta. The population-scale migration of Delta Smelt is believed to occur quickly in response to inflowing freshwater and turbidity (Grimaldo et al. 2009; Sommer et al. 2011). Thereafter, the best available scientific information suggests that fish make local movements, but there is no evidence for further population-scale migration (Polanksy et al. 2018). "First Flush" conditions may be triggered between December 1 and January 31 and include:
    - running 3-day average of the daily flows at Freeport is greater than 25,000 cfs and
    - running 3-day average of the daily turbidity at Freeport is 50 NTU or greater, or
    - real-time monitoring (Appendix C) indicates a high risk of migration and dispersal into areas at high risk of future entrainment.
- This "First Flush" may only be initiated once during the December through January period and will not be required if:
    - spent female Delta Smelt are collected in monitoring surveys.
- Salmonids Presence: After January 1, if more than 5 percent of any one or more salmonid species (wild young-of-year Winter-Run, wild young-of-year Spring-Run, or wild Central Valley Steelhead) are estimated to be present in the Delta as determined by their appropriate monitoring working group based on available real-time data, historical information, and modeling.

4.10.5.10.2 Additional Real-Time OMR Restrictions and Performance Objectives:

Reclamation and DWR shall manage to a more positive OMR than -5,000 cfs based on the following conditions:

- Turbidity Bridge Avoidance ("South Delta Turbidity"): After the Integrated Early Winter Pulse Protection (above) or February 1 (whichever comes first) and until a ripe or spent female is detected or April 1 (whichever is first), Reclamation and DWR propose to manage exports in order to maintain daily average turbidity in Old River at Bacon Island (OBI) at a level of less than 12 NTU. The purpose of this action is to minimize the risk to adult Delta smelt in the Old and Middle River Corridor, where they are subject to higher entrainment risks. This action seeks to avoid the formation of a turbidity bridge from the San Joaquin River shipping channel to the south Delta fish facilities, which historically has been associated with elevated salvage of pre-spawning adult Delta Smelt. If the daily average turbidity at Bacon Island cannot be maintained less than 12 NTU, Reclamation and DWR will manage exports to achieve an OMR no more negative than -2,000 cfs until the daily average turbidity at Bacon Island drops below 12 NTU. However, if 5 consecutive days of OMR less negative than -2,000 cfs do not reduce turbidity at Bacon Island below 12 NTU in a given month, Reclamation and DWR may determine that OMR restrictions to manage turbidity are infeasible, and will instead implement an OMR target that is deemed protective, based on turbidity, adult Delta Smelt distribution and salvage, but not a more negative OMR than -5,000 cfs.

Reclamation and DWR recognize that readings at individual sensors or localized groups of sensors can generate spurious results in real-time. To avoid triggering an OMR flow action during a sensor error or a localized turbidity spike that might be caused by local flows or a wind-driven event, Reclamation and DWR will consider and review data from other locations. In the event that the daily average turbidity at OBI is 12 NTU (or greater) and Reclamation and DWR believe that a Turbidity Bridge Avoidance action is not warranted based on additional data sources (isolated and/or wind-driven turbidity event at OBI), Reclamation and DWR will take no additional action and provide the supporting information to the Service within 24 hours.

Larval and Juvenile Delta Smelt: Reclamation and DWR will use results produced by USFWS approved life cycle models to manage the annual entrainment levels of larval/juvenile Delta Smelt. The Service’s models will be publicly vetted and peer reviewed prior to March 15, 2020. The USFWS will coordinate with the Delta Fish Monitoring Working Group to identify a Delta Smelt recruitment level that Reclamation and DWR can use in OMR management. The life cycle models statistically link environmental conditions to recruitment, including factors related to loss as a result of entrainment such as OMR flows. In this context, recruitment is defined as the estimated number of post-larval delta smelt in June per number of spawning adults the prior February-March.

Reclamation and DWR, in coordination with the Service will operationalize the life cycle model results through the use of real-time monitoring for the spatial distribution of Delta Smelt. On or after March 15 of each year, if QWEST is negative, and larval or juvenile delta smelt are within the entrainment zone of the pumps based on real-time sampling of spawning adults or young of year life stages, Reclamation and/or DWR will run hydrodynamic models and forecasts of entrainment, informed by the EDSM or other relevant survey data to estimate the percentage of larval and juvenile delta smelt that could be entrained. If necessary, Reclamation will manage exports to limit entrainment to be protective based on the modeled recruitment levels. Reclamation and DWR will re-run hydrodynamic models when operational changes or new sampling data indicate a potential change in entrainment risk. This process will continue until the offramp criteria have been met as described in the "End of OMR Management" below. In the event the life cycle models cannot be operationalized in a manner that can be used to inform real-time operations then Reclamation, DWR and the Service will coordinate to develop an alternative plan to provide operational actions protective of this life stage.

- Cumulative Loss Threshold:
  - Reclamation and DWR propose to avoid exceeding cumulative loss thresholds over the duration of the Biological Opinions for:

- Natural Winter-Run Chinook Salmon (cumulative loss= 8,738)
- Hatchery Winter-Run Chinook Salmon (cumulative loss= 5,356)
- Natural Central Valley Steelhead from December through March (cumulative loss= 6,038)
- Natural Central Valley Steelhead from April 1 through June 15th (cumulative loss= 5,826).

Natural Central Valley Steelhead are separated into two time periods to protect San Joaquin origin fish that historically appear in the Mossdale trawls later than Sacramento origin fish. The loss threshold and loss tracking for hatchery Winter-Run Chinook Salmon does not include releases into Battle Creek. Loss (for development of thresholds and ongoing tracking) for Chinook salmon are based on length-at-date criteria.

- The cumulative loss thresholds shall be based on cumulative historical loss from 2010 through 2018. Reclamation's and DWR's performance objectives are intended to avoid loss such that this cumulative loss threshold (measured as the 2010-2018 average cumulative loss multiplied by 10 years) will not be exceeded by 2030.
- If, at any time prior to 2024, Reclamation and DWR exceed 50% of the cumulative loss threshold, Reclamation and DWR will convene an independent panel to review the actions contributing to this loss trajectory and make recommendations on modifications or additional actions to stay within the cumulative loss threshold, if any.
- In the year 2024, Reclamation and DWR will convene an independent panel to review the first five years of actions and determine whether continuing these actions are likely to reliably maintain the trajectory associated with this performance objective for the duration of the period.
- If, during real-time operations, Reclamation and DWR exceed the cumulative loss threshold, Reclamation and DWR would immediately seek technical assistance from USFWS and NMFS, as appropriate, on the coordinated operation of the CVP and SWP for the remainder of the OMR management period. In addition, Reclamation and DWR shall, prior to the next OMR management season, charter an independent panel to review the OMR Management Action consistent with "Chartering of Independent Panels" under the "Governance" section of this Proposed Action. The purpose of the independent review shall be to evaluate the efficacy of actions to reduce the adverse effects on listed species under OMR management and the non-flow measures to improve survival in the south Delta and for San Joaquin origin fish.

- Single-Year Loss Threshold:
  - In each year, Reclamation and DWR propose to avoid exceeding an annual loss threshold equal to 90% of the greatest annual loss that occurred in the historical record from 2010 through 2018 for each of:
    - Natural Winter-Run Chinook Salmon (loss= 1.17% of JPE)
    - Hatchery Winter-Run Chinook Salmon (loss= 0.12% of JPE)
    - Natural Central Valley Steelhead from December through March (loss =1,414)
    - Natural Central Valley Steelhead from April through June 15 (loss = 1,552)

Natural Central Valley Steelhead are separated into two time periods to protect San Joaquin Origin fish that historically appear in the Mossdale trawls later than Sacramento origin fish. The loss threshold and loss tracking for hatchery Winter-Run Chinook Salmon does not include releases into Battle Creek. Loss (for development of thresholds and ongoing tracking) for Chinook salmon are based on length-at-date criteria.

- During the year, if Reclamation and DWR exceed the average annual loss from 2010 through 2018, Reclamation and DWR will review recent fish distribution information and operations with the fisheries agencies at WOMT and seek technical assistance on future planned operations. Any agency may elevate from WOMT to a Directors discussion, as appropriate.
- During the year, if Reclamation and DWR exceed 50% of the annual loss threshold, Reclamation and DWR will restrict OMR to a 14-day moving average OMR index of no more negative than -3,500 cfs, unless Reclamation and DWR determine that further OMR restrictions are not required to benefit fish movement because a risk assessment shows that the risk is no longer present based on real-time information.
- The -3500 OMR operational criteria adjusted and informed by this risk assessment will remain in effect for the rest of the season. Reclamation and DWR will seek NMFS technical assistance on the risk assessment and real-time operations.
- During the year, if Reclamation and DWR exceed 75% of the annual loss threshold, Reclamation and DWR will restrict OMR to a 14-day moving average OMR index of no more negative than -2,500 cfs, unless Reclamation and DWR determine that further OMR restrictions are not required to benefit fish movement because a risk assessment shows that the risk is no longer present based on real-time information.
- The -2500 OMR operational criteria adjusted and informed by this risk assessment will remain in effect for the rest of the season. Reclamation and DWR will seek NMFS technical assistance on the risk assessment and real-time operations.
- Risk assessments (identified above): Reclamation and DWR will evaluate and adjust OMR restrictions under this section by preparing a risk assessment that considers several factors including, but not limited to, real-time monitoring, historical trends of salmonids exiting the delta, entering the south delta, fish detected in salvage, and relevant environmental conditions. Risks will be measured against the potential to exceed the next single year loss threshold. Reclamation and DWR will share its risk assessment and supporting documentation with USFWS and NMFS, seek their technical assistance, discuss the risk assessment and future operations with WOMT at its next meeting, and elevate to the Directors as appropriate.
- If, during real-time operations, Reclamation and DWR exceed the single-year loss threshold, Reclamation and DWR would immediately seek technical assistance from USFWS and NMFS, as appropriate, on the coordinated operation of the CVP and SWP for the remainder of the OMR management period. In addition, Reclamation and DWR shall, prior to the next OMR management season, charter an independent panel to review the OMR Management Action consistent with “Chartering of Independent Panels” under the “Governance” section of this Proposed Action. The purpose of the independent review shall be to evaluate the efficacy of actions to reduce the effects on listed species under OMR management and the non-flow measures to improve survival in the south Delta and for San Joaquin origin fish.

Reclamation and DWR propose to continue monitoring and reporting the salvage at the Tracy Fish Collection Facility and Skinner Delta Fish Protection Facility. Reclamation and DWR propose to continue the release and monitoring of yearling Coleman NFH late-fall run as yearling Spring-Run Chinook Salmon surrogates.

4.10.5.10.3 Storm-Related OMR Flexibility:

Reclamation and DWR may operate to a more negative OMR up to a maximum (otherwise permitted) export rate at Banks and Jones Pumping Plants of 14,900 cfs (which could result in a range of OMR values) to capture peak flows during storm-related events. A storm related event occurs when precipitation falls in the Central Valley and Delta watersheds and Reclamation and DWR determine that the Delta outflow index indicates a higher level of flow available for diversion. Reclamation and DWR will define storm-related events in the first year of implementation of this proposed action. Reclamation and DWR will continue to monitor fish in real-time and will operate in accordance with “Additional Real- time OMR Restrictions,” above. Under the following conditions, Reclamation and DWR shall not pursue storm-related OMR flexibility for capturing peak flows from storm-related events if:

- Integrated Early Winter Pulse Protection (above) or Additional real-time OMR restrictions (above) are triggered. Under such conditions, Reclamation and DWR have already determined that more restrictive OMR is required.
- An evaluation of environmental and biological conditions indicates more negative OMR would likely cause Reclamation and DWR to trigger an Additional real-time OMR restriction (above).
- Salvage of yearling Coleman NFH late-fall run as yearling Spring-Run Chinook Salmon surrogates exceeds 0.5% within any of the release groups.
- Reclamation and DWR identify changes in spawning, rearing, foraging, sheltering, or migration behavior beyond those anticipated to occur under OMR management.

Reclamation and DWR will continue to monitor conditions may resume management of OMR to no more negative than -5,000 cfs if conditions indicate the above offramps are necessary to avoid additional adverse effects. If storm-related flexibility causes the conditions in “Additional Real-Time OMR Restrictions”, Reclamation and DWR will implement additional real-time OMR restrictions.

4.10.5.10.4 End of OMR Management:

OMR criteria may control operations until June 30 (for Delta Smelt and Chinook salmon), until June 15 (for steelhead/rainbow trout), or when the following species-specific off ramps have occurred, whichever is earlier:

- Delta Smelt: when the daily mean water temperature at CCF reaches 77°F for 3 consecutive days;
- Salmonids:
  - when more than 95 percent of salmonids have migrated past Chipps Island, as determined by their monitoring working group, or
  - after daily average water temperatures at Mossdale exceed 71.6°F for 7 days during June (the 7 days do not have to be consecutive).

4.10.5.10.5 Real-Time Decision Making and Salvage Thresholds

When real-time monitoring demonstrates that criteria in “Additional Real-Time OMR Restrictions and Performance Objectives” are not supported, then Reclamation and DWR may confer with the

Directors of NMFS, USFWS, and CDFW if they desire to operate to a more negative OMR than what is specified in this section. Upon mutual agreement, the Directors of NMFS and USFWS may authorize Reclamation and DWR to operate to a more negative OMR than the “Additional Real-Time OMR Restrictions”, but no more negative than -5000 cfs. This process would be separate from the risk analysis process referenced above.

4.10.5.11 *Delta Smelt Summer-Fall Habitat*

The Delta Smelt Habitat Action is intended to improve Delta Smelt food supply and habitat, thereby contributing to the recruitment, growth, and survival of Delta Smelt. The current conceptual model is that Delta Smelt habitat should include low salinity conditions of 0-6ppt, turbidity of approximately 12 NTU, temperatures below 75°F, food availability, and littoral or open water physical habitats (FLaSH Synthesis, pp. 15-25). The Delta Smelt Summer-Fall Habitat Action is being undertaken recognizing that the highest quality habitat in this large geographical region includes areas with complex bathymetry, in deep channels close to shoals and shallows, and in proximity to extensive tidal or freshwater marshlands and other wetlands. The Delta Smelt Summer-Fall Habitat Action is to provide these habitat components in the same geographic area through a range of action to improve water quality and food supplies.

Reclamation and DWR propose to use structured decision making to implement Delta Smelt habitat actions. In the summer and fall (June through October) of below normal, above normal and wet years, based on the Sacramento Valley Index, the environmental and biological goals are, to the extent practicable, the following:

- Maintain low salinity habitat in Suisun Marsh and Grizzly Bay when water temperatures are suitable;
- Manage the low salinity zone to overlap with turbid water and available food supplies; and
- Establish contiguous low salinity habitat from Cache Slough Complex to the Suisun Marsh.

The action will initially include modifying project operations to maintain a monthly average 2 ppt isohaline at 80 km from the Golden Gate in above normal and wet water years in September and October. Reclamation and DWR will also implement additional measures that are expected to achieve additional benefits. These measures include, but are not limited to:

- Suisun Marsh Salinity Control Gate (SMSCG) operations for up to 60 additional days (not necessarily consecutive) from June 1 through October 31 of below normal and above normal, years. This action may also be implemented in wet years if preliminary analysis shows expected benefits;
- Food enhancement actions, e.g., those included in the Delta Smelt Resiliency Plan to enhance food supply. These projects include the North Delta food-web project, Sacramento River Deepwater Ship Channel lock reoperation, and Roaring River distribution system reoperation. Reclamation and DWR will monitor dissolved oxygen at Roaring River distribution system drain location(s) during Delta Smelt food distribution actions to ensure compliance with Water Quality Objectives established in the San Francisco Bay Basin Plan. These actions are listed in further detail below:
    - *Sacramento Deepwater Ship Channel Food Study:* Reclamation proposes to partner with the City of West Sacramento and West Sacramento Area Flood Control Agency to repair or replace the West Sacramento lock system to hydraulically reconnect the ship channel with the mainstem of the Sacramento River. When combined with an ongoing food web study, the

reconnected ship channel has the potential to flush food production into the north Delta. An increase in food supply is likely to benefit Delta Smelt and their habitat.

- *North Delta Food Subsidies / Colusa Basin Drain Study:* DWR, Reclamation, and water users propose to increase food entering the north Delta through flushing nutrients from the Colusa Basin into the Yolo Bypass and north Delta. DWR, Reclamation, and water users would work with partners to flush agricultural drainage (i.e., nutrients) from the Colusa Basin Drain through Knight's Landing Ridge Cut and the Tule Canal to Cache Slough, improving the aquatic food web in the north Delta for fish species. Reclamation would work with DWR and partners to augment flow in the Yolo Bypass in July and/or September by closing Knights Landing Outfall Gates and routing water from Colusa Basin into Yolo Bypass to promote fish food production.
- *Suisun Marsh and Roaring River Distribution System Food Subsidies Study:* Water users propose to add fish food to Suisun Marsh through coordinating managed wetland flood and drain operations in Suisun Marsh, Roaring River Distribution System food production, and reoperation of the Suisun Marsh Salinity Control Gates. As noted in the Delta Smelt Resiliency Strategy, this management action may attract Delta Smelt into the high-quality Suisun Marsh habitat in greater numbers, reducing use of the less food-rich Suisun Bay habitat (California Natural Resources Agency 2016). Infrastructure in the Roaring River Distribution System may help drain food-rich water from the canal into Grizzly Bay to augment Delta Smelt food supplies in that area. In addition, managed wetland flood and drain operations can promote food export from the managed wetlands to adjacent tidal sloughs and bays. Reclamation and DWR will monitor dissolved oxygen at Roaring River Distribution System drain location(s) to ensure compliance with Water Quality Objectives established in the San Francisco Bay Basin Plan when Delta Smelt food actions are being taken.

- If the measures above (or others developed through collaborative science processes) result in benefits that are determined to provide similar or better protection than the 80 km salinity management action, Reclamation and DWR will work with USFWS to modify this component of the PA to implement the new actions in lieu of the salinity management action. When determining whether or not the measures above provide similar or better protection, Reclamation and DWR will consider, at minimum, the following:
  - Habitat acreages in Suisun Marsh, Grizzly Bay, and other adjacent areas available to support Delta Smelt recruitment (e.g. 0-6 ppt at Belden's Landing, non-lethal temperatures, etc.),
  - Recruitment projections based on lifecycle modeling and/or monitoring to evaluate the expected trend in Delta Smelt with and without the 80 km salinity management action, and
  - The presence (or absence) of Delta Smelt in both the target areas (main Delta channels and Suisun Marsh) and other areas (such as Montezuma Sough and Cache Slough), including information from monitoring, presence/absence modeling, or similar tools.

These considerations (listed above) and implementation of other actions will be more fully defined and developed through the structured decision making or other review process. The review will include selection of appropriate models, sampling programs, and other information to be used. The process will be completed prior to implementation and may be improved in subsequent years as additional information is synthesized and reviewed as described below.

Reclamation and DWR will develop a Delta Smelt Summer-Fall Habitat Action Plan to meet the environmental and biological goals in years when summer-fall habitat actions are triggered. In above normal and wet years, operating to a monthly average X2 of 80 km in September and October is the initial operation to provide a specific acreage of low salinity habitat. In every action year, Reclamation and DWR may propose, based on discussions with the USFWS, a suite of actions that would meet the action's environmental and biological goals.

Although Reclamation and DWR agree to treat the Delta Smelt Summer-Fall Habitat Action as an in-basin use, Reclamation intends to meet Delta outflow augmentation in the fall primarily through export reductions as they are the operational control with the most flexibility in September and October. Storage releases from upstream reservoirs may be used to initiate the action by pushing the salinity out further in August and early September; however, the need for this initial action will depend on the hydrologic, tidal, storage, and demand conditions at the time. In addition, storage releases may be made in combination with export reductions during the fall period during high storage scenarios where near-term flood releases to meet flood-control limitations are expected. In these scenarios, Reclamation will make releases in a manner that minimizes redd dewatering where possible. In the event that Reclamation determines the Delta outflow augmentation necessary to meet 2 ppt isohaline at 80 km from the Golden Gate as described above cannot be met through primarily export reductions and is expected to have a high storage cost, Reclamation will still implement the rest of this action, and will meet with NMFS and USFWS to discuss alternate potential approaches that improve habitat conditions.

4.10.5.11.1 Collaborative Planning Process

Reclamation shall form a Delta Coordination Group (Reclamation, DWR, USFWS, NMFS, CDFW, and representatives from federal and state water contractors). The Group will utilize one of the existing structured decision-making models, or adopt a new model, to analyze proposed summer-fall habitat actions. Through the Delta Coordination Group Reclamation and DWR shall develop a multi-year science and monitoring plan consistent with the structured decision-making models within 9 months of signing the ROD. The Delta Coordination Group may use the IEP or CSAMP (or similar entity) to review project design and the science and monitoring plan.

Within six months of signing the National Environmental Policy Act Record of Decision ("ROD"), the Delta Coordination Group shall meet to select a structured decision-making model; and complete model runs testing various approaches to satisfying the environmental and biological goals, utilizing the available tool box of approaches. The Delta Coordination Group shall provide the initial results of its modeling exercise in a memorandum to Reclamation, DWR, and USFWS.

The process for Delta Smelt Summer-Fall Habitat Action development and approval is as follows:

- January: Reclamation and DWR will provide a synthesis of potential updates to the science and monitoring plan annually based on available data and analysis from prior years. Preliminary analyses from prior year will be shared with DCG.
- March: The water year designation is not fully known until approximately May 1; however, planning for a summer-fall action requires several weeks. Therefore, the Delta Coordination Group will develop an initial proposal accounting for varying forecasted hydrology and temperatures. The proposal will include the hypotheses to be tested, the suite of actions and operations to test the hypotheses, potential off-ramps, and expected outcomes.
- April: In April of each below normal, above normal or wet water year, Reclamation and DWR shall meet to develop a Habitat Action Plan accounting for forecasted hydrology and temperatures over the summer and fall. The Habitat Action Plan shall describe how the proposed action will meet the environmental and biological goals as well as assess and apply off-ramps as needed. The preliminary action shall be selected and fully described by April 30.

- June through October: Reclamation and DWR share preliminary monitoring results through the Delta Coordination Group.
- October (of following calendar year when an action is taken): Reclamation and DWR shall provide a synthesis of the study results to the Delta Coordination Group by October of the following year an action is undertaken. The Delta Coordination Group shall review the synthesis of results and use the results of the monitoring to inform a subsequent Structured Decision-Making modeling exercise using the tool box of available approaches. Reclamation and DWR shall provide the results of the subsequent structured decision-making exercise to USFWS by March of the following year.

The Delta Smelt Summer-Fall Habitat action would be incorporated into the “Four Year Review” under the “Governance” section of this PA, and all reasonable and practical recommendations shall be incorporated into the Delta Smelt Summer-Fall Habitat Action. The structured decision-making model and the multi-year science and monitoring plan will be part of this Peer Review.

4.10.5.12 *Conservation Measures*

Reclamation and DWR are proposing conservation measures to avoid and minimize or compensate for CVP and SWP project effects, including take, on the species under review in this biological assessment as well as contribute to the recovery and enhancement of species and their habitats. These conservation measures include non-flow actions that benefit listed species without impacting water supply or other beneficial uses. Actions could be implemented in part or fully through agreements and cost share with the State of California and potentially under the Voluntary Agreement alternative under the State Water Resources Control Board update to the Bay-Delta Water Quality Control Plan.

4.10.5.12.1 Tracy Fish Collection Facility

Reclamation proposes to continue to screen fish from Jones Pumping Plant with the TFCF. The TFCF uses behavioral barriers consisting of primary louvers and four rotating traveling screens aligned in a single row 7 degrees to the flow of the water to guide entrained fish into holding tanks before transport by truck to release sites at the confluence of the Delta. The TFCF was designed to handle smaller fish (less than 200 mm) that would have difficulty fighting the strong pumping plant-induced flows, as the intake is essentially open to the Delta and impacted by tidal action. The number of pumps (units) running at the Jones Pumping Plant (JPP) dictates the flow and velocity at the TFCF. There are 6 units at JPP but a maximum of 5 can used; each unit increases the velocity through the TFCF primary channel by approximately 0.5 ft/sec.

The primary louvers are in the primary channel just downstream of the trash rack structure. The traveling water screen is in the secondary channel.

The louvers allow water to pass through onto the pumping plant, but the openings between the slats are tight enough and angled against the flow of water to prevent most fish from passing between them and to enable the fish to enter one of four bypass entrances along the louver arrays. Reclamation proposes to install a carbon dioxide injection device to allow remote controlled anesthetization of predators in the secondary channels of the TFCF.

The current primary louver cleaning procedures and operations involve lifting each individual louver panel, 36 total, out of the water to spray wash the debris. Generally, each primary louver panel is lifted and lowered back into place three times per day, although frequency of cleaning may be increased or decreased according to pumping rate and debris loads. It takes approximately 3-7 minutes to lift, spray clean, and lower each louver panel back into place. While export pumping may be reduced to address damaged louver panels, issues during cleaning, or other maintenance scenarios where facilities are not capable of effectively salvaging fish, complete shutdown of pumping usually does not occur due to issues related to the primary louvers. At 5 Jones Pumping Plant units running, louvers are cleaned before the incoming tide as much as possible. The morning day shift usually begin cleaning as soon as they start their work, around 0600. During high debris periods, operators monitor differentials and clean before any problems arise. At a minimum, all 36 louver panels are cleaned 2-3 times a day but during heavy debris loads, operators clean 3-6 times a day. At 2-4 JPP units, operators determine when to clean and making sure the louvers do not reach 1 ft differential. At 1 JPP unit, operators will normally clean periodically during the incoming tide. Generally, less frequent cleaning is required in early summer (low averages of 60 minutes per day) and much higher during the winter months (high averages of 440 minutes per day). This means that there is a louver panel lifted 1-7.5 hours per day depending on season, pumping rates, and debris loads.

When south Delta hydraulic conditions allow, and conditions within the original design criteria for the TFCF, the louvers are operated to achieve water approach velocities for striped bass of approximately 1 foot per second from May 15 through October 31 and for salmon of approximately 3 feet per second from November 1 through May 14.

Fish passing through the facility are sampled at intervals of 30 minutes every 2 hours year-round. Approximately 52 different species of fish are entrained into the TFCF each year; however, the total numbers are significantly different for the various species salvaged. Fish observed during sampling intervals are identified by species, measured to fork length, examined for marks or tags, and placed in the collection facilities for transport by tanker truck to the release sites in the north Delta away from the pumps. Hauling trucks used to transport salvaged fish to release sites inject oxygen and contain an 8 parts per thousand salt solution to reduce stress. In addition, TFCF personnel monitor for the presence of spent female Delta Smelt in anticipation of expanding the salvage operations to include sub-20 mm larval Delta Smelt detection.

TFCF personnel monitor for the presence of spent female Delta Smelt by euthanizing all adult Delta Smelt that are collected in the 30-minute fish count, determine the gender and the gonadal or sexual maturation stage of the Delta Smelt, and determine if the eggs have reached Stage IV, the stage when eggs are ready for release (0.9 to 10 mm in diameter and easily stripped). Stages V (i.e., postvitellogenic stage) and VI (i.e., postovulatory, or spent stage) are expected soon after Stage IV observation. Stages are determined and reported real-time when a biologist is present or the following morning after smelt detection and collection. Stage or gonad maturation is determined using egg stage descriptions from Mager (1996).

Larval smelt sampling at the TFCF commences once a trigger is met (detection of a spent female at CVP and SWP being one of three triggers). Fish count screen with a 2.4 mm mesh size opening is replaced with one that has a mesh size of 0.5 mm to retain larval fish. Sampling is done four times a day (04:00, 10:00, 16:00, 22:00) and all larval smelt are identified to species and reported the day after collection.

Salvage of fish occurs at the TFCF 24 hours per day, 365 days per year. Fish are salvaged in flow-through holding tanks (6.1-m diameter, 4.7-m deep) that provide continuous flows of water (Sutphin and Wu 2008). Fish are maintained in these holding tanks for 8-24 hours depending on the species of fish that are being salvaged, the number of fish salvaged, and debris load. The number of fish that are salvaged in TFCF holding tanks is generally estimated by performing a 30 minute fish-count subsample every 120 minutes (2 hours). The number of each species of fish collected in the subsample is determined and then multiplied by 4 (120 pumping minutes/30 minute fish-count subsample = expansion factor of 4) to estimate the total number of each species of fish, as well as the total number of fish, that were salvaged in TFCF holding tanks during the 120 minute period. Pumping minutes and fish-count minutes could potentially deviate from 120 minutes and 30 minutes, respectively, which would change the expansion factor used to estimate total fish salvage.

If no Chinook Salmon, Steelhead, or Delta Smelt are salvaged, fish can be maintained in TFCF holding tank for up to 24 hours. If a Chinook Salmon or Steelhead is collected during fish-counts, fish can only be maintained in TFCF holding tanks for up to 12 hours. If a Delta Smelt is collected during fish-count, salvaged fish may only be held in TFCF holding tanks for up to 8 hours. When fish can be maintained in TFCF holding tanks for 24 hours, fish transport (fish-haul) generally occurs each morning. When 2 fish- hauls per day are necessary, a night fish haul is added. When 3 fish-hauls are necessary, they are usually completed at 7 am, 3pm, and 9:30 pm each day. Fish-haul is also dictated by the Bates Tables which uses size classes, species, and water temperature as indicators for when to conduct a fish-haul.

During normal operations, salvaged fish are transported approximately 49.9 km and released at one of two Reclamation release sites near the confluence of the Sacramento and San Joaquin Rivers (Antioch Fish Release Site and Emmaton Fish Release Site). In general, the Emmaton Fish Release Site is used for fish-hauls performed during daytime hours and the Antioch Fish Release Site is used for fish-hauls performed during nighttime hours. This is done for safety and security reasons as the Antioch Fish release Site has a gate that can be locked behind the operator after he/she enters the release site area. Upon arrival at release sites, operators measure certain important water quality parameters (dissolved oxygen, salinity, and temperature) prior to releasing fish. This is done to verify that water quality parameters remain acceptable during fish transport. As a conservation measure, Reclamation proposes to increase the number of release sites to reduce predation.

Reclamation would conduct studies and physical improvements aimed to improve fish survival and improve TFCF efficiency, reducing mortality through the facility, fish hauling and release operations through the Tracy Fish Facility Improvement Program. Activities include louver improvement and replacement, predation studies and piscivorous predator control, improvement of hydrologic monitoring and telemetry systems, holding area improvements including fish count automation and tank aeration and screening, improvement of data management as well as aquaculture facility maintenance, operation and improvements. TFCF studies are established at annual multi-agency meetings of the Tracy Tech Advisory Team. Reclamation would provide written reports of study results on the TFFIP website.

4.10.5.12.2 Skinner Fish Facility

DWR proposes to continue to screen fish from Banks Pumping Plant with the. Skinner Fish Facility, located west of the CCF, 2 miles upstream of the Banks Pumping Plant. The Skinner Fish Facility has behavioral barriers to keep fish away from the pumps that lift water into the California Aqueduct. Large fish and debris are directed away from the facility by a 388-foot-long trash rack. Smaller fish are diverted from the intake channel into bypasses by a series of behavioral barriers (metal louvers), while the main flow of water continues through the louvers and toward the pumps. These fish pass through a secondary system of louvers or screens and pipes into seven holding tanks, where a subsample is counted and recorded. The salvaged fish are then returned to the Delta in oxygenated tank trucks. The sampling frequency at TFCF will be maintained at the Skinner Fish Facility.

4.10.5.12.3 Additional Measures

- *San Joaquin Basin Steelhead Telemetry Study*: Continuation of the 6-Year Steelhead telemetry study for the migration and survival of San Joaquin Origin Central Valley Steelhead.
- *Steelhead Lifecycle Monitoring Program*: Develop infrastructure that will support a functioning life cycle monitoring program in the Stanislaus River and a Sacramento basin CVP tributary (e.g. Clear Creek, Upper Sacramento, American River) to evaluate how actions related to stream flow enhancement, habitat restoration, and/or water export restrictions affect biological outcomes including juvenile and adult population abundance, age structure, growth and smoltification rates, and anadromy and adaptive potential in these two populations. The goal of this monitoring program will be to improve understanding of steelhead demographics and, when combined with other steelhead-focused parts of the Proposed Action (San Joaquin and Delta steelhead telemetry study), inform actions that will increase steelhead abundance and improve steelhead survival through the Delta.
- *San Joaquin Basin Steelhead Collaborative*: Within 1 year, Reclamation will coordinate with CSAMP to sponsor a workshop for developing a plan to monitor steelhead populations within the San Joaquin Basin and/or the San Joaquin River downstream of the confluence of the Stanislaus River, including steelhead and rainbow trout on non-project San Joaquin tributaries. The goal for the monitoring program will be to estimate the juvenile and adult population abundance in the San Joaquin River basin. The plan would be delivered to the IEP for prioritization and implementation, where feasible, for actions within the responsibility of the CVP and SWP and other members of the IEP. If the IEP is not able to implement the plan, the plan may be raised at the Director Level Collaborative Planning Meeting described under the “Governance” section of this PA for resolution.
- *San Joaquin River Scour Hole Predation Reduction*: Reclamation and DWR would form a project team to address the scour hole in the San Joaquin River at the Head of Old River. The project team would plan and implement measures to reduce the predation intensity at that site through modifications to the channel geometry and associated habitats.
- Habitat Restoration: DWR and Reclamation propose to continue to implement existing restoration efforts that are part of the environmental baseline but are not yet complete, including:
    - *Tidal Habitat Restoration*: Completing, by 2030, the remaining approximately 6,000 acres of tidal habitat restoration in the Delta of the 8,000 acres DWR has begun. Reclamation and/or DWR would monitor, operate, and maintain the tidal habitat restoration, including obtaining permanent land rights. Consistent with the current regulatory process, future separate consultations would address the effects to listed species from habitat restoration.
    - *Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project*: Reclamation and DWR will provide increased acreage of seasonal floodplain rearing habitat available in the lower Sacramento River basin by 2030.
- *Predator Hot Spot Removal*: Reclamation would coordinate with water users to remove predator hot spots in the Bay- Delta. This includes minimizing lighting at fish screens and bridges, and possibly removing abandoned structures.
- *Delta Cross-Channel Gate Improvements:* The DCC is more than 65 years old and its gates rely on remote operators to travel to the facility to change their position. When the gates are open, they provide a critical diversion structure for freshwater reaching the CVP south Delta pumping station. The gates are closed to prevent scouring (during high flows), reduce salinity intrusion in the western Delta, and protect Sacramento River ESA-listed and non-listed salmonids. Additional DCC operation would allow for improved exports and water quality without additional adverse

effects on salmonids. Reclamation proposes to evaluate improvements to automate and streamline operation of the Delta Cross-Channel gates. Reclamation would modernize DCC's gate materials and mechanics to include adding industrial control systems, increasing additional staff time, and improve physical and biological monitoring associated with the DCC daily and/or tidal operations as necessary to maximize water supply deliveries.

- *Tracy Fish Facility Improvements:* Reclamation would improve the TFCF to reduce loss by: (1) incorporating additional fish exclusion barrier technology into the primary fish removal barriers, (2) incorporating additional debris removal systems at each trash removal barrier, screen, and fish barrier, (3) Constructing additional channels to distribute the fish collection and debris removal among redundant paths through the facility, (4) Construct additional fish handling systems and holding tanks to improve system reliability; and (5) Incorporate remote operation into the design and construction of the facility. Facility improvements will improve survival of fish salvaged and potentially reduce the loss factors to allow for additional certainty on OMR management with low impacts from salvaging salmonids.
- *Clifton Court Forebay Mortality Reduction:* DWR would continue implementation of projects to reduce mortality of ESA-listed fish species. These measures that would be implemented include: (a) continued evaluation of predator relocation methods; (b) controlling aquatic weeds; and (c) exploration of additional predation reduction measures. Please see Appendix G for study results from the last decade.
- *Skinner Fish Facility Performance Improvements*: DWR proposes to continue implementing studies to better understand and continuously improve the performance of the Skinner Fish Facility including: a) operational changes to salvage release scheduling and location to reduce post-salvage predation, and b) continued refinement and improvement of the fish sampling and hauling procedures and infrastructure to improve the accuracy and reliability of data and fish survival.
- *Salvage Release Sites:* Reclamation proposes to continue work with DWR to incorporate flexibility in salvage release sites, using DWR's sites, or sites on a barge.
- *Small Screen Program*: Reclamation and DWR propose to continue to work with existing authorities (Anadromous Fish Screen Program) to screen small diversions throughout Central Valley CVP/SWP streams and the Bay-Delta.
- *Reintroduction Efforts for Delta Smelt:* Reclamation proposes to fund a two-phase process that would lead to annual supplementation of the wild Delta Smelt population with propagated fish within 3-5 years from issuance of the biological opinion. The first step in this process will be the development of a supplementation strategy within one year of the issuance of the BiOp that will describe the capacity needed at hatchery facilities to accommodate the Delta Smelt production needed to meet genetic and other hatchery considerations with a goal of increasing production to a number and the life stages necessary to effectively augment the population. The Service will be the lead on the development of this supplementation strategy. The strategy will include identification of regulatory processes to address, science studies to complete, potential facility expansion and improvements, and schedules and deliverables to support the second phases and the larger Conservation Hatchery, described below.

  The second step will involve using the existing UC Davis Fish Conservation and Culture Laboratory (FCCL). Reclamation and DWR are the primary funding sources for FCCL, which maintains the refugial population of Delta Smelt and generates additional captive-bred fish for research. The FCCL has maintained a continuous refugial population since 2008. The FCCL has closed the life cycle of Delta Smelt meaning that they can produce new generations of fish at their facility with or without the addition of new wild spawners, and keep enough progeny alive to repeat the process for multiple generations. Annually, the FCCL exports approximately 33,000 fish of different life stages for use in research. Additionally, approximately 32,000 adults are reared in the refuge population. To achieve these production levels, the FCCL frequently removes fish at the egg and juvenile stages. Additional funding will support expansion of facilities to maintain these fish and increase rearing capacity to provide up to approximately 125,000 adults within 3 years. By 2030, Reclamation proposes to support a larger Conservation Hatchery, described below, to take over the role of supplementing the wild population.

- *Delta Fish Species Conservation Hatchery:* Reclamation proposes to partner with DWR to construct and operate a conservation hatchery for Delta Smelt, by 2030. The conservation hatchery would breed and propagate a stock of fish with equivalent genetic resources of the native stock and at sufficient quantities to effectively augment the existing wild population, so that they can be returned to the wild to reproduce naturally in their habitat.
- *Sediment Supplementation Feasibility Study:* Reclamation proposes to develop and implement a sediment supplementation feasibility study. The goal of this study will be to determine methods to reintroduce sediment in the Delta to increase turbidity which would provide better habitat conditions for all life stages of Delta Smelt, including increased cover for juveniles and feeding facilitation for larval smelt. This study will include, at minimum, consideration of sediment placement upstream of the Delta during low flow periods in the spring, summer and/or fall, followed by sediment remobilization following inundation during seasonal high flows. Reclamation will coordinate with the Service and other agencies to address necessary permitting for this study. Reclamation will coordinate with the Service on the design and findings of this study, including monitoring measures to assess its effectiveness and feasibility as a long-term management program, a method to phase implementation if required for permitting and other compliance needs.

4.10.6 Stanislaus River (East Side Division)

Reclamation operates the CVP East Side Division for flood control, agricultural water supplies, hydroelectric power generation, fish and wildlife protection, and recreation. In the Stanislaus River watershed, Reclamation owns and operates New Melones Dam and Reservoir (2.4 MAF capacity). The Tri-Dam Project, a partnership between the Oakdale Irrigation District (OID) and South San Joaquin Irrigation District (SSJID), consists of Donnells and Beardsley Dams, located upstream of New Melones Reservoir on the middle fork Stanislaus River, and Tulloch Dam and Powerplant, located approximately 6 miles downstream of New Melones Dam on the mainstem Stanislaus River. Releases from Donnells and Beardsley Dams affect inflows to New Melones Reservoir. The main water diversion point on the Stanislaus River is Goodwin Dam, located approximately 2 miles downstream of Tulloch Dam. OID and SSJID manage the Tulloch and Goodwin Dam infrastructure through separate agreements with both Reclamation and Reclamation’s CVP water service contractors (Stockton East Water District and the Central San Joaquin Water Conservation District) to meet Reclamation’s Stanislaus River objectives, CVP contractor deliveries, and deliveries to the OID and SSJID service areas.

The Stanislaus River watershed has annual obligations that exceed the average annual runoff in a given year due to several factors, including SWRCB water rights decisions D-1641, D-1422 and D-1616, the 1987 CDFG agreement, CVPIA objectives, the 2009 biological opinion, the 1988 Agreement and Stipulation with OID and SSJID, riparian water right diverters, and CVP water delivery contracts.

Over the past decade, Reclamation has worked with Stanislaus River water users and related agencies in developing a revised operating plan for New Melones Reservoir that addresses multiple objectives, including a more predictable and sustainable operation, minimizing low storage conditions in successive drought years, and providing flows to support listed species and critical habitat. These efforts have allowed multiple agencies and stakeholders to provide input on potential solutions; however, a final plan has not been completed.

The operating plan described below is intended to replace often overlapping and conflicting operational components of previous federal and state flow requirements and is representative of Reclamation's contribution to any current or future flow objectives on the Lower San Joaquin River at Vernal is.

4.10.6.1 *Seasonal Operations*

Reclamation proposes to meet water rights, contracts, and agreements that are specific to the East Side Division and Stanislaus River. Senior water right holders (OID and SSJID) will receive annual water deliveries consistent with the 1988 Agreement and Stipulation, and water will be made available to CVP contractors in accordance with their contracts and applicable shortage provisions.

In high storage, high inflow conditions, Reclamation will operate for flood control in accordance with the USACE flood control manual. Because New Melones is a large reservoir relative to its annual inflow, flood control is relatively infrequent; however, Tulloch Lake, located downstream of New Melones Reservoir, is subject to high local inflows, and may be in flood control operations for brief periods when New Melones Reservoir is not. During these periods, releases from Tulloch may be used to meet flow objectives, schedules, or requirements on the lower Stanislaus River below Goodwin Dam.

Reclamation proposes to operate New Melones Reservoir (as measured at Goodwin Dam) in accordance with a Stepped Release Plan (SRP) that varies by hydrologic condition/water year type as shown in Table 4-13.

Table 4-13. New Melones SRP Annual Releases by Water Year Type

Water Year Type	Annual Release (TAF)
Critical	184.3
Dry	233.3
Below normal	344.6
Above normal	344.6
Wet	476.3

The New Melones SRP will be implemented similarly to current operations under the 2009 biological opinion with a default daily hydrograph, and the ability to shape monthly and seasonal flow volumes to meet specific biological objectives. The default daily hydrograph is the same as prescribed under current operations for critical, dry, and below normal water year types. The difference occurs in above normal and wet years, where the minimum requirement for larger releases is reduced from current operations to promote storage for potential future droughts and preserve cold water pool. When compared to minimum daily flows from Appendix 2-E of the 2009 biological opinion (2-E), the daily hydrograph for the New Melones SRP is identical for critical, dry, and below normal year types; above normal and wet year types follow daily hydrographs for below normal and above normal year types from 2-E, respectively. The complete daily hydrograph for the New Melones SRP is available in Appendix B.

For the New Melones SRP, Reclamation proposes to classify water year types using the San Joaquin Valley “60-20-20” Water Year Hydrologic Classification (60-20-20) developed for D-1641 implementation. Previous operating plans for New Melones Reservoir relied on the New Melones Index (NMI) to determine water year type, calculated by summing end-of-February storage and forecasted inflow through September. Because the reservoir can store more than twice its average inflow, the NMI resulted in a water year type determination that was more closely tied to storage rather than hydrology. Changing from the NMI to 60-20-20 is expected to provide operations that better represent current hydrology and correlate more closely to water year types for other nearby tributaries.

Reclamation proposes to convene the Stanislaus Watershed Team (successor to the Stanislaus Operating Group), consisting of agency representatives and local stakeholders having direct interest on the Stanislaus River, at least monthly to share operational information and improve technical dialogue on the implementation of the New Melones SRP. The Stanislaus Watershed Team will also provide input on the shaping and timing of monthly or seasonal flow volumes to optimize biological benefits.

During the summer, Reclamation is required to maintain applicable dissolved oxygen standards on the lower Stanislaus River for species protection. Reclamation currently operates to a 7.0 mg/L dissolved oxygen requirement at Ripon from June 1 to September 30. Reclamation proposes to move the compliance location to Orange Blossom Bridge, where the species are primarily located at that time of year.

4.10.6.2 *Conservation Measures*

Reclamation and DWR are proposing conservation measures to avoid and minimize or compensate for CVP and SWP project effects, including take, on the species under review in this biological assessment as well as contribute to the recovery and enhancement of species and their habitats. These conservation measures include non-flow actions that benefit listed species without impacting water supply or other beneficial uses. Actions could be implemented in part or fully through agreements and cost share with the State of California and potentially under the Voluntary Agreement alternative under the State Water Resources Control Board update to the Bay-Delta Water Quality Control Plan.

- Spawning Habitat Restoration: Under the CVPIA (b)(13) program, Reclamation’s annual goal of gravel placement is approximately 4,500 tons in the Stanislaus River.
- Rearing Habitat Restoration: Reclamation proposes to construct an additional 50 acres of rearing habitat adjacent to the Stanislaus River by 2030.
- Temperature Management Study: Reclamation will study approaches to improving temperature for listed species on the lower Stanislaus River, to include evaluating the utility of conducting temperature measurements/profiles in New Melones Reservoir.
- Yellow-billed Cuckoo Surveys: Reclamation will coordinate with the USFWS to develop a baseline survey for the Yellow-billed cuckoo. The survey for this action would focus on the critical habitat areas, associated project sites, and occupied habitat within the action area. In addition, the baseline survey would incorporate the efforts from the Yolo Restoration Project and other related projects when conducting protocol-level surveys for Yellow-billed Cuckoo in the over-lapping project areas. Results from Yellow-billed Cuckoo surveys conducted by other

agencies and organizations within the Action Area will be analyzed by Reclamation when determining baseline conditions for the species and effects resulting from project activities. By reducing redundant survey efforts, Reclamation would be able to leverage their resources to cover areas not recently surveyed and develop a more comprehensive baseline survey. Reclamation would coordinate and discuss with USFWS on the potential need for additional surveys for specific project areas and surveys to monitor the effects of project activities over the project timeline. Information collected in the baseline surveys could be used to inform ecological surrogate models in the future, potentially replacing the need for follow-up presence/absence surveys. In addition, Reclamation will follow the nesting bird protocols during construction activities and consider the needs of Yellow-billed cuckoo when designing and implementing salmonid habitat restoration projects. Results of Yellow-billed cuckoo surveys and findings from ecological surrogate models shall be shared with the U.S. Fish and Wildlife Service Bay-Delta Fish and Wildlife Office no later than 120 days after completion.

4.10.7 San Joaquin River (Friant Division)

Reclamation operates the Friant Division for flood control, irrigation, M&I, and fish and wildlife purposes. Facilities include Friant Dam, Millerton Reservoir, and the Friant-Kern and Madera Canals. Friant Dam provides flood control on the San Joaquin River, provides downstream releases to meet senior water rights requirements above Gravelly Ford, provides Restoration Flow releases under Title X of Public Law 111-11, and provides conservation storage as well as diversion into Madera and Friant-Kern Canals for water supply. Water is delivered to about a million acres of agricultural land in Fresno, Kern, Madera, and Tulare Counties in the San Joaquin Valley via the Friant-Kern Canal south into Tulare Lake Basin and via the Madera Canal northerly to Madera and Chowchilla Irrigation Districts. A minimum of 5 cfs is required to pass the last holding contract diversion located about 40 miles downstream of Friant Dam near Gravelly Ford.

The SJRRP implements the San Joaquin River Restoration Settlement Act in Title X of Public Law 111-11. USFWS and NMFS issued programmatic biological opinions in 2012 that included project-level consultation for SJRRP flow releases. Programmatic ESA coverage is provided for flow releases up to a certain level, recapture of those flows in the Lower San Joaquin River and the Delta, and all physical restoration and water management actions listed in the Settlement.

The Stipulation of Settlement of NRDC vs. Rogers, is based on two goals—the Restoration Goal and the Water Management Goal. To achieve the Restoration Goal, the Settlement calls for, among other things, releases of water from Friant Dam to the confluence of the Merced River (referred to as Restoration Flows) according to the hydrographs in Settlement Exhibit B. To achieve the Water Management Goal, the Settlement calls for the development and implementation of a plan for recirculation, recapture, reuse, exchange or transfer of Restoration Flows for reducing or avoiding impacts on water deliveries to all the Friant Contractors caused by Restoration Flows. Recapture of Restoration Flows may occur upstream of a capacity restricted reach, or downstream of the Merced River confluence. Recapture can occur at Banta-Carbona, Patterson, or West Stanislaus Irrigation District facilities, or at Jones or Banks Pumping Plants. Recapture of Restoration Flows in the Sacramento San Joaquin Delta under this proposed action would average 65 TAF, ranging from approximately 25 TAF to 78 TAF depending on the year type.

4.10.7.1 *Conservation Measures*

Lower SJR Rearing Habitat: Reclamation may work with private landowners to create a bottom-up, locally driven regional partnership to define and implement a large-scale floodplain habitat restoration effort in the Lower San Joaquin River. This stretch of the San Joaquin River is cut-off from its floodplain due to an extensive levee system, with two notable exceptions at Dos Rios Ranch (1,600 acres) and the San Joaquin River National Wildlife Refuge (2,200 acres). In recent years, there has been growing interest in multi-benefit floodplain habitat restoration projects in the Central Valley that can provide increased flood protection for urban and agricultural lands, improved riparian corridors for terrestrial plants and wildlife, and enhanced floodplain habitat for fish. The resulting restoration could include thousands of acres of interconnected (or closely spaced) floodplain areas with coordinated and/or collaborative funding and management. Such a large-scale effort along this corridor would require significant support from a variety of stakeholders, which could be facilitated through a regional partnership.

Yellow-billed Cuckoo Surveys: Reclamation will coordinate with the USFWS to develop a baseline survey for the Yellow-billed cuckoo. The survey for this action would focus on the critical habitat areas, associated project sites, and occupied habitat within the action area. In addition, the baseline survey would incorporate the efforts from the Yolo Restoration Project and other related projects when conducting protocol-level surveys for Yellow-billed Cuckoo in the over-lapping project areas. Results from Yellow-billed Cuckoo surveys conducted by other agencies and organizations within the Action Area will be analyzed by Reclamation when determining baseline conditions for the species and effects resulting from project activities. By reducing redundant survey efforts, Reclamation would be able to leverage their resources to cover areas not recently surveyed and develop a more comprehensive baseline survey. Reclamation would coordinate and discuss with USFWS on the potential need for additional surveys for specific project areas and surveys to monitor the effects of project activities over the project timeline. Information collected in the baseline surveys could be used to inform ecological surrogate models in the future, potentially replacing the need for follow-up presence/absence surveys. In addition, Reclamation will follow the nesting bird protocols during construction activities and consider the needs of Yellow-billed cuckoo when designing and implementing salmonid habitat restoration projects. Results of Yellow-billed cuckoo surveys and findings from ecological surrogate models shall be shared with the U.S. Fish and Wildlife Service Bay-Delta Fish and Wildlife Office no later than 120 days after completion.

4.10.8 South of Delta

San Luis Reservoir is an offstream storage facility located along the California Aqueduct downstream of Jones and Banks Pumping Plants. The CVP and SWP share San Luis Reservoir storage roughly 50/50 (CVP has 966 TAF of storage, SWP has 1062 TAF of storage). San Luis Reservoir is used by both Projects to meet deliveries to their contractors during periods when Delta pumping is insufficient to meet demands. San Luis Reservoir is also operated to supply water to the CVP San Felipe Division in San Benito and Santa Clara Counties.

San Luis Reservoir operates as a regulator on the CVP/SWP system, accepting any water pumped from Banks and Jones that exceeds contractor demands, then releasing that water back to the aqueduct system when the pumping at Jones and Banks is insufficient to meet demands. The reservoir allows the CVP/SWP to meet peak-season demands that are seldom balanced by Jones and Banks pumping.

As San Luis Reservoir is drawn down to meet contractor demands, it usually reaches its low point in late August or early September. From September through early October, demand for deliveries usually drops to be less than the Jones and Banks diversions from the Delta, and the difference in Jones and Banks pumping is then added to San Luis Reservoir, reversing its spring and summer decline and eventually filling the San Luis Reservoir - typically before April of the following year.

4.11 Items Not Included in This Consultation

This document includes context on the entirety of operations of the CVP and SWP. However, not all these actions are being consulted on, either because they were the subject of prior consultations or due to other legal authority. Reclamation and DWR are consulting on the exercise of discretion in operational decision making, including how to comply with the terms of their respective existing water supply and settlement contracts (which includes the impacts of maximum water diversions under the terms of these contracts), and other legal obligations. Reclamation and DWR are not consulting on:

- Flood control
- Folsom Water Control Manual
- Oroville Dam and Feather River operations
- Execution of new CVP water service or repayment contracts, or the prior execution of existing contracts that were the subject of separate but parallel prior consultations
- Execution of new settlement contracts and agreements, or the prior execution of existing contracts that were the subject of separate but parallel prior consultations
- Contract conversion
- Operations and maintenance activities of CVP minor facilities
- Exchange Contractor deliveries from Friant Dam
- SJRRP flows and lower SJR recapture
- TRRP flows
- Coordinated Operation Agreement
- D-1641
- Contra Costa Water District Operations
- Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project
- Suisun Marsh Habitat Management, Preservation, and Restoration Plan
- Suisun Marsh Preservation Agreement
- California WaterFix

4.12 Governance

Reclamation anticipates three implementation approaches for the proposed action. The first, Core Water Operation, involves Reclamation and DWR operating the projects within the bounds of the proposed action with regular performance monitoring and reporting. The second, Scheduling, includes water-shed based groups of the five agencies (i.e., Reclamation, DWR, USFWS, NMFS, CDFW) and water users providing input to Reclamation and DWR on scheduling and routing specific blocks of water identified in the proposed action (i.e., pulse flows). The third, Collaborative Planning, involves program teams of the five agencies and water users working together to define, study, and implement specific components of the proposed action.

4.12.1 Core Water Operation

The Core Water Operation serves as the foundation for meeting regulatory requirements and providing for Reclamation and DWR to operate the CVP and SWP, while reducing the stressors on listed species influenced by those ongoing operations. through real-time monitoring. The Core Water Operation consists of operational actions that do not require subsequent concurrence to define annual operation. For the Core Water Operation, Reclamation would implement activities, monitor performance, and report on compliance with the commitments in the proposed action. The Real - Time Water Operations Charter, (Charter) described in Appendix C describes how Reclamation and DWR will monitor and report on ESA Section 7 commitments under the proposed action and how the five agencies, public water agencies, tribes, and other participants will communicate, and coordinate real-time water operations decisions. The Charter also describes the deliverables, schedule, and decision-making processes.

The Core Water Operation also provides for regulatory coordination in the event conditions exceed the ability to anticipate how Reclamation and DWR would operate (e.g., Tier 4 Shasta Cold Water Pool management). Reclamation and DWR must demonstrate compliance with the commitments in the proposed action and provide sufficient information for an evaluation of reinitiation triggers through regular monitoring and reporting.

As part of Core Water Operation, fishery agencies would provide information to Reclamation and DWR on the real-time disposition of species through specific monitoring workgroups. This information would inform the risk analysis performed by Reclamation and DWR.

4.12.2 Scheduling

For components of the proposed action identified as part of the Scheduling implementation approach, fishery agencies and water users in watershed-based groups would provide scheduling recommendations to Reclamation and DWR on duration, timing, and magnitude of specific blocks of water. Reclamation and DWR will evaluate and consider the recommendations and operate the CVP and SWP to those schedules as feasible.

4.12.3 Collaborative Planning

As part of the Proposed Action, Reclamation will pursue and implement certain actions through collaborative planning with the goal of continuing to identify and undertake actions that benefit listed species. Collaborative planning will make use of the Collaborative Science and Adaptive Management Program, Central Valley Project Improvement Act, Interagency Ecological Program, and Delta Plan Interagency Implementation Committee, successors to the forums, or complementary forums, e.g. Voluntary Agreement forums. Each of these programs has established governance, work planning, implementation, reporting, and independent review.

Where necessary, Reclamation and DWR will form project teams comprised of fishery agency and water users that assist Reclamation and DWR on the implementation of specific actions. The CVPIA develops priorities across CVPIA fish-related provisions and watersheds in the Central Valley. The process uses an Adaptive Resource Management (ARM) approach with support from Decision-Support Models (DSMs) to prioritize implementation of management actions that have the highest probability of achieving biological objectives for naturally produced populations of native anadromous fish. The ARM approach also guides plans for monitoring and research by synthesizing existing monitoring data, annually updating DSMs using new information, and estimating the value of new information to the decision-making process. CSAMP and DPIIC have similar tools in various stages of development.

The Sacramento River Settlement Contractors approved *A Resolution Regarding Salmon Recovery Projects in the Sacramento River Watershed, Actions Related to Shasta Reservoir Annual Operations, and Engagement in the Ongoing Collaborative Sacramento River Science Partnership Effort*. Pursuant to the resolution, the SRS Contractors will continue their active engagement and leadership in the ongoing collaborative Sacramento River Science Partnership effort.

Reclamation will use CSAMP to convene an annual Directors Level Collaborative Planning meeting with NMFS, DWR, CDFW and USFWS to review collaborative planning actions (including restoration, monitoring, and research actions), discuss the resources each agency can contribute, and discuss strategies for collectively influencing and supporting the likelihood that priority restoration, monitoring, and research actions and their beneficial effects will be implemented.

Reclamation and DWR have a strong record of accomplishment in benefiting species through habitat restoration, facility improvements, monitoring, and science, as documented in work plans and accomplishment reports. Specific examples of recent projects in partnership with stakeholders, but not an exhaustive list, include:

- Shasta Division (Sacramento River)
    - Market Street gravel addition in 2019
    - Reading Island side channel restoration in 2018
    - Lake California side channel restoration in 2018
    - Additional gravel at the Keswick Dam launch site in 2018
- Clear Creek planning and 2019 award of funds for the completion of the Phase 3C
- American River
    - Nimbus side channel restoration in 2014;
    - Sacramento Bar restoration in 2016.
- Stanislaus River
    - Goodwin Canyon gravel addition in 2016;
    - Landcaster Road side channel in 2017.
- Delta and Suisun Marsh
    - McCormack Williamson Tract tidal and floodplain habitat in 2018
    - Yolo Flyway Farms tidal restoration in 2018
    - Decker Island tidal restoration in 2018
    - Tule Red tidal restoration in scheduled for fall of 2019
    - Winter Island tidal restoration scheduled for fall of 2019
    - Dutch Slough tidal and floodplain restoration construction ongoing since 2018
    - Freemont Weir adult fish passage in 2019
    - Knight’s Landing Outflow Gates in 2016

  - Wallace Weir barrier and rescue facility in 2019
  - Suisun Marsh Gate Reoperation Pilot in 2018
  - Roaring River Drain Gate Installation in 2018
- Fish Passage and Screening
  - Deer Creek Irrigation District Dam in 2017;
  - Mill Creek Fish Passage Assessment and Restoration Project in 2016;
  - Lower Deer Creek Falls Fish Passage Improvement Project in 2018;
  - RD2035 Woodland Davis intake in 2016;
  - Small screen program through the Family Farm Alliance for Locke Ranch on the Mokelumne, Hidden Valley Range on the San Joaquin, Clover Creek/Millville on Clover Creek, and Oswald WD on the Feather River in 2017;
- Science and Monitoring
  - Directed Outflow Project in 2017, 18, and 19
  - Enhanced Delta Smelt Monitoring Program
  - Six-Year Steelhead Telemetry Study
  - Salmon and Sturgeon Assessment of Indicators by Lifestage
  - Salvage Monitoring Studies

The action agencies' collaborative planning programs are robust and account for the technical, social, and economic complexities of implementing large-scale habitat restoration programs. Reclamation has the authority to undertake these actions, subject to appropriations, under Reclamation Law including authorizations for the Central Valley Project, Fish and Wildlife Coordination Act, Central Valley Project Improvement Act (1992), Calfed Bay-Delta Authorization Act (2004), and Water Infrastructure Improvements for the Nation (WIIN) Act (2016). Reclamation's historical annual appropriations bills include funding of spawning and rearing habitat, fish screens, fish salvage, hatcheries, and specific restoration programs. Sources include the Bay-Delta Fund, Central Valley Project Restoration Fund, and Water and Related Resources Fund. Future obligations and expenditures are subject to appropriation by Congress.

To fund these actions, DWR has the statutory authority to require the reimbursement in the SWP contracts for water and power for any costs DWR incurs for SWP-relate fish and wildlife preservation (Water Code Sections 11912, 12937 and 12938).

Reclamation and DWR also commit to continue to support collaborative efforts that are underway in other forums that will benefit species. Reclamation and/or DWR agree to track, and where appropriate and within the agencies' authority, champion, sponsor, and/or implement projects consistent with applicable laws, similar to the processes described for the projects identified above.

4.12.4 Compliance and Performance Reporting

Reclamation and DWR will annually report on water operations and fish performance seasonally and in an annual summary. The monitoring programs and schedule for reporting are described in

Appendix C. Changes to the proposed action would occur based on the reinitiation triggers provided by 50 CFR 402.16. These triggers include:

a) If the amount or extent of taking specified in the incidental take statement is exceeded;

b) If new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered;

c) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion; or

d) If a new species is listed or critical habitat designated that may be affected by the identified action.

Reclamation will monitor take for evaluating trigger (a) above; Reclamation will monitor the effects of the proposed action for the purpose of evaluating trigger (b) above. If Reclamation decides to modify the proposed action, Reclamation will evaluate the changes to the proposed action based on trigger (c) above. Consistent with 50 CFR 402.16, the USFWS and/or NMFS may also reinitiate formal consultation as appropriate. Reclamation will coordinate with DWR as an “applicant” and support DWR’s coordination with CDFW.

4.12.5 Drought and Dry Year Actions

Within 18 months of executing the Record of Decision, Reclamation shall coordinate with DWR to develop a voluntary toolkit to be exercised at the discretion of Reclamation, DWR, other agencies, participating water users, and/or others for the operation of Shasta Reservoir during critical hydrologic year types. The toolkit shall include, at a minimum: measures at the Livingston-Stone National Fish Hatchery; the potential for translocation of fish; and facility improvements to reduce the adverse effects of critical and dry years on listed species. Drought and dry year planning will include the measures under Shasta Cold Water Pool Management Dry Years, Drought Years, and Successive Dry Years.

In Tier 3 and Tier 4 years, Reclamation shall meet and confer with USFWS, NMFS, DWR, CDFW, and Sacramento River Settlement Contractors on voluntary measures to be considered if drought conditions continue into the following year, including measures that may be beyond Reclamation and DWR’s discretion. If dry conditions continue, Reclamation will regularly meet with this group (and potentially other agencies and organizations) to evaluate current hydrologic conditions and the potential for continued dry conditions that may necessitate the need for development of a drought contingency plan (that may include actions from the toolkit) for the water year.

The Sacramento River Settlement Contractors approved A Resolution Regarding Salmon Recovery Projects in the Sacramento River Watershed, Actions Related to Shasta Reservoir Annual Operations, and Engagement in the Ongoing Collaborative Sacramento River Science Partnership Effort. Pursuant to the resolution, during drier water years with operational conditions as described in the Tier 3 and Tier 4 scenarios, the SRS Contractors will meet and confer with Reclamation, NMFS, and other agencies as appropriate to determine if there is any role for the SRS Contractors in connection with Reclamation’s operational decision-making for Shasta Reservoir annual operations in those years. This determination will include consideration of what actions are feasible, consistent with the terms of the SRS Contracts. In addition to the 25% reduction during Shasta Critical Years as set forth in the SRS Contracts, the types of actions that may be considered include, but are not necessarily limited to: (1) the scheduling of spring diversions by the SRS Contractors; (2) voluntary, compensated water transfers by the SRS Contractors subject to Reclamation approval; and (3) delayed SRS Contractor diversion for rice straw decomposition during the fall months. Any mutually agreeable proposed actions resulting from these meet and confer discussions must be consistent with the terms of the SRS Contracts and may also be subject to other regulatory approvals.

By February of each year following a critical hydrologic year type, Reclamation shall report on the measures employed and assess the effectiveness. The toolkit shall be revisited at a frequency of not more than 5 years after the ROD.

4.12.6 Chartering of Independent Panels

Reclamation and DWR agree to charter independent panels to review actions as described in certain components of the Proposed Action. Independent panels shall review actions consistent with the standards of the Delta Stewardship Council and applicable Reclamation and DWR guidance. Experts on the panel shall provide information and recommendations but shall not make consensus recommendations to Reclamation. NMFS and USFWS may provide technical assistance and input in the development of the charter. Reclamation and DWR shall provide the results of the independent review to NMFS and USFWS. Reclamation shall coordinate with DWR to document a response to the independent review including whether implementation of alternative strategies would require reinitiation consistent with the reinitiation triggers provided by 50 CFR 402.16. Nothing the chartering of and responding to independent panels precludes NMFS nor USFWS from exercising its statutory responsibilities under the ESA.

4.12.7 Four Year Reviews

In January of 2024 and January of 2028, Reclamation and DWR would charter an independent panel to review the following actions:

- Upper Sacramento Performance Metrics
- OMR management and measures to improve juvenile salmonid survival through the South delta
- OMR management measures and life cycle models used to manage Delta Smelt larval/juvenile entrainment.
- Delta Smelt Summer and Fall Habitat Actions
- Steelhead Research and Monitoring Actions

Reclamation and DWR may incorporate additional information into the reviews in coordination with local, state, and federal partners.

Chapter 5 Effects

The potential effects of the proposed action on listed species are evaluated in this section. Under Section 7 of the ESA, Reclamation must ensure that the proposed action will not "jeopardize the continued existence of any endangered or threatened species, by reducing appreciably the likelihood of survival or recovery of a listed species in the wild or adversely modifying listed habitat appreciably diminishes the value of critical habitat for both the survival and recovery of a listed species." The analyses in this section thus consider the potential effects the proposed action is likely to cause to listed species, including effects at all life stages, anticipated response, and cumulative effects.

Reclamation established a without action scenario as part of the environmental baseline to isolate and define potential effects of the proposed action apart from effects of non-proposed action causes. The model run representing this scenario does not include CVP and SWP operations, but does include the operations of non-CVP and non-SWP facilities, such as operation of public and private reservoirs on the Yuba, Tuolumne, and Merced rivers. The without action scenario plays the crucial role in the effects analysis of establishing the likelihood of species survival and recovery under the environmental baseline (i.e., the effects on survival and recovery from all non-proposed action causes).

The additional effects of habitat restoration, predation from invasives, water quality, and other effects on species from federal, state, and private actions are also analyzed. These effects are part of the baseline. However, in a consultation on an ongoing action, such as operation of the CVP and SWP, the baseline analysis must project a future condition without the action in order to isolate the effects of the action from the without action scenario and, in turn, a determination of whether the action is likely to jeopardize listed species and/or destroy or adversely modify critical habitat.

Included for context in the effects analysis is a current operations scenario that represents current operations of the CVP and SWP (including the 2008 and 2009 biological opinion requirements), along with federal, state, and private operations on other rivers (e.g., Yuba, Tuolumne, and Merced Rivers). The current operations scenario is included for context in the effects analysis. When appropriate, the analysis considers differences between the effects of current operations and the proposed action, because the effects of current operations provide a reasonable measure of likely future effects of similar measures in the proposed action.

The Secretary has a wide degree of discretion in determining the analytic framework and tools used to develop the biological assessment. The ESA does not impose a mandatory duty to use any specific model or scientific methodology, but merely requires that Reclamation provide to the Services "the best scientific and commercial data available or which can be obtained during the consultation for an adequate review of the effects that an action may have upon listed species or critical habitat." 50 C.F.R. § 402.14(d). In previous analyses, Reclamation has utilized a variety of technical models and other tools in preparing its biological assessment. Those efforts were not required by the ESA, which does not set a standard of absolute scientific certainty, and nor does it demand that an agency obtain new information to make its determination. Rather, the "best available data" standard only requires the agency to consider scientific information presently available. Reclamation determined that the modeling and other analytical efforts used in this biological assessment provide ample basis for the Services to conduct an adequate review of the effects of the action on the species.

5.1 Analytical Approach – Aquatic Species

The effects analysis herein is organized into potential effects from the proposed action on listed species, listed species' designated critical habitat, and Essential Fish Habitat (EFH). For the purposes of analysis of Pacific Coast Salmon EFH and effects to Southern Resident Killer Whale, also included are analyses of potential effects of the proposed action on unlisted Central Valley Fall-run/Late Fall-run Chinook Salmon ESU, Upper Klamath-Trinity Rivers Fall-run Chinook Salmon ESU, and Upper Klamath-Trinity Rivers Spring-run Chinook Salmon ESU.

For each species, the effects analysis is broken into three sections: 1) operations and maintenance, 2) conservation measures, and 3) critical habitat. In the proposed action, operations and maintenance is the Core Water Operation and includes all aspects of operating and maintaining the CVP and SWP, as described in seasonal operation to meet flood control, navigation, water supply (water right obligations, contracts, and agreements), fish and wildlife, power generation, and recreational purposes. Operation and maintenance includes the Shasta Temperature Control Device, spring pulse flows, fall and winter refill, Delta Cross Channel operations, the Tracy Fish Collection Facility and Skinner Fish Facility, and OMR management. Components of operations and maintenance also include, for example, agricultural barriers, Rock Slough intake, water transfers, and aquatic weed removal. Enhanced real-time monitoring and predictive tools also are part of operation and maintenance of the proposed action. Operations and maintenance also includes operation of a raised Shasta Dam in accordance with the criteria in the proposed action.

Conservation measures are additional actions included to address the effects of the operations and maintenance on listed species. Conservation measures include spawning and rearing habitat, cold water pool management tools, Summer-Fall Delta Smelt Habitat, Suisun Marsh Salinity Control Gate operations, Small Screen Program, predator hot spot removal, Delta Fishes Conservation Hatchery, Delta Cross Channel, Tracy Fish Facility, Skinner Fish Facility, and Shasta TCD improvements.

In the figures, WOA is the without action scenario, PA is the proposed action scenario, and COS is the current operations scenario, as modeled in CalSim. The buffers around WOA and the PA represent uncertainty.

5.2 Analytical Approach – Species Analyses

The effects analyses evaluate potential effects to life stages (for example, egg, alevin, fry, juvenile, adult) of each species based on species-specific conceptual models. The effects section is arranged by species beginning with a brief summary of the relevant conceptual model, followed by consideration of the potential effects of the proposed action.

The sub-section for each proposed action component considers the exposure of each life stage to the component, largely based on species timing summaries included in the introduction to each species section and other sources cited in the text. Consideration of exposure focuses on the extent to which a component overlaps in time and location with the life stage. Potential effects of exposure to the proposed action component on individuals of the species are then analyzed. This analysis is generally qualitative, although the potential effects of flow-dependent actions are informed to the extent possible by modeling of the various operational scenarios, and is related to the conceptual model for the life stage transition being analyzed.

5.3 Analytical Approach – Critical Habitat Analyses

The analyses of potential effects on species' designated critical habitat follow the species analyses. Potential positive and negative effects to primary constituent elements (PCEs)/physical and biological features (PBFs) of critical habitat are analyzed for the relevant components of the proposed action. These analyses often draw on the foundation provided in the species analyses. Analysis of effects to critical habitat is guided by consideration of recent analyses by USFWS (2017a) and NMFS (2017), which included refined interpretation of critical habitat PCEs/PBFs relative to the original descriptions at the time critical habitat was designated.

5.4 Analytical Approach – Essential Fish Habitat Analyses

The analysis of EFH focuses on three species groups represented by fishery management plans (NMFS 2017): Pacific Coast Salmon, Coastal Pelagic Species, and Pacific Coast Groundfish. For Pacific Coast Salmon, the analysis is informed by the species and critical habitat analyses for listed salmon, and is augmented by analysis of potential effects to unlisted Central Valley Fall-run/Late Fall-run Chinook Salmon ESU, Upper Klamath-Trinity Rivers Fall-run Chinook Salmon ESU, and Upper Klamath-Trinity Rivers Spring-run Chinook Salmon ESU. The analysis of potential effects to Coastal Pelagic Species focuses on Northern Anchovy as it is the main representative of that group that could be affected by the proposed action. Similarly, the analysis of potential effects to Pacific Coast Groundfish focuses on Starry Flounder. Potential effects of the proposed action to designated Habitat Areas of Particular Concern (HAPC) are also considered, namely complex channels and floodplain habitats, thermal refugia, spawning habitat, estuaries, and marine and estuarine submerged aquatic vegetation (NMFS 2017, p.1210).

5.5 Without Action Scenario

Under WOA conditions Sacramento River water would flow through Shasta and Keswick reservoirs with gates and river valves open, resulting in minimal storage and no control of flow release volumes or water temperatures. Water would not be transferred from the Trinity River. Sacramento River flows under the WOA scenario would generally be lower in summer and fall and higher in the winter and spring than current conditions. Similar conditions would occur on the Feather, American, Stanislaus, and San Joaquin Rivers. Higher, flashier, Delta outflows would occur in the winter and spring with lower Delta outflows in the summer and fall than current conditions. Jones and Banks Pumping Plants in the Delta would not operate. Flows would rapidly pass through channelized pathways.

Higher WOA flows in winter and spring could have both positive and negative effects on salmonids. Benefits of higher flows include lower water temperatures, increased dissolved oxygen (DO), increased habitat complexity, more rearing habitat, more refuge habitat, increased availability of prey, less predation risk, less entrainment risk, lower potential for pathogens and disease, lower concentrations of toxic contaminants, and emigration cues. Impacts from higher flows including higher stranding risk because of greater flow fluctuations, and higher contaminants loading from stormwater runoff.

Reduced flows under WOA conditions during dry fall months would have impacts on spawning adults, eggs, and alevin, and on rearing juvenile salmonids, resulting in increased temperature-dependent mortality of eggs, reduced juveniles growth rate and higher mortality of the juveniles, and a reduced population abundance.

Impacts of low flows include (Windell et al. 2017):

- Higher water temperatures and lower DO
- Reduced habitat complexity
- Less side-channel rearing habitat
- Less floodplain habitat and less connectivity of floodplains with the river mainstem
- Less refuge habitat
- Reduced availability and quality of prey organisms
- Greater crowding and competition
- Greater predation risk
- Greater entrainment risk
- Greater potential for pathogens and diseases
- Higher concentrations of toxic contaminants
- Reduced emigration cues

Under the WOA conditions, storage levels would be low and, assuming stratification developed, cold water pools would be small and unmanaged. However, unlike flows, which as noted above are expected to be similar under WOA conditions to those of an uncontrolled hydrology, water temperatures may differ from those of an uncontrolled hydrology because the shallow reservoir that would remain behind dams would absorb significant heat during warm, sunny days.

5.6 Chinook Salmon, Sacramento River Winter-run ESU

In the proposed action, the effects of the seasonal operation, as compared to WOA, include lower, more stable, flows in the fall and winter for emergence, rearing, and migration; lower flows in the spring; and higher flows in the summer. Higher flows in the summer lead to improved temperatures for Winter-run spawning, egg incubation, and emergence. Operation of the Shasta Temperature Control Device (TCD) provides for Winter-run Chinook Salmon egg incubation water temperature needs. The restoration of spawning and rearing habitat in the Upper Sacramento River, operation of weirs to inundate floodplain rearing habitat in the Yolo Bypass, tidal habitat restoration, and predator hot spot removal further increases growth and survival of Winter-run Chinook Salmon. Delta Cross Channel operations and OMR management, as part of the Core Water Operation under the proposed action, seeks to minimize and/or avoid entrainment risk. Improvements at the Tracy Fish Collection Facility and Skinner Fish Facility as part of the conservation measures associated with the proposed action reduce facility loss, a direct adverse effect of facility entrainment.

Construction of Shasta and Keswick Dams blocked access to areas of suitable temperatures for egg incubation. Temperature dependent mortality plays an important role in egg incubation and emergence. Operation of Shasta Dam for cold water pool management is required to avoid the 100 percent temperature dependent egg mortality that would occur under the WOA scenario; however, Reclamation’s ability to meet temperature needs is limited to the available cold water in any given year. In addition, reservoir releases can affect temperature only so far downstream in the Sacramento River before ambient air temperature controls. The proposed action provides for considering the primary location of Winter-run Chinook Salmon redds in most years (above the Clear Creek confluence), the critical stages within egg incubation for cold water, building cold water for the water temperature management season, and avoiding exhausting the supply of cold water before the end of the water temperature management season. The approach provides for operable parameters that incorporate the limitations on managing cold water in light of hydrologic uncertainty, balancing risks, and management experience during the most recent drought. The proposed action increases Winter-run Chinook Salmon egg to fry survival more reliably compared to the COS while minimizing restrictions on meeting project obligations to water supply, water quality, and other species.

Bank protection, dams, and lower peak flows prevents the natural replenishment and maintenance of suitable spawning habitat. Gravel augmentation and the restoration of spawning habitat under the proposed action addresses the lack of sediment continuity with dams in the degraded baseline. Flood protection reduced the historical off-channel rearing habitat of Winter-run Chinook Salmon to the limited channel areas between levees. Lower fall and winter flow reduces the inundation of potential rearing habitat for Winter-run Chinook Salmon; therefore, the proposed action restores rearing habitat in areas inundated by proposed action flows to reduce the effects from the Core Water Operation.

Real-time monitoring informs when Winter-run Chinook Salmon are likely to pass the Delta Cross Channel and provides for closures to prevent entrainment into the central and south Delta. OMR management for Winter-run Chinook Salmon establishes generally protective criteria to avoid entrainment. Additional protective measures occur based on salvage. Enhanced monitoring in real-time and predictive tools provide additional information that allows for a more flexible water operation under the proposed action when environmental criteria indicate that entrainment is less likely based on fish behavior and the effects of behavioral cues. Operation of the salvage facilities reduces the effects of entrainment due to export operations. Improvements at fish collection facilities will further reduce impacts of the proposed action as compared to WOA

Other stressors continue to impact Winter-run Chinook Salmon including harvest, contaminants, invasive species, disease, climate change. These factors will continue to reduce the ability of Winter-run Chinook Salmon to reproduce and rebuild populations in the river. Continued operation of the Livingston-Stone National Fish Hatchery provides a buffer against external risks and protects against extinction.

5.6.1 Life Stage Timing

General life stage timing and location information for Winter-run Chinook Salmon is provided in Table 5.6-1 to identify where the proposed action overlaps with the species. Additional detail regarding juvenile life stage timing at various monitoring locations is provided in Appendix F, *Juvenile Salmonid Monitoring, Sampling, and Salvage Timing Summary from SacPAS*.

Table 5.6-1. The Temporal Occurrence of Adult (a) and Juvenile (b) Winter-run Chinook Salmon in the Sacramento River and Delta (NMFS 2017, p.67).

Relative Abundance	High				Medium				Low			
a) Adults freshwater												
Location	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Sacramento River basin[a,b]	Medium	Medium	Medium	Medium	Medium	Medium	Medium				Medium	Medium
Upper Sacramento River spawning[c]					Low	High	High	Medium				
Delta	Medium	Medium	Medium	Medium	Low	Low	Low					Medium
b) Juvenile emigration												
Location	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Sacramento River at Red Bluff[d]	Low	Low	Low				Low	Medium	Medium	Medium	Medium	Medium
Sacramento River at Knights Landing[e]	High	Medium	Low							Low	Medium	High
Sacramento trawl at Sherwood Harbor[f]	Medium	High	High	Low							Medium	High
Midwater trawl at Chipps Island[g]	Medium	Medium	High	High	Low							Low

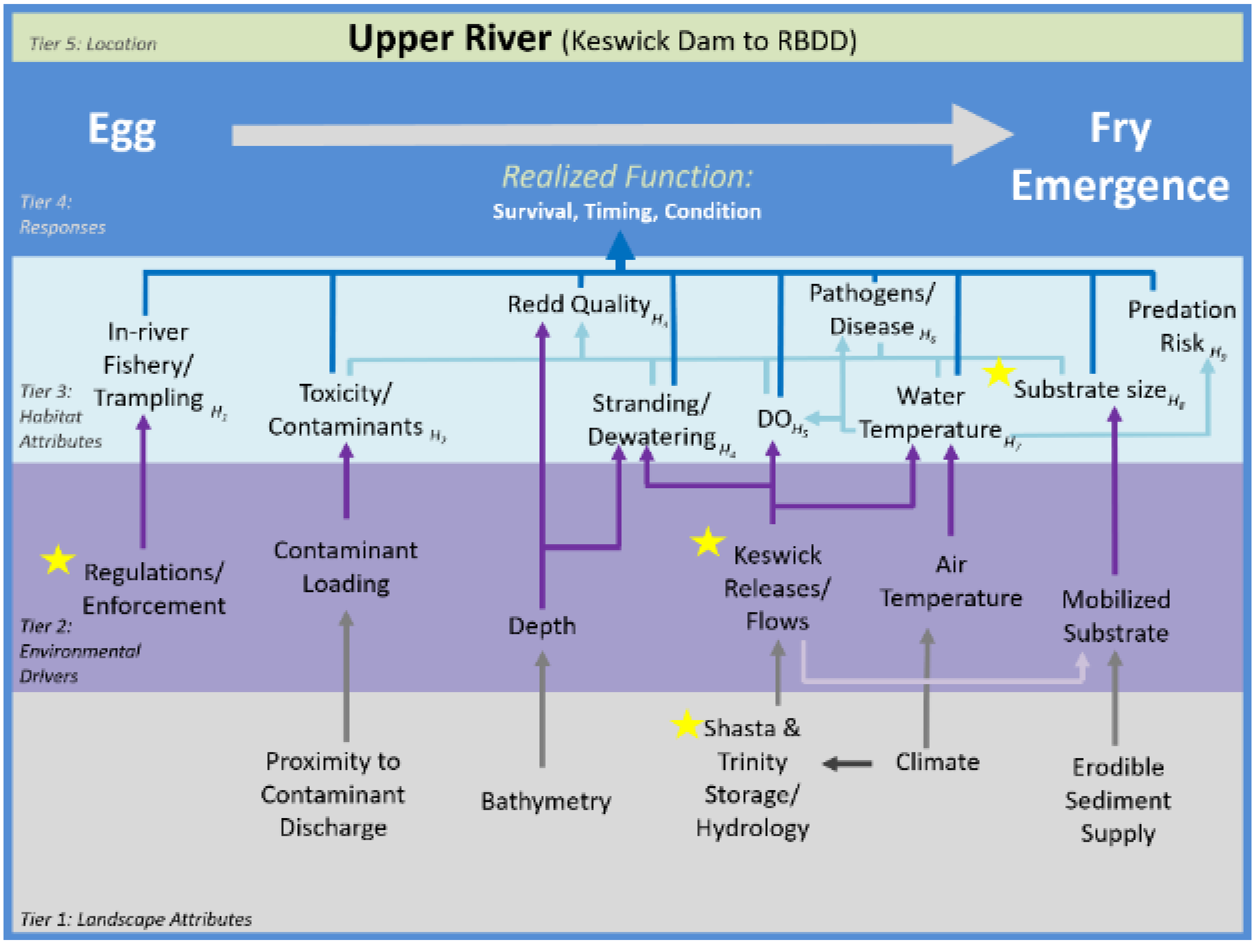
Sources: [a] (Yoshiyama et al. 1998); (Moyle 2002); [b](Myers et al. 1998) ; [c] (Williams 2006) ; [d] (Martin et al. 2001); [e] Knights Landing Rotary Screw Trap Data, CDFW (1999-2011); [f,g] Delta Juvenile Fish Monitoring Program, USFWS (1995-2012)

Note, it is likely that juvenile emigration in the Sacramento trawl at Sherwood Harbor is also high in January, as it is in December and February.

5.6.2 Conceptual Model Linkages

The Salmon and Sturgeon Assessment of Indicators by Life Stage (SAIL) conceptual models describe life stage transitions of Winter-run Chinook Salmon. SAIL life stage transitions include egg and alevin mortality, egg to fry emergence, juvenile rearing to outmigrating, adult migration, and adult holding.

In the upper Sacramento River (Keswick Dam to Red Bluff Diversion Dam), the SAIL conceptual model defines the egg incubation and alevin development stage as the duration of eggs in a redd to the emergence of fry (Windell et al. 2017). The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.6-1.

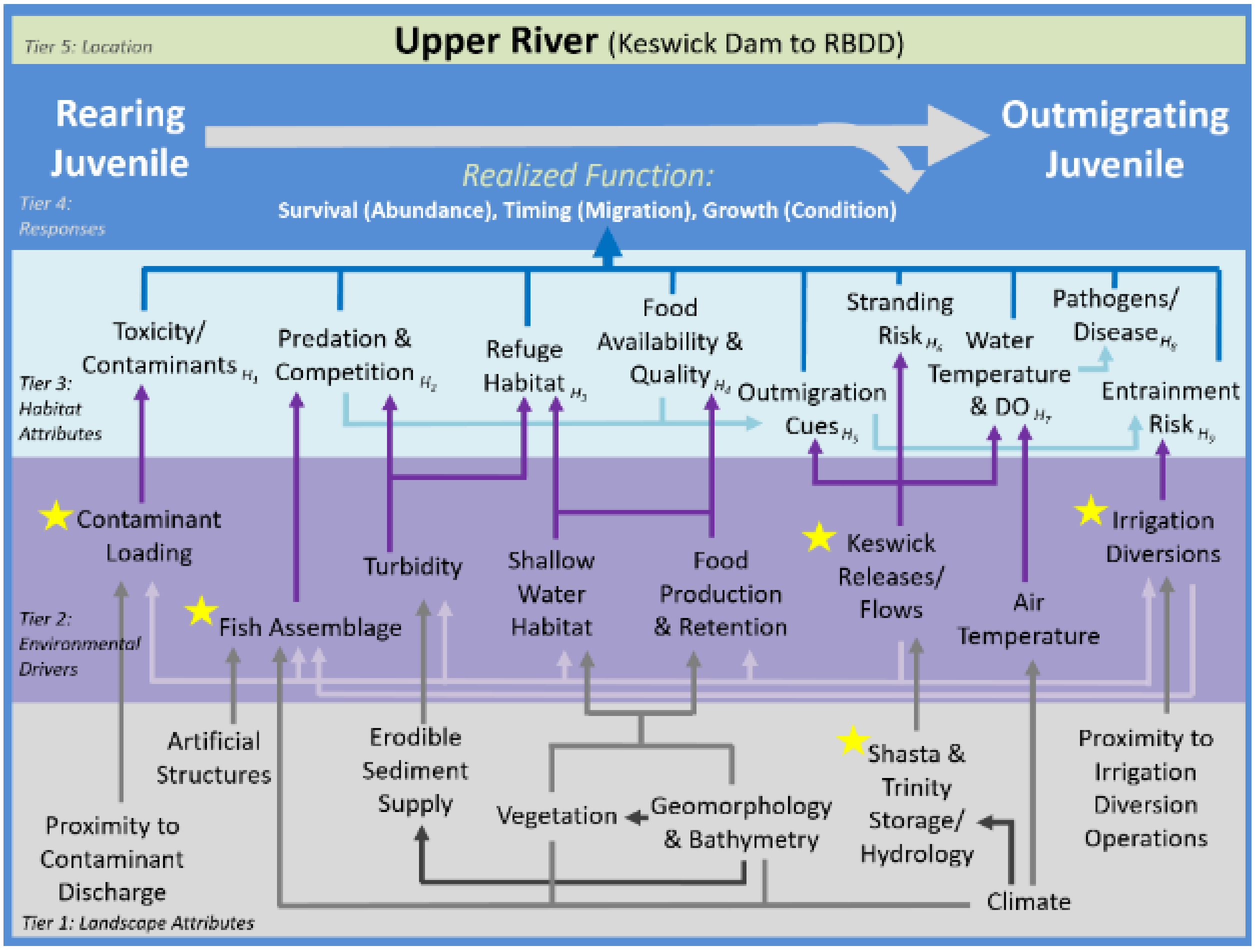


Source: Windell et al. (2017). Note: Hypotheses are referenced by the H-number for habitat attributes and potential management actions discussed by Windell et al. (2017) are denoted by stars.

Figure 5.6-1. Conceptual Model of Drivers Affecting the Transition of Winter-run Chinook Salmon from Egg to Emerging Fry in the Upper Sacramento River.

As compared to WOA, egg to fry attributes relevant to the proposed action include bathymetry and redd quality (modified by habitat restoration), and the effects of Keswick releases on redd dewatering, temperature and DO (cold water pool management). Effects in the baseline include trampling, contaminants, habitat degradation, disease, air temperatures, water temperatures, and predation.

In the upper Sacramento River (Keswick Dam to Red Bluff Diversion Dam), the SAIL conceptual model defines juvenile rearing and out migration as the duration from emergence as fry to down river migration (Windell et al. 2017). The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.6-2.

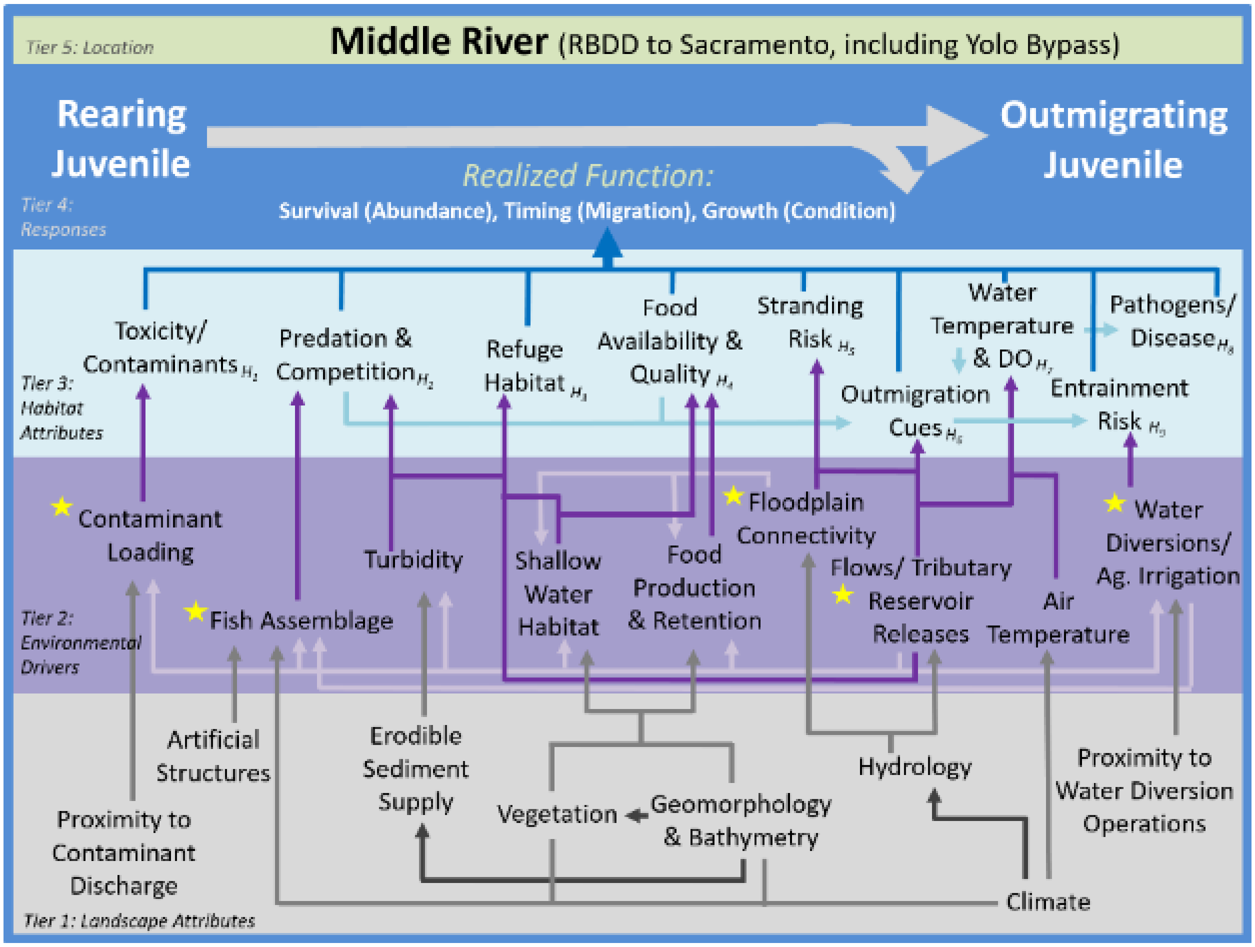


Source: Windell et al. (2017). Note: Hypotheses are referenced by the H-number for habitat attributes and potential management actions discussed by Windell et al. (2017) are denoted by stars.

Figure 5.6-2. Conceptual Model of Drivers Affecting the Transition of Winter-run Chinook Salmon from Rearing Juvenile to Outmigrating Juvenile in the Upper Sacramento River.

Upper Sacramento River rearing to outmigrating juvenile attributes relevant to the proposed action include dilution (e.g., toxicity and contaminants), water temperatures (which also affect DO, food availability, predation, pathogens, and disease), river stage and flow velocity (which affect habitat connectivity, bioenergetics, food availability, and predation), entrainment and stranding risk, and potentially affects cues that stimulate outmigration (Windell et al. 2017, Moyle 2002).

Juvenile rearing and migration in the middle Sacramento River from Red Bluff Diversion Dam to the I Street Bridge and the hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.6-3.

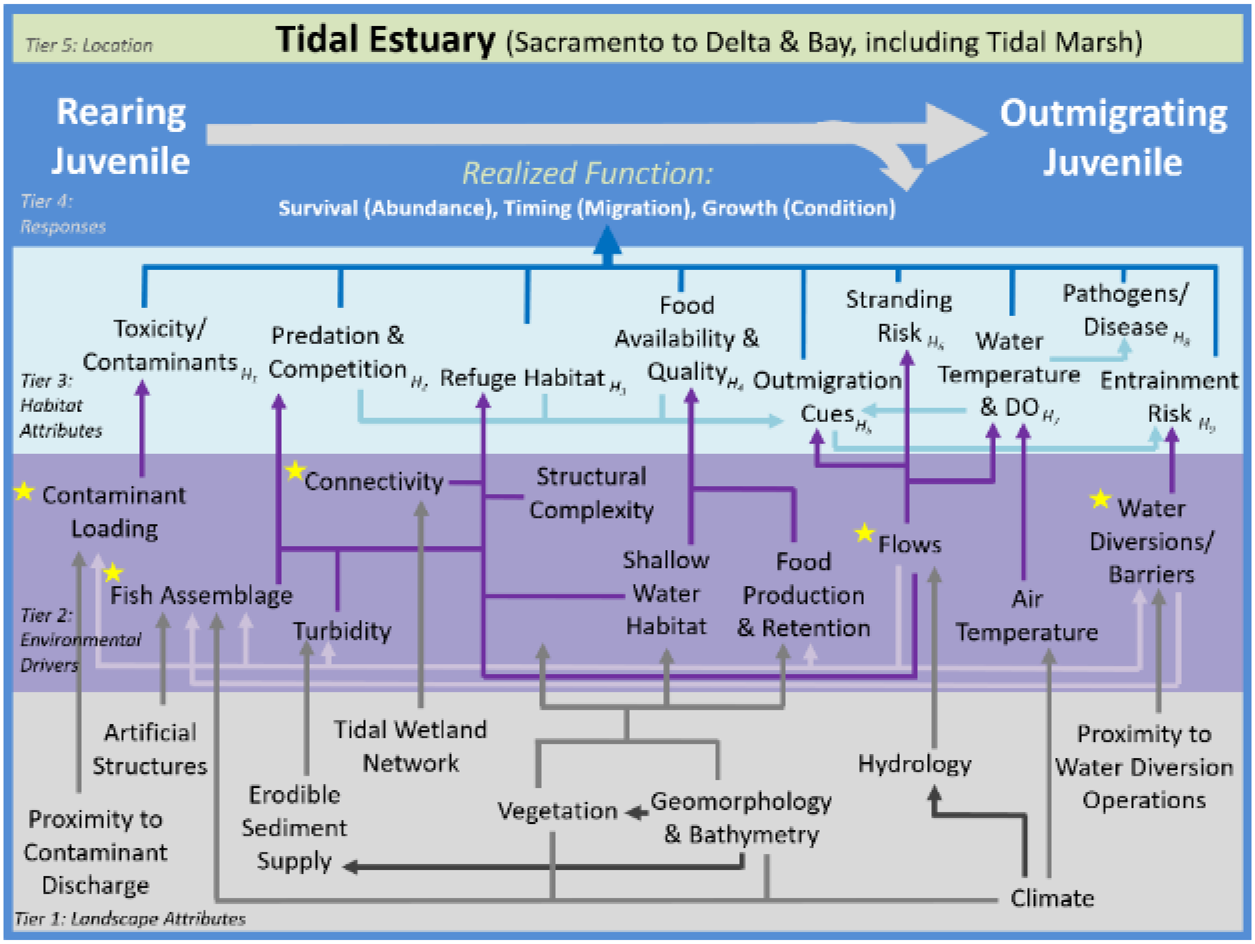


Source: Windell et al. (2017). Note: Hypotheses are referenced by the H-number for habitat attributes and potential management actions discussed by Windell et al. (2017) are denoted by stars.

Figure 5.6-3. Conceptual Model of Drivers Affecting the Transition of Winter-run Chinook Salmon from Rearing Juvenile to Outmigrating Juvenile in the Middle Sacramento River.

Middle Sacramento River rearing to outmigrating juvenile attributes relevant to the proposed action include: dilution (e.g., toxicity and contaminants), water temperatures (which also affect DO, food availability, predation, pathogens, and disease), river stage and flow velocity (which affect habitat connectivity, bioenergetics, food availability, and predation), entrainment and stranding risk, and potentially affects cues that stimulate outmigration (Windell et al. 2017, Moyle 2002).

Juvenile rearing and migration in the tidal estuary and bays life stage transition includes tidal Sacramento River downstream of the I Street Bridge in Sacramento City, the Sacramento-San Joaquin Delta, and the Suisun, San Pablo and San Francisco Bays. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.6-4.



Source: Windell et al. (2017). Note: Hypotheses are referenced by the H-number for habitat attributes and potential management actions discussed by Windell et al. (2017) are denoted by stars

Figure 5.6-4. Conceptual Model of Drivers Affecting the Transition of Winter-run Chinook Salmon from Rearing Juvenile to Outmigrating Juvenile in the Bay-Delta.

Tidal estuary and bay juvenile rearing and migration attributes relevant the proposed action include outmigration cues and entrainment risk.

The adult migration from the ocean to the upper Sacramento River life stage includes the entire Bay-Delta and Sacramento River system. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.6-5.

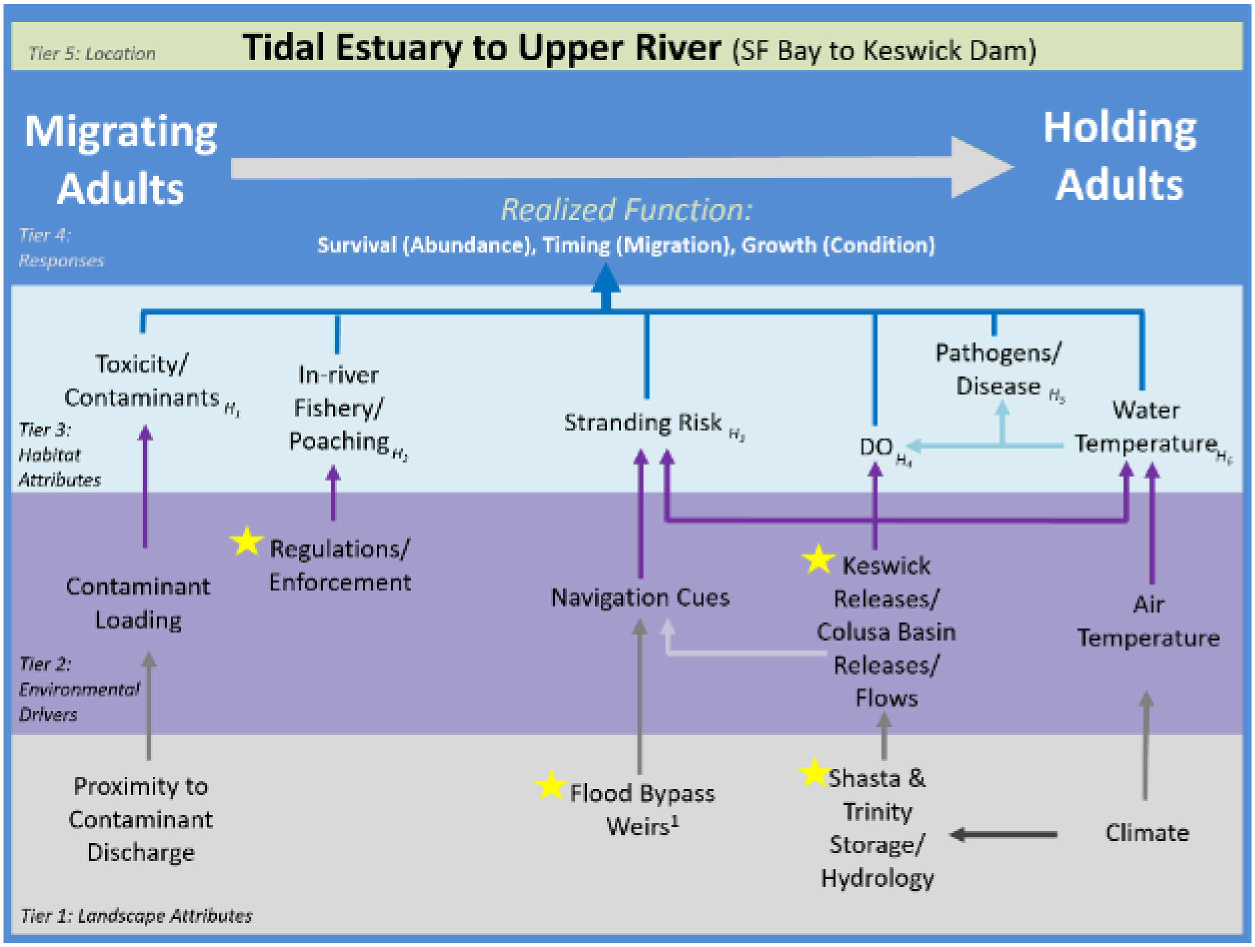


Figure 5.6-5. Conceptual Model of Drivers Affecting the Transition of Winter-run Chinook Salmon from Migrating Adults in the Bay-Delta to Holding Adults in the Upper Sacramento River.

Continuing their upstream migration from the Delta, Winter-run Chinook Salmon adults enter the middle Sacramento River and ultimately make their way to the upper River, beginning as early as December, where they hold within 10 to 15 miles of Keswick Dam until they are ready to spawn (Windell et al. 2017). Adult migration attributes relevant to the proposed action include, as indicated by the SAIL conceptual model (Figure 5.6-5), water temperature, DO, and other habitat attributes that influence the timing, condition, and survival of adult Winter-run Chinook Salmon during their upstream migration and holding in the middle and upper Sacramento River. Instream flow from Keswick Dam releases relative to flow from the lower Yolo and Sutter bypasses and agricultural drains may affect navigation cues and straying of Winter-run Chinook Salmon adults into canals and behind weirs, increasing their stranding risk (Figure 5.6-5).

The adult holding to spawning life stage in the upper Sacramento River includes Keswick Dam to the Red Bluff Diversion Dam. It also includes selecting sites for and building spawning redds. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.6-6.

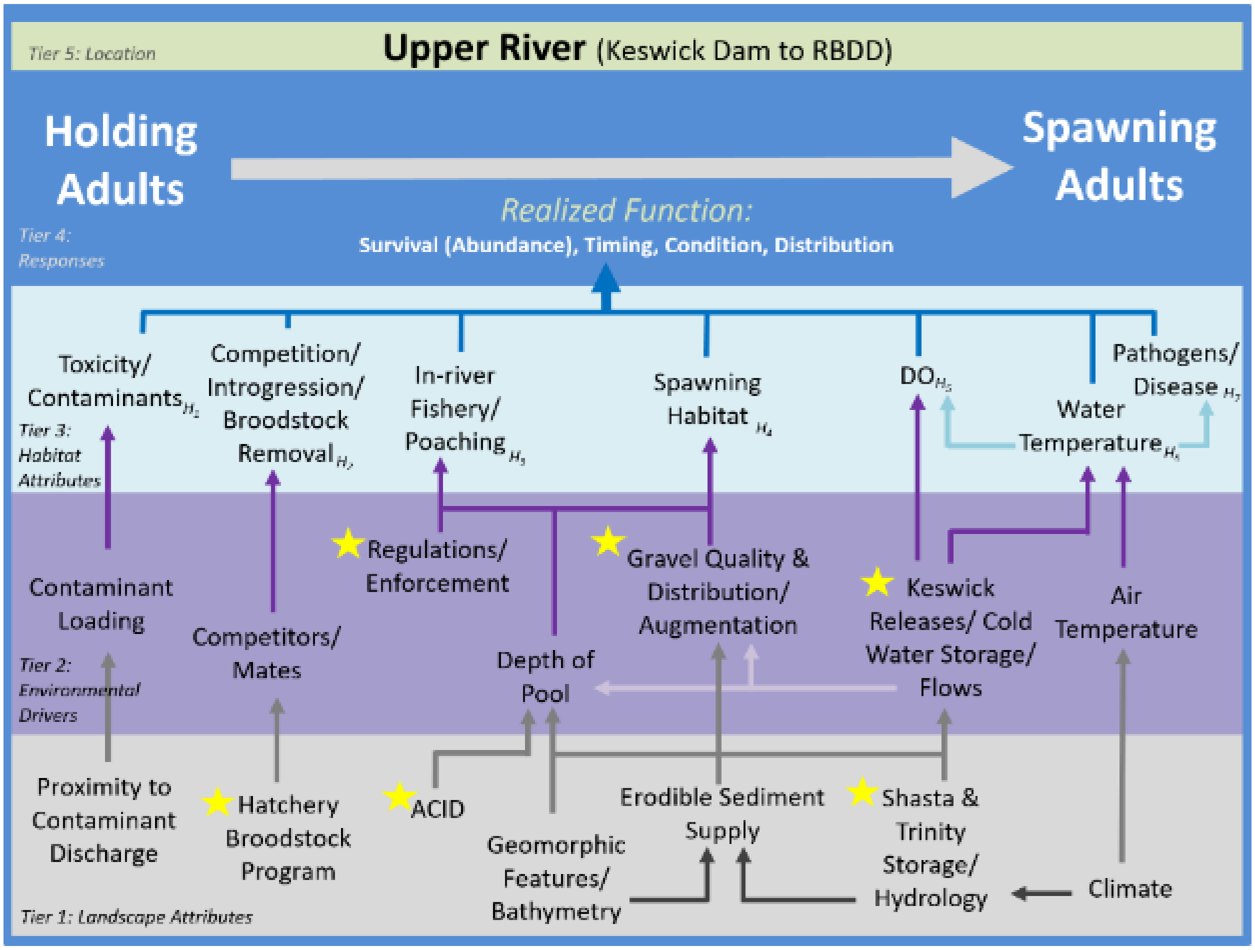


Figure 5.6-6. Conceptual Model of Drivers Affecting the Transition of Winter-run Chinook Salmon Adults from Holding to Spawning in the Upper Sacramento River.

Adult holding attributes relevant to the proposed action include primarily water temperature and DO.

The SAIL conceptual models describe the attributes affecting different life stage transitions. In the following subsections, attributes from the proposed action affecting Winter-run Chinook Salmon are discussed. These include releases from Keswick Dam and the resulting flows in the upper Sacramento River, combined with other environmental drivers, affect water temperature, DO, and other habitat attributes that influence the timing, condition and survival of eggs and alevins in the spawning redds.

5.6.3 Effects of Operations & Maintenance

Water temperatures in the upper Sacramento River during summer and fall are closely tied to flow because both are determined by operations and storage releases at Shasta and Keswick dams and transfers from the Trinity River. Under WOA conditions, there would be no Shasta and Keswick reservoir operations to control storage or releases, no transfer of water from the Trinity River Basin, and no control of flow or water temperature in the upper Sacramento River. Shasta storage levels would be reduced (Figure 5.6-7) and, assuming stratification developed, the cold water pool would be small and unmanaged. Further, the shallow reservoir that would remain behind Shasta Dam would absorb significant heat during warm, sunny days.

In the upper Sacramento River, where all Winter-run Chinook Salmon spawning occurs, modeling results showed WOA monthly mean water temperatures (HEC-5Q WOA scenario) during most of May through November spawning and incubation period would be high, ranging from ~46 degrees Fahrenheit in November, to 73 degrees Fahrenheit in July. During the peak spawning and incubation period, June through September, water temperatures would consistently exceed both the 56 degrees Fahrenheit and 53.5 degrees Fahrenheit water temperature thresholds (Figures 5-15 through 5-18 in the HEC5Q Temperatures section of Appendix D). Such conditions would make survival of incubating eggs and alevins impossible, eliminating the Winter-run Chinook Salmon population from the Sacramento River and reducing the extent of the ESU to a single population in Battle Creek.

Monthly mean water temperatures at Keswick would be high during the July through September period, ranging from ~63 degrees Fahrenheit during September to 72 degrees Fahrenheit during July and August, thereby exceeding the 61 degrees Fahrenheit water temperature thresholds in all years (Figures 5-16 through 5-18 in the HEC5Q Temperatures section of Appendix D). Water temperatures during these months would be even higher at other locations in the upper Sacramento River, ranging as high as 79 degrees Fahrenheit at Red Bluff Diversion Dam during July (Figure 10-16 in the HEC5Q Temperatures section of Appendix D). By October, the mean monthly water temperatures under the WOA scenario would be lower, remaining at or below the 61 degrees Fahrenheit in all years (Figure 5-7 in the HEC5Q Temperatures section of Appendix D). The water temperatures would remain below 61 degrees Fahrenheit from November through March (Figures 5-8, 5-10, 5-11, and 5-12 in the HEC5Q Temperatures section of Appendix D), by which time few Winter-run Chinook Salmon juveniles remain in the upper Sacramento River. The warm conditions in the upper Sacramento River during July through September would likely make survival of juvenile Winter-run Chinook Salmon impossible in the Sacramento River. Under the WOA, Winter-run Chinook Salmon could persist as a single population in Battle Creek (Phillis et al. 2018).

The low fall flows under WOA conditions would likely result in reduced conditions in juvenile Winter-run Chinook Salmon rearing habitats in the Sacramento River. During October and November, in years with dry hydrology, the flows would often fall below 3,250 cfs Keswick release for October through March as well as the target of 5,000 cfs at Wilkins Slough (note that the 3,250 cfs minimum flow is not required below the Red Bluff Diversion Dam (SWRCB 1990). As described by Windell et al. (2017), potential negative effects of the low flows include higher water temperatures and lower DO, reduced habitat complexity, less side-channel rearing habitat, less floodplain habitat and less connectivity of floodplains with the river mainstem, less refuge habitat, reduced availability and quality of prey organisms, greater crowding and competition, greater predation risk, greater entrainment risk, greater potential for pathogens and diseases, higher concentrations of toxic contaminants, and reduced emigration cues.

CalSim modeling indicates that from December through March, the first part of the period during which Winter-run Chinook Salmon adults migrate upstream through the middle Sacramento River to holding habitat in the upper River, there are low flows at Wilkins Slough and Keswick that would be low enough to create potential passage problems for immigrating adults. The most severe conditions would be at Wilkins Slough in May, when over 30 percent of years would have flows lower than the 5,000 cfs minimum flow requirement (NCWA 2014). These conditions would create poor passage conditions for adult Winter-run Chinook Salmon migrating upstream, possibly resulting in a reduction in spawning and recruitment of the new year-class.

Under WOA, upper Sacramento River flows modeled by CalSim for the December through August holding period are low in December, except in wet years, high during January through May, except in dry years, low in June, except in wet years, and low in almost every year during July and August (Figures 15-

9 through 15-17 in the CalSim II Flows section of Appendix D). In general, higher flows are likely to benefit holding adult Winter-run Chinook Salmon by affording better water quality (including cooler water temperatures and higher DO), reduced exposure to pathogens, and lower risk from anglers (Windell et al. 2017). The low flows in July and August would likely be stressful to holding adults and reduce suitable areas for redd construction.

From December through April, mean water temperatures under the WOA scenario are consistently below the 61 degrees Fahrenheit threshold for holding adults and mostly below this threshold in May (Figures 5-9 through 5-14 in the HEC5Q Temperatures section of Appendix D). During June through August, however, the water temperatures are almost entirely above the threshold (Figures 5-15 through 5-17 in the HEC5Q Temperatures section of Appendix D). The water temperatures reach as high as 72 degrees Fahrenheit in July and August.

The critical temperature threshold for spawning adults are the same as those discussed previously for incubating eggs and alevins (i.e., 56 degrees Fahrenheit and 53.5 degrees Fahrenheit). These thresholds would be exceeded under the WOA scenario in almost all years from May through August, but would be exceeded only occasionally during December through April (Figures 5-9 through 5-17 in the HEC5Q Temperatures section of Appendix D). Water temperatures under the WOA scenario would be poorly suited for holding or spawning Winter-run Chinook Salmon adults during the summer months.

The COS provides context and analytical support for the potential positive and negative effects of the proposed action. Reservoir operations work with a limited resource to balance the current needs of the fish populations, cold water storage for the following year, and sufficient space for flood control in the winter and spring. During the first part of the juvenile rearing period, July through September, operations are largely dictated by needs of incubating Winter-run Chinook Salmon eggs and larvae. After September, current operations target several requirements, including stable river flows to minimize dewatering of Winter-run Chinook Salmon redds and stranding of juveniles, suitable flow and temperature conditions for Spring-run and Fall-run Chinook Salmon spawning, incubation and rearing, and conserving storage for the next year's cold-water pool. The minimum flow requirement for the upper Sacramento River from October 1 until April 1 is 3,250 cfs from State Water Resources Control Board Water Rights Order 90-5. Delta operation under the COS seeks to support exports while minimizing and/or avoiding entrainment of listed species. Fall X2 conditions for Delta smelt are also considered under the COS (USFWS 2008).

5.6.3.1 Upper Sacramento River Seasonal Operations including Shasta Cold Water Pool Management

Under WOA conditions, there would be no Shasta and Keswick reservoir operations to control storage or releases, and no transfer of water from the Trinity River Basin. Therefore, there would be no control of flow or water temperature in the upper Sacramento River, where Winter-run Chinook Salmon spawn. Reservoir gates and river valves would be kept open, resulting in minimal storage (Figure 5.6-7). The similarity to uncontrolled flows is reflected in seasonal flows under the WOA scenario in the Sacramento River at Keswick, with low summer and fall flows and high winter and spring flows (Figures 5-7 through 5-18 in the CalSim II Flows section of Appendix D). Other locations in the Sacramento River show similar seasonal flow patterns (Tables 15-1 through 15-3, 16-1 through 16-3, and 17-1 through 17-3 in the CalSim II Flows section of Appendix D).

Under the proposed action, flows in the upper Sacramento River result from controlled releases from Shasta and Keswick reservoirs, as well as transfers from the Trinity River. These releases and transfers are determined by a suite of laws, regulations, contracts, and agreements to address demands of water users, requirements for water quality, and needs of fish populations throughout the river and the Delta, including Winter-run Chinook Salmon.

The primary difference between proposed action and current operations modeling for the Sacramento River upstream of the Delta is in operations of Shasta and Keswick reservoirs for cold water pool management and the COS requirement for Fall X2.

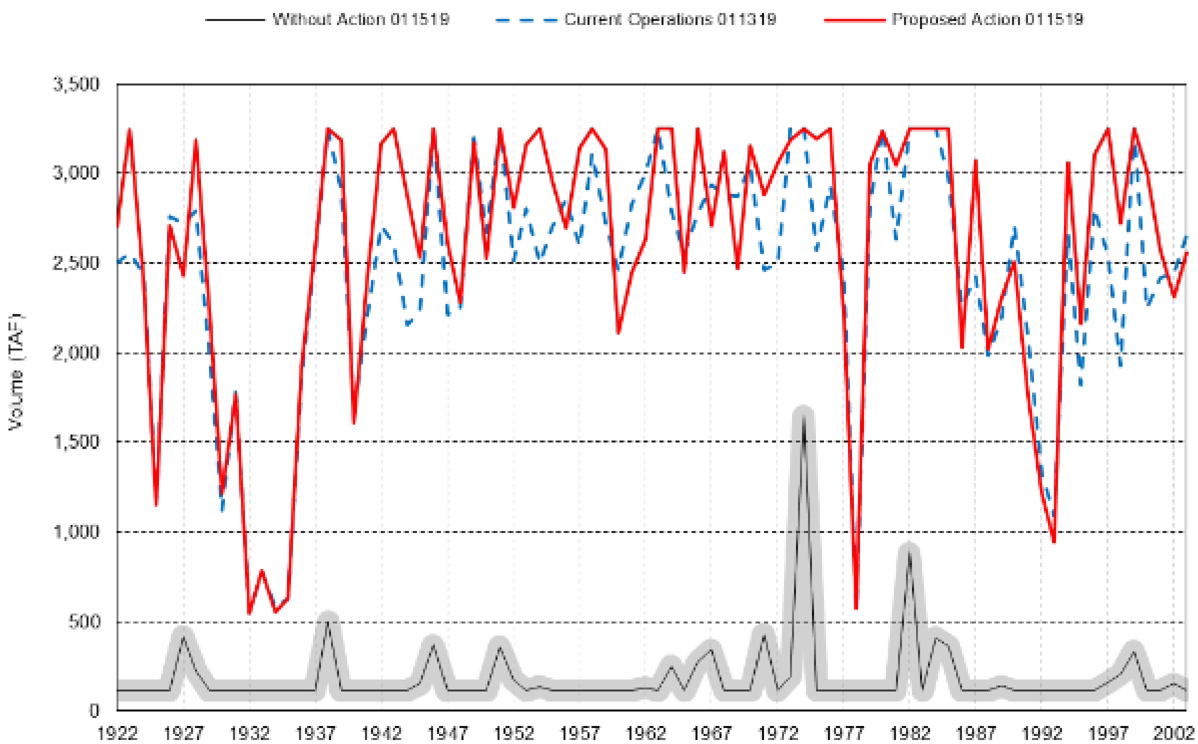


Figure 5.6-7. ShastaStorage. CalSim II Estimates of Mean Shasta Storage, 1923-2002.

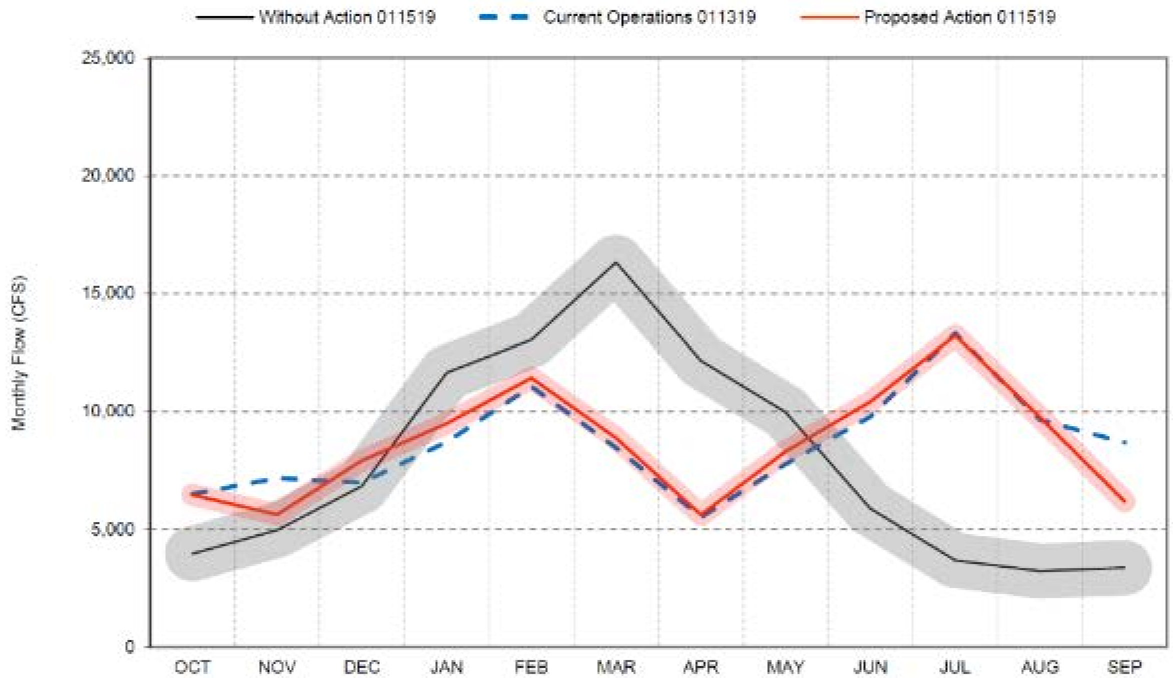


Figure 5.6-8. Calsim II Sacramento River Flow downstream of Keswick Reservoir, Long-term Average

The CalSim modeling shows large seasonal changes in the differences in upper Sacramento River flow between the WOA scenario and the proposed action. In July through October, the WOA flows are consistently well below those of the proposed action (Figures 15-16 through 15-18 and 15-7, and Tables 15-1 through 15-3, 16-1 through 16-3, and 17-1 through 17-3 in the CalSim II Flows section of Appendix D). By November there is little difference between the WOA and proposed action scenarios, except in years with the highest flows. In January, the WOA flows are higher than the proposed action at most flow levels (Figure 15-10 in the CalSim II Flows section of Appendix D) and in March the WOA flows are consistently higher than the proposed action flows (Figure 15-12 in the CalSim II Flows section of Appendix D). These seasonal changes result primarily from Shasta Reservoir storage releases under the proposed action during June through September, when uncontrolled flows are low, and diversions to Shasta Reservoir storage under the proposed action during winter and spring, when uncontrolled flows are high. Diversion to storage is higher in spring than in winter because the flood control pool in the reservoir can be reduced during spring as flood risk declines.

The differences in flows between the WOA scenario and the proposed action and COS scenarios would likely have very large effects on Winter-run Chinook Salmon juveniles and their habitats. The lower summer and fall flows under the WOA scenario would likely result in reduced conditions in juvenile rearing habitats, including less habitat complexity, side channel habitat structure, refuge habitat, and greater disease potential (Windell et al. 2017). As noted previously, the higher WOA flows in winter and spring could have both positive and negative effects on rearing juvenile Winter-run Chinook Salmon. Benefits include increased floodplain and side-channel habitat, better feeding conditions, reduced competition and predation; decreased water temperatures and increased DO; and enhanced emigration flows. Negative impacts include increased stranding risk (due to greater flow fluctuations), and increased contaminant loading from stormwater runoff. Although conditions may be suboptimal for juvenile Winter-run Chinook Salmon, the impacts of increased summer and fall flows under the proposed action and COS would be beneficial compared to the WOA. During summer and fall juvenile Winter-run

Chinook Salmon are less robust due to young age and are more sensitive to stressful conditions than other times of the year (NMFS 2009). Therefore, juveniles would be less susceptible to reduced winter and spring flows under the proposed action and COS as compared to the WOA.

CalSim modeling indicates that upper Sacramento River flows during the period of juvenile rearing in the upper Sacramento River are generally similar between the proposed action and COS (Figures 15-7 through 15-12 and 15-16 through 15-18, and Tables 15-1 through 15-3, 16-1 through 16-3, and 17-1 through 17-3 in the CalSim II Flows section of Appendix D), except for higher flows during September under the COS scenario in the upper range of flows (Figure 15-18 in the CalSim II Flows section of Appendix D). The COS flows are also higher than the proposed action flows during November (Figure 15-8 and Table 15-3 in the CalSim II Flows section of Appendix D) where Reclamation proposes to rebuild storage and cold water pool for the subsequent year.

Flow under the COS and proposed action scenario are consistently well above the WOA flow in all months of the primary spawning and incubation period, especially in dry years (Figures 15-15 through 15-18 in the CalSim II Flows section of Appendix D). Therefore, all potential adverse effects of low flows on Winter-run Chinook Salmon spawning and incubation listed above are expected to be much less severe under the proposed action or COS than under the WOA.

The low summer and fall flows under the WOA conditions would likely result in reduced conditions for spawning and incubation of Winter-run Chinook Salmon in the upper Sacramento River (Figures 15-7 through 15-9 and 15-15 through 15-18, and Tables 15-1 through 15-3, 16-1 through 16-3, and 17-1 through 17-3 in the CalSim II Flows section of Appendix D). The WOA flows range from 772 cfs in August to about 63,000 cfs in March. During dry years, the flows would often fall below the proposed action flow for October through March of 3,250 cfs.

In the uppermost section of the Sacramento River, where most Winter-run Chinook Salmon spawning occurs, flows the WOA scenario during the May through November spawning and incubation period, are generally low (Figures 15-16 through 15-18 in the CalSim II Flows section of Appendix D). Reduced flows under WOA conditions during the driest summer and fall months would have significant negative effects on rearing habitat of Winter-run Chinook Salmon juveniles. Water temperatures would be too high to successfully reproduce; hence, no juvenile Winter-run Chinook Salmon would be present under WOA.

The higher WOA flows in winter and spring could have both positive and negative effects on rearing juvenile Winter-run Chinook Salmon. The impacts of low flows listed above are generally ameliorated by higher flows, but there can be adverse effects including higher stranding risk because of increased use of flood plains combined with greater flow fluctuations, and higher contaminants loading from stormwater runoff.

The USEPA (2003) defines 61 degrees Fahrenheit as the critical seven-day average daily maximum (7DADM) water temperature for Chinook Salmon juveniles. While this source is commonly cited and used to identify general temperature thresholds for most species and life-stages in this document, it is based on data from fish in the Pacific Northwest and based on different thermal regimes with smoother average temperatures. In addition to the lack of local relevance, 7DADM has operational challenges as a compliance metric, including the fact that it will create a lag in the data (Figure 5.6-9 below). The 2017 Long-term Operations Biological Opinions (LOBO) Biennial Science Review (Gore, 2018) stated that for datasets that are not centered on the mean, the moving average will create a lag in the data that can bias the average by the previous data point, and that alternate averaging approaches should be considered in addition to 7DADM, such as a weighted moving average. Gore et al state that, “The proposed 7DADM significantly lags the observed data. However, both a 3-day and 4-day average daily maximum both follow the sharp rise in observed temperature with less lag at the temperature peak." Reclamation will continue to use this reference as a general characterization of the temperature tolerance of lifestages and species in this document, with the understanding that it is inappropriate to use as a compliance metric and that local temperature tolerance studies would be preferred, when completed.

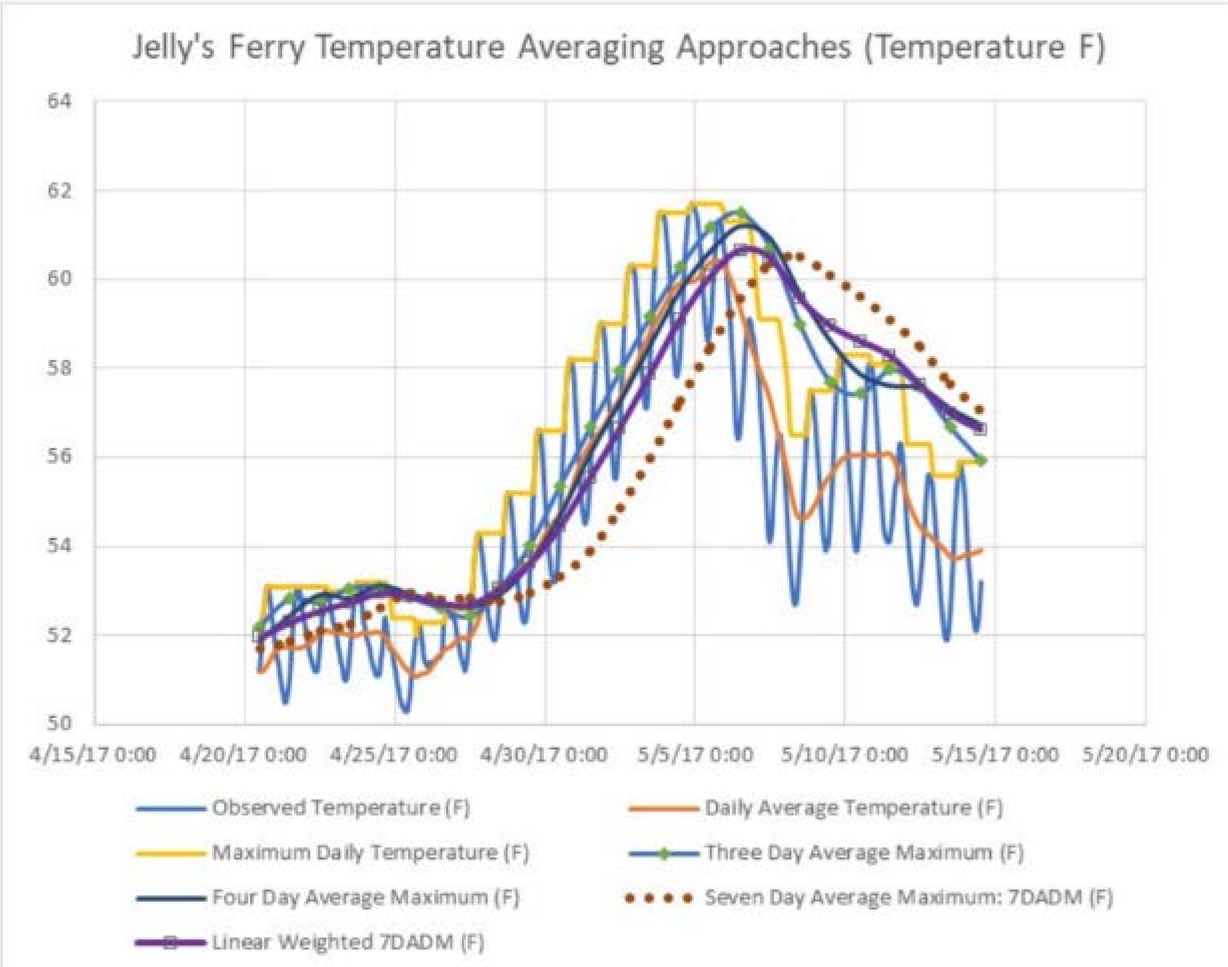


Figure 5.6-9. Comparison of Averaging Approaches that could be used to Specify Temperature at Jelly's Ferry (reproduced from the 2017 LOBO review report, Gore 2018)

The USEPA (2003) defines 64 degrees Fahrenheit as the critical 7DADM water temperature for Chinook Salmon juveniles rearing, based on Pacific Northwest fish and not considering operational limitations of 7DADM. In the middle Sacramento River below the Colusa Basin Drain, which is close to Knights Landing, the WOA scenario monthly mean water temperatures would be high during October, ranging up to 73 degrees Fahrenheit and exceeding the 64 degrees Fahrenheit threshold in about 80 percent of years (Figure 5-7 in the HEC5Q Temperatures section of Appendix D). The water temperatures would remain well below 64 degrees Fahrenheit from November through March (Figures 5-9 through 5-12 in the HEC5Q Temperatures section of Appendix D), by which time most Winter-run Chinook Salmon juveniles have migrated into the Delta.

5.6.3.1.1 Egg to Fry Emergence

Windell et al. (2017) links egg to fry survival with releases from Keswick and water temperatures. Critical water temperatures thresholds for Winter-run Chinook Salmon vary by life stage, with eggs and alevins the most sensitive to elevated temperatures. Under the WOA, there is no temperature management. The presence of a large cold water pool and the flexibility afforded by the TCD make possible the provision of much colder water under COS and the proposed action in the upper Sacramento River during the May through November spawning and incubation period than would be possible under the WOA. Under the proposed action, the river's temperatures are controlled by selective withdrawal through the TCD at Shasta Reservoir and by balancing releases between Lewiston (Trinity River) and Shasta reservoirs.

Operation of the Shasta TCD provides for cold water to maintain egg incubation and avoid temperature dependent mortality. The availability of cold water depends upon reservoir stratification and is not known until April; however, the amount of water in storage provides an indicator. Under the WOA scenario, no storage results in little cold water. Under the proposed action improvements in storage improve the ability to manage cold water for Winter-run Chinook Salmon incubation. Figure 5.6-10 shows the modeled temperature management tiers and operational parameters that influence the tiers, based on storage, for the last 19 years of the CalSim period of record. Figure 5.6-11 shows the same figure for the full 1922-2003 CalSim period of record.

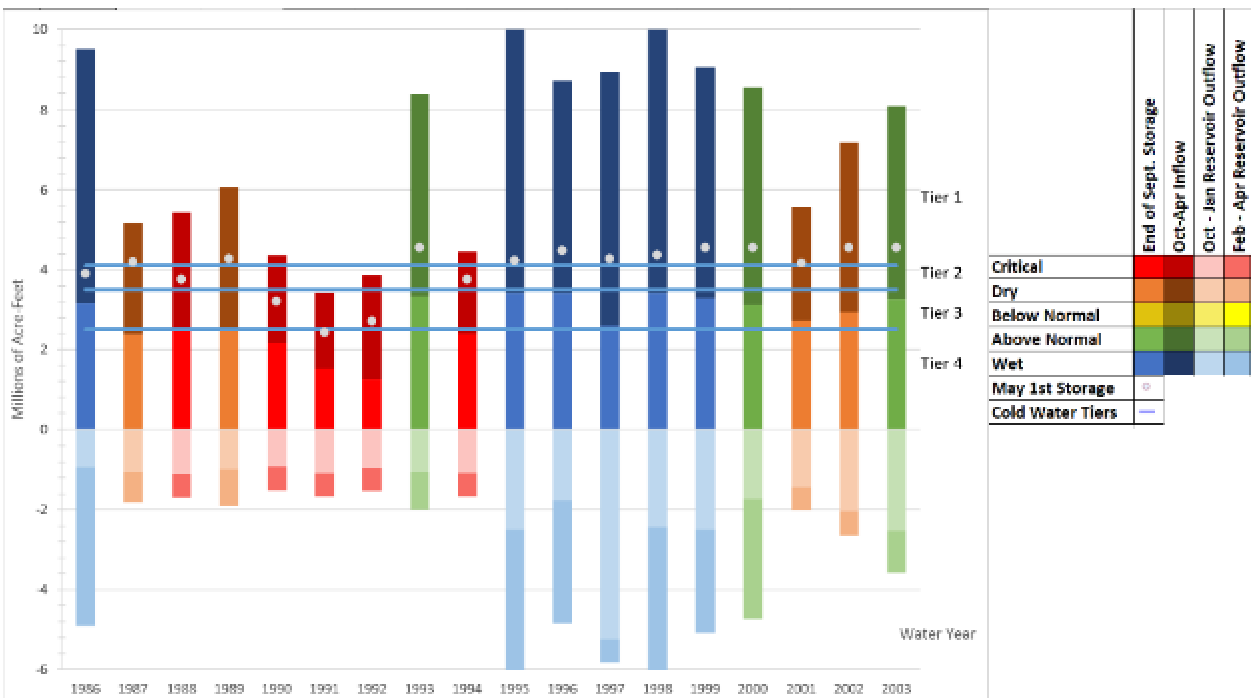


Figure 5.6-10. CalSim Prior Storage, Inflow, and Releases for May 1 Cold Water Capabilities (1986-2003 for ease of visualization)

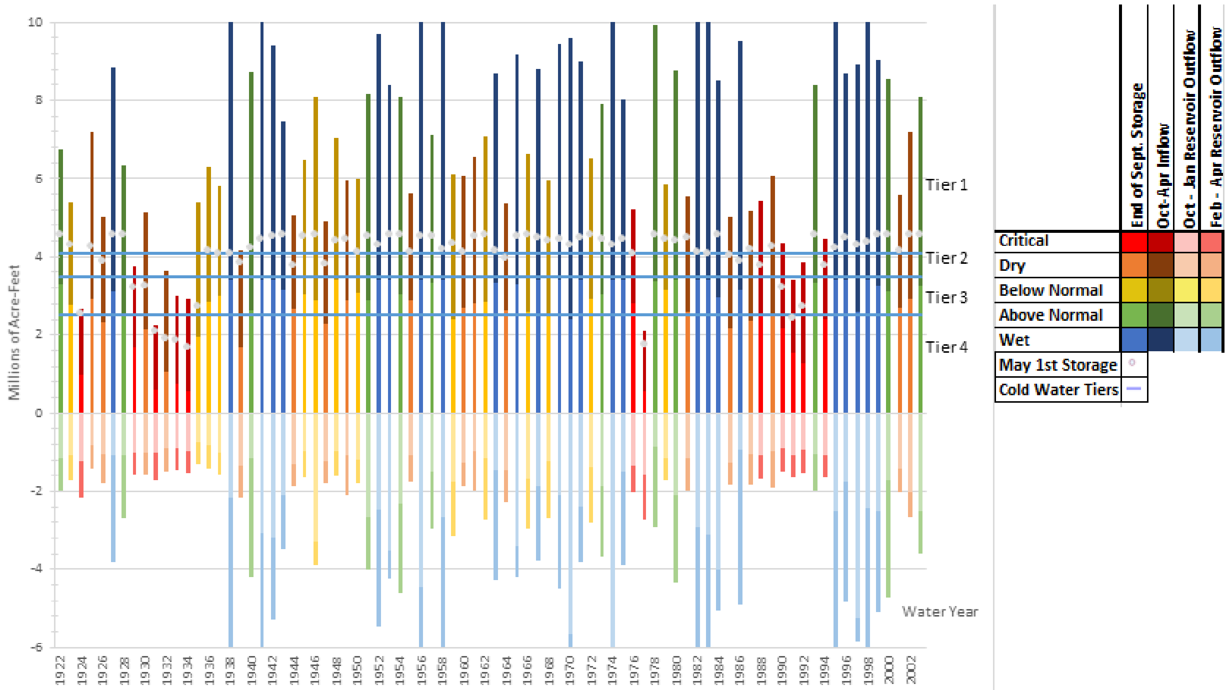


Figure 5.6-11. CalSim Prior Storage, Inflow, and Releases for May 1 Cold Water Capabilities (1922-2003)

CalSim modeling over the 1922-2003 period of record indicates Reclamation is in Tier 1 over 69 percent of the time and in Tier 4 less than 8 percent of the time (Tier 2 in 17% of the years, and Tier 3 in 7% of the years). End of September storage has little influence on the subsequent tier as releases for flood management and other purposes (e.g. dewatering) erode the storage. Actions to rebuild storage when storage is known to be low can shift operations into a higher tier, to some degree; however, the cold water resource depends primarily on inflow.

Although it does not include the altered water operations, historical data provides information to infer how operations may change under the proposed action. Figure 5.6-12 shows recent history (since 2001) that is largely not simulated within Calsim.

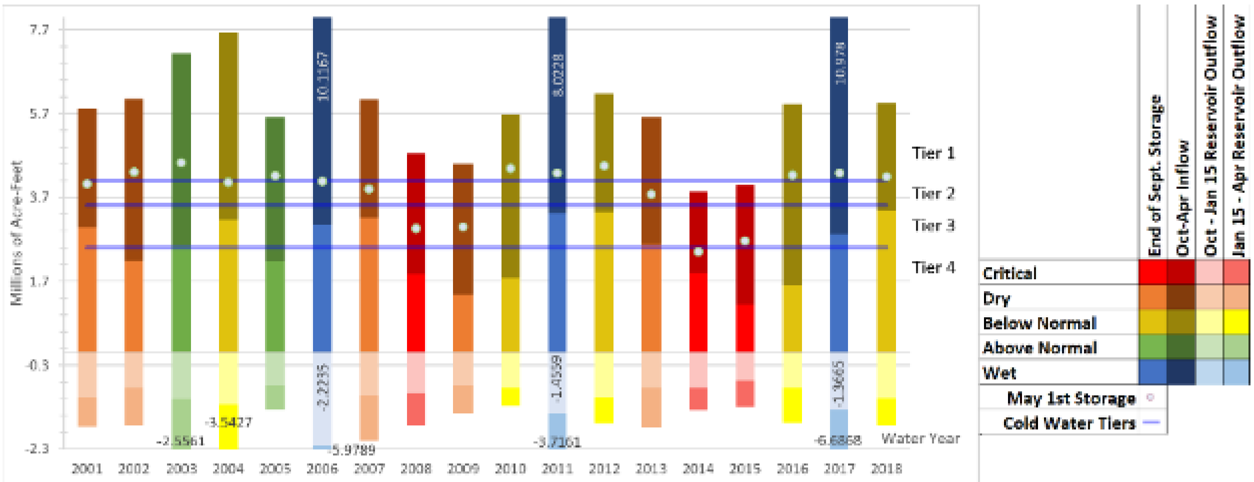


Figure 5.6-12. Historical Prior Storage, Inflow, and Releases for May 1 Cold Water Capabilities

Reviewing the end of September storages shows little ability to modify the tier in the subsequent year. Reviewing the releases (shown as negative on the Y-axis) indicates that lower releases in the fall of 2013 could have improved conditions for 2014.

The main difference in flow and water temperature management between the proposed action and COS during the June through September Winter-run Chinook Salmon spawning and incubation period would be in how the TCD would be operated to preserve sufficient cold water pool and what water temperature thresholds would be used.

Under the proposed action as modeled in the HEC-5Q temperature model, mean monthly water temperatures at Clear Creek during May through November range from roughly 48 degrees Fahrenheit in May to 67 degrees Fahrenheit in September (Figures 5.6-13 through 5.6-20).

The proposed action incorporates new water temperature management measures based on water temperatures that include a water temperature target of 53.5 degrees Fahrenheit in the Sacramento River above the Clear Creek confluence (CCR). CCR is a surrogate for the downstream-most redd. Some redds occur downstream of clear creek, however the 53.5 F target is below the 56 F threshold and cold water will propagate further downstream. Targeting CCR avoids the need to use additional cold water over areas where few redds occur.

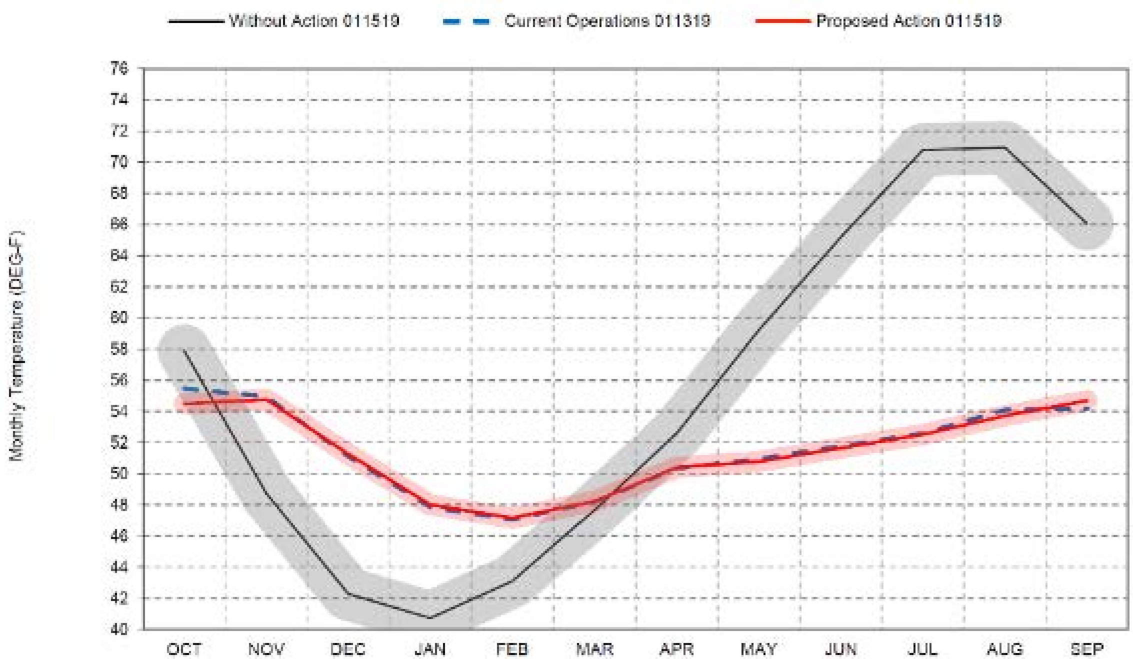


Figure 5.6-13. HEC-5Q Sacramento River Water Temperatures at Clear Creek by Monthly Average

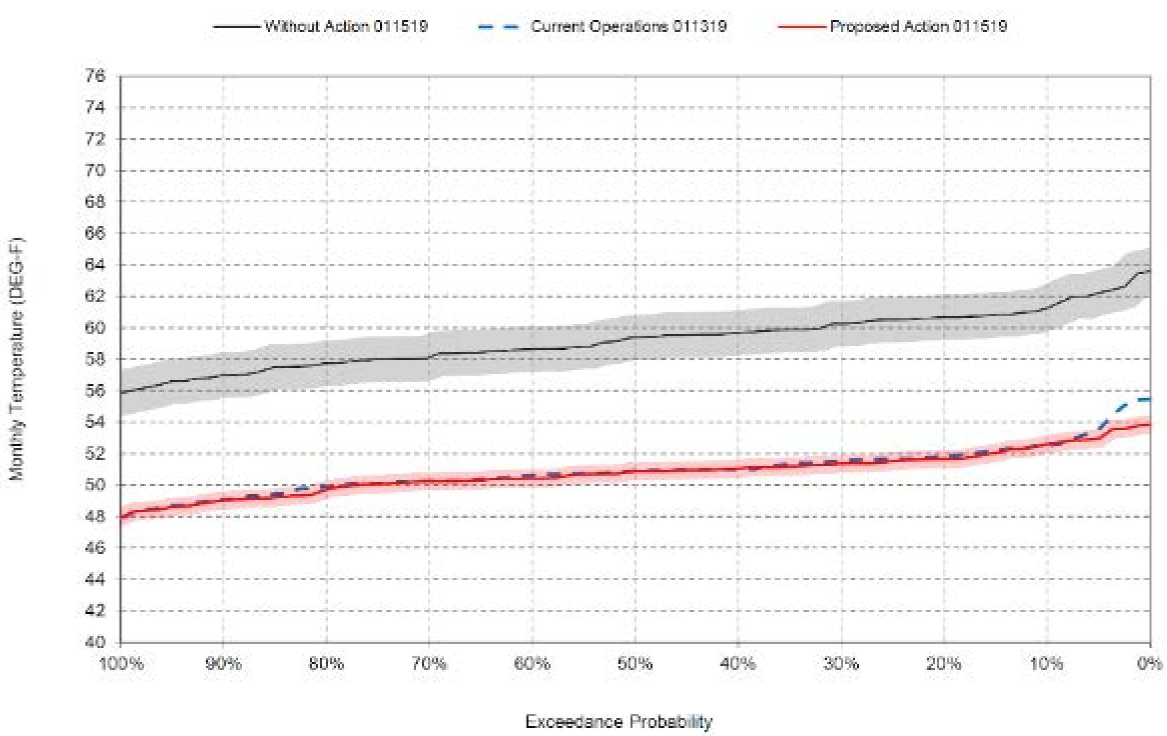


Figure 5.6-14. HEC-5Q Sacramento River Water Temperatures at Clear Creek under the WOA, proposed action, and COS scenarios, May

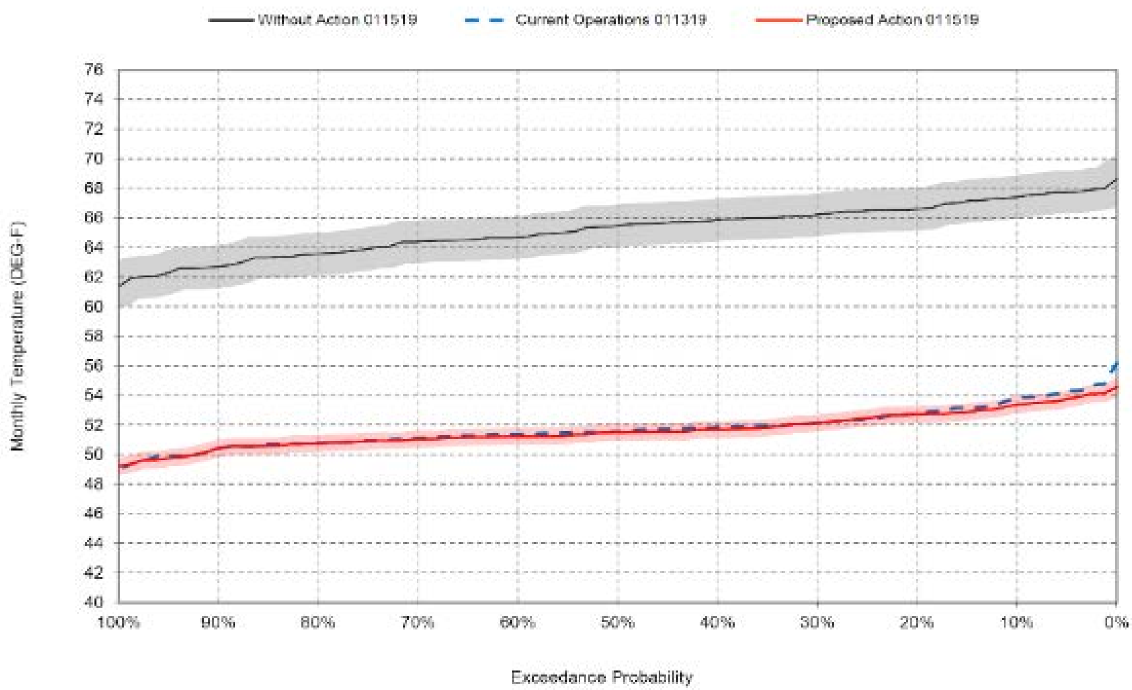


Figure 5.6-15. HEC-5Q Sacramento River Water Temperatures at Clear Creek under the WOA, proposed action, and COS scenarios, June

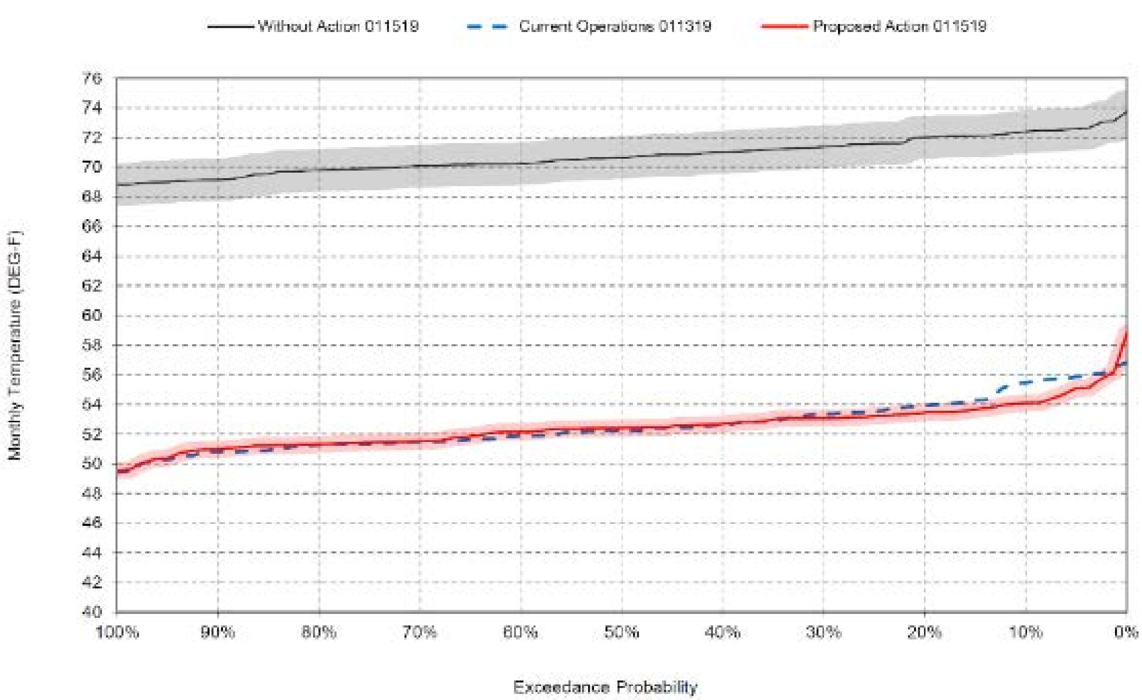


Figure 5.6-16. HEC-5Q Sacramento River Water Temperatures at Clear Creek under the WOA, proposed action, and COS scenarios, July

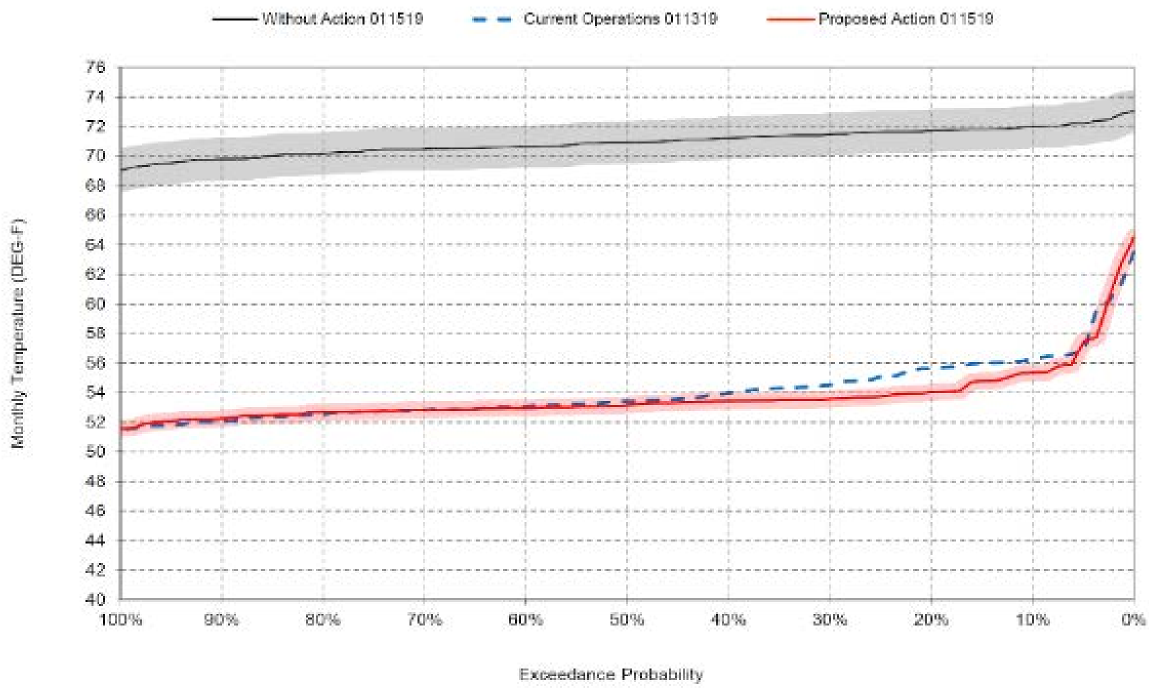


Figure 5.6-17. HEC-5Q Sacramento River Water Temperatures at Clear Creek under the WOA, proposed action, and COS scenarios, August

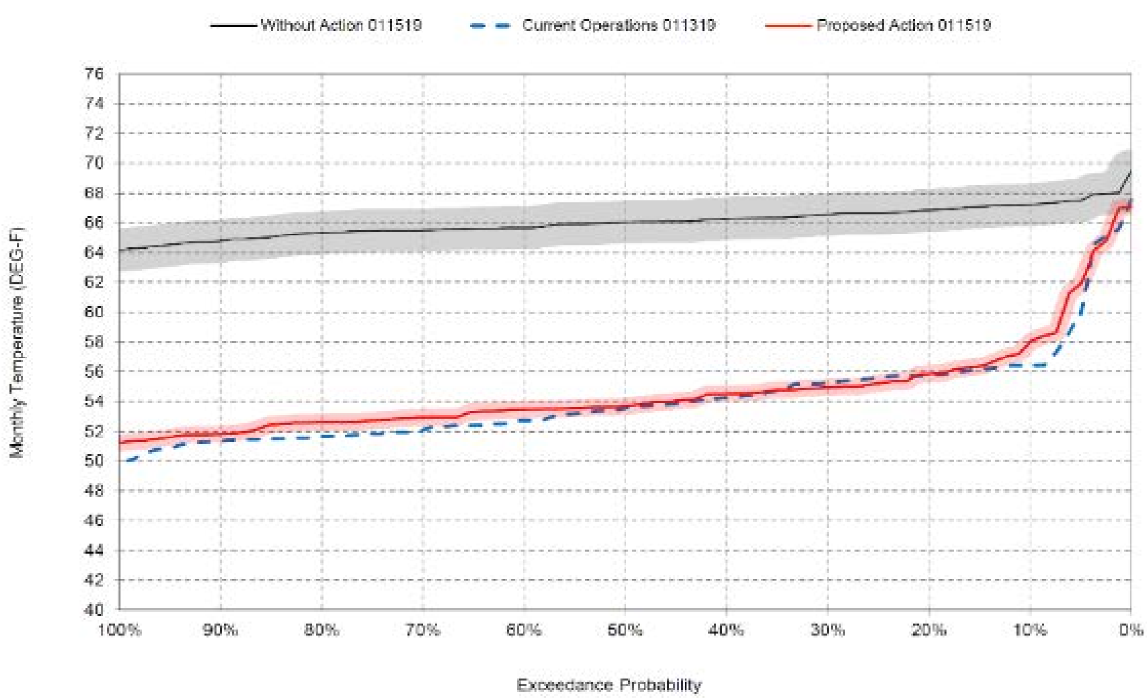


Figure 5.6-18. HEC-5Q Sacramento River Water Temperatures at Clear Creek under the WOA, COS and proposed action scenarios, September

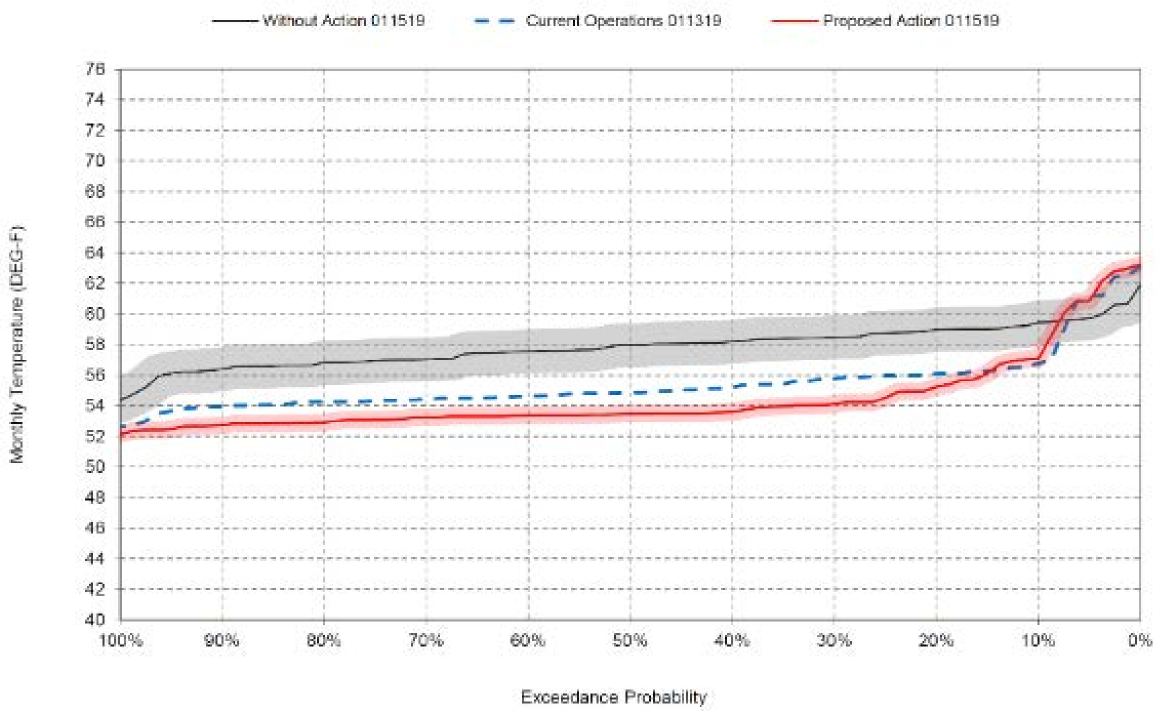


Figure 5.6-19. HEC-5Q Sacramento River Water Temperatures at Clear Creek under the WOA, proposed action, and COS scenarios, October

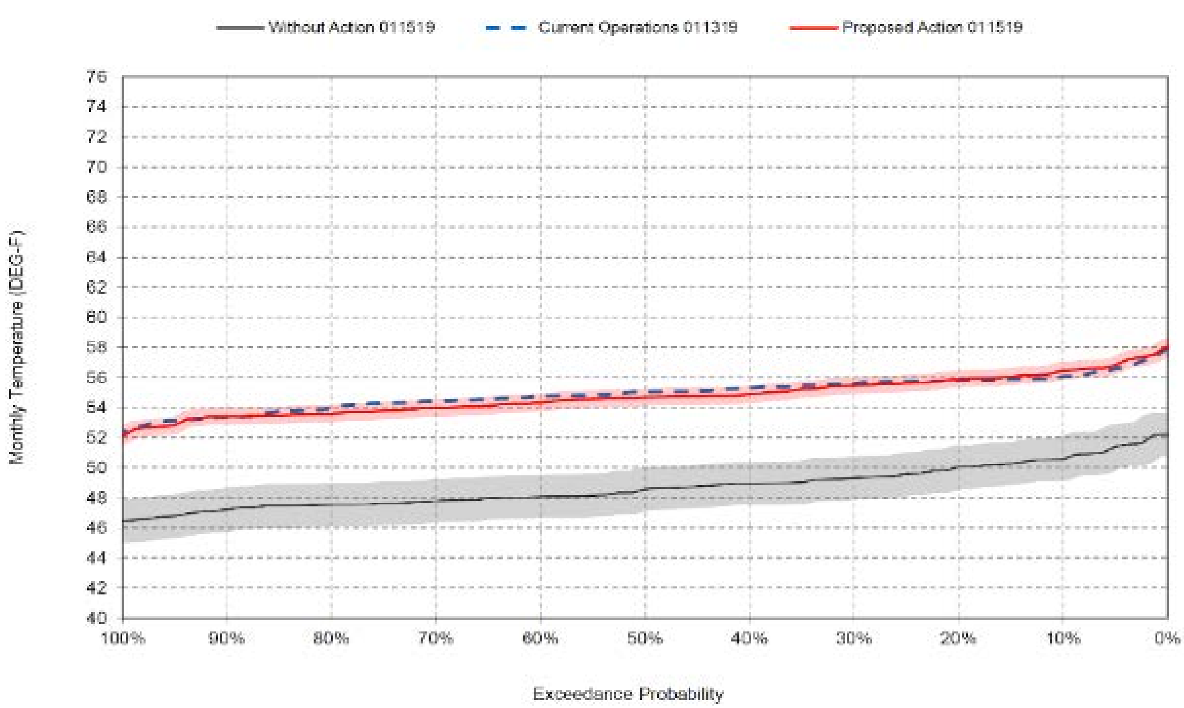


Figure 5.6-20. HEC-5Q Sacramento River Water Temperatures at Clear Creek under the WOA, proposed action, and COS scenarios, November

While the HEC-5Q model provides 6-hour data, the results presented here are monthly averages, which should reasonably estimate daily average temperatures near the Keswick Dam because operations at Shasta and Keswick dams create relatively stable summer flow and water temperature conditions. Variable weather conditions and travel time of water result in greater fluctuations around the mean further downstream of the dam. During the June through September peak spawning and incubation period, the water temperatures at Clear Creek exceed the 53.5 degrees Fahrenheit threshold in at most 30 percent of years (50% for September). During October, when the cold water pool is especially at risk of being depleted, the water temperatures would exceed the 53.5 degrees Fahrenheit threshold in about 50 percent of years. There is little difference in water temperatures among the proposed action and COS scenarios during all months except October (Figures 5.6-13 through 5.6-20). In October, temperature modeling indicates that the proposed action has an improvement over the current operations scenario in 80% of the years, and an improvement over the WOA scenario in 90% of the years, decreasing October temperatures by 1-2 degrees Fahrenheit as compared to COS, and 4-5 degrees as compared to WOA. The proposed action conserves cold water earlier in the year and is able to extend cooler temperatures into October.

Summer water temperatures under the proposed action and COS scenarios are consistently much lower than those under the WOA scenario (Figures 5.6-15 through 5.6-18). These results indicate that the proposed action and COS, relative to the WOA, provide a clear benefit to Winter-run Chinook Salmon eggs and alevins incubating in the upper Sacramento River. In view of the improved water temperature management operations planned for the proposed action, this action is expected to benefit the Winter-run Chinook Salmon eggs and alevins relative to current operations.

Martin et al. (2017) developed an egg mortality model for Winter-run Chinook Salmon on the Upper Sacramento River and performed regression on historical data to find a critical incubation temperature for eggs of 53.6 degrees Fahrenheit below which minimal mortality due to temperature occurred. The 2017 LOBO review (Gore, 2018), stated that the Martin et al. (2017) approach represents a powerful predictive model for salmon vulnerability to temperature exposure but that the results of the oxygen diffusion model should be tested under field conditions. The model is sensitive to extremely small changes in flow velocity, and it may be problematic to apply a density dependent model that lacks mechanistic basis or site-specific information. Additionally, new laboratory studies from UC Davis (Del Rio et al. 2019) affirm earlier findings (USFWS 1999) that embryo survival is not appreciably impaired at daily mean water temperatures at or near 56 °F except in conditions of hypoxia.

Newer models, described in Anderson (2018), are similar but include different assumptions and provide for more targeted water temperature management practices in the upper Sacramento River (Anderson 2018). Both the Martin et al. (2017), and Anderson (2018) models were used to estimate water-temperature related mortality of Winter-run Chinook Salmon eggs to fry under the WOA, proposed action, and COS. Martin et al applies mortality based on the season-long temperature. Anderson applies mortality based on just the temperature of the 5 days preceding hatch. The modeling was based on the HEC 5Q water temperature estimates at Keswick Reservoir under the three scenarios for the range for years (1922 to 2002) used for the CalSim and HEC 5Q modeling. Figure 5.6-21 gives the exceedance curves for the water-temperature related egg to fry mortalities under the WOA, COS, and proposed action scenarios. Separate results are given for the Martin et al. (2017) and Anderson 2018 modeling.

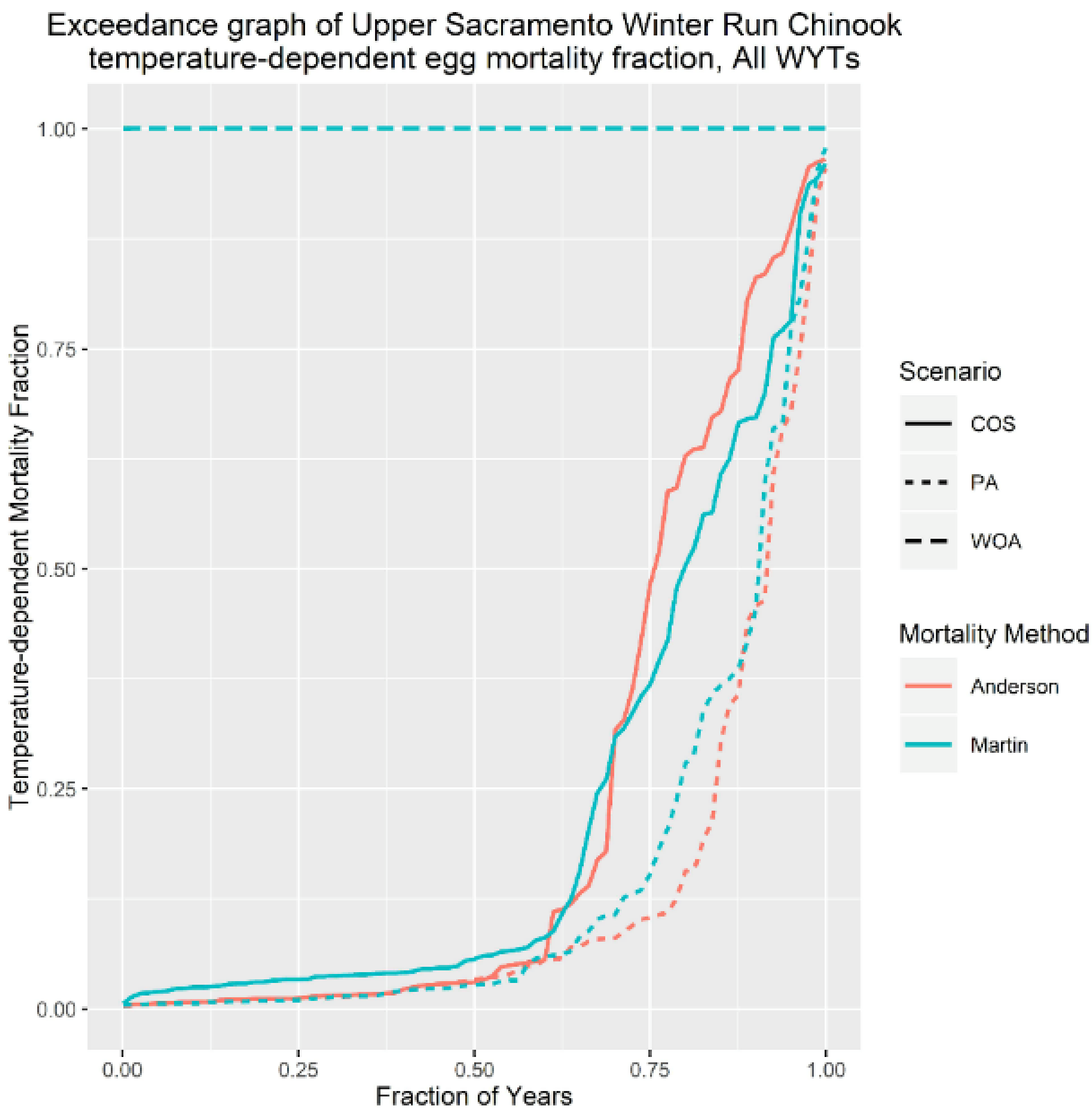


Figure 5.6-21. Exceedance curves of Upper Sacramento River Winter-run Chinook Salmon Temperature-Dependent Egg to Fry Mortality for All Water Year Types

The modeled mortality rate for the WOA scenario is 100 percent for both models used (Figure 5.6-21). This result is the same as that deduced from the HEC 5Q water temperature results presented previously in the water temperature section. Differences between the Martin and Anderson model results are generally small, but tend to show slightly higher mortalities for years with overall lower mortalities (i.e., cooler water temperatures) for the Martin model and slightly higher mortalities for years with overall high mortalities (warmer temperatures) for the Anderson model. For both models, the proposed action mortalities are less than the COS mortalities for the majority of years in all water year types, with some lower performance in some above-normal water-year types.

Figure 5.6-21 combines results for all water year types, including wet years, when there is little temperature-related mortality. This obscures the modeling results for drier years, when egg/alevin mortalities are especially high. In critically dry years, the proposed action continues to outperform current operations, with up to a 40 percent improvement in mortality above current operations in some critically dry years (Figure 5.6-22). As discussed above, the proposed action optimization of water temperatures early in the year leads to significant October improvements in temperatures driving these large improvements in temperature dependent mortality in wetter critically dry years.

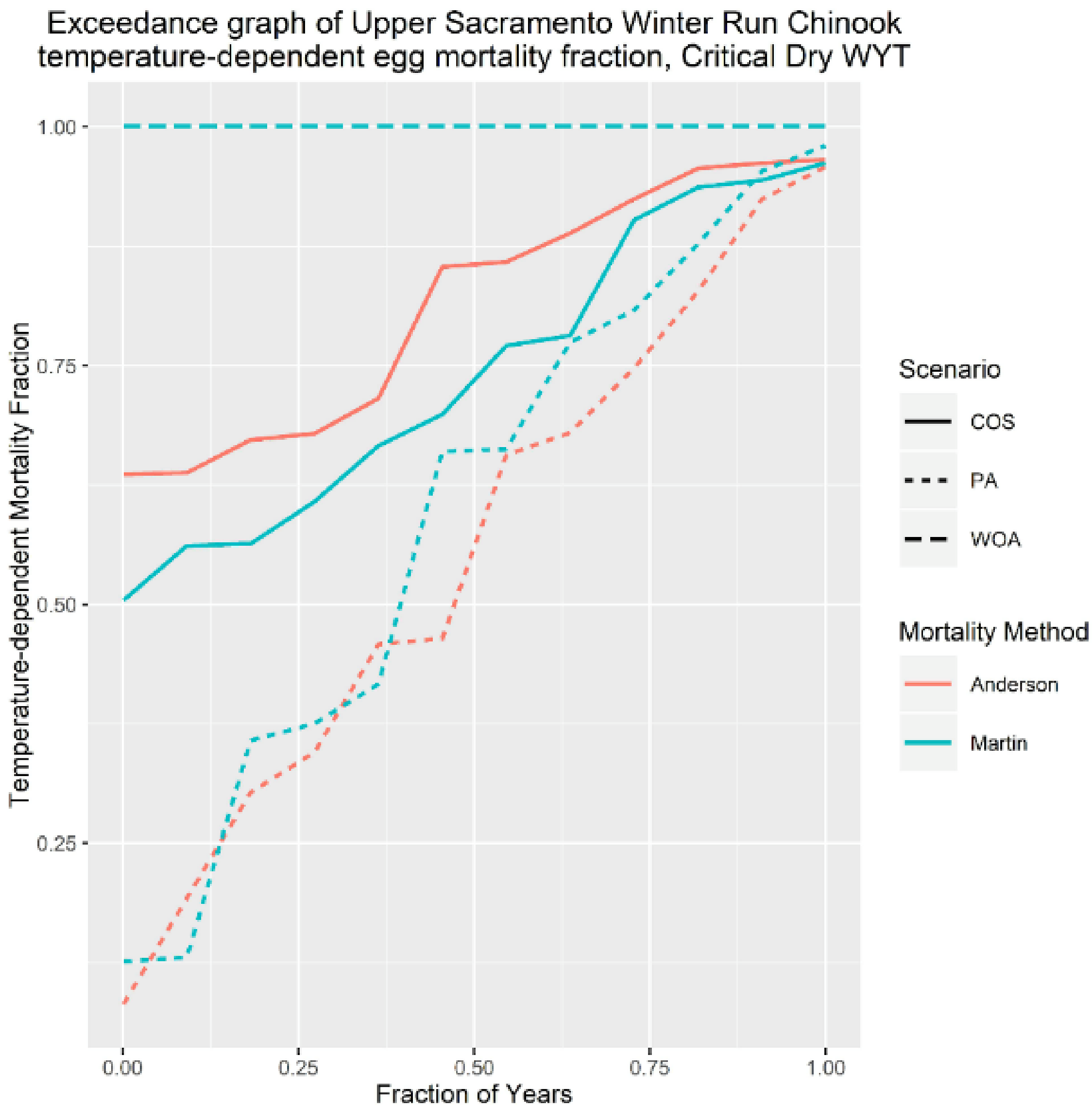


Figure 5.6-22. Exceedance curves of Upper Sacramento River Winter-run Chinook Salmon Temperature-Dependent Egg to Fry Mortality for Critically Dry Water Year Types

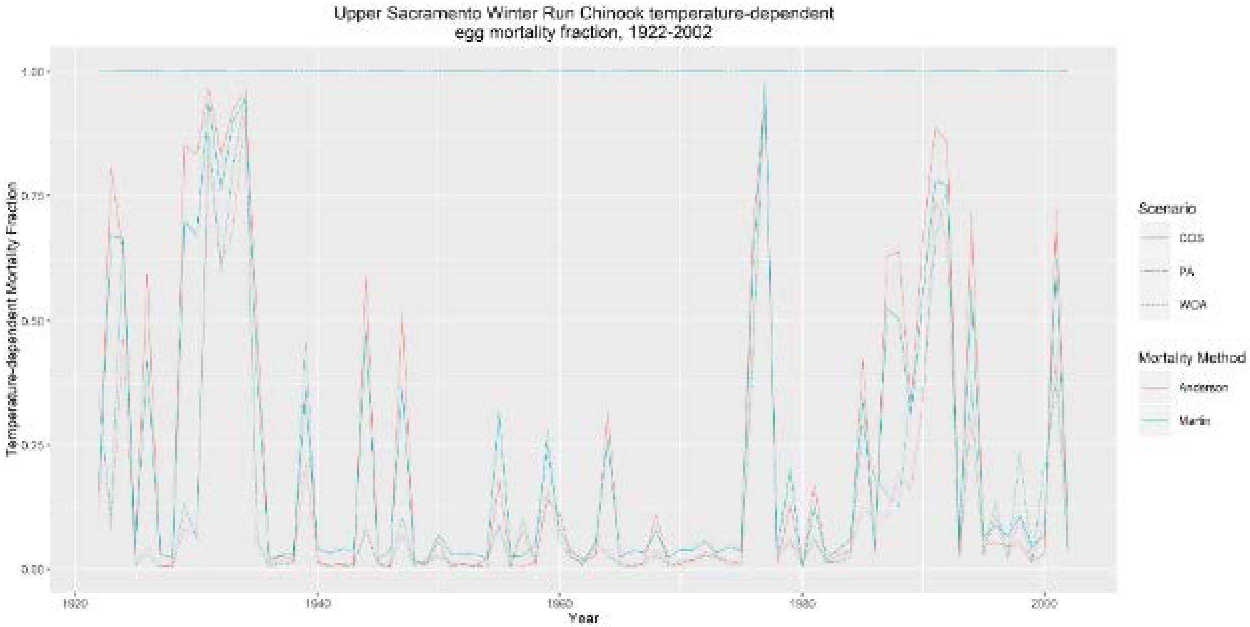


Figure 5.6-23. Estimated Winter-run Chinook Salmon Egg to Fry Average Annual Mortalities (average of Martin and Anderson mortality estimates) and HEC 5Q Estimates of June through September Monthly Average Water Temperatures at Keswick from 1922 to 2002.

The highest estimated mortality rates consistently occur during periods of high water temperatures, such as the droughts of the late 1920 through the mid-1930s, 1976 and 1977, and the late 1980s through the early 1990s (Figure 5.6-23).

The impacts of increased summer and fall flows under the proposed action compared to WOA and COS would be beneficial for egg and alevin survival. The proposed action and COS have lower May flows than WOA, at the very beginning of the spawning and incubation period. However, the proposed action and COS have higher flows than WOA during the rest of the period of egg and alevin incubation for Winter-run Chinook Salmon.

5.6.3.1.2 Rearing to Outmigrating Juveniles in Upper Sacramento River

Winter-run Chinook Salmon juveniles rear throughout the upper Sacramento (Keswick to Red Bluff) from July through March, with a peak rearing period during August through December, and emigrate from the upper river during this period (Table 5.6-1). The proportion of juveniles surviving to emigrate from the upper Sacramento River depends largely on habitat conditions, including instream flow (Windell et al. 2017). Instream flow affects other factors through dilution (e.g., toxicity and contaminants), water temperatures (which also affects DO, food availability, predation, pathogens, and disease), river stage and flow velocity (which affect habitat connectivity, bioenergetics, food availability, and predation), entrainment and stranding risk, and potentially affects cues that stimulate outmigration (Windell et al. 2017, Moyle 2002).

Water temperatures under the proposed action are consistently lower than those under the WOA scenario during May through September, moderately lower in October, similar during March and April, and above the WOA scenario from November through February (Figure 5.6-23 below). Under the proposed action as modeled in HEC-5Q, monthly mean water temperatures at Balls Ferry exceed the 61 degrees Fahrenheit threshold for rearing juvenile Winter-run Chinook Salmon only in about 5 percent of years in August, September, and October, and in no years during the other months (see Appendix D, *Modeling*). There is little difference in water temperatures between the proposed action and COS scenarios during the period of Winter-run Chinook Salmon rearing in the upper Sacramento River.

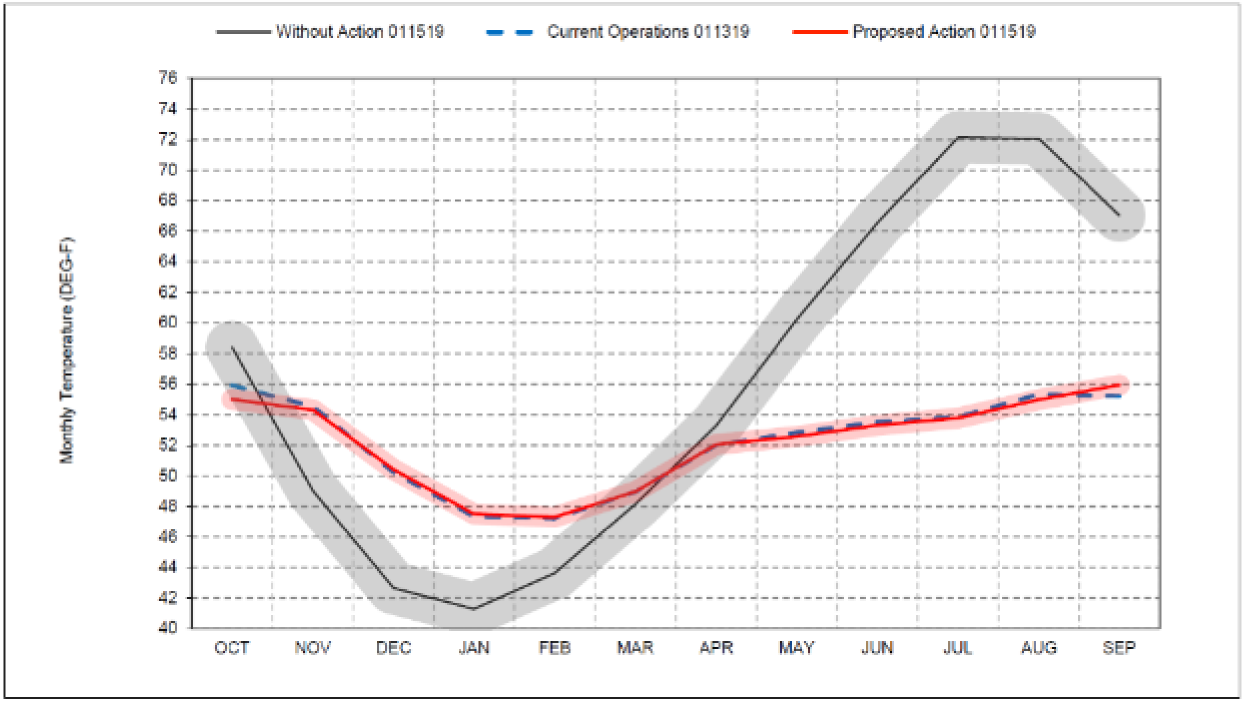


Figure 5.6-24. Sacramento River at Balls Ferry Long-term Average Temperatures

Flows during summer and fall of dry and critically dry years generally have the greatest potential to adversely affect the juvenile life stage in the upper Sacramento River because reservoir storage and cold water pool in these seasons and water year types may be insufficient to provide suitable flow and water temperature conditions in the rearing habitats. The proposed action would help protect Winter-run Chinook Salmon from water temperature extremes through the end of October in all but the driest years.

The benefits of the lower summer and fall water temperatures under the proposed action outweigh potential adverse effects of higher winter water temperatures because the summer and fall temperatures are often near critical temperature thresholds and, therefore, more of a limiting factor. Also, the juveniles are at their youngest and therefore most vulnerable during summer and fall. These results indicate that water temperatures under the proposed action provide benefits to rearing juvenile Winter-run Chinook Salmon in the upper Sacramento River relative to the WOA.

Events in recent years have demonstrated that water temperatures in the upper Sacramento River under current operations negatively impact Winter-run Chinook Salmon, perhaps including rearing juveniles. With the proposed improvements in water temperature management under the proposed action, adverse effects on Winter-run Chinook Salmon are expected to lessen.

5.6.3.1.3 Rearing to Outmigrating Juveniles in Middle Sacramento River

Many of the factors that affect rearing and outmigrating Winter-run Chinook Salmon juveniles in the middle Sacramento River are similar to those described above for the upper Sacramento River. As indicated by the SAIL conceptual model (Figure 5.6-3), flows from the upper Sacramento River and tributaries of the middle Sacramento, combined with other environmental drivers such as floodplain connectivity, food production and retention, and water diversions, affect water temperature, DO, food availability, stranding, outmigration cues and other habitat attributes that influence timing, condition, and survival of rearing juvenile Winter-run Chinook Salmon. The proportion of juveniles surviving to emigrate from the middle Sacramento River depends largely on growth and predation, which are greatly affected by habitat conditions, including instream flow (Windell et al. 2017). The main difference between the juveniles in the middle Sacramento River and those in the upper river with respect to these adverse effects is that the juveniles in the middle river would generally be less sensitive to the effects because their greater age and size would result in greater robustness.

Juvenile Winter-run Chinook Salmon spend varying amounts of time rearing in the upper Sacramento River following emergence before migrating to the middle River. They use the middle Sacramento River as rearing habitat and a migratory corridor to the Delta. The majority of Winter-run-sized juveniles occur in the middle Sacramento River from October through March (Table 5.6-1), with peak occurrence in December and January. The timing of peak migration is typically associated with the earliest occurrence of high flow storm events during the migration season (Windell et al. 2017).

Flows in the middle Sacramento River under the WOA scenario, as was true for the upper Sacramento River, would generally be low during summer and fall and higher in the winter and early spring (Figure 5.6-24 below).

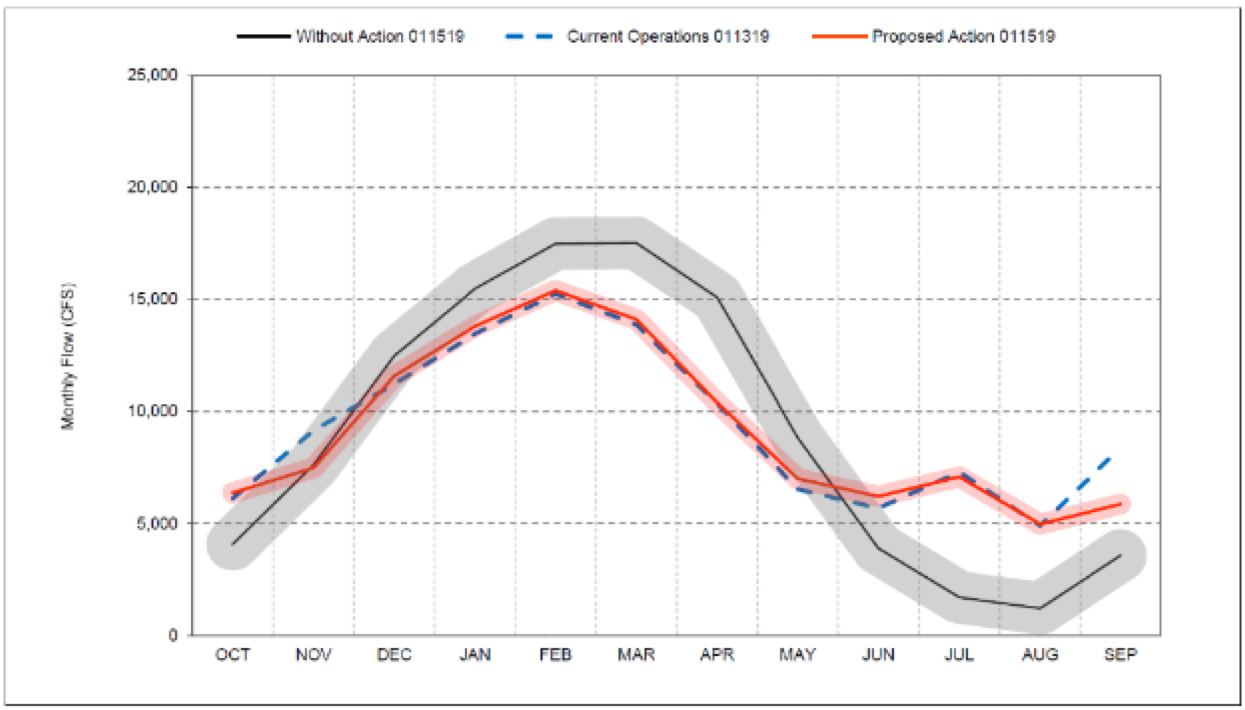


Figure 5.6-25. Sacramento River Flows at Wilkins Slough, Long-Term Average

As was true for the upper Sacramento River, the CalSim modeling results show large seasonal changes in the differences in middle Sacramento River flow between the WOA scenario and the proposed action. In October, the WOA scenario flows are below those of the proposed action except for the wettest years. By November, there is little difference in flow between the WOA and proposed action scenarios, except in the middle-high quarter of flows years, when the WOA flows tend to be moderately higher. In December through February, the WOA flows are generally similar to or higher than the proposed action and in March the WOA flows are consistently higher than the proposed action flows. These seasonal changes result primarily from Shasta Reservoir storage releases under the proposed action during June through September, when uncontrolled flows are low, and Shasta Reservoir storage releases under the proposed action during winter and spring, when uncontrolled flows are high. Diversion to storage is higher in spring than in winter because the flood control pool can be reduced during spring as flood risk declines.

The differences in flows between the WOA scenario and the proposed action would likely have large effects on Winter-run Chinook Salmon juveniles and their habitat. The higher summer and fall flows under the proposed action would likely result in improved conditions in juvenile rearing habitats, including more habitat complexity, side channel habitat structure, refuge habitat, and less disease potential. The lower proposed action flows in winter and spring, compared to WOA, could have both positive and negative effects on rearing juvenile Winter-run Chinook Salmon. Potential effects include less floodplain and side-channel habitat; poorer feeding conditions, increased competition and predation; higher water temperatures and lower DO; and reduced emigration flows. Potential benefits include lower stranding risk because of less flow fluctuations and lower contaminants loading from stormwater runoff. Although conditions may still be stressful for juvenile Winter-run Chinook Salmon, the impacts of increased summer and fall flows under the proposed action and COS would be beneficial compared to the WOA. Juveniles are younger and less robust during summer and fall and more sensitive to stressful conditions than other times of the year (NMFS 2009). Therefore, juvenile Winter-run Chinook Salmon would be less susceptible to reduced winter and spring flows under the proposed action as compared to the WOA.

Inundated floodplains of the middle Sacramento River, such as the Yolo and Sutter Bypasses, have proven particularly successful habitats for juvenile salmon growth (Katz, 2017). This success has been attributed to optimum water temperature, lower water velocity, and higher food quality and food density relative to the main channel. Reduced predator and competitor density also likely contribute to high growth rates observed for juvenile salmon rearing in floodplains (Windell et al. 2017).

CalSim modeling indicates that middle Sacramento River flows during October through March are generally similar between proposed action and COS scenario, except during September and November of above normal and wet years, for which the mean flows under the COS scenario are higher (see Appendix D, *Modeling* and Figure 5.6-24 above). Despite flow reductions compared to COS, the November proposed action flows for the middle ranges of the exceedance curves (roughly 6,000 cfs to 13,000 cfs) would generally be suitable for rearing Winter-run Chinook Salmon juveniles (USFWS 2005).

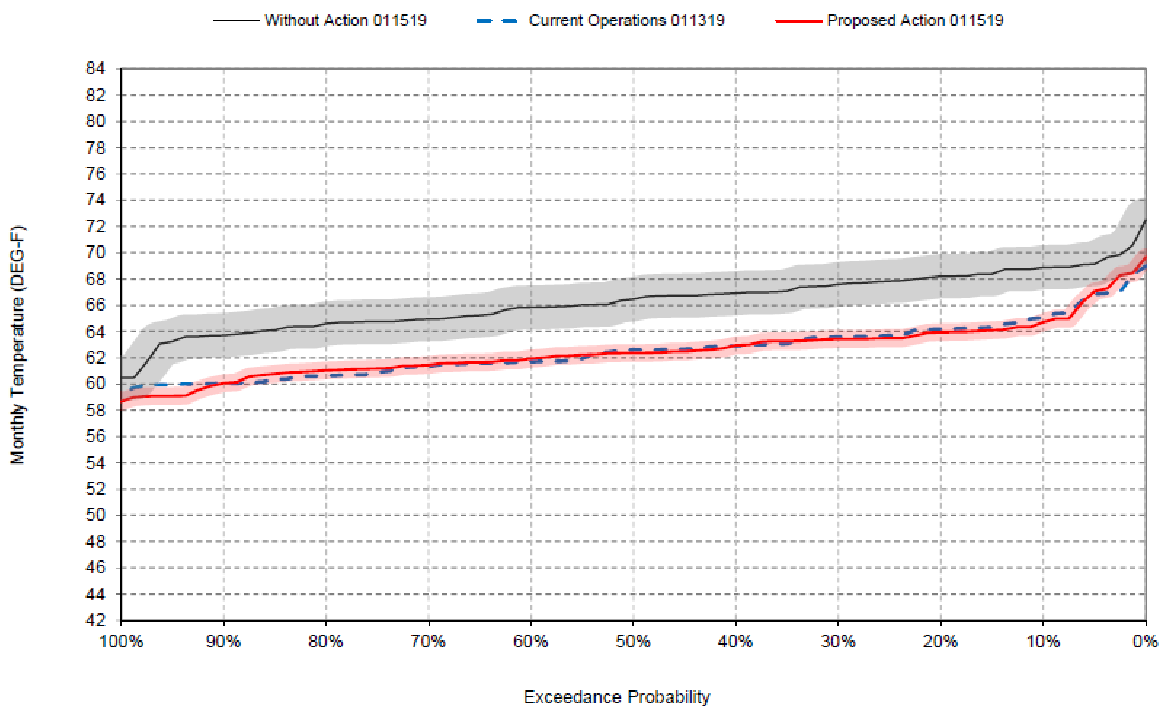


Figure 5.6-26. HEC-5Q Sacramento River Water Temperatures at Knights Landing under the WOA, proposed action, and COS scenarios, October

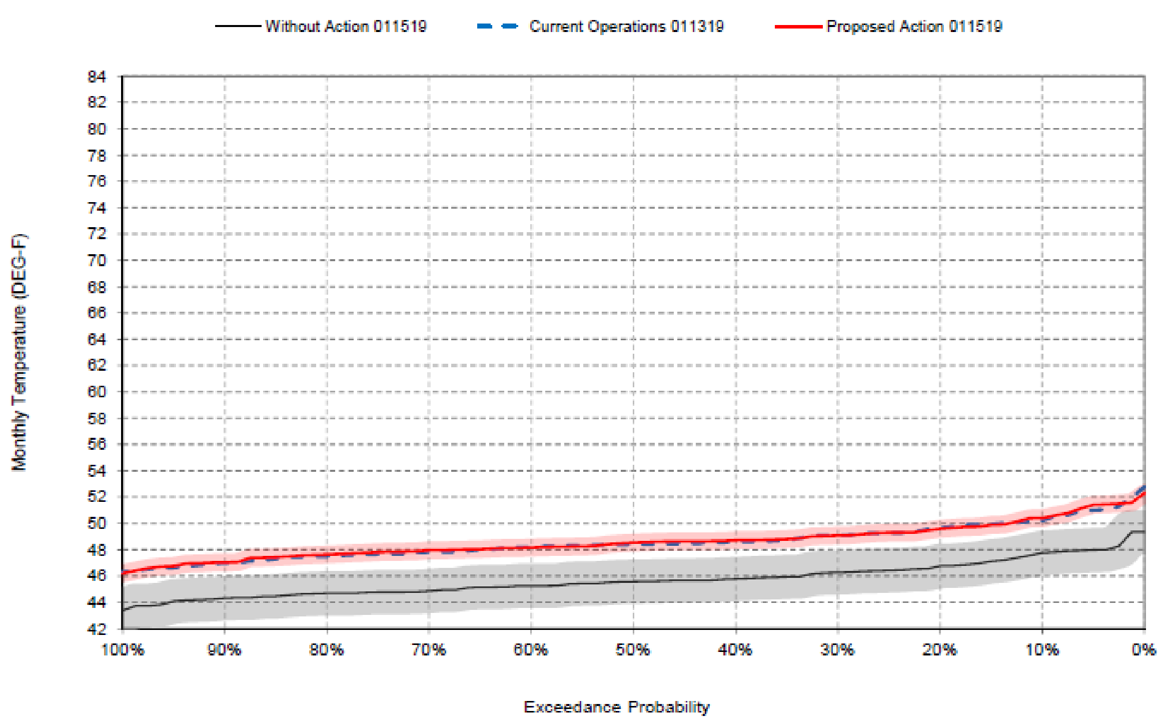


Figure 5.6-27. HEC-5Q Sacramento River Water Temperatures at Knights Landing under the WOA, proposed action, and COS scenarios, December

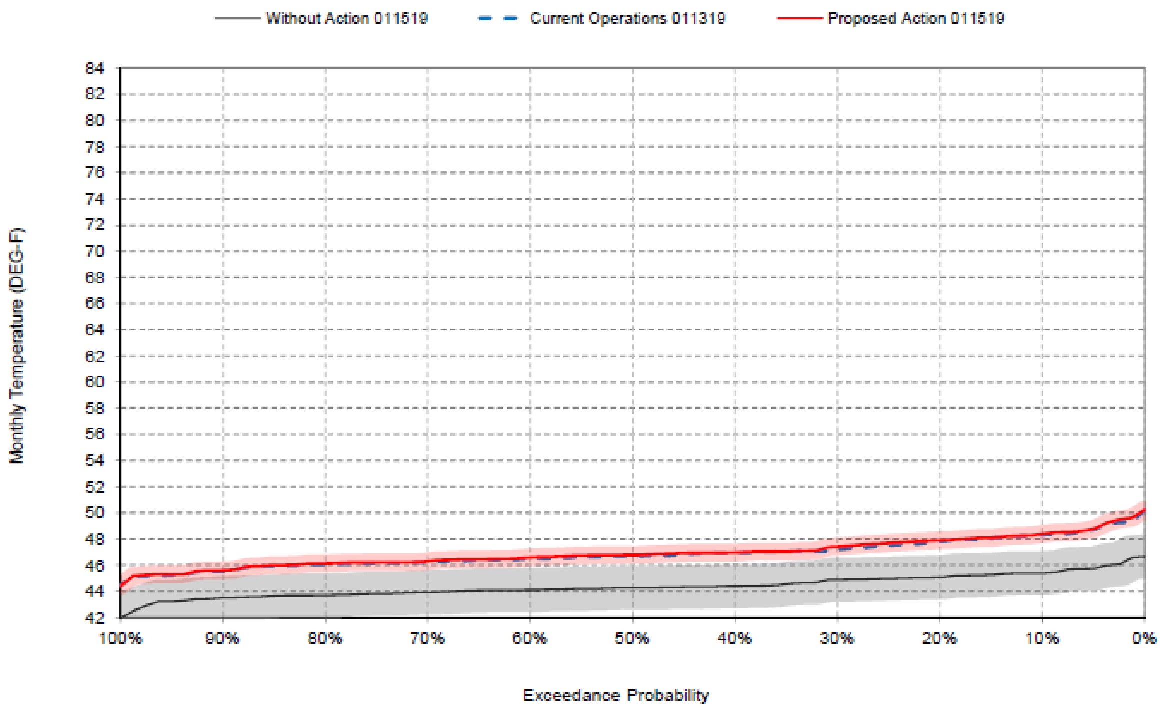


Figure 5.6-28. HEC-5Q Sacramento River Water Temperatures at Knights Landing under the WOA, proposed action, and COS scenarios, January

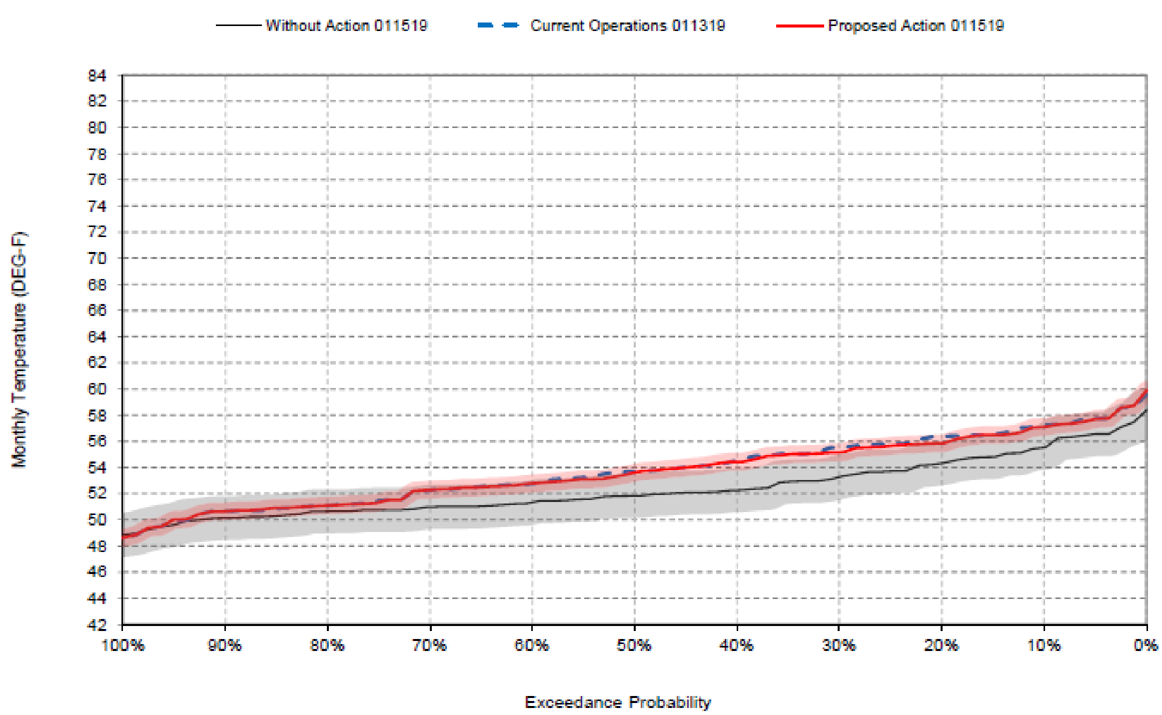


Figure 5.6-29. HEC-5Q Sacramento River Water Temperatures at Knights Landing under the WOA, proposed action, and COS scenarios, March

Under the proposed action scenarios, monthly average water temperatures below the Colusa Basin Drain would range from about 59 to 69 degrees Fahrenheit during October, exceeding the 64 degrees Fahrenheit threshold in about a third of the years (Figure 5.6-25). From November through March, water temperatures for both scenarios would remain well below the 64 threshold (e.g., Figures 5.6-27 and 5.6-28).

Water temperatures under the proposed action are lower than those under the WOA scenario during October in most years (Figures 5.6-25), similar during March (Figure 5.6-28), and above the WOA scenario water temperatures from November through February (e.g. Figure 5.6-26 and 5.6-27). Water temperatures during most of the October through March period under the WOA scenarios and the proposed action are suitable for juvenile Winter-run Chinook Salmon that rear in and emigrate from the middle Sacramento River, therefore, Winter-run Chinook Salmon juveniles are not expected to be impacted by the proposed action water temperatures.

5.6.3.1.4 Adult Migration from Ocean to Upper Sacramento River

CalSim modeling indicates that WOA flows are generally similar to or moderately higher than proposed action during December through February (see Appendix D, *Modeling*). In March, April and May, however, the WOA flows are considerably higher than the proposed action, except for May flows in critical water years (see Appendix D, *Modeling*). The lower flows at Wilkins Slough under the proposed action during March and April, as well as January and February in drier years, would likely affect adult Winter-run Chinook Salmon migrating in the middle Sacramento River by reducing water quality and increasing stranding, straying, poaching, and disease risks (Windell et al. 2017). Conditions under the proposed action would be better in May of drier years, when flows in ten percent of WOA years are below 1,000 cfs (Figure 5.6-29). In these low WOA years, the proposed action would reduce passage problems for upstream migrating adults.

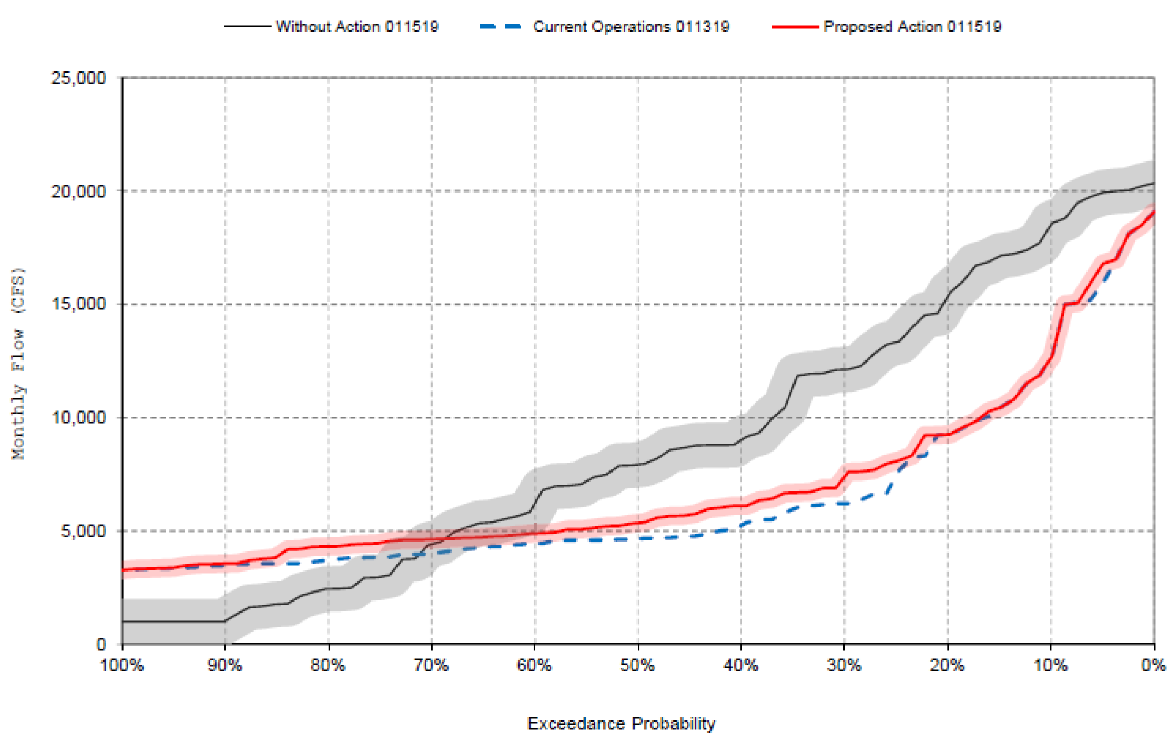


Figure 5.6-30. Modeled Sacramento River Flows at Wilkins Slough, May

In the middle Sacramento River downstream of the Colusa Basin Drain, water temperatures under the proposed action scenarios are similar to WOA water temperatures during May, except in warmer years, when the WOA water temperatures are higher (Figure 5.6-29). The proposed action water temperatures are generally above the WOA water temperatures from December through April (e.g. Figures 14-9 through 14-13 in the HEC5Q Temperatures section of Appendix D). In the upper Sacramento River at Keswick, water temperatures under the proposed action scenarios are similar to WOA water temperatures during March (Figure 5-12 in the HEC5Q Temperatures section of Appendix D), well above the WOA scenario water temperatures from December through February (e.g. Figures 5-9 through 5-11 in the HEC5Q Temperatures section of Appendix D), and well below the WOA scenario water temperatures in April and May (Figures 5.6-30 and 5.6-31).

Water temperatures during December through April period are suitable for adult Winter-run Chinook Salmon immigrating in the middle Sacramento River or holding in the upper river (68 degrees). In May, however, modeled water temperatures in the middle river below the Colusa Basin Drain (at Knight's Landing) exceed the threshold for immigrating adults in a large percentage of years under the WOA scenarios and the proposed action, with a greater percentage of years exceeding the threshold under the WOA scenario. At Keswick, only about four percent of years are expected to exceed the 61 degrees Fahrenheit threshold for holding adults under the WOA scenario, and no years are expected to exceed the threshold under the proposed action and COS scenarios. The anticipated water temperature differences among the scenarios during May are expected to result in greater negative impacts on the immigrating Winter-run Chinook Salmon adults in the middle Sacramento River under the WOA conditions than under the proposed action and COS conditions.

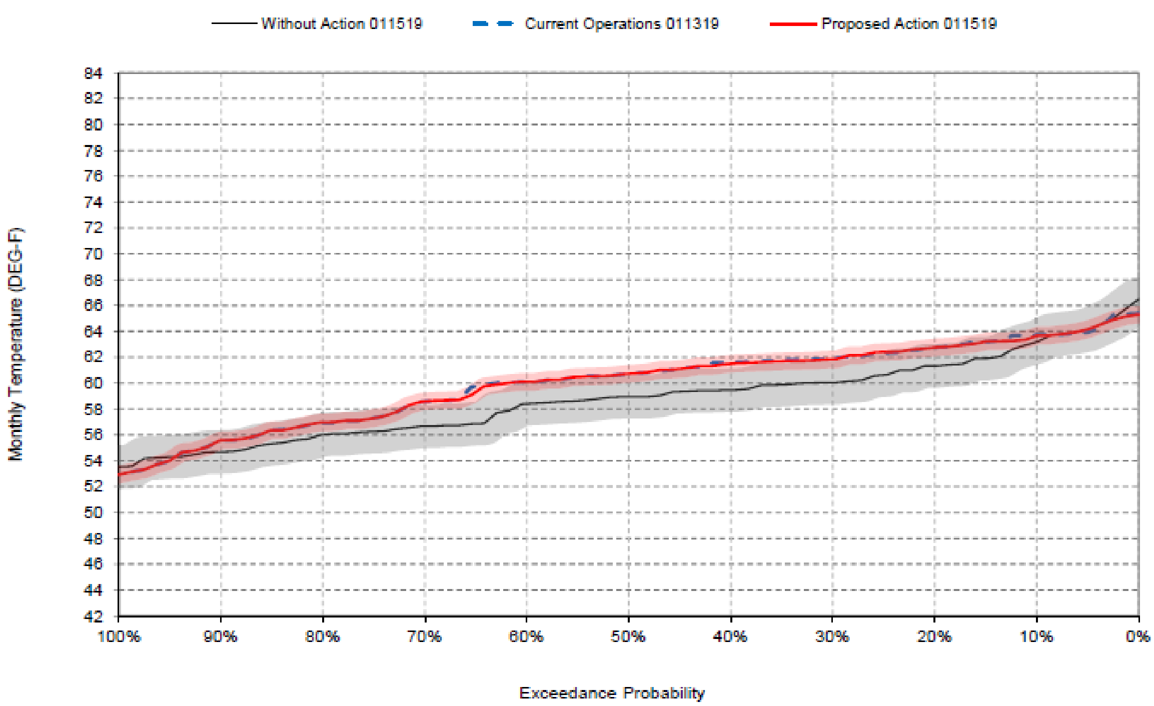


Figure 5.6-31. HEC-5Q Sacramento River Water Temperatures at Knights Landing under the WOA, COS and proposed action scenarios, April

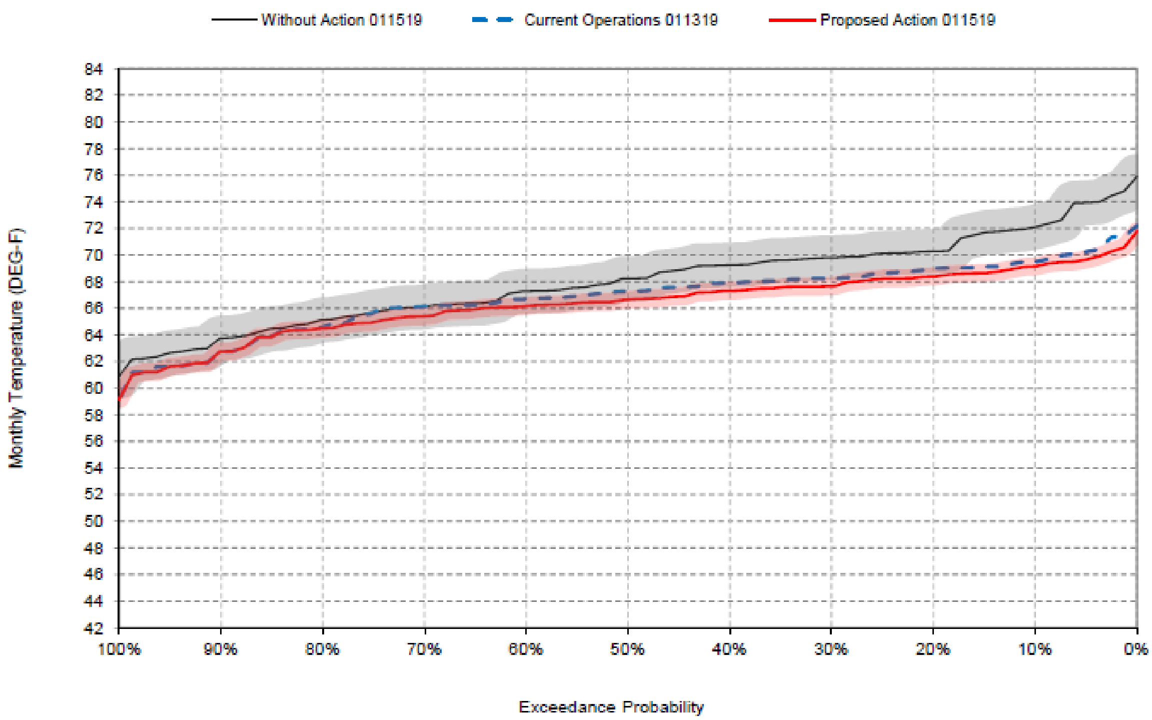


Figure 5.6-32. HEC-5Q Sacramento River Water Temperatures at Knights Landing under the WOA, COS and proposed action scenarios, May

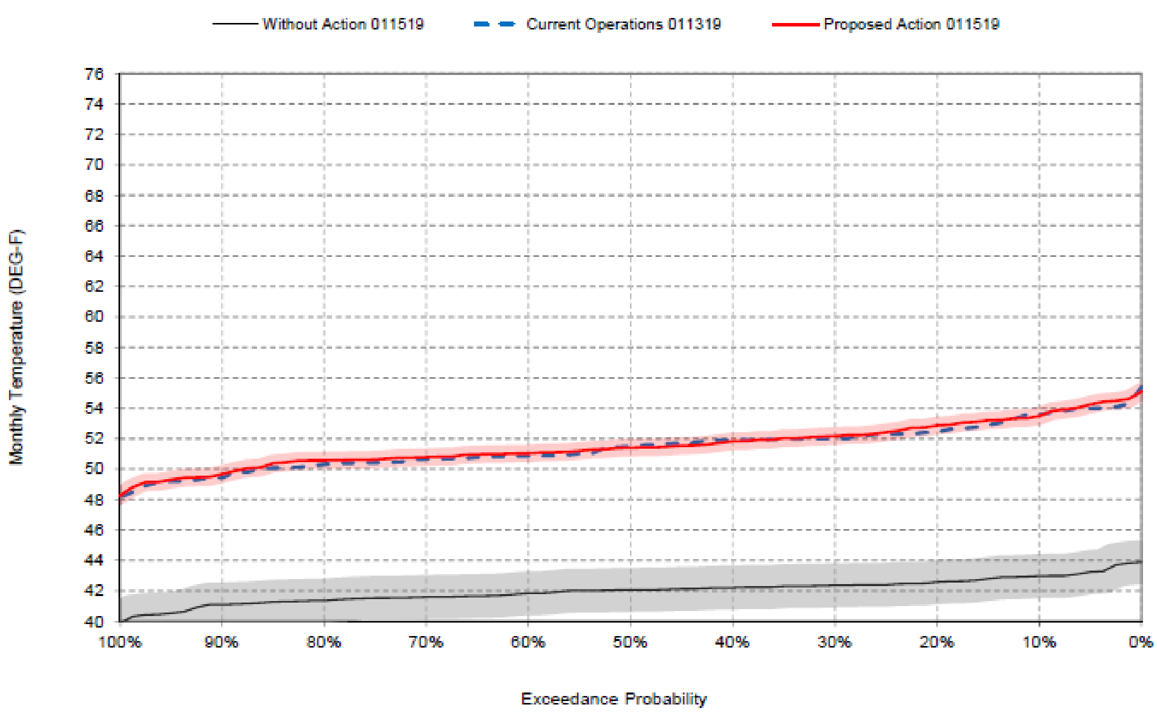


Figure 5.6-33. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the WOA, COS and proposed action scenarios, December

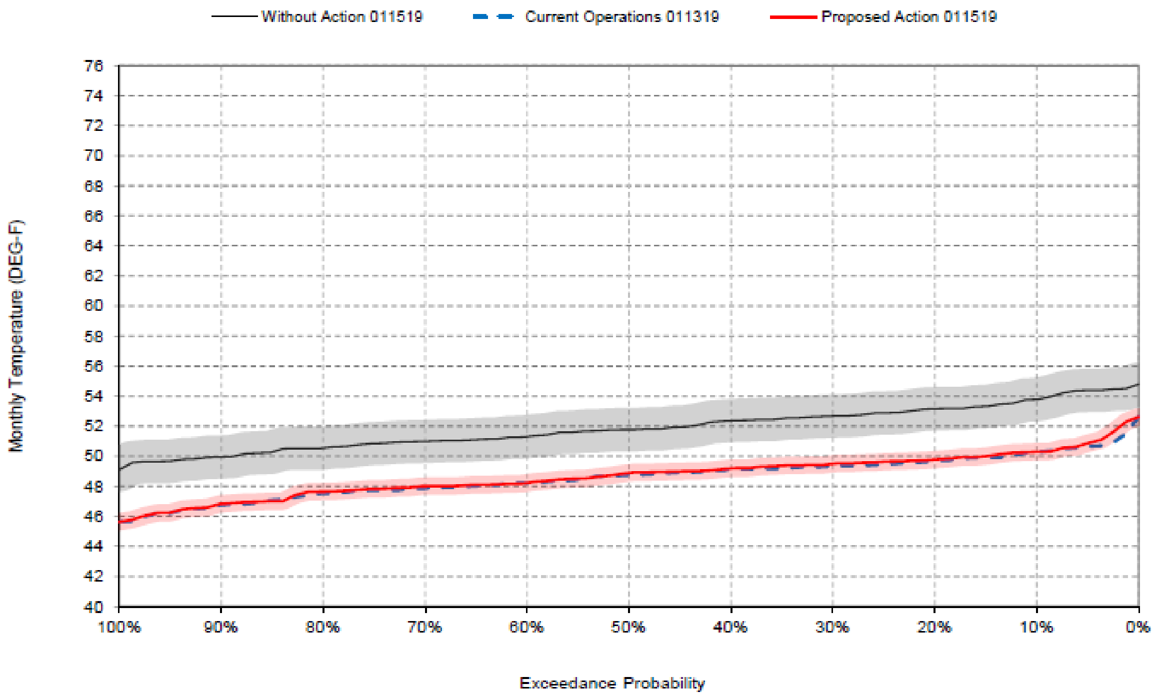


Figure 5.6-34. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the WOA, COS and proposed action scenarios, April

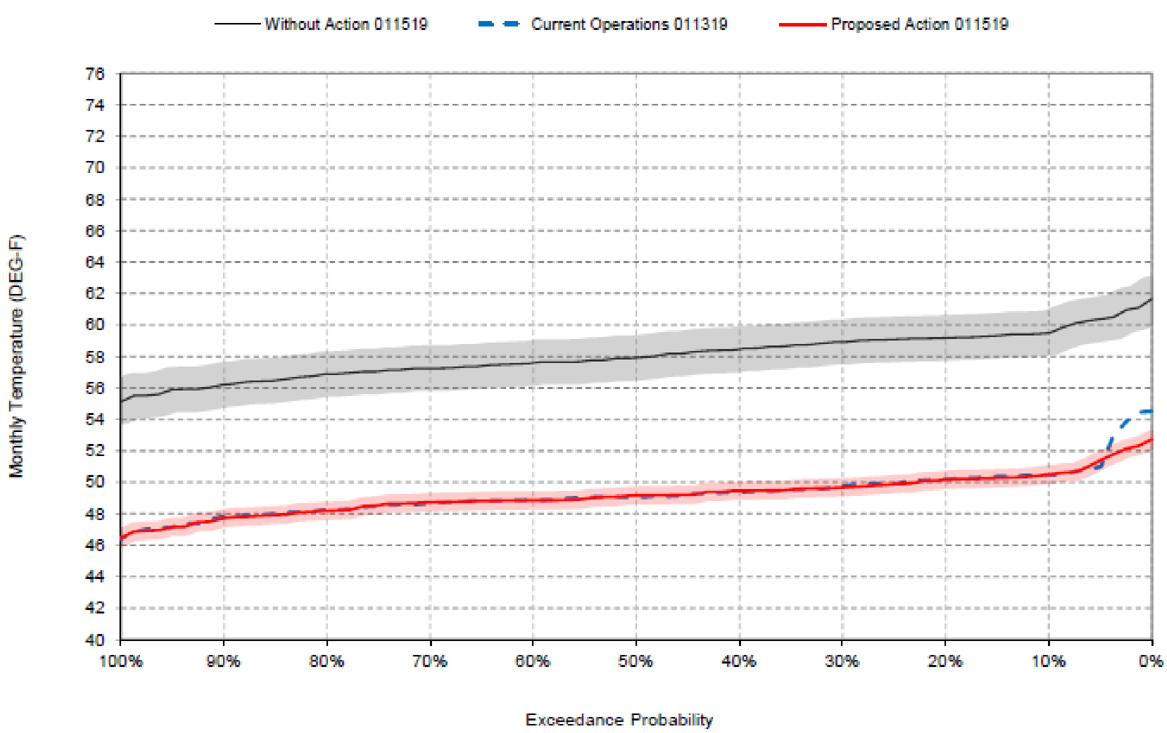


Figure 5.6-35. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the WOA, COS and proposed action scenarios, May

There are few differences in water temperatures between the proposed action and COS scenarios during any of the months that adult Winter-run Chinook Salmon migrate upstream in the middle Sacramento River or hold in the upper river (see Appendix D, *Modeling*). Under the proposed action and COS scenarios, the monthly mean water temperatures in the middle Sacramento River below the Colusa Basin Drain would be below the 68 degrees Fahrenheit threshold for immigrating adults from December through April, but would exceed the threshold in May in about 30 percent of the years (Figure 5.6-31). In the upper Sacramento River at Keswick Dam under the proposed action and COS scenarios, the average water temperatures would be well below the 61 degrees Fahrenheit threshold for holding adults from December through May (Figures 5.6-32-34). The May water temperatures in the middle Sacramento River modeled for many years under both the proposed action and COS scenarios would likely negatively impact Winter-run Chinook Salmon adults migrating at that time in the middle Sacramento River, compared to WOA.

5.6.3.1.5 Adult Holding in the Upper Sacramento River

As indicated by the SAIL conceptual model (Figure 5.6-6), flows from Keswick Dam releases affect water temperature, DO, and other habitat attributes that influence the timing, condition, distribution, and survival of adult Winter-run Chinook Salmon during their holding and spawning in the upper Sacramento River. The period of holding is essentially the same as that for upstream migration in the middle and upper Sacramento River, December through May. Spawning extends this period through June, July and August.

CalSim modeling also indicates that WOA flows are generally similar to or moderately higher than proposed action during December through February (Figures 15-9 through 15-11 in the CalSim II Flows section of Appendix D), are much higher than proposed action during March and April and during May of wetter years (Figures 15-12 through 15-14 in the CalSim II Flows section of Appendix D), and are lower than proposed action flows during June through August (Figures 15-15 through 15-17 in the CalSim II Flows section of Appendix D). In general, higher flows are likely to benefit holding and spawning adult Winter-run Chinook Salmon by affording better water quality (including cooler water temperatures and higher DO), reduced exposure to pathogens, lower risk from anglers, and a greater area of river bed with suitable attributes for redds (Windell et al. 2017). The proposed action scenarios would have much higher flows than the WOA scenario during summer, when flow is generally low and so particularly likely to limit Winter-run Chinook Salmon holding and spawning success. Therefore, the proposed action is expected to be more protective of Winter-run Chinook Salmon than the WOA conditions.

Flows during the December through August period would generally be similar between the proposed action and COS scenario (Figure 15-9 through 15-17 in the CalSim II Flows section of Appendix D). The biggest differences among these scenarios would occur in June for the upper 70 percent of flows, when proposed action scenario flows would be slightly greater than COS flows. The differences occur over a range of flows from 8,000 cfs to 16,000 cfs, all of which are suitable for holding and spawning adults (USFWS 2003), therefore, flows are not expected to substantially affect adult Winter-run Chinook Salmon.

As noted above, the period of adult holding and spawning in the upper Sacramento River extends from December through August. In the upper Sacramento River at Keswick, water temperatures under the proposed action are similar to WOA water temperatures during March (Figure 5-12 in the HEC5Q Temperatures section of Appendix D), well above the WOA scenario water temperatures from December through February (Figure 5-9 through 5-11 in the HEC5Q Temperatures section of Appendix D), and well below the WOA scenario water temperatures in April through August (Figures 5-13 through 5-17 in the HEC5Q Temperatures section of Appendix D). Water temperatures under the WOA scenario exceed the

61 degrees Fahrenheit holding threshold in almost all years during June through August and the 56 and 53.5 degrees Fahrenheit spawning threshold in almost all years during May through August. In contrast, water temperatures under the proposed action do not exceed the 61 degrees Fahrenheit holding threshold in almost all years of every month in the December through August period and do not to exceed the 56 and 53.5 degrees Fahrenheit thresholds in almost all years of all months in the period, except for 3 and 10 percent of years in July and August, respectively. These results indicate that the proposed action, relative to the WOA, provides a clear benefit to adult Winter-run Chinook Salmon individuals holding and spawning in the upper Sacramento River.

There are few differences in water temperatures among the proposed action and COS scenarios during any of the months that adult Winter-run Chinook Salmon hold and spawn in the upper Sacramento River (e.g., Figures 5-9 through 5-17 in the HEC5Q Temperatures section of Appendix D). At Keswick Dam, under the proposed action and COS, the mean water temperatures would be below the 61 degrees Fahrenheit threshold for holding adults for all months from December through August, except for the warmest one percent of years in August (Figure 5-17 in the HEC5Q Temperatures section of Appendix D). The 56 degrees Fahrenheit thresholds for spawning adults would be exceeded under the proposed action and COS scenarios only during August in about five percent of years, while the 53.5 degrees Fahrenheit threshold would be exceeded in May through August under COS, but only July and August under the proposed action. The proposed action exceeds the 53.5 degree Fahrenheit threshold 10 percent fewer years in July, and 15 percent less years in August compared to COS. In view of the improved water temperature management operations, including less releases for Delta outflow and more cold water storage, the proposed action is expected to benefit the Winter-run Chinook Salmon adults relative to the COS.

5.6.3.2 Spring Pulse Flows

5.6.3.2.1 Egg to Fry Emergence

As shown in the conceptual model, flow releases affect stranding/dewatering of redds (not applicable in the spring), dissolved oxygen, and temperature. In addition, spring pulse flows could reduce cold water pool available for Winter-run Chinook Salmon eggs, reducing egg survival. Therefore, Reclamation only proposes pulse flows if projected May 1 Shasta storage indicates a likelihood of sufficient cold water to support summer cold water pool management (likely storage greater than 4 MAF). Reclamation would not make a spring pulse release if the release would cause Reclamation to drop into a Tier 4 Shasta summer cold water pool management (i.e., the additional flow releases would decrease cold water pool such that summer Shasta temperature management drops in Tier 4), would interfere with meeting performance objectives, or would interfere with the ability to meet other anticipated demands on the reservoir.

5.6.3.2.2 Rearing to Outmigrating Juveniles in Upper and Middle Sacramento River

As indicated in the conceptual model, spring pulse flows could help trigger outmigration of Winter-run Chinook Salmon juveniles. See the Spring-run Chinook Salmon section for a discussion of benefits of spring pulses for outmigrating juveniles.

5.6.3.2.3 Adult Migration from Ocean to Upper Sacramento River

Spring pulses would have potentially beneficial effects for Winter-run Chinook Salmon adults who are migrating up the Sacramento River in the late spring. As indicated in the conceptual model, the spring pulses could cool temperatures, improved dissolved oxygen, and help avoid stranding, allowing for better passage and increased adult survival.

5.6.3.3 Fall and Winter Refill and Redd Maintenance

5.6.3.3.1 Egg to Fry Emergence

As shown in the conceptual model, flow releases affect stranding/dewatering, dissolved oxygen, and temperature. The proposed action would allow for higher fall flows than WOA, leading to less dewatering of the last few emerging Winter-run Chinook Salmon redds. The proposed action would also reduce overall instances of temperature dependent mortality compared to the COS, as reduced fall flows helps to build storage for the next year, but may result in dewatering limited redds in certain years in order to protect the next year's cold water resource. Rearing to Outmigrating Juveniles in Upper and Middle Sacramento River

Winter-run Chinook Salmon rearing and outmigrating juveniles would experience higher fall flows than under WOA, leading to more food, rearing habitat, and cover. Flows would be similar to those under COS, or lower.

5.6.3.4 Delta Seasonal Operations

Under WOA conditions, the Delta Cross channel would be closed and no CVP or SWP diversion would occur. The proposed action stores water in the fall, winter, and spring for release and conveyance through the Delta in the summer and fall.

5.6.3.4.1 Rearing to Outmigrating Juveniles in Bay-Delta

Rearing Winter-run Chinook Salmon are present in the Delta between October and May. Key habitat attributes relevant to seasonal operations in the Delta include outmigration cues and entrainment risk.

Hydrodynamic changes associated with river inflows and South Delta exports have been suggested to adversely affect juvenile Chinook Salmon in two distinct ways: 1) "near-field" mortality associated with entrainment to the export facilities, and 2) "far-field" mortality resulting from altered hydrodynamics. Near-field or entrainment effects of proposed seasonal operations can be assessed by examining patterns of proportional population entrainment available from decades of coded wire tag studies (e.g. Zeug and Cavallo 2014). A foundation for assessing far-field effects has been provided by work of the Collaborative Adaptive Management Team's (CAMT) Salmonid Scoping Team (SST). The SST completed a thorough review of this subject and defined a driver-linkage-outcome (DLO) framework for specifying how water project operations (the "driver") can influence juvenile salmonid behavior (the "linkage") and potentially cause changes in survival or routing (the "outcome"). The SST concluded altered "Channel Velocity" and altered "Flow Direction" were the only two hydrodynamic mechanisms by which exports and river inflows could affect juvenile salmonids in the Delta. Figure 5.6-35 provides a simplified conceptual model of the DLO defined by the CAMT SST.

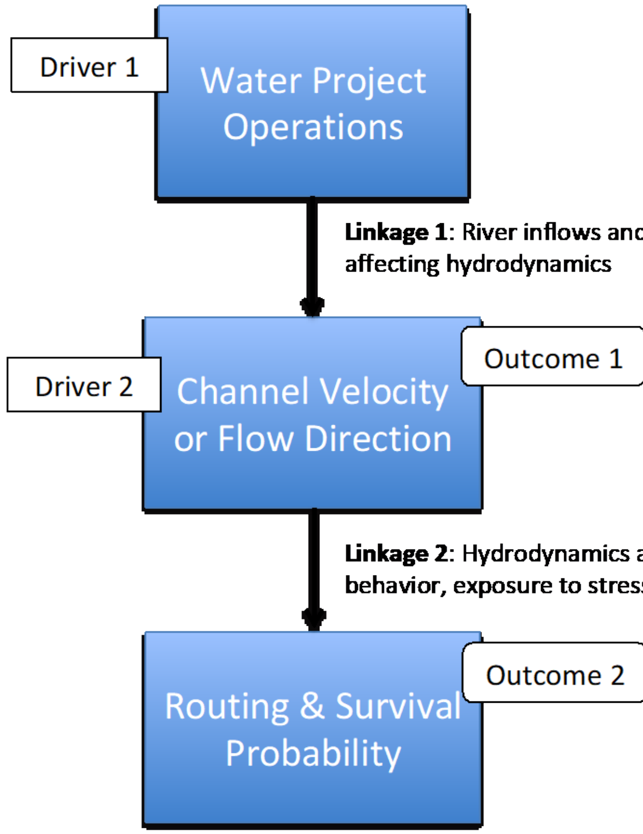


Figure 5.6-36. Conceptual Model for Far-field Effects of Water Project Operations on Juvenile Salmonids in the Delta. This CM is a Simplified Version of the Information Provided by the CAMT SST.

In order to assess the potential for water project operations to influence survival and routing, Reclamation and DWR analyzed Delta hydrodynamic conditions by creating maps from DSM2 Hydro modeling. The maps are based on a comparative metric, proportion overlap (more below), to capture channel-level hydrodynamic details as a single number for color-scale mapping of Delta channels.

The objective of the comparative metric is to summarize the water velocity time series for each channel and scenario such the channel-level comparison is captured in a single number. For the proportion overlap metric, kernel density estimates are calculated on each time series. The kernel density estimates represent a non-parametric smoothing of the empirical distribution of time series values. The proportion overlap of two kernel density estimates is calculated with the following steps: 1) calculate the total area under the curve (AUC_t) as the sum of the AUC for each density estimate, 2) calculate the AUC of the overlapping portions (AUC_o) of the two density distributions being compared, and 3) calculate the overlapping proportion of the density distributions as AUC_o/AUC_t. Proportion overlap is naturally bound by zero and one; a value of zero indicates no overlap and a value of one indicates complete overlap. Lower values of proportion overlap identify channels demonstrating larger differences in a scenario comparison.

The proportion overlap metric is best applied over relatively short time periods because seasonal and annual variation in water velocity can overwhelm differences between scenarios. Thus, Reclamation calculated proportion overlap for every DSM2 channel for two seasons (Dec-Feb, Mar-May) in each water year (1922-2003). DSM2 output was excluded from water year 1921 to allow for an extensive burn-in period. The proportion overlap was calculated based on hourly DSM2 output. Because each season was roughly 90 days, each comparison involved roughly 4,300 DSM2 values (2 scenarios * 24 hours * 90 days) for each channel.

Because the proportion overlap was calculated for each channel in each water year, the proportion overlap values were summarized prior to mapping (i.e., not feasible to map proportion overlap for every comparison in every water year). To summarize, the minimum and median proportion overlap for each channel for each water year type for each comparison was found. The minimum values represent the maximum expected effect. The median values represent the average expected effect. Note that the year with the minimum (or median) proportion overlap for one channel might not be the same year as for another channel.

5.6.3.4.1.1 Entrainment

As there are no exports under WOA, there is no entrainment risk under WOA. In the December through May period, the average total export rate, under the proposed action, is slightly higher compared to COS. Therefore, slightly higher entrainment is expected as compared to COS.

Zeug and Cavallo (2014) analyzed more than 1,000 release groups representing more than 28 million coded wire tagged juvenile fish including winter, late fall and fall run Chinook Salmon. This data represents large release groups of tagged smolts where the number of fish representing each release group lost to entrainment at the export facilities has been estimated. Cavallo (2016) provided a supplemental assessment of Winter-run Chinook Salmon entrainment risk (building upon Zeug and Cavallo 2014) that showed total CVP and SWP exports described entrainment risk better than OMR or other flow metrics. Entrainment loss results as reported below represents the proportion of coded wire tagged Winter-run Chinook Salmon released upstream of the Delta which were entrained at South Delta export facilities. This proportion accounts for and includes expansion for sampling effort at the salvage facilities and also prescreen mortality. With total exports of ≤ 6,500 cfs, entrainment loss rates for Winter-run Chinook Salmon range between 0 and 1.5 percent (mean 0.1%) (Zeug and Cavallo, 2014). With total exports greater than 6,500 cfs, entrainment losses range between 0 and 4 percent (mean 0.25%) (Zeug and Cavallo, 2014). For December through February, the proposed action has an average total export rate similar to COS (7,988 and 7,622 cfs respectively; Figure H-1 – Appendix H, *Bay-Delta Aquatics Effects Figures*), and will therefore have similar entrainment risk. In the March through June period, total exports for the proposed action increase entrainment risk relative to COS (5,873 vs. 4,174 cfs, respectively; Figure H-2 – Appendix H, *Bay-Delta Aquatics Effects Figures*), but entrainment losses should average 0.1 percent and not exceed 1.5 percent. While entrainment risk will increase under the proposed action as compared to WOA or COS, the proposed action includes restrictions to OMR (-3,500 cfs and -2,500 cfs) when loss of Winter-run Chinook salmon or steelhead reaches 50 percent of the annual loss threshold. CalSim modeling incorporates an assumption for this cumulative salvage restriction.

According to SacPAS (Appendix F, *Juvenile Salmonid Monitoring, Sampling, and Salvage Timing Summary from SacPAS*), between 0 and 6000 unclipped Winter-run Chinook salmon are currently salvaged at CVP and SWP fish facilities each year, and between 0 and 8000 clipped Winter-run Chinook salmon from the Livingston Stone Fish Hatchery. Salvage estimates are made by counting fish for 30 minutes every 2 hours, and multiplying by 4 to obtain the estimate for the number of fish that are entrained into Tracy Pumping Plant or eaten by predators in the canal or fish facility. Entrainment results in harassment and often mortality for juvenile Chinook salmon. Fish that are counted are salvaged and trucked back to the Delta where they are released and may complete their lifecycle.

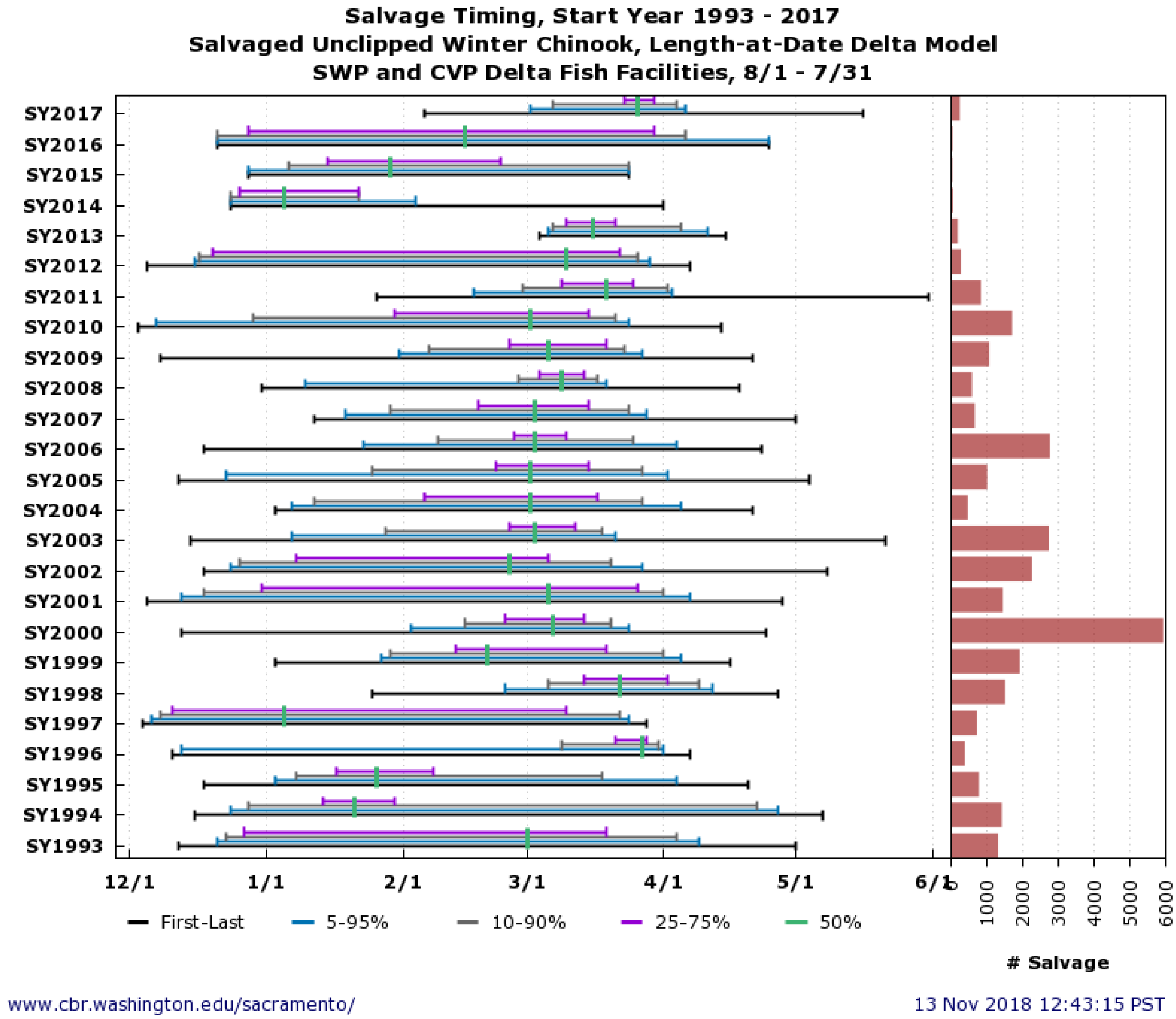


Figure 5.6-37. Juvenile Winter-run Chinook Salmon salvage at Jones and Banks Pumping Plants

5.6.3.4.1.2 Routing

Routing of juvenile Chinook Salmon into alternative migration routes is closely related to hydrodynamics (Perry et al. 2015; Cavallo et al. 2015; Steel et al. 2012). Changes to hydrodynamics in Delta channels resulting from the proposed action were evaluated using DSM2. Juvenile Winter-run Chinook Salmon are present in the Sacramento River at Sherwood Harbor upstream of the first distributary junctions between November and March with peak abundance in February and March (Table 5.6-1).

Comparing the proposed action to WOA in the December to February period revealed velocity overlap <50% in Dry, Above Normal and Wet years and <60% in Critical and Below Normal years (Figure H-4 – Appendix H, *Bay-Delta Aquatics Effects Figures*) with higher velocities in the WOA scenario in all water year types. This pattern indicates routing into the interior Delta would be higher under the proposed action than under WOA (Perry et al. 2015). In the March to May period comparison of the proposed action revealed similar patterns of velocity overlap indicating routing into the interior Delta would be higher under the proposed action during March to May. Comparing the proposed action with WOA in March to May revealed low overlap in Sacramento River main stem velocities between the Steamboat-

Sutter Junction and the DCC-Georgiana Slough junction (Figure H-6– Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocities were higher under the WOA scenario, indicating routing into the interior Delta under the proposed action would be higher than WOA.

Abundance of juvenile Winter-run Chinook Salmon at Chipps Island peaks in March and April but fish are collected between December and May (Table 5.61). During this time period, Winter-run Chinook Salmon originating from the Sacramento River that enter the interior Delta via Georgiana Slough and the Delta Cross Channel can potentially be exposed to hydrodynamic effects associated with the CVP and SWP that could affect routing. Once these fish arrive at the junction of the Mokelumne River and the San Joaquin River, they can move south toward the export facilities or west toward the ocean. The December to February period analysis of DSM2 data indicates that there is little change to velocities in the region of the junction of the Mokelumne and San Joaquin rivers between the proposed action and WOA (Figures H-7 and H-8 – Appendix H, *Bay-Delta Aquatics Effects Figures*).). Similar results were obtained when comparing the proposed action to WOA in the March to May period (Figures H-9 and H-10– Appendix H, *Bay-Delta Aquatics Effects Figures*).).

In the December to February period, velocity overlap between proposed action and COS in the Sacramento River main stem between the Sutter-Steamboat and DCC/Georgiana Slough Junctions, was more than 50 percent in all water year types (Figure H-3 – Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocities were higher under proposed action in all water year types in December through February indicating routing into the interior Delta would be lower relative to COS (Perry et al. 2015 described for the December-February period (Figure H-11 – Appendix H, *Bay-Delta Aquatics Effects Figures*).).

Overall, the proposed action results in lower flows in the Delta in the spring than under WOA, during the outmigrating juvenile time period. Survival probabilities are non-linear; however, the lower discharge at Freeport in the spring under the proposed action results in greater probability of routing into the interior Delta, which has the lowest survival probability regardless of flow.

5.6.3.4.1.3 Through-Delta Survival

Perry et al. (2018) found that the effect of flow on survival is not uniform throughout the Delta. Relationships between flow and survival were significant only in reaches where flow changes from bi-directional to unidirectional when discharge increases.

To examine potential effects of the proposed action, changes in velocity distributions were examined for the Sacramento River at Walnut Grove and Steamboat Slough which are both in this “transitional” region. During the December to February period at Walnut Grove, there are higher velocities under WOA than the proposed action (Figure H-12– Appendix H, *Bay-Delta Aquatics Effects Figures*). When the proposed action was compared to WOA at Steamboat Slough, overlap was moderate to high with values between 42.6 and 72.6 percent (Figure H-14– Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocities were higher under the WOA in all water year types (Figure H-14– Appendix H, *Bay-Delta Aquatics Effects Figures*). In the March through May period at Walnut Grove, when the proposed action was compared to WOA, velocity overlap was variable among water year types from a low of 14.1% in Wet years to 56.9% in Critical years (Figure H-16– Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocity overlap was lower when proposed action was compared to WOA at Steamboat Slough in the March through May period (Figure H-18– Appendix H, *Bay-Delta Aquatics Effects Figures*). The lowest value occurred in Wet years (19.1%) and highest in Critical years (69.5%). In all water year types, velocities were greater under the WOA relative to the proposed action.

Overall, the proposed action results in lower flows in the Delta in the spring than under WOA, during the outmigrating juvenile time period. Survival probabilities are non-linear; however, the lower discharge at Freeport in the spring under the proposed action results in lower survival in the transition reaches. Lower flows also lead to greater probability of routing into the interior Delta, which has the lowest survival probability regardless of flow.

5.6.3.5 Delta Cross Channel Operations

5.6.3.5.1 Rearing to Outmigrating Juveniles in Bay-Delta

Under WOA conditions, the DCC would remain closed and Winter-run would not be entrained into the central and south Delta through the DCC. Under the proposed action, the DCC may be closed for up to 45 days from November through January for fishery protection purposes. From February 1 through May 20, the gates are closed for fishery protection purposes. The gates may also be closed for 14 days from May 21 through June 15 for fishery protection purposes. The peak migration of juvenile Winter-run Chinook Salmon in the Sacramento River at Sherwood Harbor, which is near the DCC, occurs from February through March (Table 5.6-1). Therefore, the DCC is closed for the majority of the juvenile Winter-run Chinook Salmon migration period in the Sacramento River and as such the proportion of juvenile Winter-run Chinook Salmon exposed to an open DCC would be negligible. Juvenile Chinook Salmon entrained into an open DCC and transported to the interior Delta have reduced survival (Perry et al. 2010; Perry et al. 2018).

5.6.3.6 Agricultural Barriers

Neither juvenile nor adult Winter-run Chinook Salmon are not expected to co-occur in space or time with the agricultural barriers indicating no potential impacts. After this point, in this document, if no effects are expected for a species, the proposed action component will not be discussed.

5.6.3.7 Contra Costa Water District Rock Slough Intake

CCWD’s operations in the proposed action are consistent with the operational criteria specified in separate biological opinions and permits that govern operations at CCWD’s intakes and Los Vaqueros Reservoir (NMFS 1993; NMFS 2007; NMFS 2010; NMFS 2017; USFWS 1993a; USFWS 1993b; USFWS 2000; USFWS 2007; USFWS 2010; USFWS 2017; CDFG 1994; CDFG 2009). The subject of this consultation is the actual diversion of water through the Rock Slough Intake, covered under the 2009 biological opinion on the long-term coordinated operations of the CVP and SWP. However, since the 2009 biological opinion, the Rock Slough Fish Screen has been built, and entrainment of salmonids resulting from diverting water the into Rock Slough intake has been fully avoided. Adverse effects of fish screen operation are covered under the 2017 biological opinion.

The Contra Costa Canal Rock Slough Intake is located on a dead-end slough, far from the main migratory route for Winter-run Chinook Salmon (NMFS 2017), approximately 18 miles from the Sacramento River via the shortest route. Designated critical habitat for Winter-run Chinook Salmon does not occur within Rock Slough, but is present further to the north in the Delta (NMFS 2017; NMFS 2014). Salmonids are expected to avoid the area of the Rock Slough Intake during certain times of the year based on historical water temperatures.

Fish monitoring prior to the construction of the Rock Slough Fish Screen (RSFS) indicates the timing and magnitude of Winter-run Chinook Salmon presence near the Rock Slough Intake. Since 1994, fish monitoring has been conducted by CDFW and CCWD consistent with the separate biological opinions and permits that govern CCWD’s operations. From 1994 through 1999, CDFW conducted fish monitoring at the Rock Slough Intake and in the Contra Costa Canal up to the first pumping plant. Over this 6-year period, CDFW captured a total of 13 juvenile Winter-run Chinook Salmon from January through May (CDFG 2002; NMFS 2017). From 1999-2009, the 11 years prior to construction of the RSFS, CCWD's Fish Monitoring Program collected no juvenile or adult Winter-run Chinook Salmon at the Rock Slough Headworks (Reclamation 2016; NMFS 2017).

Since construction of the RSFS, operation of the hydraulic rake cleaning system has been shown to trap and kill adult Chinook Salmon and other non-listed fish (Reclamation 2016). From 2011-2018, 47 salmon were recovered at the RSFS (Reclamation 2016, Appendix A; Tenera 2018a), but none of the captured fish were identified as Winter-run Chinook Salmon (NMFS 2017).

NMFS issued a biological opinion in 2017 (NMFS 2017) that considered improvements to the RSFS facility including the hydraulic rake cleaning system, operations and maintenance (O&M) of the RSFS and associated appurtenances, and administrative actions such as the transfer of O&M activities from Reclamation to CCWD. NMFS determined that the O&M of RSFS may result in the incidental take of juvenile Winter-run Chinook Salmon and provided an incidental take limit based upon the number of listed fish collected in the pre and post-construction RSFS monitoring (NMFS 2017). The incidental take provided in NMFS 2017 is five juvenile Winter-run Chinook Salmon per year.

5.6.3.7.1 Juveniles

Due to the location of the Rock Slough Intake near the end of a dead-end slough, far from the main migratory routes, juvenile Winter-run Chinook Salmon are not likely to be in the vicinity of the Rock Slough Intake. However, according to NMFS (2017), juvenile salmon can be "drawn" into the south Delta under reverse flows and high CVP and SWP pumping rates. One indicator of reverse flows is the net flow in Old and Middle Rivers (OMR). Rock Slough Intake is located on Rock Slough, approximately 3.5 miles west of the junction of Rock Slough and Old River, which is over 12 river miles north of the gates to the SWP Clifton Court Forebay. Given its location, the Rock Slough Intake does not affect OMR, and any effect that diversions at Rock Slough Intake would have in the Old and Middle River corridor would be to increase the northerly (positive) flow away from the Banks and Jones Pumping Plants.

However, diversions at the Rock Slough Intake could affect flows in the San Joaquin River at Jersey Point, which is approximately 14 river miles from the Rock Slough Intake (via the shortest route through Franks Tract). Mean velocity in a river channel can be calculated by dividing the flow rate by the cross-sectional area of the channel. The maximum effect of Rock Slough diversions on the channel velocity would be the maximum diversion rate (350 cfs) divided by the minimum cross-sectional area of the channel. This calculation assumes that all water diverted at Rock Slough comes from the San Joaquin River at Jersey Point, which is a conservative assumption (i.e., overestimates the effect on velocity). The cross-sectional area of the San Joaquin River at Jersey Point is approximately 60,500 square feet (sf), but varies depending on the tidal stage from approximately 56,000 sf (at low tide and low San Joaquin River flow) to 68,000 sf (at high tide and high San Joaquin River flow) as shown in Figure 5.6-36.

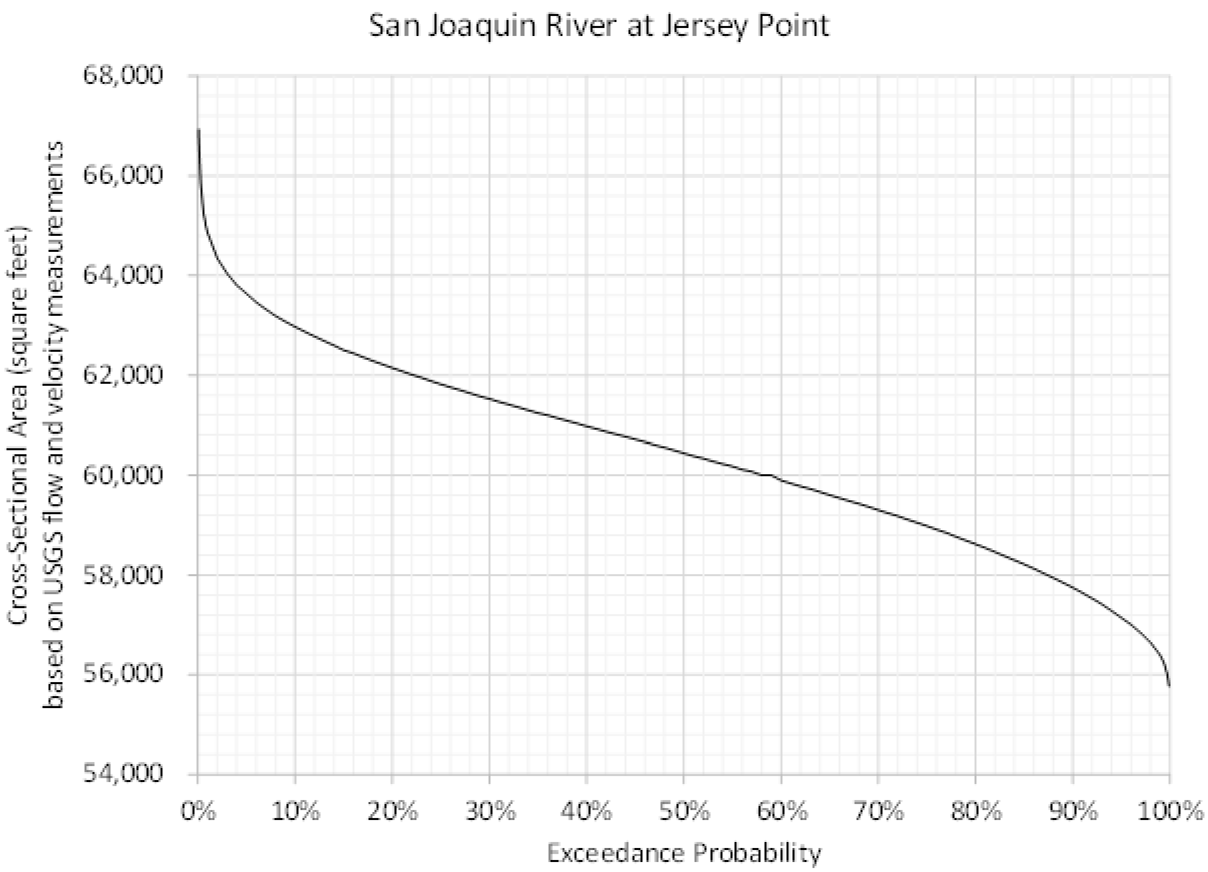


Figure 5.6-38. Cross-sectional area of the San Joaquin River at Jersey Point (Station: 11337190) Calculated from USGS Measurements of Flow and Velocity every 15 Minutes for Water Years 2014 through 2018.

The maximum effect of water diversions at Rock Slough Intake on velocity in the San Joaquin River at Jersey Point is calculated as 350 cfs divided by 56,000 square feet; resulting in 0.00625 feet per second (ft/sec). For comparison, the velocity threshold for design of fish screens to prevent impingement of salmonids is 0.33 ft/sec, which is 50 times the maximum possible contribution from Rock Slough diversions. Furthermore, the actual effect is likely to be much lower than 0.00625 ft/sec because the water diverted at the Rock Slough Intake does not all come from the San Joaquin River west of Jersey Point.

Recognizing that CCWD owns and operates two additional intakes in the south Delta, the combined effect of all three intakes is examined. CCWD's Old River Intake and Middle River Intake have a physical capacity of 250 cfs at each intake. If CCWD were to divert at all three intakes at the maximum capacity at the same time, total CCWD diversions would be 850 cfs. The corresponding effect on velocity in the San Joaquin River at Jersey Point would be 0.015 ft/sec. The velocity threshold used to protect salmonids from diversions in the vicinity of fish screens (0.33 ft/sec) is over 21 times greater than the maximum possible contribution from CCWD's combined physical capacity. The water diversions at the Rock Slough Intake when combined with diversions at CCWD's Old River Intake and Middle River Intake have a negligible effect on velocity along the migratory path for juvenile Winter-run Chinook Salmon and are not likely to affect the movement of juvenile salmonids.

Nonetheless, even extremely small changes in velocity can affect the movement of neutrally buoyant articles such as phytoplankton. To examine the effect on neutrally buoyant particles, the distance that a particle would travel due to the maximum permitted Rock Slough diversions over the course of a day is calculated. A change in velocity of 0.00625 ft/sec could move a neutrally buoyant particle approximately 540 ft over the course of the day (0.00625 ft/sec * 86,400 sec/day). For comparison, the tidal excursion on the San Joaquin River at Jersey Point during a flood tide (i.e., the distance a particle will travel tidally upstream during a flood tide) is about 34,000 ft on average (or 6.4 miles), which is about 63 times the distance that diversions at Rock Slough could move a particle at the same location over the course of a full day. Therefore, the maximum possible contribution of diversions at Rock Slough on movement of neutrally buoyant particles such as phytoplankton is not significant in comparison to the tidal excursion and mixing at this location.

5.6.3.7.2 Adults

Rock Slough is poor habitat with relatively high water temperature and a prevalence of aquatic weeds. Due to the location of the Rock Slough Intake near the end of a dead-end slough, far from the main migratory routes, and due to the poor quality of habitat within the slough, adult Winter-run Chinook Salmon are not likely to be in the vicinity of the Rock Slough Intake and have never been observed in 24 years of fish monitoring (1994-2018). However, if some adults stray into Rock Slough, the water exiting the Contra Costa Canal on ebb tide may create a false attraction to adult salmon that are migrating upstream (NMFS 2017).

NMFS has advised Reclamation that salmonids will likely be less attracted to the area near the intake if tides can be reduced (Reclamation 2016). As illustrated in NMFS (2017) (Figure 10), water diversions at the Rock Slough Intake reduce the ebb tidal flows through the RSFS. Thus, the diversion of water at the Rock Slough Intake, which is the subject of this consultation, reduces the false attraction created by the ebb tides existing the Contra Costa Canal. Furthermore, it is worth noting that the ebb tidal flow in Rock Slough will be substantially reduced when the Contra Costa Canal is encased in a pipeline. This ongoing, multi-phased project (the Canal Replacement Project) is being conducted as a separate action by CCWD and has undergone separate environmental review. Completion of the Canal Replacement Project will result in tidal flows being significantly reduced at the Rock Slough Intake. Modeling of the area indicates that with only the first two phases complete, ebb flows reach up to 160 cfs, but with the Contra Costa Canal fully encased, ebb flows would be greatly muted to about 10 cfs.
Although the likelihood that adult Winter-run Chinook Salmon will be present near the Rock Slough Intake is low, a small number of fish could stray into Rock Slough, or be attracted by the flows exiting the Contra Costa Canal on ebb tides.

5.6.3.8 North Bay Aqueduct

The proposed action includes the North Bay Aqueduct (NBA) intake in the North Delta and operation of the Barker Slough Pumping Plant. Listed salmonids may be present in the waterways adjacent to the Barker Slough Pumping Plant (monitoring data is available at https://www.wildlife.ca.gov/Regions/3). There should be no discernable effect to the Winter-run Chinook salmon due to the operations of the Barker Slough Pumping Facility. This is due to the infrequent presence of Winter-run Chinook salmon in the monitoring surveys indicating a low risk of entrainment. Further, Barker Slough Pumping Facility fish screens are designed to protect juvenile salmonids per NMFS criteria and should prevent entrainment while greatly minimizing any impingement of fish against the screen.

5.6.3.9 Water Transfers

Under the WOA scenaro, there is no pumping from the Delta and therefore no water transfers through Jones or Banks Pumping Plants. Under the proposed action, Reclamation is extending the water transfer window until November, from the current July through September window. This extension could result in increased flows entering the Delta and increased pumping at Jones and Banks Pumping Plants.

Egg, alevin, and fry lifestages of Winter-run Chinook Salmon do not occur in the Delta, and therefore would not be impacted by this action. Winter-run Chinook Salmon juveniles enter the Delta starting in December, and therefore would be unlikely to be exposed to increased pumping of water transfers through November. Adults returning from the ocean could possibly be in the Delta in July; however, they are strong swimmers, large fish that can avoid predators, and are unlikely to have impacts associated with direct entrainment of the pumping plants.

5.6.3.10 Clifton Court Aquatic Weed Removal

Juvenile Winter-run Chinook salmon are the only lifestage with a possibility of effects due to Clifton Court aquatic weed removal. Few if any juvenile Winter-run Chinook Salmon would be expected to be exposed to the Clifton Court Forebay Aquatic Weed Control Program. Juvenile Winter-run Chinook Salmon are present in the Delta between December and May with a peak in March and April (Table 5.6-1). The application of aquatic herbicide to the waters of CCF will occur during the summer months of July and August. Thus, the probability of exposing Winter-run Chinook Salmon to the herbicide is very low. Based on typical water temperatures in the vicinity of the salvage facilities during this period, the water temperatures would be incompatible with salmonid life history preferences, generally exceeding 70 degrees Fahrenheit by mid-June. Mechanical harvesting would occur on an as-needed basis and, therefore, Winter-run Chinook Salmon could be exposed to mechanical harvesting, if entrained into the CCF.

5.6.3.11 OMR Management

The proposed action includes management of Old and Middle River reverse flows (OMR) to minimize risk of entrainment to fish species, including restricting OMR flows to -5000 cfs when between 5 and 95 percent of any salmonid species are in the Delta, or January 1 to June 30, whichever window is smaller. Delta seasonal operations above describe entrainment in more detail. Restricting OMR flows to -5,000 cfs will reduce or avoid entrainment. Triggers based on salvage that further restrict OMR will further reduce entrainment. Enhanced monitoring and predictive tools will further reduce entrainment while increasing operational flexibility. Figure 5.6-37 shows historical salvage under the COS. Salvage under the proposed action is anticipated to be similar or less.

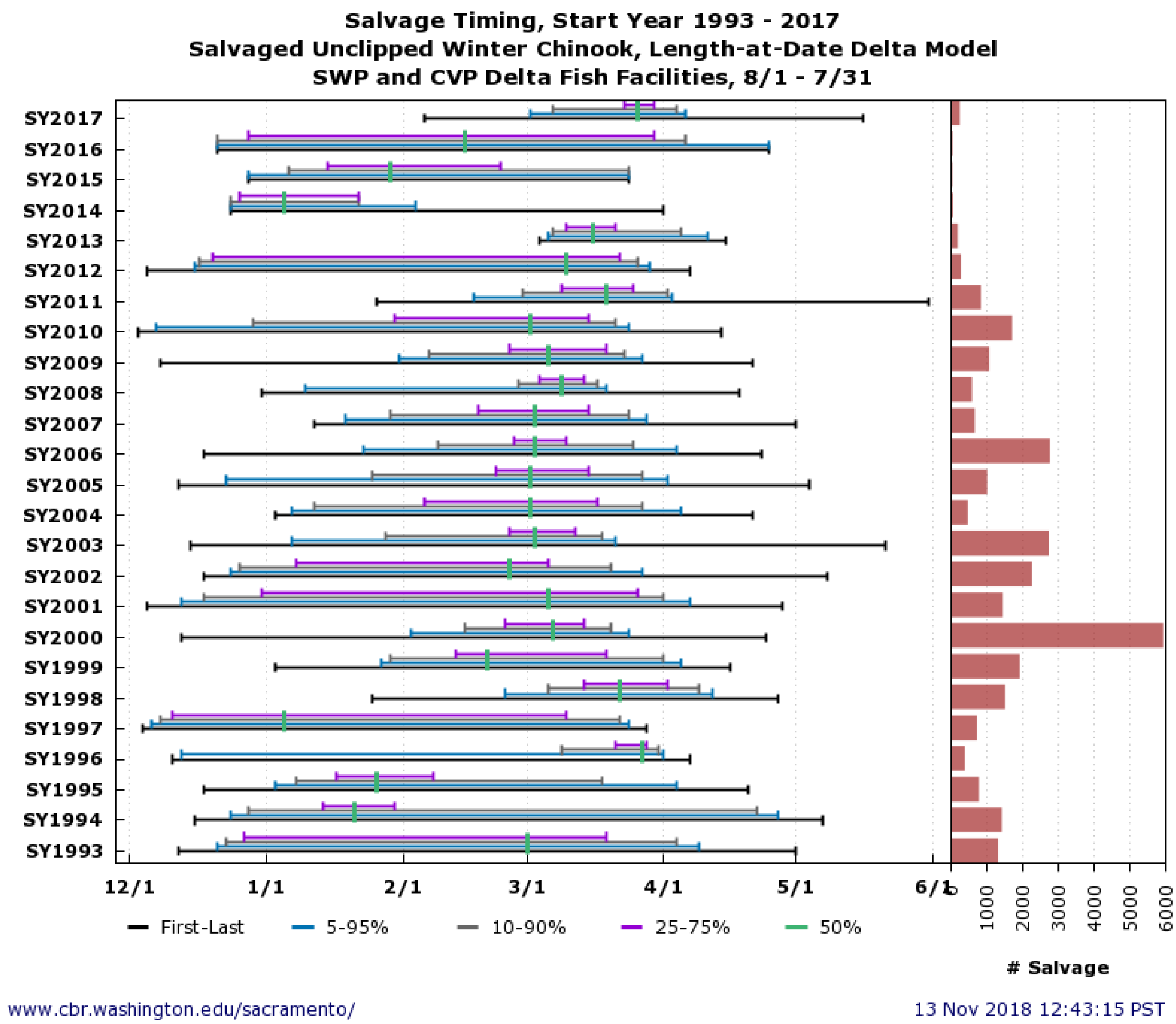


Figure 5.6-39. Salvage of Winter-run Chinook Salmon from 2009 to2018.

5.6.3.12 Operation of a Shasta Dam Raise

Reclamation would operate a raised Shasta Dam consistent with the rest of the proposed action. Therefore, effects described elsewhere in the document would also apply to the operation of a raised Shasta Dam, and there would be no operational changes.

5.6.4 Effects of Conservation Measures

The following are proposed conservation measures that are intended to offset the effects of operations and maintenance. These conservation measures would only occur due to the implementation of the Proposed Action and are beneficial in nature. The following analysis looks at the construction related effects of the measures and the benefits to the population once completed. Conservation measures would not occur under WOA.

5.6.4.1 Rice Decomposition Smoothing

Reclamation's proposed action to work with the SRS Contractors to smooth rice decomposition water demands would allow for higher fall flows than WOA, leading to less dewatering of the last few emerging Winter-run Chinook Salmon redds.

Under the proposed action, lower releases compared to the COS in late October and early November would result in late spawning Winter-run Chinook Salmon less likely to spawn in shallow areas that would be subject to dewatering during winter base flows.

Winter-run Chinook Salmon rearing and outmigrating juveniles would experience higher late fall flows than under WOA, leading to more food, rearing habitat, and cover.

5.6.4.2 Spring Management of Spawning Locations

Hendrix (2017) performed statistical analysis indicating that there is a correlation between warmer spring temperatures and later spawning Winter-run Chinook Salmon. This could result in an extended Shasta cold water pool management season beyond October 31. To offset this potential but uncertain effect, Reclamation will work with NMFS to experiment with spring temperatures and study the effects on spawning locations of Winter-run Chinook Salmon redds.

A spawning location study could result in beneficial or negative impacts to adult holding. Colder spring temperatures might allow for earlier spawning, and then emergence before temperatures have warmed in the late/summer and fall, leading to a successful life history strategy. Or, colder spring temperatures might result in Shasta Reservoir running out of cold water pool by the time of emergence, leading to mortality of Winter-run Chinook Salmon eggs or alevin.

5.6.4.3 Battle Creek Restoration

Under the Proposed Action, Reclamation would accelerate implementation of the Battle Creek Salmon and Steelhead Restoration Project. NMFS and USFWS Biological Opinions were issued in 2005 on this project, and that consultation discusses effects of Battle Creek restoration.

5.6.4.4 Lower Intakes near Wilkins Slough

5.6.4.4.1 Egg/Alevin Mortality

Egg and fry of Winter-run Chinook Salmon would not be affected by the construction of a new diversion and screens near Wilkins Slough, based Winter-run Chinook Salmon adults spawning from May through August with peak spawning during June and July (Table 5.6-1). Most spawning occurs within 10 miles of Keswick Dam (Windell et al. 2017) and spawning does not occur in Wilkins Slough. In addition, the construction of the diversion and screens would occur during an in-water work window (June 1 and October 1) so effects of construction on Winter-run Chinook Salmon eggs and fry would not occur. Replacement of the fish screens would allow for lower releases from Shasta in drought years and better preserve the cold water pool.

5.6.4.4.2 Egg to Fry Emergence

The installation of fish screens near Wilkins Slough would be beneficial to Winter-run Chinook Salmon egg and fry. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning.

Additionally, the installation of new diversions and screens that would operate at lower flows, would directly benefit fish of all life stages. The egg and fry lifestage of Winter-run Chinook Salmon, as well as the population, would benefit from this action.

5.6.4.4.3 Rearing to Outmigrating Juvniles in Upper Sacramento River

The installation of fish screens near Wilkins Slough would be beneficial to rearing and emigrating Winter-run Chinook Salmon in the Middle Sacramento River. As described earlier in rearing to outmigrating juveniles in the Upper Sacramento River. The rearing and emigrating Winter-run Chinook Salmon individuals in the middle Sacramento River, as well as the population, would benefit from this action.

Outmigrating juvenile Winter-run Chinook Salmon in the Upper Sacramento River would not be affected by the construction of a new diversion and fish screens near Wilkins Slough, based Winter-run Chinook Salmon juveniles emigrating from October through February with peak emigration occurring from December through January (Table 5.6-1). Construction of diversions and fish screens near Wilkins Slough would occur during an in-water work window (June 1 and October 1) so effects of construction on emigrating Winter-run Chinook Salmon is not expected.

If rearing Winter-run Chinook Salmon are present during the June 1 through October 1 in-water work window, individuals may be exposed to temporary disturbances associated with the construction of a cofferdam. Water quality may be temporarily disturbed, in addition to noise associated with construction of the cofferdam. Additionally, fish rescue operations may need be conducted during the period when water within the coffered area needs to be pumped. However, implementation of AMM's identified in Appendix E, *Avoidance and Minimization Measures* would further minimize those effects.

Construction of lowering intakes at Wilkins Slough would not have effects on rearing and emigrating Winter-run Chinook Salmon in the middle Sacramento River.

5.6.4.4.4 Rearing to Outmigrating Juveniles in Bay-Delta

Rearing to outmigrating juvenile Winter-run Chinook Salmon in the Bay-Delta would not be affected by the construction of a new diversion and fish screens near Wilkins Slough, based on Winter-run Chinook Salmon juveniles emigrating from October through February with peak emigration occurring from December through January (Table 5.6-1). Construction of diversions and fish screens near Wilkins Slough would occur during an in-water work window (June 1 and October 1) so effects of construction on rearing and emigrating Winter-run Chinook Salmon in the Bay-Delta is not expected.

5.6.4.4.5 Adult Migration from Ocean to Upper Sacramento River

The installation of fish screens near Wilkins Slough would be beneficial to immigrating adult Winter-run Chinook Salmon. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults. Additionally, the installation of new diversions and screens that would operate at lower flows would directly benefit fish of all life stages. Individual immigrating adult Winter-run Chinook Salmon, as well as the population, would benefit from this action.

Immigrating adult Winter-run Chinook Salmon would not be affected by the construction of a new diversion and fish screens near Wilkins Slough, based on adult Winter-run Chinook Salmon immigrating through the Delta into the Sacramento River Basin between December through April (Table 5.6-1). Construction of diversions and fish screens near Wilkins Slough would occur during an in-water work window (June 1 and October 1) so effects of construction on immigrating Winter-run Chinook Salmon in the Bay-Delta is not expected.

5.6.4.4.6 Adult Holding in the Upper Sacramento River

Wilkins Slough nor the Sacramento River near Wilkins Slough does not contain the necessary cool water habitat for holding Winter-run Chinook Salmon. Therefore, construction of a new diversion and fish screens near Wilkins Slough would not affect holding Winter-run Chinook Salmon.

5.6.4.5 Shasta Temperature Control Device Improvements

If feasibility analysis leads to construction of TCD improvements, improvements to the Shasta TCD would potentially improve performance of the structure that maintains suitable temperatures for Winter-run Chinook Salmon that spawn in the upper Sacramento River (from Keswick Dam to the Red Bluff Diversion Dam) from May through August, with peak spawning during June and July (Table 5.6-1). Fry emergence occurs up to two months after eggs are spawned, so effects of water temperature and flow in the upper Sacramento River on Winter-run Chinook Salmon fry and alevins potentially occur from May through October, but occur primarily during June through September. The ability to better manage the cold water pool and cold water releases would result in increased probability and likelihood of maintaining suitable spawning, incubating, and rearing temperatures throughout the season in all but the driest years.

The improved flow management associated with the Shasta TCD improvements under the proposed action would be expected to provide some benefit to adult Winter-run Chinook Salmon adults relative to the COS and WOA.

5.6.4.6 Sacramento River Spawning and Rearing Habitat

5.6.4.6.1 Egg/Alevin Mortality

Reclamation proposes to create additional spawning habitat by injecting 40-55 tons of gravel into the Sacramento River by 2030, using the following sites: Salt Creek Gravel Injection Site, Keswick Dam Gravel Injection Site, South Shea Levee, Shea Levee, and Tobiasson Island Side Channel. This additional spawning habitat would help meet the spawning habitat needs on the Sacramento River, shown below. At least an additional 100 acres of spawning habitat is needed to support the target Winter-run Chinook Salmon doubling goal population of 110,000 returning adults. Additional gravel would lead to improved hyporheic flow to move dissolved oxygen to redds, and reduced density-dependent spawning effects (unlikely due to current low population size).

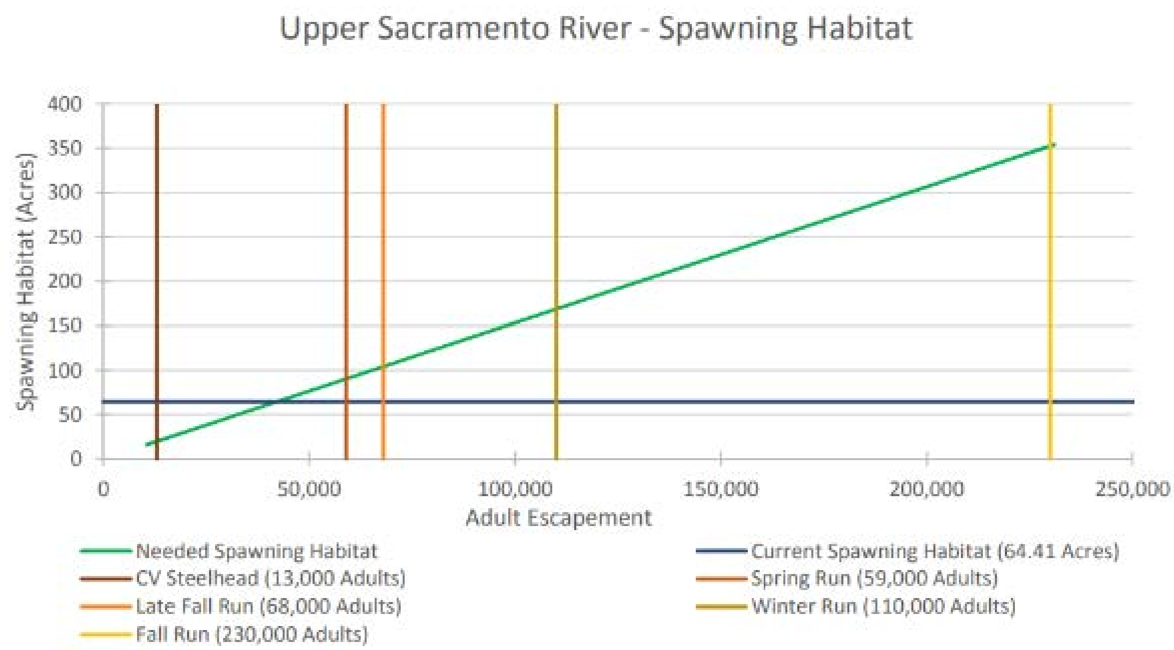


Figure 5.6-40. Spawning Habitat versus Adult Escapement

Construction of spawning and rearing habitat could affect Winter-run Chinook Salmon eggs in the river. Based on the proposed in-water work windows for the upper Sacramento River (see AMM2 *Construction Best Management Practices and Monitoring* in Appendix E, *Avoidance and Minimization Measures*), Winter-run Chinook Salmon adults, eggs, and alevins would be subject to potential adverse effects from proposed spawning (e.g, gravel augmentation) and rearing habitat (e.g., side channel) restoration projects in the upper Sacramento River associated with the proposed action. Construction activities could result in mortality of eggs and alevins by crushing if heavy equipment enters the stream channel or otherwise disturbs existing redds during in-water activities. Eggs and alevins could also be negatively impacted by increases in suspended sediment, turbidity, and contaminant exposure risk, leading to indirect impacts on individuals from reductions in habitat quality in the redd (e.g., reduced flow and dissolved oxygen from increases in sediment deposition) or direct impacts from sublethal and lethal exposures to contaminants. Although these potential effects may be unavoidable, exposure of the Winter-run Chinook Salmon population to construction effects would be low based on the limited extent of proposed restoration projects relative to the overall distribution of spawning adults, and the implementation of other AMMs described in Appendix E, *Avoidance and Minimization Measures*. These measures include AMM1, which requires worker awareness training, AMM2, which specifies monitoring oversight by a qualified biologist, and AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention and containment.

5.6.4.6.2 Egg to Fry Emergence

See egg mortality above.

5.6.4.6.3 Rearing to Outmigrating Juveniles in Upper Sacramento River

Reclamation and the SRSC propose to create 40-60 acres of side channel habitat at no fewer than 10 sites in Shasta and Tehama County by 2030, including Cypress Avenue, Shea Island, Anderson River Park; South Sand Slough; Rancheria Island; Tobiasson Side Channel; and Turtle Bay. Creation of this additional 40-60 acres of rearing habitat would help increase the quantity and quality of Winter-run Chinook Salmon juvenile rearing habitat in the Upper Sacramento River. Reclamation estimates that this additional 50 acres of rearing habitat could support the progeny of 5,600 returning adult salmonids based on the relationship shown in the plot below.

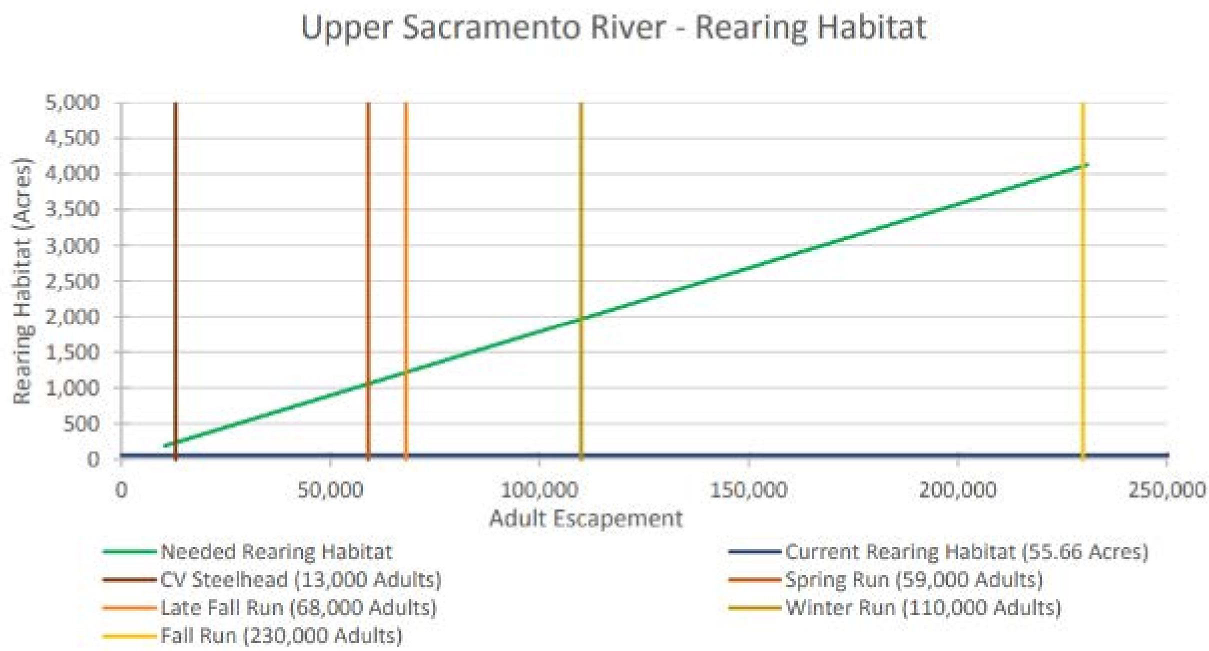


Figure 5.6-41. Rearing habitat versus Adult Escapement

Construction of spawning and rearing habitat could lead to some impacts to early rearing fry in the upper Sacramento River. See egg mortality above for a discussion of effects and minimization measures.

5.6.4.6.4 Rearing to Outmigrating Juveniles in Middle Sacramento River

See rearing to outmigrating juveniles in the Upper Sacramento River above.

5.6.4.6.5 Adult Migration from Ocean to Upper Sacramento River

Winter-run Chinook Salmon adults would not be exposed to benefits or construction impacts of spawning and rearing habitat as they are not co-located in time or space.

5.6.4.6.6 Adult Holding in the Upper Sacramento River

Additional spawning habitat could also benefit adults holding upstream. See egg mortality above.

5.6.4.7 Small Screen Program

5.6.4.7.1 Egg to Fry Emergence

No egg-to-emergence Winter-run Chinook Salmon would be exposed to fish screens since this life stage occurs within the redds and would not be exposed to fish screens. Therefore, there would be no effects from the operation of fish screens for this life stage.

Sacramento River Winter-run Chinook Salmon in the egg-to-emergence life stage may be exposed to the effects of construction of screens on water diversion intakes since this live stage occurs during the typical timing of in-water construction (July 15–October 15). Embryo and alevin development in the redd occurs in the spring through mid-October, following the mid-April to mid-August spawning period (peaking in June), lasting 10 to 14 weeks, (Vogel and Marine 1991) with fry emerge from the gravel occurring from late July to early August and continuing through October (Fisher 1994). Since spawning occurs in gravel substrate in relatively fast-moving, moderately shallow riffles or along banks with relatively high water velocities (Fisher 1994), there is the potential for redds to occur in the work areas or in the direct vicinity of the construction sites. However, these work areas are localized and the number of redds is expected to be low. Potential effects include the disturbance of redds and temporary, localized fine sediment disturbance and deposition in spawning and embryo incubation areas directly adjacent construction sites. There may be a minor effect to a small number of individuals, although the risk from these potential effects would be minimized through the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures*.

5.6.4.7.2 Rearing to Outmigrating Juveniles in Upper Sacramento River

The operation of fish screens on water diversions would beneficially affect juvenile Winter-run Chinook Salmon in the upper Sacramento River by reducing the entrainment of rearing and migrating fish into unscreened or poorly screened diversions. There is the potential for adverse effects to this life stage, including injury or mortality from exposure to screens that are not functioning properly due to lack of maintenance, occlusion, debris accumulation or other factors. However, the risk of this exposure will be minimized since the screens would be designed to meet NMFS and CDFW fish screen criteria and protect this life stage. Therefore, it is concluded that the operation of fish screens would result in beneficial effects for this life stage, due to the reduced risk of entrainment and injury.

Few juvenile Winter-run Chinook Salmon in the upper Sacramento are expected to be exposed to the effects of construction of screens on water diversion intakes. Since Winter-run Chinook Salmon exhibit both ocean-type and stream-type life histories, juveniles are present near year-round (Table 5.6-1) and will likely be present during the timing of in-water construction (July 15 – October 15), the work area for these projects is small, limiting exposure to construction. Potential short-term adverse effects may include temporary degradation of water quality, including increased turbidity and suspended sediments and sediment deposition in the direct vicinity of the work area, and the temporary displacement of individual fish in the work area. If fish are present in the work area, flowing water will be isolated and fish captured and relocated to an appropriate location in an effort to minimize possible mortality. Juveniles would likely experience increased levels of stress and injury during handling, which could be exacerbated by poor water quality (i.e., increased temperatures, low dissolved oxygen saturation), and prolonged periods of holding between capture and release. There may be a minor effect to a small number of individuals, although the risk from these potential effects would be would be minimized through the implementation of general AMMS identified in Appendix E, *Avoidance and Minimization Measures*. In addition, the appropriate conservation measures and handling techniques will be employed to ensure that the stress resulting from handling and transport is short-lived and minor.

5.6.4.7.3 Rearing to Outmigrating Juveniles in Middle Sacramento River

The operation of fish screens on water diversions would beneficially affect juvenile Winter-run Chinook Salmon in the middle Sacramento River by reducing the entrainment of rearing and migrating fish into unscreened or poorly screened diversions. There is the potential for adverse effects to this life stage, including injury or mortality from exposure to screens that are not functioning properly due to lack of maintenance, occlusion, debris accumulation or other factors. However, the risk of this exposure will be minimized since the screens would be designed to meet NMFS and CDFW fish screen criteria and protect this life stage. Therefore, it is concluded that the operation of fish screens would result in beneficial effects for this life stage, due to the reduced risk of entrainment and injury.

Few juvenile Winter-run Chinook Salmon rearing and outmigrating in the middle Sacramento River are expected to be exposed to the effects of construction of screens on water diversion intakes. Since Winter-run Chinook Salmon exhibit both ocean-type and stream-type life histories, juveniles are present near year-round and use this reach for rearing and migration (NMFS 2014) and will likely be present during the timing of in-water construction (July 15 – October 15), the work area for these projects is small, limiting exposure to construction.

Potential short-term adverse effects may include temporary degradation of water quality, including increased turbidity and suspended sediments and sediment deposition in the direct vicinity of the work area, and the temporary displacement of individual fish in the work area. If fish are present in the work area, flowing water will be isolated and fish captured and relocated to an appropriate location in an effort to minimize possible mortality. Juveniles would likely experience increased levels of stress and injury during handling, which could be exacerbated by poor water quality (i.e., increased temperatures, low dissolved oxygen saturation), and prolonged periods of holding between capture and release. There may be a minor effect to a small number of individuals, although the risk from these potential effects would be minimized through the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures*. In addition, the appropriate conservation measures and handling techniques will be employed to ensure that the stress resulting from handling and transport is short-lived and minor.

5.6.4.7.4 Rearing to Outmigrating Juveniles in Bay-Delta

There may be some overlap Winter-run Chinook Salmon with the main late spring-fall irrigation period for small diversions. Diversion screening could reduce entrainment of late migrating individuals. It is important to note that only a small proportion of the population would be exposed.

Few if any juvenile Winter-run Chinook Salmon rearing and outmigrating in the Bay-Delta are expected to be exposed to the effects of construction of screens on water diversion intakes. Juvenile Winter-run Chinook Salmon primarily migrate from November through early May (NMFS 2014), largely outside of the timing of in-water construction (July 15 – October 15). In addition, the work area for these projects is small, limiting exposure to construction.

5.6.4.7.5 Adult Migration

The operation of fish screens on water diversions would beneficially affect migrating adult Winter-run Chinook Salmon by reducing the entrainment of fish into unscreened or poorly screened diversions.

Few if any adult Winter-run Chinook Salmon are anticipated be exposed to the effects of construction of screens on water diversion intakes. The adult immigration occurs from December through July, the majority pass RBDD from January through May (peaking in mid-March) (NMFS 2009; NMFS 2014), which is largely of the timing of in-water construction (July 15 – October 15). AMMs would reduce any risk.

5.6.4.7.6 Adult Holding

The operation of fish screens on water diversions would beneficially affect adult Winter-run Chinook Salmon holding in the upper Sacramento River by reducing the entrainment of fish into unscreened or poorly screened diversions.

Adult Winter-run Chinook Salmon in may be exposed to the effects of construction of screens on water diversion intakes based on the timing of in-water construction (August–October), the May through August spawning period for (NMFS 2014). AMMs would reduce any risk.

5.6.4.8 Conservation Hatchery (Winter-run Chinook Salmon)

Expansion of Livingston-Stone National Fish Hatchery would allow increased operation to sustain Winter-run Chinook Salmon, particularly during drought years. The purpose would be to provide artificial rearing and spawning habitat when in-river environmental conditions (low flow and high temperatures) are not suitable for egg-fry life stages. Expanded hatchery production may address most SAIL CM components. Effects of increased hatchery production will depend on complex interactions between hatchery and natural-origin fish and their environment. It will be important to couple other conservation measures together with increased production to ensure that it addresses losses of natural production. For example, if in-river conditions are not conducive to migration downriver, fish produced at the hatchery may need to be trucked to a point with higher downstream survival. Livingston-Stone National Fish Hatchery operates an “integrated” hatchery program with the intention of minimizing genetic divergence between hatchery and natural components of the population by exchanging spawners between them (Paquet et al. 2011). A natural consequence of expanding numbers of hatchery fish is an increase of hatchery origin fish on in-river spawning grounds. This coupled with low survival of natural-origin fish may influence the genetic management criteria to include hatchery-origin spawners and variable numbers of males and females under drought conditions.

5.6.4.9 Adult Rescue (Yolo and Sutter Bypasses)

Existing facilities such as the updated Fremont Weir ladder and Wallace Weir fish rescue facility have improved fish passage in the Yolo Bypass and between the bypass and the river, however, there is still the potential for stranding in isolated pools when hydrologic connectivity is not possible within the Yolo Bypass. Under certain circumstances with the proposed action, adult fish rescue may still be necessary at Fremont Weir.

Under the proposed action, the Yolo Bypass Salmonid Habitat Restoration and Fish Passage project provides additional adult fish passage at different locations and additional times compared to WOA and COS. Under the WOA, these facilities would exist but would not be operated for fish passage and rescue. Additionally, under the proposed action Reclamation would undertake, fund, and/or assist in adult fish rescue operations as needed at Fremont, Wallace, and Tisdale Weirs, which would not occur under the WOA. The proposed action and COS would provide more passage and rescue and more opportunities for adult spawning Winter-run Chinook Salmon compared to the WOA.

5.6.4.9.1 Egg to Fry Emergence

The operation of adult rescue is targeted towards adult salmonids and sturgeon, including adult Winter-run Chinook Salmon, that become trapped in the Yolo and Sutter bypasses, with the goal of increasing the number of adults returning to spawning areas; therefore, this effort could increase the the number of Winter-run Chinook Salmon eggs and emerging fry in the Sacramento River from increased spawner abundance.

5.6.4.9.2 Rearing to Outmigrating Juveniles in Middle Sacramento River

Juvenile Winter-run Chinook Salmon occur in the Yolo and Sutter Bypasses when Sacramento River flows overtop the Fremont and/or Tisdale Weirs. Although they are unlikely to occur in the bypasses during periods when flow does not overtop the weirs, proposed modifications to the Fremont Weir to increase inundation of the Yolo bypass for floodplain rearing would provide juveniles with more consistent access to the Yolo bypass. Therefore, these juveniles could be exposed to the effects of adult rescue activities if they become stranded with adults that are targeted by adult rescue activities. The number of juvenile Winter-run Chinook Salmon that would be expected to be exposed to the effects of adult rescue activities would be based on the timing of proposed adult rescue activities, gear type used to rescue adults, and the typical seasonal occurrence of this life stage in the Yolo and Sutter bypasses.

Individual juvenile Winter-run Chinook Salmon exposed to adult rescue activities would be at risk of increased stress, injury, and/or mortality during efforts to capture stranded adults, handling and transport. Injury and increased stress associated with capture, handling, and transport may reduce disease resistance, swimming ability, and osmoregulatory ability in juveniles, thereby adversely affecting survival of affected individuals after release. Furthermore, the risk of these effects to this life stage may be dependent on fish size (fish collected at a smaller [younger] size may be more susceptible to injury and stress) and timing of collection (fish collected later in the season when water quality conditions [e.g., water temperature] generally are more stressful for fish may make fish more susceptible to injury and stress-related effects). The risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*), and any potential adverse effects on individual juvenile Winter-run Chinook Salmon would be expected to be offset by benefits associated with increased numbers of adult Winter-run Chinook Salmon returning to spawning grounds.

As such, it is concluded that there will be no impacts from from adult rescue activities in the proposed action on this life stage of Winter-run Chinook Salmon (no rescue of adult Winter-run Chinook Salmon).

5.6.4.9.3 Rearing to Outmigrating Juveniles in Bay-Delta

Adult fish rescue in the Yolo Bypass and Sutter Bypasses does not affect environmental conditions such as juvenile rearing and migration in the tidal estuary and bays that influence the timing, condition and survival of juvenile Winter-run Chinook Salmon in the middle Sacramento River. This action would not have impacts to this life stage, aside from beneficial indirect effects of increased potential spawners.

5.6.4.9.4 Adult Migration from Ocean to Upper Sacramento River

Exposure of this life stage to adult rescue effects would be restricted only to those adult Winter-run Chinook Salmon that become stranded in the Yolo and Sutter Bypasses and subsequently rescued and released to the Sacramento River. Adults that migrate in-river or that do not become stranded in the Yolo and Sutter bypasses would be unaffected by adult rescue activities. The number of adult Winter-run Chinook Salmon that would be expected to be exposed to the effects of adult rescue activities would be based on the abundance of adults that stray into the bypasses and the timing and frequency of stranding events in the bypasses.

Individual adult Winter-run Chinook Salmon exposed to adult rescue activities would be at risk of increased stress, injury, and/or mortality, which could vary in intensity depending on the techniques used to capture individuals. Injury and increased stress associated with capture, handling and transport may affect survival of affected individuals after release. The risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*). Adult Winter-run Chinook Salmon that are rescued may be exposed to detrimental effects; however, individuals would have greater opportunities for spawning success compared to WOA.

As such, it is concluded that the overall population-level effects would be beneficial on this life stage of Winter-run Chinook Salmon from adult rescue activities relative to WOA (no rescue of stranded adult Winter-run Chinook Salmon in Yolo and Sutter bypasses).

5.6.4.10 Juvenile Trap and Haul (Winter-run Chinook Salmon)

5.6.4.10.1 Rearing to Outmigrating Juveniles in Upper Sacramento River

The number of juvenile Winter-run Chinook Salmon that would be expected to be exposed to the effects of juvenile trap and haul activities would be based on the timing of proposed juvenile trap and haul activities (December 1 to May 31), trapping efficiency, and the typical seasonal occurrence of this life stage in the Sacramento River (Table 5.6-1). Individual juvenile Winter-run Chinook Salmon exposed to juvenile trap and haul activities would be at risk of increased stress, injury, and/or mortality. Injury and increased stress associated with handling and transport may reduce disease resistance, swimming ability, and osmoregulatory ability in juveniles, thereby adversely affecting survival of affected individuals after release.

Furthermore, the risk of these effects to this life stage may be dependent on fish size (fish collected at a smaller [younger] size may be more susceptible to injury and stress) and timing of collection (fish collected later in the season when water quality conditions [e.g., water temperature] generally are more stressful for fish may make fish more susceptible to injury and stress-related effects). The risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*), and any potential adverse effects on individual juvenile Winter-run Chinook Salmon would be expected to be offset by benefits associated with expected increased survival of the overall brood-year of Winter-run Chinook Salmon. Juvenile Winter-run Chinook Salmon would benefit from juvenile trap and haul activities relative to WOA (no trapping and hauling of juvenile Winter-run Chinook Salmon during drought years).

5.6.4.10.2 Rearing to Outmigrating Juveniles in Middle Sacramento River

If temporary juvenile collection weirs are placed in Middle Sacramento River, potential effects associated with juvenile trap and haul on this life stage would be same as those described above for the rearing to outmigrating juveniles in the upper Sacramento River life stage.

5.6.4.10.3 Rearing to Outmigrating Juveniles in Bay-Delta

Exposure of this life stage to trap and haul effects would be restricted only to those juvenile Winter-run Chinook Salmon trapped in the upper and middle Sacramento River and subsequently released to the lower Sacramento River and/or Bay-Delta. Wild juveniles that migrate in-river to the Bay-Delta (either before December 1 or that avoid capture by the temporary juvenile collection weirs after December 1) would not be affected by juvenile trap and haul activities. Potential effects associated with juvenile trap and haul on this life stage would be same as those described above in for the rearing to outmigrating juveniles in the upper Sacramento River life stage.

5.6.4.10.4 Adult Migration

Because transported juveniles are more likely to have impaired homing behavior as adults, juvenile trap and haul activities may increase the rate of straying by returning adults. Adults that stray into tributaries or that are otherwised delayed from reaching adult holding areas in the Upper Sacramento River would not be expected to spawn successfully because of the lack of suitable habitat in tributaries. Negative effects on this life stage of adult Winter-run Chinook Salmon from juvenile trap and haul activities would be small compared to WOA (no trapping and hauling of juvenile Winter-run Chinook Salmon during drought years) and would be potentially offset by benefits (increased juvenile survival and ultimately increased adult escapement) associated with the juvenile trap and haul program.

5.6.4.11 American River Spawning and Rearing Habitat

Pursuant to CVPIA 3406(b)(13), Reclamation proposes to implement the Cordova Creek Phase II and Carmichael Creek Restoration projects, and increase woody material in the American River. Reclamation also proposes to conduct gravel augmentation and floodplain work at: Paradise Beach, Howe Ave, Howe Avenue to Watt Avenue, William Pond Outlet, Upper River Bend, Ancil Hoffman, Sacramento Bar - North, El Manto, Sacramento Bar - South, Lower Sunrise, Sunrise, Upper Sunrise, Lower Sailor Bar, Nimbus main channel and side channel, Discovery Park, and Sunrise Stranding Reduction.

Juvenile Winter-run Chinook Salmon in the middle Sacramento River may use the lower American River as non-natal rearing habitat during late fall and winter. The habitat improvements in the American River would increase quality and quantity of rearing habitat available to juvenile Winter-run Chinook Salmon and be a net benefit to the population. The additional rearing habitat is not expected negatively impact juveniles. Winter-run Chinook Salmon naturally emigrate once they reach a threshold size in the spring, before temperature in the lower Sacramento River and Delta warm to inhospitable levels, indicating there should not be danger of attracting and holding juveniles in American River habitat too far into the warmer time of year.

Spawning and rearing habitat project construction occurs in the American River from July to October, outside the time when Winter-run Chinook Salmon juveniles would be present so there would be no impact on the species from construction activities.

5.6.4.12 Sacramento Deepwater Ship Channel

This action would hydrologically connect the Sacramento River with the Sacramento Deepwater Ship Channel (SDWSC) via the Stone Lock facility from mid-spring to late fall to provide foodweb benefits to Delta Smelt. Juvenile Winter-run Chinook Salmon may be exposed to the Sacramento Deepwater Ship Channel (SDWSC) component of the proposed action. Juvenile Winter-run Chinook Salmon abundance downstream of Stone Lock at Sherwood Harbor is highest in February and March, declines in April, and is moderate in November (Table 5.6-1). Juvenile Winter-run Chinook Salmon passing the Stone Lock facility when there is a hydrologic connection between the waterways could potentially be routed into the SDWSC. Estimates of salmonid survival in the SDWSC are not available to compare with rates in the Sacramento River route. However, if survival rates are similar, fish entering the SDWSC would not be exposed to entrainment into the interior Delta through the DCC or Georgiana Slough which would provide a benefit associated with the proposed action.

A hydrologically connected SDWSC could potentially attract adult Winter-run Chinook Salmon. If the connection is maintained there would likely not be impacts to adults. However, if the connection is not maintained there could be migratory delays and stranding.

5.6.4.13 North Delta Food Subsidies/Colusa Basin Drain Study

Provision of north Delta food subsidies by routing Colusa Basin drain water to the Cache Slough area through the Yolo Bypass would occur in summer/fall and therefore would have limited effects on Winter-run Chinook salmon, who are in the Delta between December and May for juveniles, and December to July for adults.

5.6.4.14 Suisun Marsh Roaring River Distribution System Food Subsidies Study

Under the proposed action, provision of Suisun Marsh food subsidies through coordination of managed wetland flood and drain operations in Suisun Marsh and draining of RRDS to Grizzly Bay/Suisun Bay in conjunction with reoperation of the SMSCG would occur in summer/fall and therefore would have limited effects on Winter-run Chinook salmon, who are in the Delta between December and May for juveniles, and December to July for adults.

5.6.4.15 Tidal Habitat Restoration (8,000 acres)

Although migration through the Delta represents a short period, a large proportion of juvenile Winter-run Chinook Salmon are expected to be exposed to 8,000 acres of tidal habitat restoration in the Delta. Tidal habitat restoration is expected to benefit juvenile Winter-run Chinook Salmon in several aspects represented by the Winter-run Chinook Salmon conceptual model, (Figure 5.6-4) including increased food availability and quality and refuge habitat from predators. These benefits can manifest in higher growth rates and increased survival through the Delta. Reclamation and DWR will consult on future tidal habitat restoration with USFWS and NMFS on potential effects to fish from construction-related effects.

5.6.4.16 Predator Hot Spot Removal

5.6.4.16.1 Rearing to Outmigrating Juveniles in Upper Sacramento River

Winter-run Chinook Salmon juveniles could be exposed to the effects of construction at predator hot spot removal locations in the Sacramento River, as the in-water work window is in the summer/fall when Winter-run Chinook Salmon juveniles are generally in the upper river. AMMs will be used to avoid and minimize impacts from construction including crushing, impingement, mortality, noise, and harassment.

5.6.4.16.2 Rearing to Outmigrating Juveniles in Middle Sacramento River

See rearing to outmigrating juveniles in the upper Sacramento River.

5.6.4.16.3 Rearing to Outmigrating Juveniles in Bay-Delta

Predator hot spot removal is primarily focused on providing positive effects to downstream-migrating juvenile salmonids including Winter-run Chinook Salmon. Although the proposed action would not be limited to existing identified hot spots (e.g., those identified by Grossman et al. 2013), the existing hotspots that may be representative of where removal efforts may be most concentrated are in the primary migratory routes of juvenile Winter-run Chinook Salmon. All hotspots are limited in scale relative to overall available habitat and previous research has not found a consistent positive effect of predator removal on juvenile salmon survival (Cavallo et al. 2012, Michel et al. 2017, Sabal et al. 2017). Winter-run Chinook Salmon juveniles in the Bay-Delta are unlikely to be exposed to the effects of construction at predator hot spot removal locations in the Sacramento River, as the in-water work window is in the summer/fall when Winter-run Chinook Salmon juveniles are generally in the upper river.

5.6.4.17 Knight's Landing Outfall Gates Fish Barrier

Reclamation and DWR's fish barrier at the Knight's Landing Outfall Gates would prevent possible entrainment of salmonids into the Colusa Basin Drain. This project would reduce entrainment and therefore increase survival of Winter-run Chinook salmon adults.

Few Winter-run Chinook salmon are expected to be exposed to in-water construction impacts due to observance of species protective work windows. Impacts of construction would be minimized in accordance with Appendix E, Avoidance and Minimization Measures.

5.6.4.18 Delta Cross Channel Gate Improvements

The DCC is an older structure which requires manual operation and increased use could result in locks braking in either open or closed positions. Migrating Winter-run Chinook salmon would benefit from faster operations that prevent straying into the central Delta and catastrophic failure of the facility. Few Winter-run Chinook Salmon are expected to be exposed to improvements to the Delta Cross Channel. Seasonal closure periods would still be in place to protect migrating salmonids. Potential diurnal operation during closure periods could increase exposure of Winter-run Chinook Salmon juveniles to entrainment into the interior Delta. Improved biological and physical monitoring associated with improvements would likely minimize potentially increased routing into the interior Delta and subsequent entrainment. Greater operational flexibility and increased gate reliability resulting from improvements would reduce the risk of gate failure that could result in higher rates of entrainment.

5.6.4.19 Tracy Fish Facility Improvements

A small proportion of juvenile Winter-run Chinook Salmon are expected to be exposed to the Tracy Fish Facility (Zeug and Cavallo 2014). However, for fish that arrive at the facility, the proposed improvements are likely to increase survival through the facility. Winter-run Chinook Salmon adults would not be expected to be exposed to the effects of construction of the carbon dioxide injection device proposed for the Tracy Fish Facility, based on the timing of in-water construction (August–October) and the typical seasonal occurrence of this life stage in the Delta (Table 5.6-1).

Few if any juvenile Winter-run Chinook Salmon would be expected to be exposed to construction of the carbon dioxide injection device proposed for the Tracy Fish Facility Improvements based on lack of observed salvage during the August–October in-water work window (Figures F.2.7, F.2.8, and F.2.9 in Appendix F, *Juvenile Salmonid Monitoring, Sampling, and Salvage Summary from SacPAS*). However, a few early migrants could occur during the in-water work window based on occurrence in the north Delta (Figures WR_Seines and WR_Sherwood in Appendix F, *Juvenile Salmonid Monitoring, Sampling, and Salvage Summary from SacPAS*).

To the extent that the construction affects the ability of juvenile Winter-run Chinook Salmon to be efficiently salvaged (as part of the entrainment risk habitat attribute in the SAIL conceptual model; Figure 5.6-44), there could be a minor effect to a small number of individuals, although risk would be minimized through appropriate AMMs (Appendix E, *Avoidance and Minimization Measures*). There is low potential exposure because of the in-water work window, the application of AMMs, and the small scale of the in-water construction.

5.6.4.20 Skinner Fish Facility Improvements

Skinner Fish Facility improvements from predator control efforts to reduce predation on listed fishes following entrainment into CCF could reduce pre-screen loss of juvenile Chinook Salmon entrained into

CCF. It is important to note that only small proportions of Winter-run Chinook Salmon are lost at the SWP (Zeug and Cavallo 2014). Measures that would be implemented include electroshocking of predators, and removal of aquatic weeds. Any Winter-run Chinook salmon incidentally collected during the electrofishing will be identified, genetic tissue samples archived as permitted, and released back into CCF. Winter-run Chinook salmon that are present in the vicinity of the electrofishing boats will be exposed to the electrical current within the water column when the boats are actively fishing. However, the greater length of the predatory fish creates a greater voltage gradient along the length of the fish, and thus less voltage is needed to anesthetize the larger predatory fish in the electric field. Therefore, anticipated effects on Winter-run Chinook salmon are low. The proposed action includes measures to avoid and minimize effects on listed species of the aquatic weed removal.

5.6.4.21 Delta Fishes Conservation Hatchery

The operation of the Delta Fish Species Conservation Hatchery would not provide benefits to any life stage of Winter-run Chinook Salmon. Potential negative effects of the Delta Fish Species Conservation Hatchery include inadvertent propagation and spread of invasive or nuisance species, which could affect juvenile Winter-run Chinook Salmon through changes in food web structure, for example, in the case of invasive quagga and zebra mussels (Fera et al. 2017). Additional impacts could include reduced water quality resulting from hatchery discharge. Potential negative effects from discharged water are expected to be minimal due to the water treatment and the very small size of the discharge compared to flows in the Sacramento River near the hatchery location. Mitigation and minimization measures detailed in the EIR/EIS for the facility (Horizon Water and Environment 2017) indicate that potential impacts are less than significant. Potential exposure of juvenile Winter-run Chinook Salmon would be restricted to a small spatial area within the primary migration route.

As with the other proposed construction activities in the Bay-Delta, few if any juvenile Winter-run Chinook Salmon would be expected to be exposed to the effects of construction of the Delta Fishes Conservation Hatchery based on the timing of in-water construction (August–October) and the typical seasonal occurrence of this life stage in the Delta (Table 5.6-1). There may be some exposure of early migrants to in-water and shoreline construction of the hatchery intake and outfall, as illustrated by timing of occurrence in Sacramento seines and trawls (Figures F.2.4 and F.2.5 in Appendix F, *Juvenile Salmonid Monitoring, Sampling, and Salvage Summary from SacPAS*). The relatively few individuals occurring near the construction site could be subject to effects similar to those previously described for habitat restoration (e.g., temporary loss of habitat leading to predation, degraded water quality, reduced foraging ability caused by reduced visibility, noise-related delay in migration, and direct effects from contact with construction equipment or isolation/stranding within enclosed areas). The risk from these potential effects would be minimized through application of AMMs (Appendix E, *Avoidance and Minimization Measures*). There is low potential exposure because of the in-water work window, the application of AMMs, and the small scale of the in-water construction.

Winter-run Chinook Salmon adults would not be expected to be exposed to the effects of construction of construction of the Delta Fish Species Conservation Hatchery based on the timing of in-water construction (August–October) and the typical seasonal occurrence of this life stage in the Delta (Table 5.6-1).

5.6.5 Effects of Monitoring

A number of monitoring activities described in Appendix C - Real Time Water Operations Charter, in section Routine Operations and Maintenance on CVP Activities would have the potential to capture Winter-run Chinook Salmon. Not all the existing IEP monitoring programs that target pelagic fish identify Chinook Salmon race. Of the programs that target and identify Winter-run Chinook Salmon, collective catches are less than 1% of the winter-run JPE (Table 5.6-2). Because such a small percentage of the total JPE is captured in the monitoring programs, the effects of the monitoring programs are not likely to have effects to the Winter-run population. These monitoring programs are important for understanding entry and residence time of Winter-run Chinook Salmon into the Delta and San Francisco Estuary.

Table 5.6-2. Monitoring Programs – Winter-run Chinook Salmon

Species	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Chipps Island Trawl																		
Winter-run Chinook Salmon	136	225	112	125	319	115	42	73	69	64	47	63	76	31	53	304	89	
Sacramento Trawl																		
Winter-run Chinook Salmon	57	130	74	118	105	55	33	20	17	11	103	0	86	10	9	111	43	
DJFMP Beach Seine Survey																		
Winter-run Chinook Salmon	123	498	299	650	373	125	51	56	182	50	292	74	136	30	80	38	330	24
CDFW Mossdale Trawl																		
Winter-run Chinook Salmon	8	0	4	1	7	21	5	5	13	11	70	2	2	0	0	18	8	
EDSM KDTR Trawls																		
Winter-run Chinook Salmon	na	na	na	na	na	na	na	Na	na	na	na	na	na	na	0	30	na	
CDFW Bay Study Trawls																		
Chinook Salmon	273	117	327	115	143	115	17	130	157	215	74	134	71	65	62	236	na	
CDFW SKT Study																		
Chinook Salmon	35	1624	1364	348	822	896	603	187	300	244	219	492	632	432	347	565	124	
Totals																		
Winter-run Chinook Salmon	324	853	489	894	804	316	131	154	281	136	512	139	300	71	142	471	470	
RBDD Rotary Trap or Juvenile Production Estimate (JPE)																		
Winter-run Chinook Salmon JPE	6964626	6181925	2786832	12109474	11818006	1864521	1952614	3728444	1049385	512192	16874039							
Percent of Total																		
Winter-run Chinook Salmon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00							

This page intentionally left blank.

5.7 Chinook Salmon, Sacramento River Winter-run ESU Critical Habitat

5.7.1 PBF1 – Access to Spawning Areas in the Upper Sacramento River

In the Sacramento River Basin, ancestral spawning areas for Winter-run Chinook Salmon are unreachable due to impassable barriers at Keswick and Shasta dams. Keswick and Shasta dams do not operate in the WOA scenario, but the dams would remain in place and continue to prevent Winter-run Chinook Salmon adults from accessing upstream spawning areas. Adult Winter-run Chinook Salmon access to their current spawning areas in the upper Sacramento River near Keswick Dam is affected by flow and temperature-related conditions in the middle and upper Sacramento River. Winter-run Chinook Salmon currently spawn between Keswick and Red Bluff Diversion dams, with most spawning within ten miles of Keswick Dam (Windell 2017). Low flow may interfere with upstream passage of adults and increases risk of straying and poaching. High water temperature makes habitat physiologically unsuitable for the adults, potentially excluding them entirely.

Under the proposed action, modeled flow in the middle Sacramento River during the December through May period of Winter-run Chinook Salmon adult immigration is similar to or slightly greater than COS, indicating no adverse flow-related effect of the proposed action on access to spawning areas relative to the COS. However, the proposed action flow is much lower than the WOA flow during many years, but the proposed action flow in these years is generally high enough (>~5,000 cfs) not to affect access of the adults to spawning areas. In the driest years, however, the proposed action flow is higher than the WOA flow. During May in the driest 25 percent of years, the modeled WOA flows are low enough to potentially obstruct upstream passage of adults, which is not the case under the proposed action. Therefore, modeling results indicate that the proposed action would have no adverse flow-related effect on access to spawning areas in the Winter-run Chinook Salmon critical habitat relative to the COS or WOA.

Adult Winter-run Chinook salmon are present in the Bay/Delta from December through July, with a peak occurrence in December and April. The adults use olfactory cues to find their way through the Delta to the Sacramento River upstream of the Delta, so higher Sacramento River flow may reduce straying to other rivers (Marston et al. 2012; NMFS 2016 *Submitted Ch5 EA Draft BA*). Flow in the Sacramento River at Rio Vista and Freeport during the period of adult migration through the Delta, December through July, is lower to much lower under the proposed action relative to the WOA in most years (e.g., Figures 32-9 through 32-16 in the CalSim II Flows section of Appendix D), but in dry years with low river flow, when the risk of straying is increased, flow is much higher under the proposed action than the WOA, especially for April through July. On balance, the effect of the proposed action on Winter-run upstream migration is uncertain.

Modeled water temperatures under all three scenarios would be favorable in the middle and upper Sacramento River for immigrating adult Winter-run Chinook Salmon during all of the immigration period, except during May for WOA temperatures in about 50 percent of years, and COS and proposed action temperatures in about 35 percent of years. These results indicate that the proposed action would have no adverse water temperature-related effect on access to spawning areas in Winter-run Chinook Salmon critical habitat relative to the COS or WOA.

5.7.2 PBF2 – Availability of Clean Gravel for Spawning Substrate

The proposed action includes projects to improve spawning habitat for Chinook Salmon in the upper Sacramento River, and these projects would likely enhance availability of clean gravel for Winter-run Chinook Salmon spawning substrate. Availability of clean gravel is affected by changes in flow. Transport of clean gravel downstream to areas currently used for spawning by Winter-run Chinook Salmon is blocked by Keswick and Shasta dams. While the WOA includes no operation of Keswick and Shasta dams, the dams would remain in place and continue to prevent transport of clean gravel from upstream sources.

Currently, the availability of clean gravel is a function of: 1) upstream supply from tributaries and gravel augmentation projects, and 2) flows, especially pulse flows, that are high enough for periodic flushing of fine sediment, but not so high as to transport the gravel downstream of the spawning area. The proposed action would not affect the amount of upstream gravel supply or natural pulse flows. However, flow during summer, when Winter-run Chinook Salmon spawn and egg/alvein incubation period, would be much higher under the proposed action than under WOA, and potentially would be high enough in some years to flush fine sediments from spawning substrates. Modeled flow during the winter months is lower under the proposed action than under WOA and therefore may reduce the ability to flush sediments from spawning substrate. Flow in the upper river under the WOA scenario is less regulated than that under the proposed action and COS scenarios, it is likely that natural pulse flows would be larger and more frequent under the WOA scenario. While pPulse flows are not included in the CALSIM modeling used to compare flow of the three project scenarios, spring pulse flows are included in the proposed action and could contribute to flushing of fine sediments.

The lower frequency of pulse flows would potentially result in less frequent and effective flushing of sediments from the spawning gravel under the proposed action than WOA. However, if WOA pulse flows were very large, they could result in downstream transport of gravel from the spawning area, without recruiting gravel from upstream due to blockage by Shasta and Keswick dams. Overall, the effect of the proposed action on the availability of clean gravel for spawning substrate in Winter-run Chinook Salmon critical habitat relative to WOA is uncertain.

5.7.3 PBF3 – Adequate River Flows for Successful Spawning, Incubation of Eggs, Fry Development and Emergence, and Downstream Transport of Juveniles

As discussed previously, there would be insignificant differences in flows between the proposed action and COS throughout the Sacramento River upstream of the Delta during most of the Winter-run Chinook Salmon spawning, rearing, and emigration periods; however, there would be large and significant differences in flows between the proposed action and WOA.

The months included in Winter-run Chinook Salmon spawning, incubation, rearing and emigration periods are May through March. During these months, proposed action and COS flows are similar, except for greater proposed action flow in June and lower proposed action flow in September and November. The effects of these flow differences are uncertain, with some attributes of habitat benefited and some attributes negatively affected by the higher flows.

The large differences in flow between the proposed action and WOA are expected to have substantial effects. Flows under the proposed action are much higher than WOA flows during the June through October period of spawning and egg/alevin incubation, which is expected to substantially benefit most PBFs of Winter-run Chinook Salmon spawning habitat. In contrast, proposed action flows are lower than

WOA flow during most years of the winter months, which is expected to reduce downstream transport and environmental cues of emigrating juvenile Winter-run Chinook Salmon.

5.7.4 PBF4 – Water Temperatures for Successful Spawning, Egg Incubation, and Fry Development

As discussed previously, water temperatures would not significantly differ between COS and proposed action in spawning and rearing reaches in the upper Sacramento River during Winter-run Chinook Salmon spawning and rearing periods; however, there would be large and highly significant differences in water temperatures between the proposed action and WOA, especially during the late spring, summer and early fall period of Winter-run Chinook Salmon spawning and egg/alevin incubation.

Water temperatures under the proposed action during May through September would range from roughly 10 to 20 degrees Fahrenheit lower than WOA water temperatures, with WOA water temperatures exceeding critical temperature thresholds for Winter-run Chinook Salmon eggs and alevins during May through September of almost every year, but proposed action water temperature remaining below the thresholds during those months in most years. Water temperature and DO based modeling analyses show 100 percent Winter-run Chinook Salmon egg and alevin mortality under WOA water temperature and DO conditions, as compared to less than 50 percent mortality in 75 percent of years under proposed action conditions. During late fall through early spring, the proposed action water temperatures are generally higher than the WOA temperatures, but the water temperatures under both scenarios are consistently below the critical temperature thresholds for Winter-run Chinook Salmon fry. Overall, the results indicate that proposed action has no effect relative to COS on PBF4, but would have major benefits relative to the WOA.

5.7.5 PBF5 - Habitat Areas and Adequate Prey that are not Contaminated

In Winter-run Chinook Salmon critical habitat upstream of the Delta, the proposed action is not likely to negatively impact contaminant sources. Primary sources of contamination in the Sacramento River upstream of the Delta are drainage and runoff from croplands and municipalities. Differences among the project scenarios in contaminated habitat and prey would most likely be caused by differences in flow levels, either because of differences in dilution of contaminants from drainage canals and other sources, or because of differences in contaminant loading resulting from inundation and runoff from croplands and municipal lands. The principal contaminants from croplands are fertilizers and pesticides, and these are applied to croplands primarily from late spring through early fall.

As indicated previously, differences in flows between the proposed action and COS would generally be small and, for both scenarios, modeled flow would be below levels that would cause inundation of croplands or cities. However, flow under WOA would often be much higher or much lower than proposed action flows.

During summer and early fall in drier years, flow under proposed action would regularly be two to three times as high as the corresponding WOA flow, so contaminants in the river would be much more diluted under the proposed action when compared to WOA. During winter and early spring, proposed action flow would often be lower than WOA flow, but use of fertilizers and pesticides is relatively low at these times of year. Flooding of the Sacramento River generally results primarily from pulse flows originating in unregulated tributaries of the river, which CalSim, a monthly time-step model, cannot model for purposes of comparing magnitudes or frequencies of flooding among the scenarios. However, as discussed for PBF3 regarding pulse flows for spawning gravels, Sacramento River flows would be much more controlled under the proposed action than under WOA. Therefore, lesser areas of croplands would likely be inundated under the proposed action than under WOA and inundations would be less frequent, resulting in lower contaminant loading from the runoff. Overall, the results indicate that the proposed action would not negatively impact Winter-run Chinook Salmon availability of uncontaminated habitat areas and prey relative to the COS and the WOA in the Sacramento River upstream of the Delta.

Increased habitat diversity potentially enhances food resources of Winter-run juveniles and higher flow generally increases habitat diversity. Higher flow in the Bay/Delta results in greater inundation of marshlands surrounding the Delta, Suisun Bay and San Pablo Bay, which potentially improves: 1) foodweb productivity, 2) access of juvenile Winter-run to more diverse food resources, 3) refuge of the juveniles from predators, and 4) refuge for resting from high velocity flows. Higher flows may also enhance foodweb productivity by transporting nutrients and plankton from productive habitats, including croplands and the Sutter and Yolo bypasses (DWR and Reclamation 2107 *Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project EIS/EIR*).

Winter-run juveniles are present in the Bay/Delta from December through May, with peak occurrence during February through April. During most of this period, Sacramento River flow at Freeport and Rio Vista, as well as Delta outflow, are substantially lower under the proposed action relative to the WOA (e.g. Figures 29-11 through 29-13, 32-11 through 32-13, and 41-11 through 41-13 in the CalSim II Flows section of Appendix D). Therefore, the proposed action is expected to negatively affect critical habitat in the Bay/Delta relative to the WOA, with respect to habitat diversity and food resources, but this conclusion has low certainty.

Lower, regulated winter and spring flow under the Proposed Action has the potential to positively and negatively affect other water quality factors in estuarine Winter-run critical habitat relative to the WOA. Lower January through May flows at Freeport and Rio Vista under the proposed action and lower Delta outflow (Figures 29-10 through 29-14, 32-10 through 32-14, and 41-10 through 41-14 in the CalSim II Flows section of Appendix D) would lead to less dilution of contaminants present in the Delta, Suisun Bay, San Pablo Bay and Central Bay, increasing their adverse effects, and could also reduce flushing of contaminated sediments out of the Bay/Delta, potentially reducing water and sediment quality in the critical habitat. However, as described above, lower upstream proposed action flows and reduced pulse flows expected during winter and spring would potentially reduce loading of contaminants related to runoff from inundated croplands, so the reduced upstream proposed action flows could result in better water quality in the Bay/Delta. Effects of flows on contaminants in other parts of the Delta are uncertain. Relative to the WOA, the PA has both positive and negative potential effects with respect to water quality in Winter-run critical habitat in the Bay/Delta, and the overall effect is uncertain.

Reduced winter-spring Delta inflow from the Sacramento River under the proposed action relative to the WOA (Figures 29-10 through 29-14 in the CalSim II Flows section of Appendix D) has the potential to reduce sediment supply and therefore turbidity during winter-spring. Turbidity helps juvenile salmon avoid predation (McElroy et al. 2018, Gregory and Levings 1998).

5.7.6 PBF6 – Riparian Habitat that Provides for Successful Juvenile Development and Survival

The effects of the proposed action on riparian habitat in Winter-run Chinook Salmon critical habitat upstream of the Delta are uncertain. Differences in riparian habitat would primarily result from differences in flow and its effect on riparian vegetation. As discussed previously, Sacramento River flow under the proposed action would generally be similar to flow under the COS, so differences in riparian habitat between these scenarios are expected to be insignificant. However, flow under the proposed action is generally much higher than WOA flow during summer and early fall and much lower than WOA flow during late winter and early spring. Also, as discussed for PBF5, inundation of floodplains is less likely under the proposed action. These conditions suggest that riparian vegetation would establish and grow less successfully during winter under the proposed action scenario, but the high summer proposed action flow could lead to some possible growth increases for vegetation that was able to establish in the lower spring flows. Therefore, the effect of the proposed action relative to the WOA on riparian habitat is uncertain.

5.7.7 PBF7 – Access Downstream so that Juveniles can Migrate from Spawning Grounds to San Francisco Bay and the Pacific Ocean

Emigration of juvenile Winter-run Chinook Salmon from spawning grounds to the Delta is potentially limited by flow and water temperature-related conditions throughout the Sacramento River upstream of the Delta. Winter-run Chinook Salmon juveniles emigrate from the upper and middle Sacramento River over a period of many months, beginning as early as July, shortly after the start of fry emergence, through the following March. Differences in modeled flows and water temperatures in juvenile Winter-run Chinook Salmon migration habitat are small between the proposed action and COS, but are large between the proposed action and WOA.

During the late fall through early spring period, flows under all three scenarios are high enough and water temperatures are low enough to sustain juvenile Winter-run Chinook Salmon. However, proposed action flows in many years during the winter and early spring are much lower than WOA flow and, because the WOA flows are uncontrolled, pulse flows are less frequent under the proposed action, even though the proposed action includes a spring pulse. Pulse flows stimulate juvenile salmon to initiate major downstream movement. Therefore, during these months the proposed action would adversely affect flow conditions for juvenile emigration relative to the WOA.

During the summer and early fall, proposed action flows are much higher than WOA flows, which would benefit emigrating juveniles. Water temperatures in the middle Sacramento River (Woodson Bridge gauge) are consistently below critical thresholds for emigrating Winter-run Chinook Salmon juveniles under all three project scenarios during every year from November through March. However, during July through September, the proposed action temperatures exceed the threshold in about half of the years while the WOA water temperatures exceed the threshold for juvenile Winter-run Chinook Salmon in every year . Also, the proposed action temperatures during these months are 10 to 15 degrees Fahrenheit cooler than the corresponding WOA temperatures.

Overall, the proposed action would provide less favorable conditions relative to the WOA scenario for emigrating juveniles during winter and early spring, because proposed action flows would generally be lower. The proposed action would provide more favorable conditions in the summer months compared to WOA because flows would be higher and water temperatures lower. On balance, the proposed action is not expected to adversely affect downstream access in critical habitat for juvenile Winter-run Chinook Salmon emigrating down river.

The proposed action is not expected to have effects on water temperature and dissolved oxygen concentration (DO) in critical habitat for Winter-run Chinook salmon in the Bay/Delta. These water quality parameters are major discriminators for comparing potential effects of the proposed action and the WOA on Winter-run Chinook in the Sacramento River upstream of the Delta. In the Bay/Delta, however, flow and water temperature of reservoir releases are generally considered to have little effect on water temperatures (Wagner et al. 2011, USFWS 2017b). However, this assessment has been based on experience with smaller flow and water temperature differences than those expected between the proposed action and WOA (USFWS 2017b), so the conclusion that the proposed action would have no effects on water temperature in the Bay/Delta relative to the Without Action scenario is uncertain. Other than near major effluents, DO in the Bay/Delta is primarily determined by water temperature. Juvenile Winter-run undergo smoltification before and while they reside in the Bay/Delta, so they are able to tolerate a wide range of salinities in the Bay/Delta.

Flow from the Sacramento, San Joaquin and other rivers tributary to the Delta, as well as tidal flows, affect the hydrodynamic of Delta channels and influence how juvenile Winter-run move through the Delta. The results of analyses of hydrodynamics and flow velocities to evaluate effects of the proposed action on routing of Winter-run juveniles in the Delta indicate that routing into the interior Delta, where the juveniles would be at higher risk from entrainment and reduced water quality (NMFS 2009), would be higher under the proposed action relative to the WOA.

Effects of the proposed action on entrainment of juvenile Winter-run at the Banks and Jones export facilities in the south Delta would be substantial compared to WOA, as the WOA scenario includes no exports from the Delta and therefore would have no entrainment at the south Delta facilities. The proposed action is expected to increase entrainment of individual Winter-run Chinook salmon relative to both current operations and WOA.

5.7.8 Effects of Conservation Measures

Spawning and rearing habitat restoration projects in the upper Sacramento River associated with the proposed action would be implemented for the benefit of salmonids, including Winter-run Chinook Salmon and elements of critical habitat. Construction may increase turbidity and contaminant exposure risk. Ultimately, restoration projects would improve access to spawning areas (PBF1) and availability of clean gravel for spawning substrate (PBF2). Construction may cause temporary localized adverse effects but are expected to result in long-term beneficial effects to critical habitat for Winter-run Chinook Salmon.

5.8 Chinook Salmon, Central Valley Spring-run ESU

The reduced spring flows of the proposed action, compared to the WOA, are likely to affect rearing and migrating Spring-run Chinook salmon and their habitat. Effects include a decrease in floodplain and side-channel habitat, reduced foraging conditions, increased competition and predation, and reduced emigration flows.

For Spring-run Chinook salmon, the proposed action includes a pulse flow in the spring from Shasta Reservoir in years when the cold water pool is likely sufficient to protect winter-run egg incubation. The pulse may improve survival for Mill, Deer, and Butte Creek Spring-run migrating through the lower Sacramento River.

In addition to the pulse flow in the spring, several conservation measures would also minimize impacts of lower spring flows on Spring-run Chinook salmon juveniles. These include spawning and rearing habitat restoration on the Sacramento River, Deer Creek, and lower San Joaquin River, tidal habitat restoration, and predator hot spot removal. Similar to winter-run Chinook salmon, OMR management establishes protective criteria to minimize and avoid entrainment based on historical salvage. Additional protective measures occur when environmental criteria indicate that entrainment is more likely and allow for more flexible operations when entrainment is less likely. The proposed action also includes conservation measures such as improvements at fish collection facilities to improve facility survival and reduce impacts of the proposed action as compared to WOA.

5.8.1 Lifestage Timing

General life stage timing and location information for Spring-run Chinook Salmon is provided in Table 5.8-1. Additional detail regarding juvenile life stage timing at various monitoring locations is provided in Appendix F, *Juvenile Salmonid Monitoring, Sampling, and Salvage Timing Summary from SacPAS*.

Table 5.8-1. The Temporal Occurrence of Adult (a) and Juvenile (b) Spring-run Chinook Salmon at Various Locations in the Central Valley (NMFS 2017, p.71).

Relative Abundance	High	Medium	Low

(a) Adult Migration

Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Delta[a]	Low	High	High	Medium	Low	Low	Low	Low	Low	Low	Low	Low												
San Joaquin Basin					Medium	Medium	Medium	Medium	High	High	High	High	Medium	Medium	Medium	Medium	Medium	Medium	Low					
Sac. River Basin[b,c]					Medium	Medium	Medium	Medium	High	High	High	High	Medium	Medium	Medium	Medium	Medium	Medium	Low					
Sac. River Mainstem[c,d]		Low	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low								
b) Adult Holding[b,c]				Low	Low	Medium	Medium	High	High	High	High	High	High	High	High	Medium	Medium	Low	Low					
c) Adult Spawning[b,c,d]															Low	Medium	High	High	Medium	Low				

(b) Juvenile Migration

Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Sac. River at RBDD[d]	High	High	Low	Low	Low	Low	Low	Low	Low												High	High	High	High
Sac. River at KL[i]	Medium	Medium	Medium	Medium	High	High	High	High	Medium	Medium											Medium	Medium	High	High
San Joaquin basin	Medium	Medium	Medium	Medium	High	High	High	High	Medium	Medium											Medium	Medium	High	High
Delta[j]	Low	Low	Low	Low	Medium	Medium	High	High	Low	Low	Low											Low	Low	Low

Sources: [a]CDFG (1998); [b]Yoshiyama et al. (1998); [c]Moyle (2002); [d]Myers et al. (1998); [e]Lindley et al. (2004); [f]CDFG (1998); [g]McReynolds et al. (2007); [h]Ward et al. (2003); [i]Snider and Titus (2000); [j]SacTrawl (2015)

Note:

Yearling spring-run Chinook salmon rear in their natal streams through the first summer following their birth. Downstream emigration generally occurs the following fall and winter. Most young-of-the-year spring-run Chinook salmon emigrate during the first spring after they hatch.

5.8.2 Conceptual Model Linkages

Central Valley (CV) Spring-run Chinook Salmon populations occur in several Central Valley streams. This section considers effects of the proposed action on the Sacramento River population. The SAIL conceptual model (Figure WR_CM1) was prepared especially for Sacramento River Winter-run Chinook Salmon, but the cause and effects relationships it diagrams apply equally well to the Spring-run population in Sacramento River. This conceptual model will be referenced throughout this section to explain links between the species and the effects of the action. The primary differences in the habitat requirements between the two runs (i.e., Winter and Spring) are the duration and the time of year that the different life stages use their habitats (NMFS 2014).

Reclamation proposes to store and release water from Shasta, Keswick Whiskeytown Dams. Storing water in the upper Sacramento River watershed is landscape level attribute in the conceptual model. The resulting dam releases and the resulting flows are environmental drivers that affect habitat attributes. The flows can influence water temperature, dissolved oxygen level (DO), the amount of stranding, outmigration cues and the timing, condition and survival of rearing CV juvenile Spring-run Chinook salmon. These flows also influence the timing, condition and survival of eggs and alevins in the spawning redds, rearing juvenile CV Spring-run Chinook salmon and holding of adult CV Spring-run Chinook salmon prior to spawning in the upper Sacramento River. These habitat attributes further influence lower level attributes, such as flow affects dilution of contaminants and toxics; water temperatures affects food availability, predation, pathogens, and disease; river stage and flow velocity affects habitat connectivity, bioenergetics, food availability, and predation, entrainment and stranding risk, and potentially affects cues that stimulate outmigration (Windell et al. 2017, Moyle 2002).

These inundated floodplains of the middle Sacramento River, such as the Yolo and Sutter Bypasses, have proven particularly successful habitats for juvenile salmon growth (Katz, 2017). This success has been attributed to optimum water temperature, lower water velocity, and higher food quality and food density relative to the main channel. Reduced predator and competitor density also likely contribute to high growth rates observed for juvenile salmon rearing in floodplains (Windell et al. 2017).

The proportion of eggs surviving to emerge as fry depends largely on the quality of conditions in the redds (Windell et al. 2017). Redd quality is affected by substrate size and composition, flow velocity, temperature, DO, contaminants, sedimentation, and pathogens and diseases. Flow affects sedimentation and gravel composition of the redds and may cause redd scour, stranding or dewatering (Windell et al. 2017). Flow also affects the surface area of riverbed available for redd construction.

Eggs and emerging fry are often exposed to geomorphic flows, and spring attraction flows based on the lifestage timing. Potential effects of these geomorphic flows include increased gravel scour which could displace incubating eggs from redds, resulting in exposure to increased predation, mechanical shock and abrasion, and increased water temperature if transported out of suitable incubation habitat, if present. Geomorphic flows could also temporarily increase suspended solids and turbidity, causing sediment deposition in redds that can reduce hydraulic conductivity through the redd and result in reduced oxygen delivery to eggs, reduced flushing of metabolic waste, and entombment of alevins via a sediment “cap” that prevents or impedes emergence (Everest et al. 1987, Lisle et al. 1989). These flows are mobilize gravel and increases the overall quality of egg incubation habitat. Critical water temperatures thresholds for CV Spring-run Chinook Salmon vary by life stage, with eggs and alevins the most sensitive to elevated temperatures. Rombough (1994) indicates that eggs at hatch generally require water temperatures no greater than about 53.5 degrees Fahrenheit because at higher temperatures DO is insufficient to satisfy metabolic demands. Central Valley Spring-run Chinook salmon eggs and alevins are assumed to be similarly affected by temperature.

The proportion of juveniles surviving to emigrate from the middle Sacramento River depends largely on growth and predation, which are greatly affected by habitat conditions, including instream flow (Windell et al. 2017). The proportion of juveniles surviving to emigrate from the upper Sacramento River depends largely on habitat conditions, including instream flow (Windell et al. 2017). Central Valley Spring-run Chinook salmon juveniles rear throughout the upper Sacramento (Keswick to Red Bluff) from November through May, with a peak rearing period during November through January, and emigrate from the upper River during this period (Table 5.8-11). Flows during fall and winter of dry and critically dry years generally have the greatest potential to adversely affect the juvenile life stage in the upper Sacramento River because reservoir storage and cold water pool in these seasons and water year types may be insufficient to provide suitable flow and water temperature conditions in the rearing habitats.

Central Valley Spring-run Chinook salmon adults spawn in the Sacramento River from August through October with peak spawning during September (Table 5.8-1). Monitoring spring-run spawning in the mainstem Sacramento River is complicated due to lack of spatial/geographic segregation and temporal isolation from fall-run. Most spring-sun spawning occurs between the Anderson-Cottonwood Irrigation District Dam to Airport Road Bridge (NMFS 2017b). Fry emergence occurs up to 3.5 months after eggs are spawned (Moyle 2002), so effects of flow resulting from the proposed action in the upper Sacramento River on incubating spring-run eggs and alevins potentially occur from August through January, peaking in November and December.

Many of the factors that affect rearing and emigrating CV Spring-run Chinook Salmon juveniles in the middle Sacramento River are similar to those described above for the upper Sacramento River. Juvenile spring-run spend varying amounts of time rearing in the upper Sacramento River following emergence before migrating to the middle River. They use the middle Sacramento River as rearing habitat and a migratory corridor to the Delta. The majority of spring-run-sized juveniles occur in the middle Sacramento River at Knights Landing from November through May (Table 5.8-1), with two separate peak occurrences: December and March through April (Table 5.8-1). The two peaks may reflect differences in the timing of emigration from different Sacramento River tributaries. For instance, emigration of young-of-year juveniles from Butte Creek occurs earlier than that from Mill and Deer creeks (NMFS 2009).

Holding for adult Spring-run Chinook Salmon in the upper Sacramento River extends from late February through early October, peaking in late April through early August (Table 5.8-1).

5.8.3 Effects of Operation and Maintenance

The WOA scenario is described previously in the Winter-run Chinook salmon effects analysis. Sacramento River flows at Keswick Dam resulting from the WOA scenario were modeled in CalSim and reflect seasonal changes, with low summer and fall flows and high winter and spring flows (Figures 15-7 through 15-18 in the CalSim II Flows section of Appendix D). Flows in the middle Sacramento River under the WOA scenario would be similar to those in the upper Sacramento River, moderately low during November and May and much higher during December through April (see Appendix D, *Modeling*). CalSim modeling indicates that during the CV Spring-run Chinook holding period in the upper Sacramento River, flows at Keswick range from about 770 cfs in August to about 63,000 cfs in March, and 40 to 50 percent of years have flows below the current 3,250 cfs required minimum flow during July through September (see Appendix D, *Modeling*).

Other locations in the Sacramento River would show similar seasonal flow patterns. Modeling results of the WOA scenario indicate that flows in CV Spring-run Chinook Salmon habitat located in the Upper Sacramento during the August through January spawning and incubation period are generally low during August through November, but are high in December and January of years with wetter hydrologies (Figures 15-7 through 15-10, and 15-17 and 15-18 in the CalSim II Flows section of Appendix D).

In the WOA scenario, flows would generally be low in fall during years with dry hydrology and often fall below the currently required minimum flows for much of fall through spring (Figures 15-8 through 15-14, and Tables 15-1 through 15-3, 16-1 through 16-3, and 17-1 through 17-3 in the CalSim II Flows section of Appendix D). The proposed action flows are higher during the fall and winter when compared to WOA, which is a benefit for spawning CV Spring-run Chinook Salmon adults and incubating eggs and alevins through increased spawning and rearing habitat. Since juveniles are youngest and most sensitive in the fall and early winter, the increased habitat conditions under the proposed action as compared to WOA would lead to increased growth rate and lower mortality of the individual juveniles and an increased population abundance. The higher proposed action flows as compared to WOA in summer would be beneficial to holding adults and increase areas suitable for redd construction, as described by Windell et al. 2017. Potential adverse effects of low flows on the upper Sacramento River are included in the Winter-run Chinook Salmon effects analysis detailed above.

Higher flows during the winter under WOA would also negatively influence spawning and egg/alevin incubation. If flows are sufficiently high, they result in excessive depths and flow velocities for constructing redds, and redds that were previously built are at risk of being scoured from the bed (NMFS 2017 CWF BO). In addition, under high flows adults may build redds in areas that are later dewatered or isolated from the main river channel when the flows decline. Modeling indicates that high flow events with rapid flow fluctuations are likely to occur in the Sacramento River under the WOA scenario. The higher flows in winter and spring could have adverse effects on rearing juvenile CV Spring-run Chinook Salmon including higher stranding risk because of increased use of flood plains and greater flow fluctuations, and higher contaminants loading from stormwater runoff. In general, higher flows are likely to benefit holding adults by affording better water quality (including cooler water temperatures and higher DO), reduced exposure to pathogens, and lower risk from anglers (Windell et al. 2017).

In the without action scenario, as described in the Winter-run Chinook salmon section, the water temperatures in the upper Sacramento River would be substantially warmer because the shallow reservoir that would remain behind Shasta Dam would absorb significant heat during warm, sunny days.

The USEPA (2003) gives 64 degrees Fahrenheit as the critical 7-day average daily maximum (7DADM) water temperature for rearing salmonid juveniles. Also, the USEPA (2003) gives 68 degrees Fahrenheit as the critical 7DADM water temperature for migrating salmonid adults and 61 degrees Fahrenheit for holding adults. As discussed in the Winter-run Chinook Salmon section above, this reference is based on Pacific Northwest fish and hydrology and does not consider the operational feasibility of operating to 7DADM.

Under the WOA scenario, the elevated water temperatures in late spring, summer and early fall, would be poorly suited for spring-run adults. Monthly mean water temperatures in spawning habitat (i.e., HEC-5Q WOA scenario) would be high in the latter part of summer during the spawning and incubation period, ranging from about 63 to 72 degrees Fahrenheit. The critical temperature thresholds for spawning adults are the same as those for incubating eggs and alevins: 56 degrees Fahrenheit and 53.5 degrees Fahrenheit. This water temperature regime greatly exceeds both thresholds (Figures 5-17 and 5-18 in the HEC5Q Temperatures section of Appendix D). During early fall, water temperatures would exceed the 56 degrees Fahrenheit threshold in about half of the years projected and would exceed the 53.5 degrees Fahrenheit threshold in all years projected (Figure 5-7 in the HEC5Q Temperatures section of Appendix D,Figures 5-11 through 5-18 and 5-7 in the HEC5Q Temperatures section of Appendix D). Such conditions would likely preclude survival of incubating CV Spring-run Chinook Salmon eggs and alevins. During the remaining months of the CV Spring-run Chinook Salmon spawning and incubation period of fall through winter, water temperatures under the WOA conditions would be consistently below 52 degrees Fahrenheit, suitable for incubating eggs and alevins (Figures 5-8 through 5-10 in the HEC5Q Temperatures section of Appendix D). However, Sacramento River Spring-run Chinook Salmon have largely finished spawning by mid-fall (Table 5.8-1). Therefore, unless the population successfully shifted its spawning to later in the winter, Spring-run Chinook Salmon would likely be eliminated from the Sacramento River mainstem under without action conditions.

During February through April, the first part of the CV Spring-run adult holding and spawning period in the upper Sacramento River, mean water temperatures under the WOA scenario are consistently below the 61 degrees Fahrenheit threshold for holding adults, and water temperatures are below this threshold in most years during May (Figures 5-9 through 5-14 in the HEC5Q Temperatures section of Appendix D). They are also below the threshold in all years during October (Figure 5-7 in the HEC5Q Temperatures section of Appendix D). During June through September, however, the water temperatures are above the threshold in almost every year (Figures 5-15 through 5-18 in the HEC5Q Temperatures section of Appendix D).

During the November through May period, temperature would range from about 38 degrees Fahrenheit during January to 63 degrees Fahrenheit during May (Figures 5-8 through 5-14 in the HEC5Q Temperatures section of Appendix D). Under the WOA scenario, water temperatures would exceed the 61 degrees Fahrenheit threshold only in May and the exceedences would occur in 2% of the years in the historical record. Water temperatures during the November through May period at other locations in the upper Sacramento River would generally be similar to those at Keswick Dam, but in May, water temperatures would range up to 69 degrees Fahrenheit at the Red Bluff Diversion Dam (RBDD), with about 15 percent of years exceeding the 61 degrees Fahrenheit threshold. The infrequent exceedances of the 61 degrees Fahrenheit threshold that would occur during May at some locations in the upper Sacramento River would potentially negatively impact rearing Spring-run Chinook Salmon juveniles. However, the exceedances would rarely occur. Furthermore, by May most juveniles have probably matured enough to acquire greater warm water temperature tolerance and most have emigrated from the upper Sacramento River (Table 5.8-1).

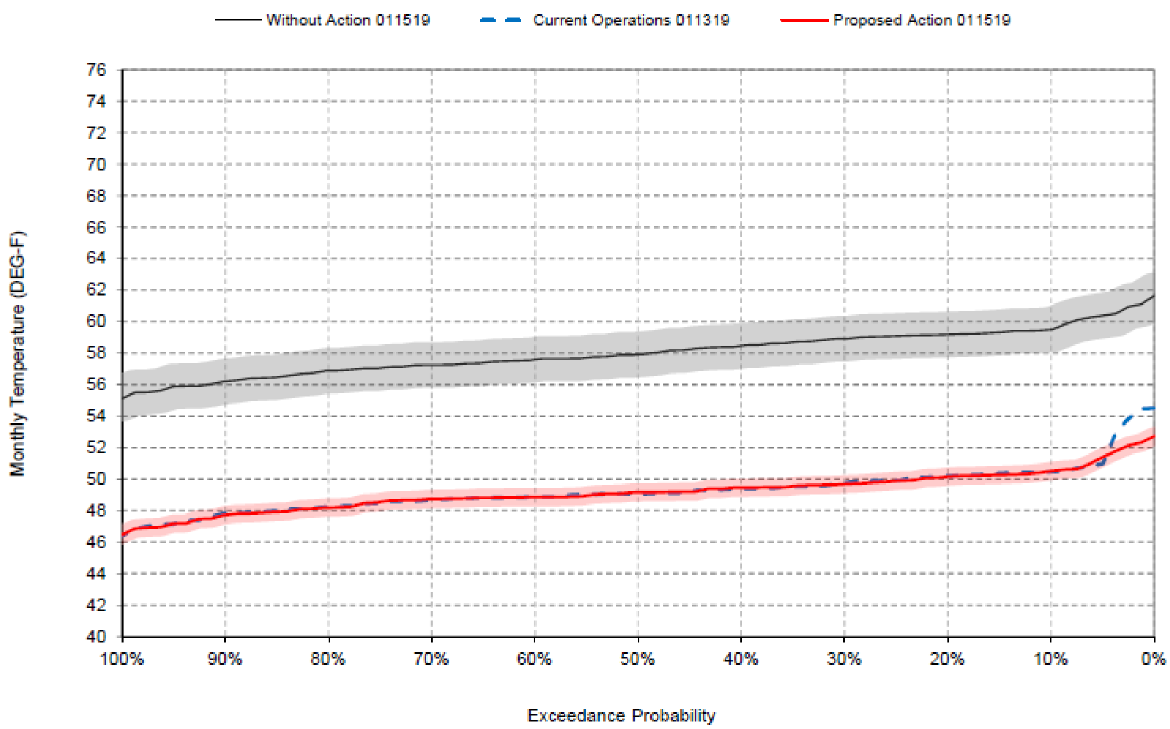


Figure 5.8-1. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the WOA, COS and proposed action scenarios, May

In the upper Sacramento River at Keswick, the WOA scenario monthly average water temperatures would be below the 61 degrees Fahrenheit threshold for holding adults from January through April and in October (Figures 5-7 and 5-10 through 5-13 in the HEC5Q Temperatures section of Appendix D), but would exceed the threshold in about 2 percent of years in May and in every year during June through September (Figures 5-14 through 5-18 in the HEC5Q Temperatures section of Appendix D). Water temperatures conditions under the WOA scenario in the summer months, June through September, would be highly stressful to adult CV Spring-run migrating upriver in the middle Sacramento River as well as those holding in the upper river.

For juveniles, the main difference between the juveniles in the middle Sacramento River and those in the upper river with respect to these adverse effects is that the juveniles in the middle river would generally be less sensitive to the effects because their greater age and size would afford them greater robustness. The low fall flows under the WOA scenario would likely result in reduced conditions in juvenile rearing habitats in the middle Sacramento River. During November and May, the flows would fall below the normal minimum flow requirements in about 37 percent of years projected.

In the middle Sacramento River below the Colusa Basin Drain, which is close to Knights Landing, the WOA scenario monthly mean water temperatures would remain below the 64 degrees Fahrenheit juvenile rearing temperature threshold from November through March (Figures 14-8 through 14-12 in the HEC5Q Temperatures section of Appendix D), but would exceed the threshold during the warmest 5 percent of years in April and the warmest 85 percent of years in May, with a maximum water temperature of 75 degrees Fahrenheit (Figures 14-13 and 14-14 in the HEC5Q Temperatures section of Appendix D).

In the middle Sacramento River at Knights Landing, the WOA scenario monthly average water temperatures would consistently be below the 68 degrees Fahrenheit threshold for immigrating adults from January through April (Figures 14-10 through 14-13 in the HEC5Q Temperatures section of Appendix D). Under the WOA scenario, water temperatures would exceed the threshold during May of about half of the years, during June through September in every year, and during October of about 20 percent of the years on record. (Figures 14-7 and 14-14 through 14-18 in the HEC5Q Temperatures section of Appendix D).

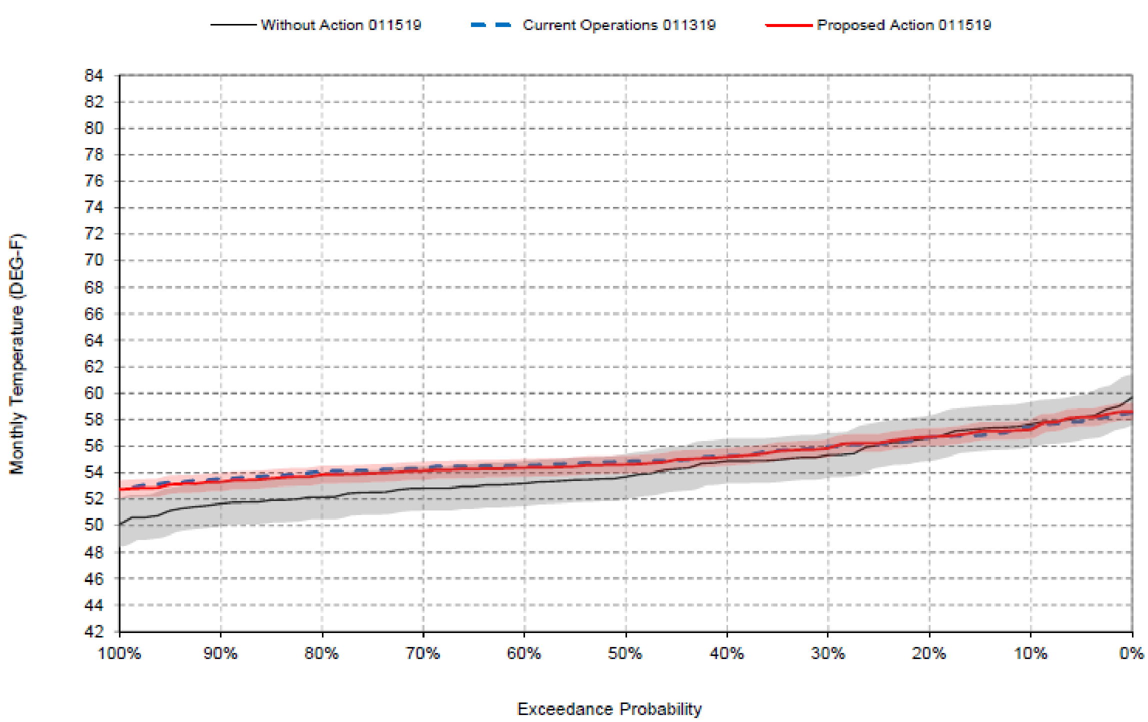


Figure 5.8-2. HEC-5Q Sacramento River Water Temperatures below Colusa Basin Drain under the WOA, COS and proposed action scenarios, November

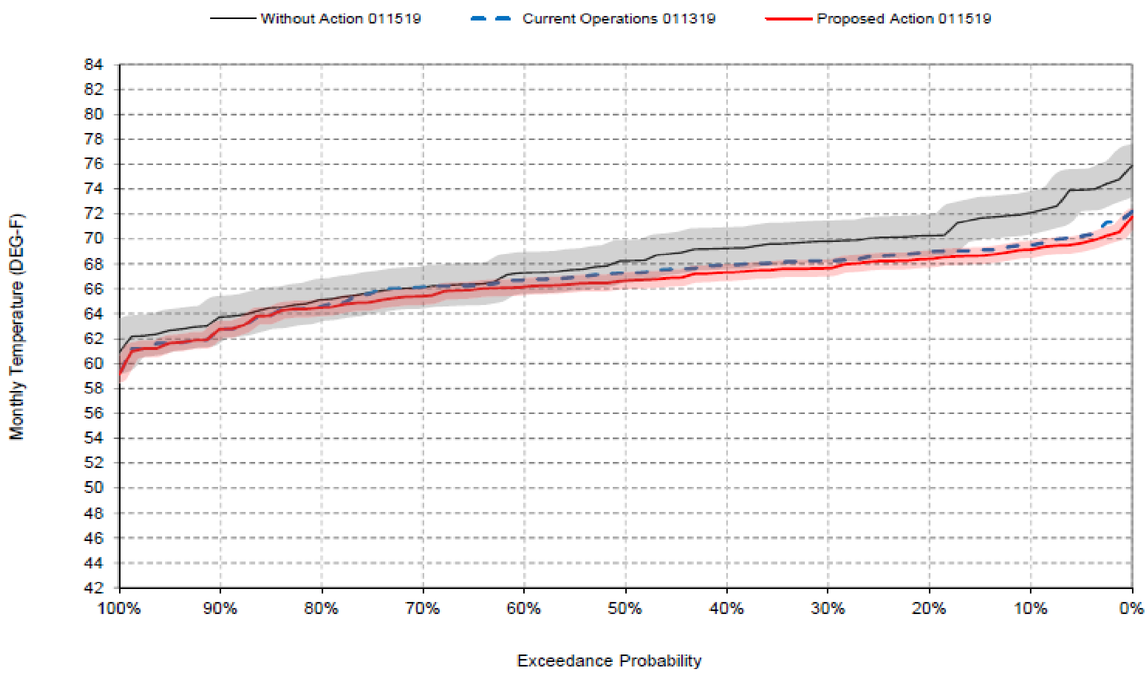


Figure 5.8-3. HEC-5Q Sacramento River Water Temperatures below Colusa Basin Drain under the WOA, COS and proposed action scenarios, May

CalSim modeling indicates that from January through April, the first half of the period during which spring-run adults migrate upstream through the middle Sacramento River to holding habitat in the upper river, the WOA scenario flows at Wilkins Slough would range from about 2,500 cfs in April to about 24,000 cfs in March (Figures 19-10 through 19-13 in the CalSim II Flows section of Appendix D), and at Keswick, the WOA flows would range from about 3,250 cfs in all four months to about 63,000 cfs in March (Figures 15-10 through 15-13 in the CalSim II Flows section of Appendix D). During the second part of the migration and holding period (May through October), the WOA flows at Wilkins Slough would range from 0 cfs in May through August to about 20,000 cfs in May (Figures 19-7 and 19-14 through 19-18 in the CalSim II Flows section of Appendix D). At Keswick, the WOA flows would range from about 772 cfs in August to about 32,000 cfs in May (Figures 15-7 and 15-14 through 15-18 in the CalSim II Flows section of Appendix D). The lowest flows at Keswick Dam during May through August would be low enough to create potential passage problems for immigrating adults, and this is even more likely for Wilkins Slough, where flows in June through August would be about 1,000 cfs or lower in about half of the years. The effects of low flow on the middle Sacramento River and for adults holding in the upper river are expected to be similar to those described by Windell et al. 2107.

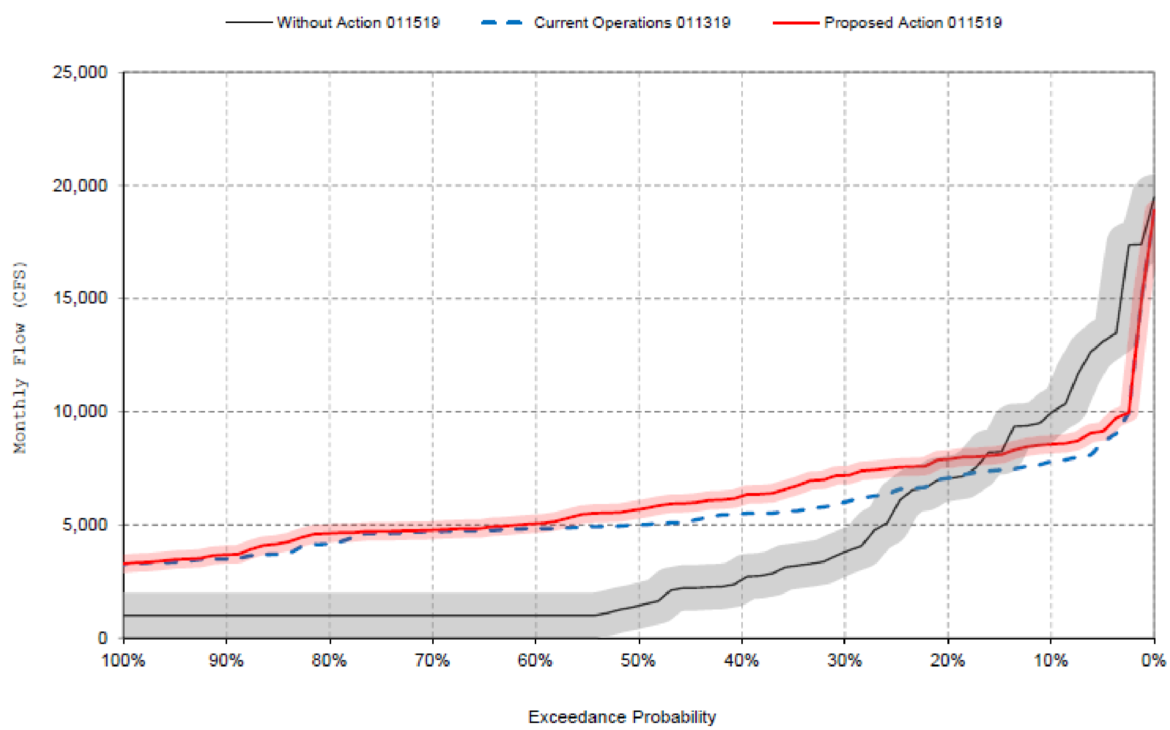


Figure 5.8-4. Modeled Sacramento River Flows at Wilkins Slough, June

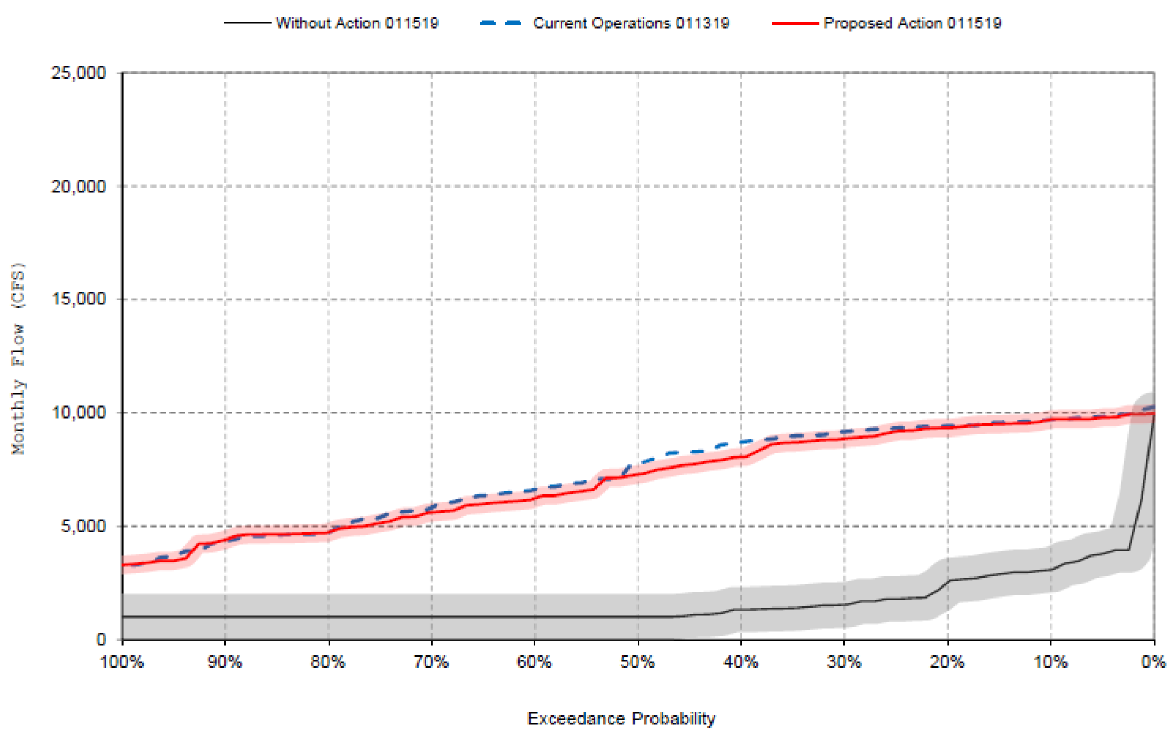


Figure 5.8-5. Modeled Sacramento River Flows at Wilkins Slough, July

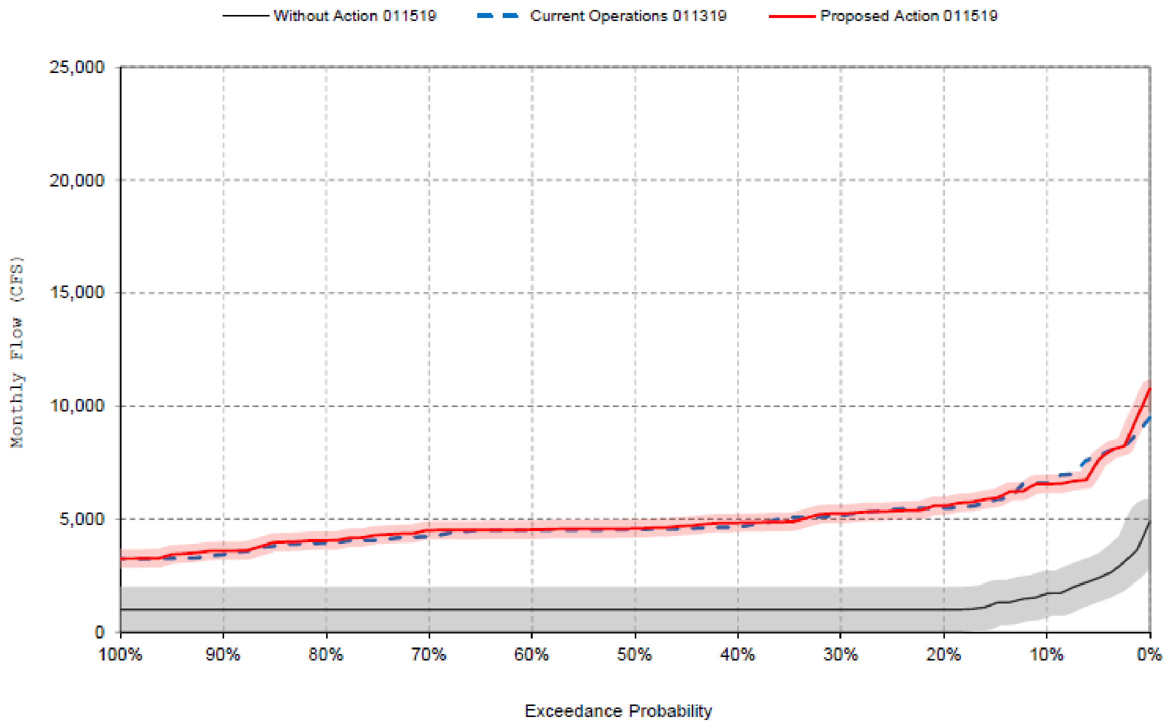


Figure 5.8-6. Modeled Sacramento River Flows at Wilkins Slough, August

5.8.3.1 Seasonal Operations of the CVP/SWP

Flows can modulate water temperature and DO concentration leading to changes in contaminant toxicity, pathogen virulence, food availability, bioenergetics and disease susceptibility. In addition, river stage and flow velocity may affect habitat connectivity, and availability which in turn may influence food availability, predation, crowding, entrainment and stranding risk, and can potentially affect cues that stimulate outmigration (Windell et al. 2017, Moyle 2002).

Flows under the proposed action are generally lower than flows under the WOA scenario during the peak seasonal timing of CV Spring-run Chinook juvenile rearing (November-May; Figure 5.8-7) in all watersheds. In particular, flows are reliably lower from January to May (Figure 5.8-7), a trend especially pronounced in wetter water year types. In contrast, flows under the proposed action are higher than WOA in the summer and fall. The likelihood of flows occurring in the proposed action that are less than the minimum instream flow requirements during these months is very low for all water year types. Lower flows during the juvenile outmigration period under the proposed action could have both beneficial and adverse effects on rearing juvenile CV Spring-run Chinook Salmon.

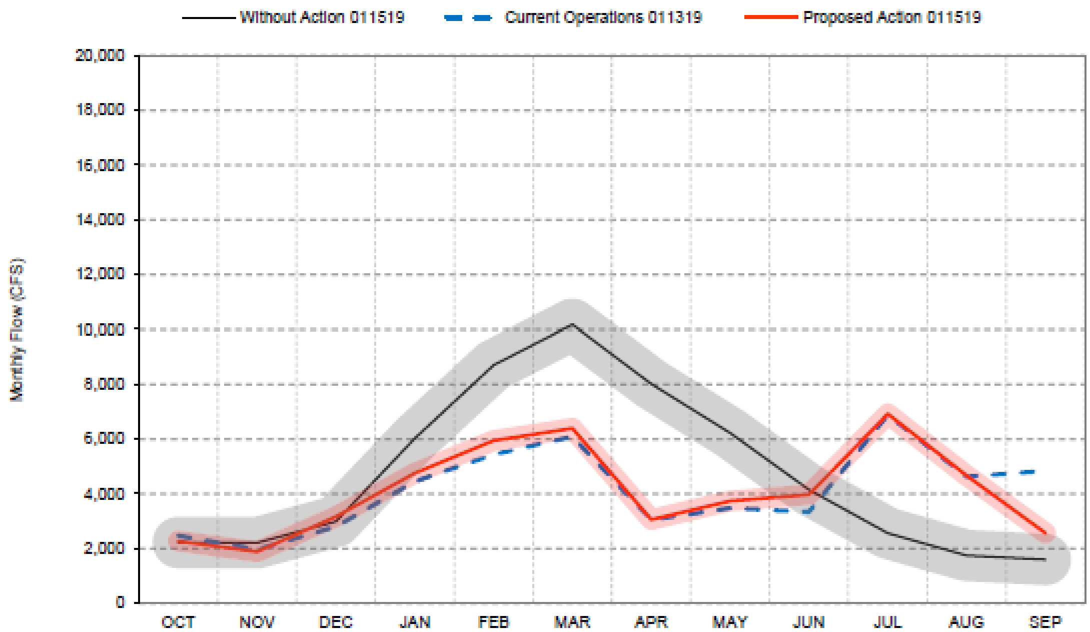


Figure 5.8-7. CalSim II estimates of Feather River Long-Term average flow below the Thermalito Afterbay in September-November and December-February.

The reduced spring flows of the proposed action, compared to the WOA, are likely to affect rearing individuals and their habitat. Beneficial effects are anticipated to be reduced stranding risk resulting from increased use of flood plain habitat and larger flow fluctuations, and reduced contaminant loading from stormwater runoff. Adverse effects include a decrease in floodplain and side-channel habitat, reduced foraging conditions, increased competition and predation, higher water temperatures and lower DO, and reduced emigration flows.

Several conservation measures proposed for Sacramento Winter-run Chinook salmon would offset any minimal adverse effects of reduced spring flows on Spring-run Chinook Salmon juveniles. These include spawning and rearing habitat on the Sacramento, Deer Creek and Stanislaus Rivers, cold water pool management on the Sacramento River, cold water pool management tools and infrastructure on the Sacramento River, predator hot spot removal and a small screen program.

Under the WOA scenario, Lake Oroville would not be operated to control storage or flow releases and no conveyance of water to San Luis Reservoir via the Banks Pumping Plant would occur. Therefore, there would be limited control of flow or water temperature in the Feather River HFC where CV Spring-run Chinook Salmon juvenile rearing occurs. Resulting water temperatures under the WOA scenario in the Feather River HFC at Gridley Bridge as modeled by the RecTemp temperature model are similar to COS and proposed action temperatures during the November to May period, but the proposed action is up to 7 degrees cooler than the without action during the critical summer holding period for Spring-run Chinook Salmon adults (Figure 5-8-8).

The increased summer flows of the proposed action, compared to the WOA, are likely to have significant benefits for holding adults by reducing water temperatures in holding areas, and associated benefits to dissolved oxygen.

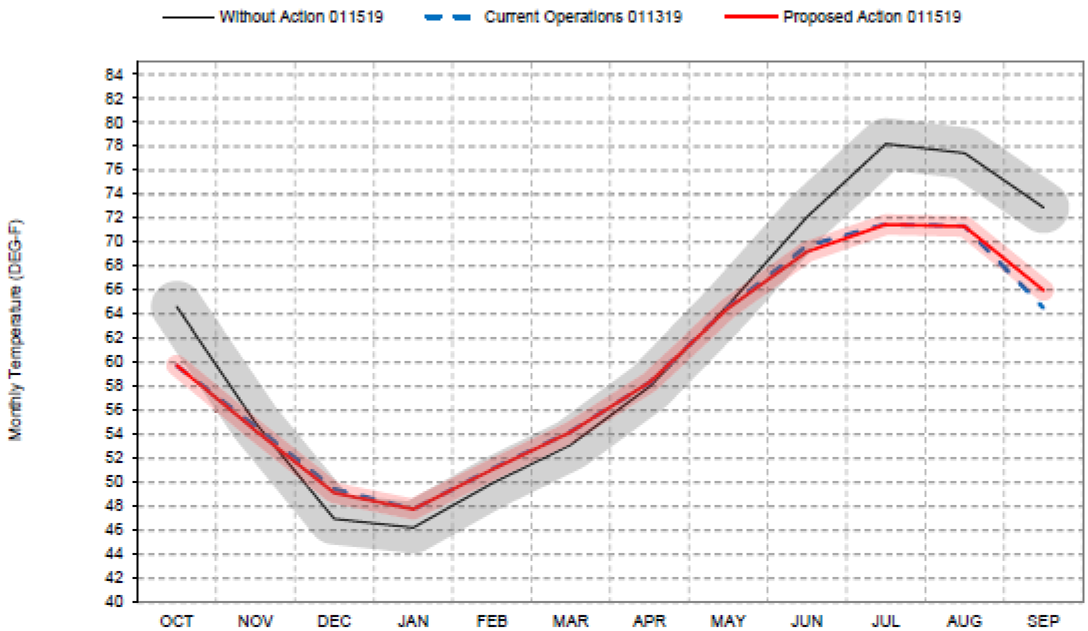


Figure 5.8-8. Long-term average RecTemp estimates of Feather River water temperature at Gridley Bridge under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action) scenarios.

5.8.3.2 Upper Sacramento River Seasonal Operations including Shasta Cold Water Pool Management

The effects of cold-water releases on Spring-run Chinook Salmon are expected to be similar to those experienced by Winter-run Chinook, but of smaller magnitude due to the seasonal timing of Spring-run Chinook Salmon spawning and juvenile rearing and the distribution of their redds.

Under the proposed action operations, flow and water temperature management in the upper Sacramento River would be largely the same as that under COS. The primary difference between the proposed action and the COS for the Sacramento River upstream of the Delta is the water temperature management of Shasta and Keswick reservoirs, especially with respect to the TCD.

5.8.3.2.1 Egg to Fry Emergence

5.8.3.2.1.1 River Flow

During summer and fall, primary operational considerations are flows required for Delta outflows, instream demands, and temperature control for Winter-run and Spring-run Chinook Salmon spawning and incubation. Proposed action flows are well above the WOA flows for the first three months (August through October) of the spring-run spawning and incubation period (Figures 15-17, 15-18, and 15-7 in the CalSim II Flows section of Appendix D). Low flows would be less frequent under the proposed action, resulting in benefits to Spring-run Chinook Salmon spawning and incubation.

Flow during the entire August through January period rarely fall below 3,250 cfs under COS, as indicated by CalSim modeling. Modeling indicates that lowest flows under the proposed action conditions are expected to be similar to the flows of the COS scenario (Figures 15-7 through 15-10, and 15-17 and 15-18 in the CalSim II Flows section of Appendix D).

Differences in flows between the proposed action and COS are small in most months, but flows are lower in the proposed action than in the COS modeling scenario in September of years with wetter hydrology (e.g., a COS flow of about 17,000 cfs corresponds to a proposed action flow of about 12,000 cfs and a COS flow of about 10,000 cfs corresponds to a proposed action flow of about 6,000 cfs) (Figure 15-18 in the CalSim II Flows section of Appendix D). After applying the Weighted Usable Area analysis for spawning habitat of Fall-run Chinook salmon juveniles, which has been used as a surrogate for Spring-run Chinook Salmon in the Sacramento River (ICF 2016 *CWF BA Appendix 5D Methods*), the lower September proposed action flows t result in an increase in spawning habitat Weighted Usable Area for Spring-run Chinook Salmon in this month (Figure 5.8-9). Although the Weighted Usable Area analyses indicate a potential increase in rearing habitat in wetter years under proposed action flows as compared to COS flows, the reductions in flow predicted for the proposed action could potentially affect other undetermined rearing habitat attributes of spring-run juveniles than those measured for the Weighted Usable Area analyses.

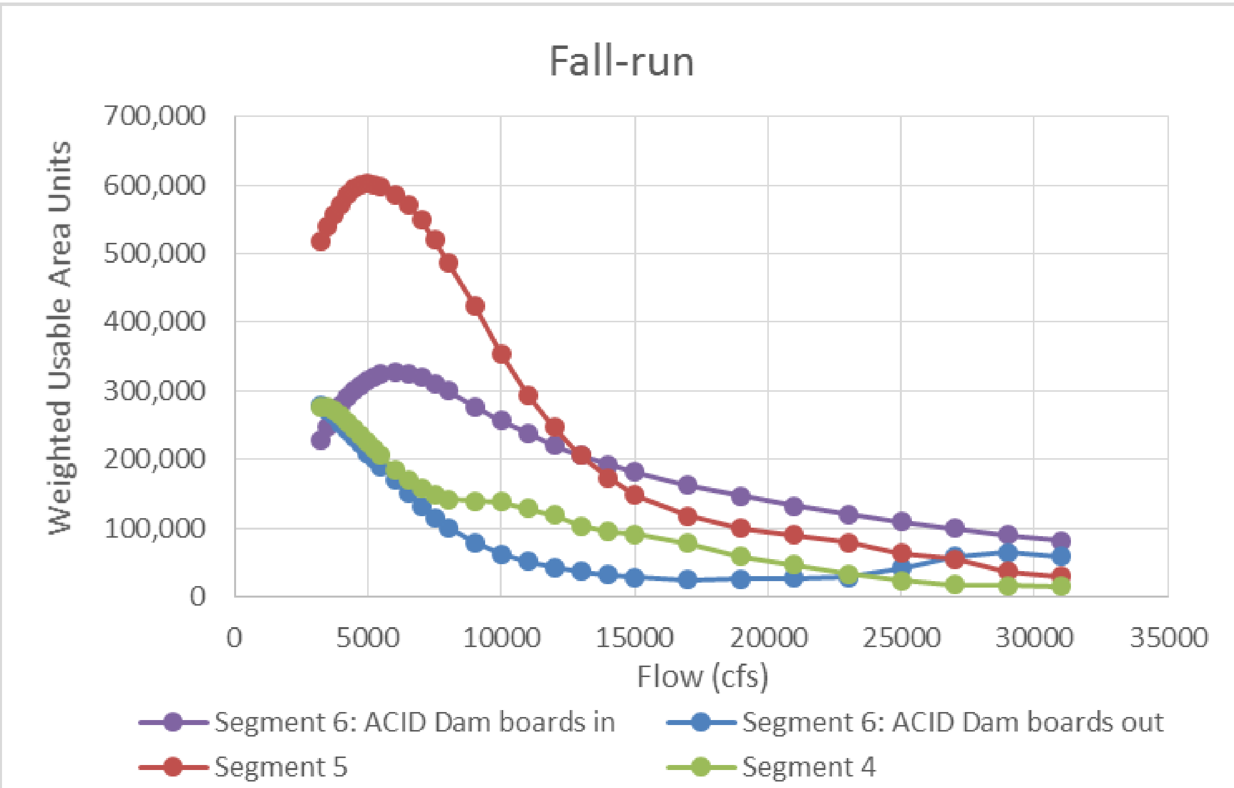


Figure 5.8-9. Spawning WUA Curves for Fall-run Chinook salmon in the Sacramento River, Segments 4 to 6. The fall-run curves were used to quantify Spring-run Chinook Salmon WUA, as discussed in the text. ACID = Anderson-Cottonwood Irrigation District.

5.8.3.2.1.2 Water Temperature

Reclamation proposes new water temperature management measures that include a water temperature maximum of 53.5 degrees Fahrenheit in the Sacramento River above the Clear Creek confluence (see below) in most years from May 15 to October 31.

The presence of a large cold water pool and the flexibility afforded by the TCD make possible the provision of much colder water under the proposed action and the COS in the upper Sacramento River during the first three months of the Spring-run Chinook Salmon spawning and incubation period than would be possible under the WOA conditions. Under the proposed action and the COS, monthly mean water temperatures at Keswick Dam range from about 50 to 66 degrees Fahrenheit during August through October (Figures 5-17, 5-18, and 5-7 in the HEC5Q Temperatures section of Appendix D). During November, water temperatures range from about 52 to 58 degrees Fahrenheit, and during December and January, they range from 43 to 55 degrees Fahrenheit (Figures 5-8 through 5-10 in the HEC5Q Temperatures section of Appendix D). While the HEC-5Q model provides 6-hour data, the results presented here are monthly averages, which should reasonably estimate daily average temperatures near Keswick Dam because operations at Shasta and Keswick dams create relatively stable summer flow and water temperature conditions. Variable weather conditions and travel time of water result in greater fluctuations around the mean further downstream of the dam.

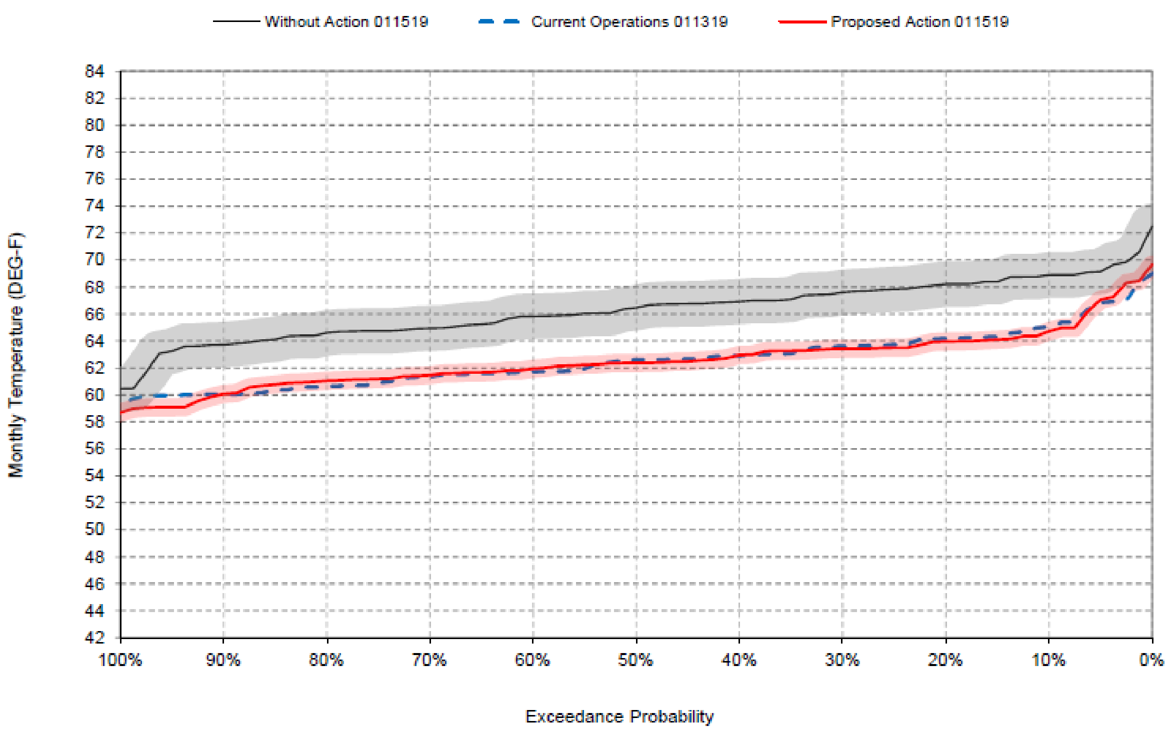


Figure 5.8-10. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the WOA and COS scenarios, October

As discussed in the Winter-run Chinook Salmon section, the proposed action has reduced temperatures by up to 2 degrees in October of most years as compared to the COS. The proposed action water temperatures exceed the 56 degrees Fahrenheit threshold approximately 20% of the time in November (see Figure below), but otherwise rarely in the fall. The proposed action exceeds 53.5 at Keswick approximately 8% of the time in August, while under the current operations temperatures at Keswick exceed 53.5 degrees Fahrenheit approximately 23% of the time. In September, the proposed action exceeds 56 degrees Fahrenheit at Keswick 10% of the time, while under the current operations water temperatures exceed 56 degrees Fahrenheit at Keswick approximately 7% of the time. Water temperatures in December and January would be consistently below the 56 degrees Fahrenheit threshold and would exceed the 53.5 degrees Fahrenheit threshold in about 10 percent of years in December and one percent in January (Figures 5-9 and 5-10 in the HEC5Q Temperatures section of Appendix D).

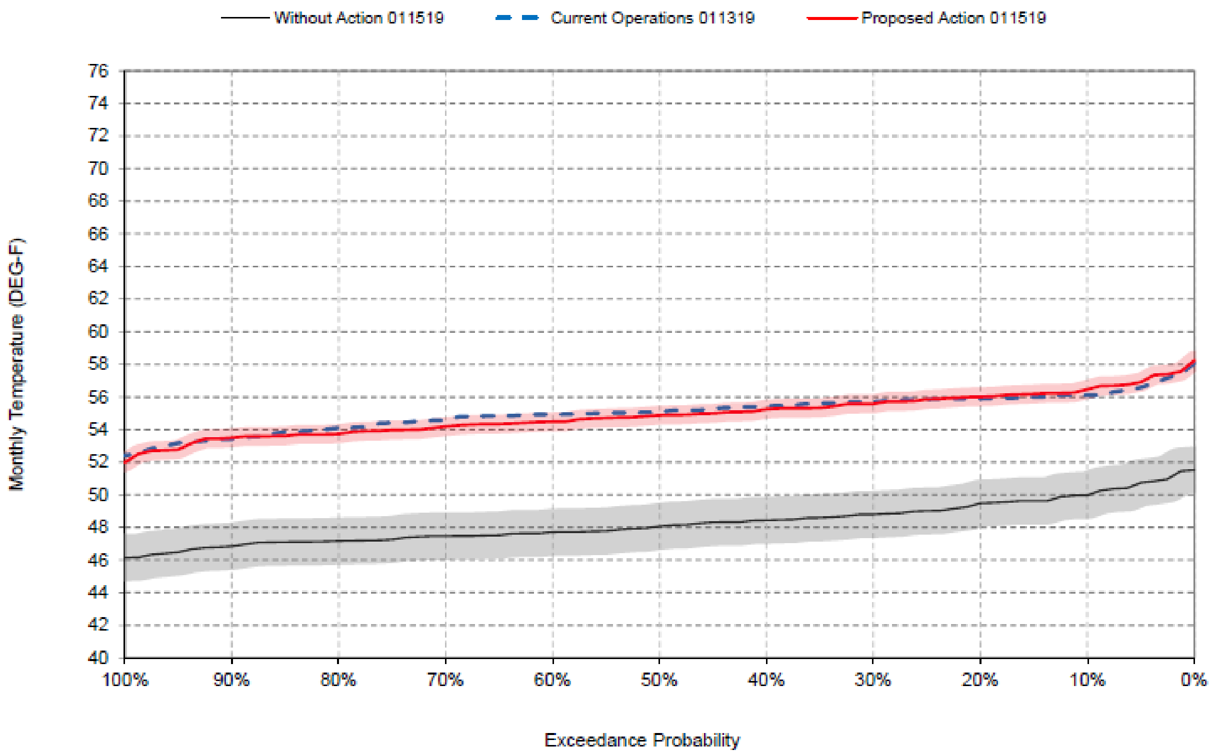


Figure 5.8-11. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the WOA and COS scenarios, November

Water temperatures under the proposed action are much lower than those under the WOA scenario from April through October (Figures 5-13 through 5-18 and 5-7 in the HEC5Q Temperatures section of Appendix D), whereas water temperatures under the proposed action are much higher than those under the WOA scenario during November through January (Figures 5-8 through 5-10 in the HEC5Q Temperatures section of Appendix D). These results indicate that the proposed action, relative to the WOA, provides a clear benefit to Spring-run Chinook Salmon eggs and alevins incubating in the upper Sacramento River during the spawning months (August through October). During November through January, when spawning is completed but eggs and alevins remain in some of the redds, water temperatures are suitable for egg and alevin incubation under the proposed action and COS scenarios, except during November, when water temperatures exceed the 56 degrees Fahrenheit threshold in 20 percent of years and the 53.5 degrees Fahrenheit threshold in more than 80 percent of years. Under the WOA scenario, water temperatures during November through January are suitable for incubating eggs and alevins, except perhaps during January in the coldest 30 percent of years, when the mean temperatures are under 40 degrees Fahrenheit (Figure 5.8-12). Such cold water temperatures are below the suitable temperature range for maximum egg and alevin survival (Moyle 2002). As noted above, the lower water temperature under the proposed action during the Spring-run Chinook Salmon spawning months would benefit the Sacramento River Spring-run Chinook Salmon population. On balance, this effect would be much greater than the adverse effect of the higher water temperatures in November of some years under the proposed action and the COS. In view of the improved water temperature management operations planned for the proposed action, this action is expected to benefit the Spring-run Chinook Salmon eggs and alevins relative to the COS and WOA.

Under the WOA, Spring-run Chinook Salmon eggs and alevins would mostly likely be eliminated from the Upper Sacramento River. Comparatively, the proposed action and the COS are beneficial to incubating Spring-run Chinook Salmon eggs and alevins. The proposed temperature management under the proposed action is expected to improve water temperatures compared to WOA and reduce operational difficulties in maintaining river habitats.

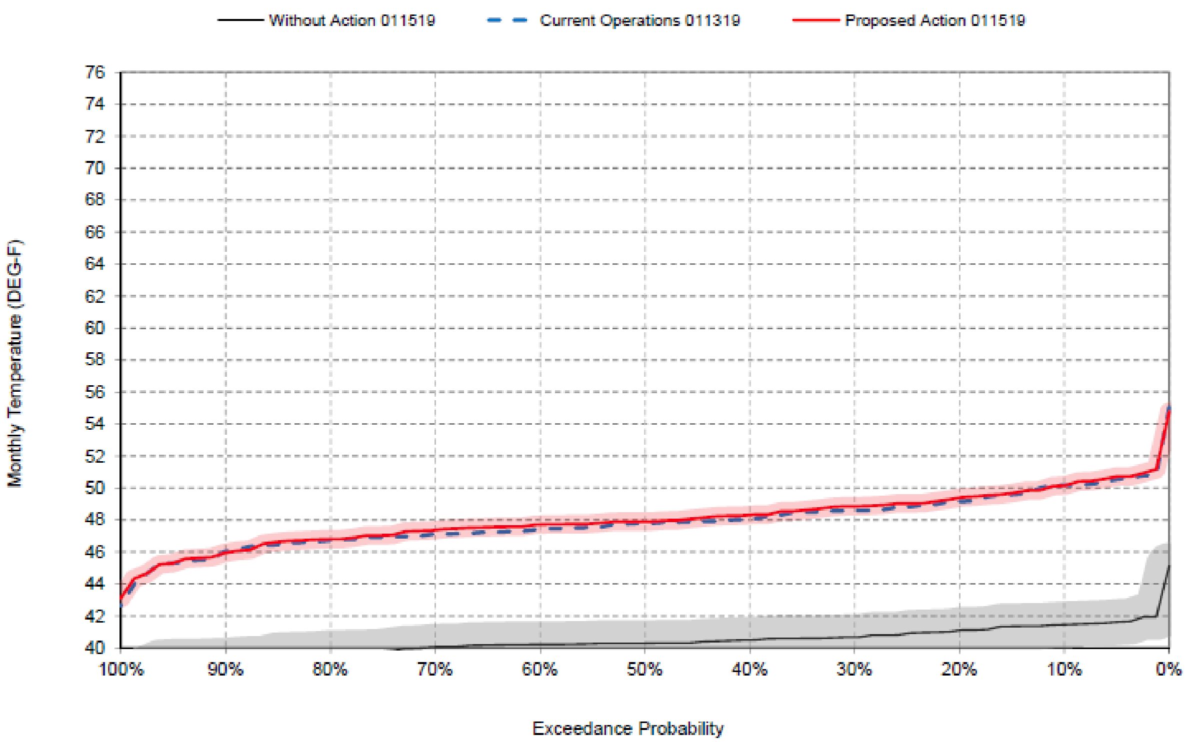


Figure 5.8-12. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the proposed action, WOA and COS scenarios, January

5.8.3.2.2 <u>Rearing to Outmigrating Juveniles in Rivers</u>

5.8.3.2.2.1 River Flow

Under proposed action operations, flow and water temperature management during the juvenile rearing and emigration period in the upper Sacramento River would be largely the same as that under COS. CalSim modeling indicates that upper Sacramento River flows during the November through May period of juvenile rearing in the upper Sacramento River are generally similar between the proposed action and the COS (Figures 15-8 through 15-14 in the CalSim II Flows section of Appendix D) except for higher flows during November under the COS scenario.

The CalSim modeling shows large seasonal changes in the differences between the proposed action and the WOA scenario and COS in upper Sacramento River flow. In November, there is little difference in flow between the WOA and proposed action scenarios, except in the highest flows years, when the proposed action flows tend to be higher. The COS flows are well above the WOA flows at most flow levels (Figure 15-8, and Tables 15-1 through 15-3, 16-1 through 16-3, and 17-1 through 17-3 in the CalSim II Flows section of Appendix D). In December and February, proposed action and COS flows are generally below WOA flows for years with dry hydrology, and are generally higher in wet years, except for the wettest Decembers (Figures 15-9 and 5-11 in the CalSim II Flows section of Appendix D). In January, proposed action and COS flows are generally moderately lower than the WOA flows and during March and April, they are well below the WOA flows (Figures 15-10, 15-12, and 15-13 in the CalSim II Flows section of Appendix D). In May, the proposed action and COS flows are well below the WOA flows in wetter years, and are slightly higher in drier years (Figure 15-14 in the CalSim II Flows section of Appendix D). These seasonal changes result primarily from Shasta Reservoir storage releases under the proposed action and COS during late fall, when uncontrolled flows are low, and also from diversions to Shasta Reservoir storage under the proposed action and COS scenarios during winter and spring, when uncontrolled flows are often high. Diversion to storage is higher in spring than in winter because the flood control pool in the reservoir can be reduced during spring as flood risk declines.

The flows resulting from differences between the WOA scenario and the proposed action and COA scenarios would likely impact Spring-run Chinook Salmon juveniles and their habitats, although the nature of the effect is undetermined. From January through April, WOA flows would often be nearly twice as high as the proposed action and COS flows during years with dry hydrology. The proposed action and COS flows in such years would generally be at the required minimum of 3,250 cfs. The Weighted Usable Area for rearing habitat of fall-run Chinook salmon juveniles, which has been used as a surrogate for Spring-run Chinook Salmon Weighted Usable Area analyses in the Sacramento River (ICF 2016 *CWF BA Appendix 5D Methods*), is at or near its maximum at 3,250 cfs (USFWS 2005). This flow was the lowest flow included in the USFWS study. Depending on the reach sampled in the study, flow of approximately 6,000 cfs, which is the most frequent flow level for dry hydrology under the WOA scenario, was estimated to have similar to much lower juvenile rearing habitat Weighted Usable Area than the 3,250 cfs flow (USFWS 2005). Although the Weighted Usable Area analyses indicate potentially greater juvenile rearing habitat Weighted Usable Area in dry years under the proposed action and COS scenarios than under the WOA scenario, the reductions in flow predicted for these scenarios would potentially affect other rearing habitat attributes of Spring-run Chinook Salmon juveniles than those measured for the Weighted Usable Area analyses, with potentially negative impacts to juveniles, but this conclusion is uncertain.

Proposed Action flows during January through May of years with wetter hydrology would generally be lower, and often much lower, than flows under the WOA scenario. Lower proposed action flows in winter and spring could have both beneficial and adverse effects on rearing juvenile Spring-run Chinook Salmon. Potential impacts of the proposed action as compared to WOA include less inundation of floodplain and side-channel habitat, reduced feeding conditions, increased competition and predation, higher water temperatures and higher DO, and reduced emigration flows, while benefits include lower stranding risk because of reduced use of flood plains and reduced flow fluctuations, and less contaminants loading from stormwater runoff. On balance, the effect of lower winter and spring flows during most years under the proposed action and COS scenarios relative to the WOA scenario on Spring-run Chinook Salmon juveniles and their rearing habitat is highly uncertain.

5.8.3.2.2.2 Water Temperature

Under the proposed action and COS (proposed action and COS HEC-5Q modeling scenarios), monthly mean water temperatures at Keswick during the November through May upper Sacramento River juvenile rearing period would range from about 43 degrees Fahrenheit during January and February to 54 degrees Fahrenheit in May (Figures 5-8 through 5-14 in the HEC5Q Temperatures section of Appendix D). These temperatures are well below the 61 degrees Fahrenheit critical water temperature threshold for juvenile Spring-run Chinook Salmon, indicating that water temperature conditions in the upper Sacramento River are well suited for juvenile Spring-run Chinook Salmon. It should be noted, however, that unlike conditions during summer and fall, when reservoir operations create relatively stable flow and water temperature conditions (See Winter-run Chinook salmon, *Water Temperature*), the mean monthly water temperatures in winter and spring do not fully capture the water temperature conditions to which the juvenile Spring-run Chinook Salmon would be exposed, because water temperatures often vary greatly over the course of a month, and even over a day. This caveat, however, applies to all results of all the modelling scenarios.

Water temperatures under the proposed action and COS are much higher than those under the WOA scenario during November through February (Figures 5-8 through 5-11 in the HEC5Q Temperatures section of Appendix D), are similar in March (Figure 5-12 in the HEC5Q Temperatures section of Appendix D), and are much lower than those under the WOA scenario in April and May (e.g., Figures 5-13 and 5-14 in the HEC5Q Temperatures section of Appendix D). On balance, water temperature conditions under the proposed action and the COS would provide moderate benefits relative to the WOA conditions to juvenile Spring-run Chinook Salmon rearing in the upper Sacramento River.

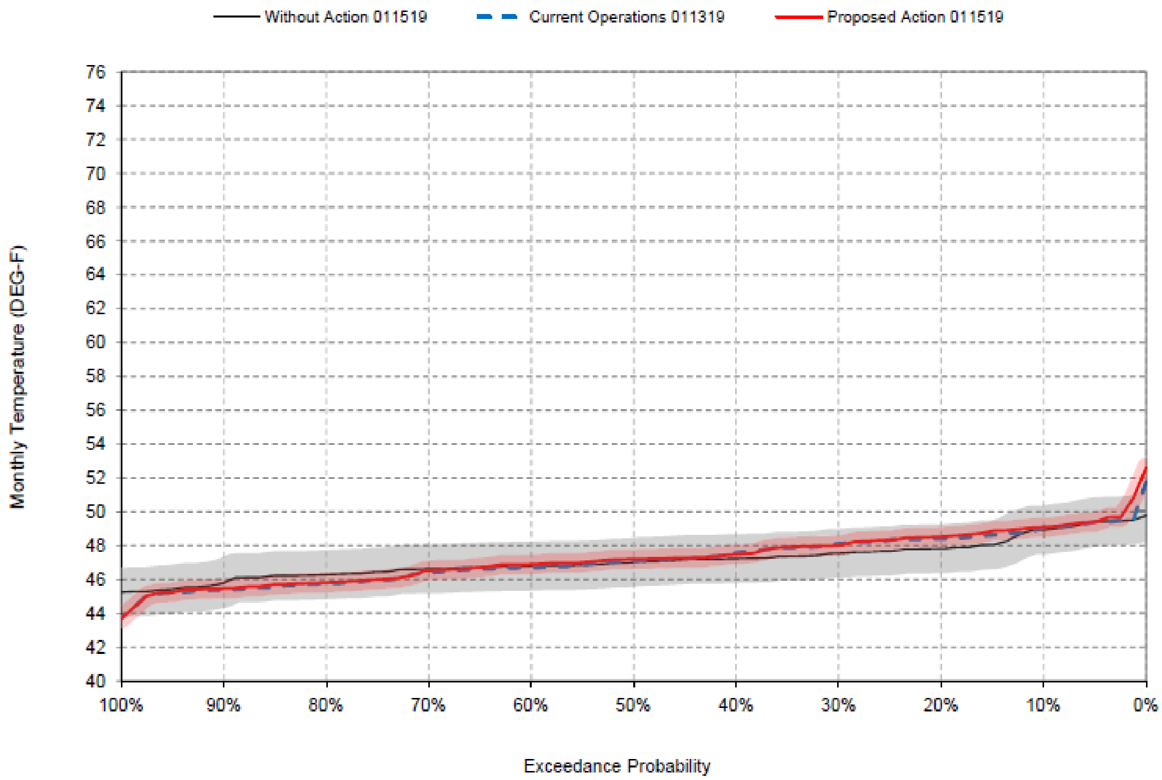


Figure 5.8-13. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the WOA, proposed action and COS scenarios, March

5.8.3.2.3 <u>Rearing to Outmigrating Juveniles in Bay-Delta</u>

5.8.3.2.3.1 River Flow

Similar upper Sacramento River, the CalSim modeling shows large seasonal changes in the differences in middle Sacramento River flow between the proposed action and COS and the WOA scenario. In November, there are small to moderate differences in flow between the proposed action and WOA scenarios, with lower flows under the proposed action scenario in the middle-high range of flow years, and higher flows under the proposed action scenario in the lower flow years, but the COS flows are consistently above the WOA flows in all but the highest flow years (Figure 19-8, and Tables 17-1 through 17-3, 18-1 through 18-13, and 19-1 through 19-3 in the CalSim II Flows section of Appendix D). In December through February, the proposed action flows are generally similar to or slightly lower than the WOA flows for most years (Figure 19-9 through 19-11, and Tables 17-1 through 17-3, 18-1 through 18-13, and 19-1 through 19-3 in the CalSim II Flows section of Appendix D), and in March and April, the proposed action flows are consistently lower than the WOA flows (Figures 19-12 and 19-13 in the CalSim II Flows section of Appendix D). In May, the proposed action flows are substantially lower than the WOA flows for the 60 percent of highest flow years and are substantially lower for the 25 percent of lowest flow years (Figure 19-14 in the CalSim II Flows section of Appendix D).

Flows resulting from differences between the proposed action and WOA scenario would likely affect Spring-run Chinook Salmon juveniles and their habitats. The lower November and May flows under the proposed action scenario during years with drier hydrology would likely result in reduced conditions in juvenile rearing habitats, including less habitat complexity, side channel habitat structure, refuge habitat, and greater disease potential.

The lower proposed action flows in December through April could have adverse effects on rearing juvenile Spring-run Chinook Salmon. Potential adverse effects include less floodplain and side-channel habitat, reduced feeding conditions, increased competition and predation, higher water temperatures and higher DO, and decreased emigration flows.

5.8.3.2.3.2 Water Temperature

Under the proposed action and COS modeling scenarios, monthly average water temperatures from November through March below the Colusa Basin Drain would range from about 44 to about 60 degrees Fahrenheit, thereby remaining well below the 64 degrees Fahrenheit threshold (Figures 14-8 through 14-12 in the HEC5Q Temperatures section of Appendix D). However, during April and May, water temperatures would range from about 53 to about 72 degrees Fahrenheit, exceeding the 64 degrees Fahrenheit threshold in 5 percent of years in April and about 85 percent of years in May, with a maximum water temperature of about 72 degrees Fahrenheit (Figures 14-13 and 14-14 in the HEC5Q Temperatures section of Appendix D).

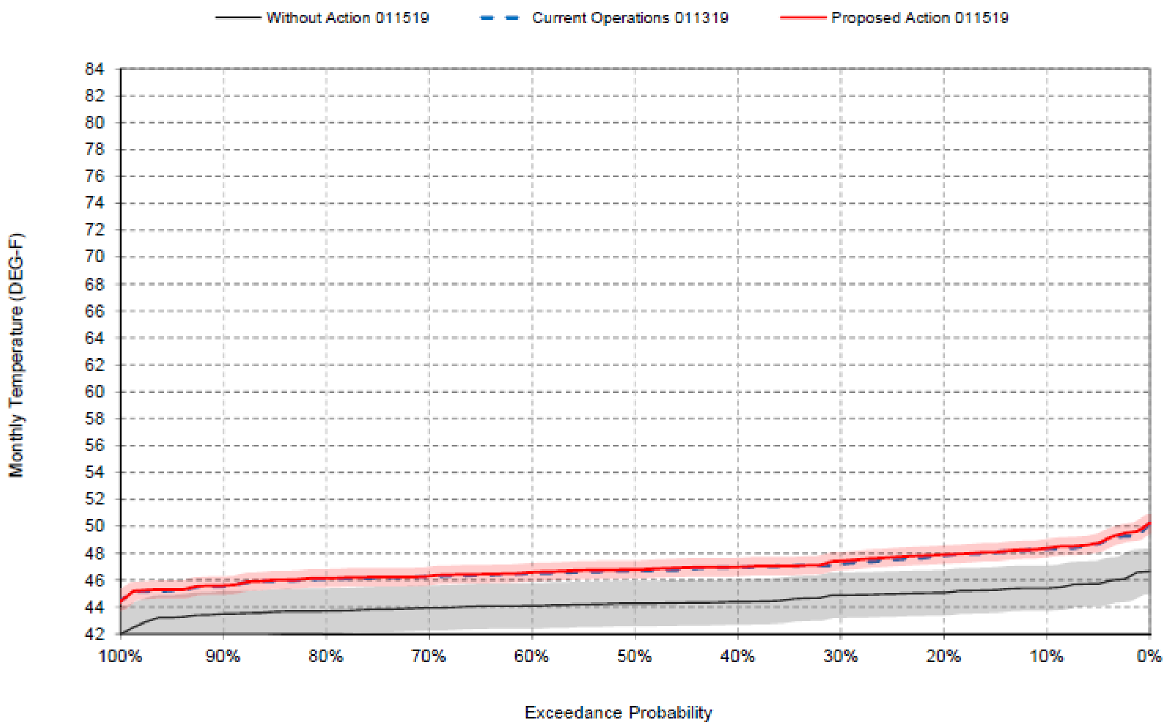


Figure 5.8-14. HEC-5Q Sacramento River Water Temperatures below Colusa Basin Drain under the WOA, COS and proposed action scenarios, January

There is little difference in water temperatures between the proposed action and COS modeling scenarios during any of the months that juvenile Spring-run Chinook Salmon rear in or emigrate from the middle Sacramento River (Figures 14-8 through 14-14 in the HEC5Q Temperatures section of Appendix D). The maximum difference between the proposed action and COS exceedance curves is approximately 1 degree Fahrenheit in May (Figure 14-14 in the HEC5Q Temperatures section of Appendix D). Water temperatures for both scenarios exceed the 64 degrees Fahrenheit threshold for most years during May, approximately 5 percent of years in April, and no water temperature exceeding this threshold during November through March.

Water temperatures under the proposed action and COS are substantially or moderately above the WOA scenario water temperatures during most years in November through April (Figures 14-8 through 14-13 in the HEC5Q Temperatures section of Appendix D), and are moderately below the WOA scenario water temperatures during most years in May (Figure 14-14 in the HEC5Q Temperatures section of Appendix D). Water temperatures during most years in the November through April period are suitable for juvenile Spring-run Chinook Salmon that rear in and emigrate from the middle Sacramento River under the WOA and the proposed action and COS scenarios. Under all three modeling scenarios during May, however, the 64 degrees Fahrenheit threshold would be exceeded in most years, with the WOA scenario having greater exceedances than the proposed action and COS, especially in warmer years. These results indicate that water temperature conditions would too warm for juvenile Spring-run Chinook Salmon rearing and emigrating in the middle Sacramento River during May under WOA, and that the proposed action improves these conditions slightly although temperatures are still not ideal. It should be noted that May is the last month during spring or summer that Spring-run Chinook Salmon juveniles are found in the middle river, and it is likely that when water temperaturs are too high they emigrate to the ocean before May.

5.8.3.2.4 Adult Migration from Ocean to Rivers

Continuing their upstream migration from the Delta, Spring-run Chinook Salmon adults enter the middle Sacramento River as early as January and ultimately make their way to the upper river, where they hold, beginning as early as February, until they are ready to spawn (Windell et al. 2017).

CalSim modeling indicates that from January through April, the first half of the period during which spring-run adults migrate upstream through the middle Sacramento River to holding habitat in the upper river, the WOA scenario flows at Wilkins Slough would range from about 2,500 cfs in April to about 24,000 cfs in March (Figures 19-10 through 19-13 in the CalSim II Flows section of Appendix D), and at Keswick, the WOA flows would range from about 3,250 cfs in all four months to about 63,000 cfs in March (Figures 15-10 through 15-13 in the CalSim II Flows section of Appendix D). During the second part of the migration and holding period (May through October), the WOA flows at Wilkins Slough would range from 0 cfs in May through August to about 20,000 cfs in May (Figures 19-14 through 19-18 and 19-7 in the CalSim II Flows section of Appendix D), and at Keswick, the WOA flows would range from about 772 cfs in August to about 32,000 cfs in May (Figures 15-14 through 15-17 in the CalSim II Flows section of Appendix D). The lowest flows at Keswick Dam during May through August would be low enough to create potential passage problems for immigrating adults, and this is even more likely for Wilkins Slough, where flows in June through August would be about 1,000 cfs or lower in about half of the years. The effects of low flow on the middle Sacramento River and for adults holding in the upper river are expected to be similar to those described by Windell et al. 2017.

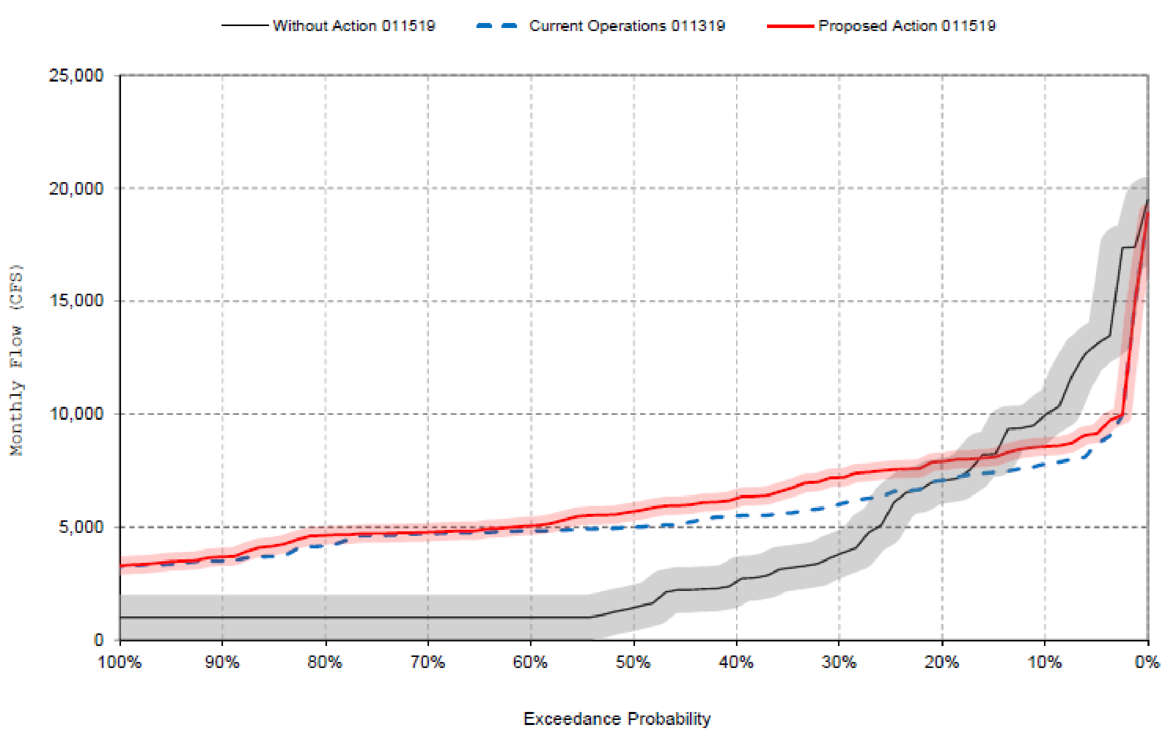


Figure 5.8-15. Modeled Sacramento River Flows at Wilkins Slough, June

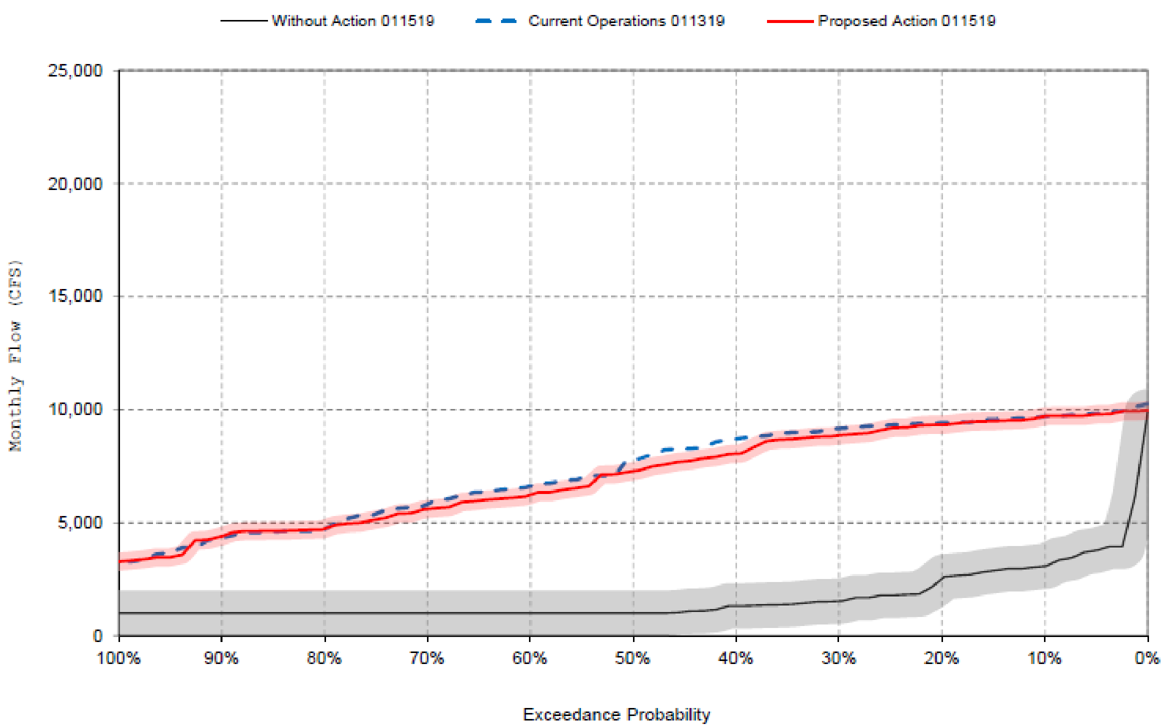


Figure 5.8-16. Modeled Sacramento River Flows at Wilkins Slough, July

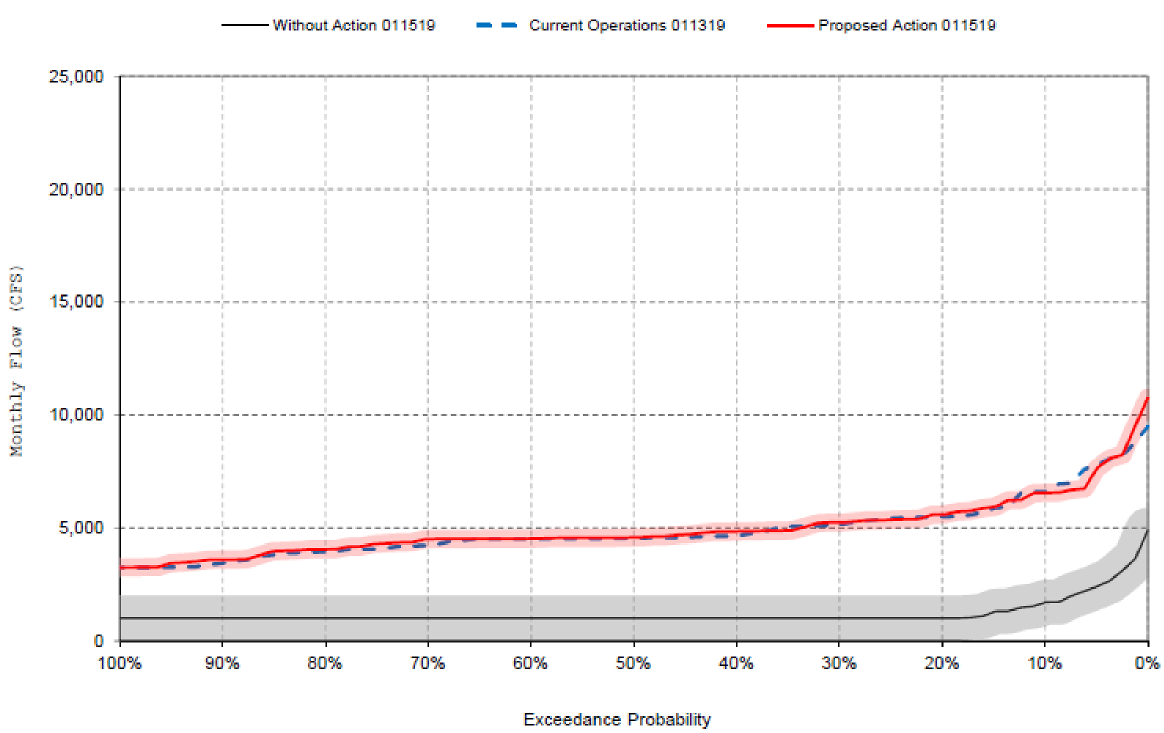


Figure 5.8-17. Modeled Sacramento River Flows at Wilkins Slough, August

During the January through October period of Spring-run Chinook Salmon immigration and holding, flows would generally be similar between the proposed action and COS (Figures 19-10 through 19-18, and 19-7; 15-10 through 15-18, and 15-7; and Tables 15-1 through 15-3, 16-1 through 16-3, 17-1 through 17-3, 18-1 through 18-3, and 19-1 through 19-3 in the CalSim II Flows section of Appendix D), except for higher flows (up to ~2,500 cfs higher) at Wilkins Slough during May and June period for the proposed action scenario for flows in the range from about 5,000 cfs to 11,000 cfs (Figure 19-14 and 19-15 in the CalSim II Flows section of Appendix D), and much higher flows (up to ~7,000 cfs) at Wilkins Slough during September for the COS scenario for flows in the range from about 8,000 cfs to 16,000 cfs (Figure 19-18 in the CalSim II Flows section of Appendix D). The differences in flow occur primarily for flows greater than 5,000 cfs, which are likely high enough to present no passage problems for upstream migrating adults. There are also substantial flow differences between the proposed action and COS at Keswick Dam during June and September (Figures 15-15 and 15-18 in the CalSim II Flows section of Appendix D), but these differences are within a range of flows (6,000 cfs to 17,000 cfs) not expected to substantively affect holding Spring-run Chinook Salmon adults.

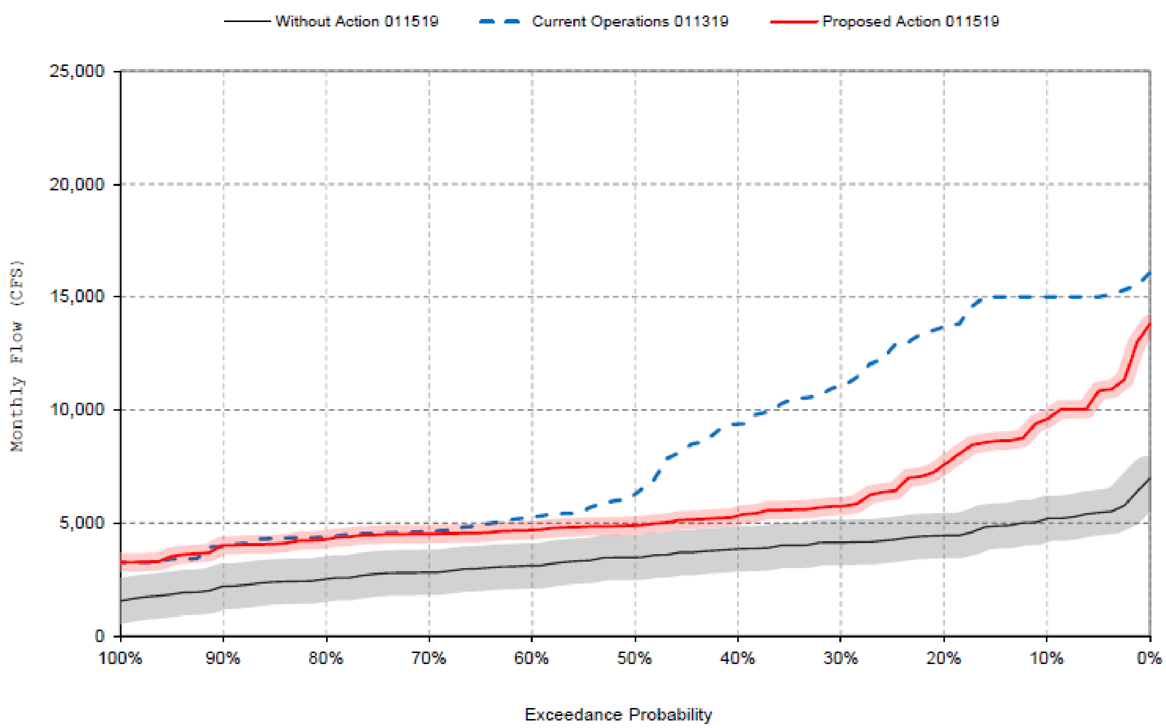


Figure 5.8-18. Modeled Sacramento River Flows at Wilkins Slough, September

The CalSim modeling shows large seasonal changes in the differences in middle and upper Sacramento River flow between the WOA, proposed action and COS. In January and February, the proposed action and COS flows are generally similar to or slightly lower than the WOA flows for most years at both Wilkins Slough and Keswick Dam (Figures 19-10, 19-11, 15-10, and 15-11; and Tables 15-1 through 15-3, 16-1 through 16-3, 17-1 through 17-3, 18-1 through 18-3, and 19-1 through 19-3 in the CalSim II Flows section of Appendix D). In March and April, the proposed action and COS flows are generally lower than the WOA flows at both locations (Figures 19-12, 19-13, 15-12 and 15-13 in the CalSim II Flows section of Appendix D). In May, the proposed action and COS flows at Wilkins Slough are substantially lower than the WOA flows for the 60 percent of highest flow years and are substantially higher for the 25 percent of lowest flow years (Figure 19-14 in the CalSim II Flows section of Appendix D), while at Keswick Dam, the proposed action and COS flows are lower than WOA flows for about 40 percent of the highest flow years and are similar in the other years (Figure 15-14 in the CalSim II Flows section of Appendix D). For the remainder of the adult immigration and holding period (June through October), the proposed action and COS flows were generally higher or much higher than the WOA flows at both locations (Figures 19-15 through 19-18 and 19-7, and 15-15 through 15-18 and 15-7 in the CalSim II Flows section of Appendix D). The higher flows during May through October in years with dry hydrologies at Wilkins Slough and Keswick Dam under the proposed action and COS relative to the WOA conditions would likely benefit adult Spring-run Chinook Salmon migrating in the middle Sacramento River and holding in the upper river by enhancing water quality and upstream passage, and reducing stranding, straying, poaching, and disease risks (Windell et al. 2017).

5.8.3.2.4.1 Water Temperature

In the middle Sacramento River downstream of the Colusa Basin Drain, water temperatures under the proposed action are similar to WOA water temperatures during May (Figure 14-14 in the HEC5Q Temperatures section of Appendix D), generally above the WOA scenario water temperatures from January through April (Figures 14-10 through 14-13 in the HEC5Q Temperatures section of Appendix D), and below the WOA scenario water temperatures during June through October (Figures 14-15 through 14-18, and 14-7 in the HEC5Q Temperatures section of Appendix D). In the upper Sacramento River at Keswick Dam, water temperatures under the proposed action and COS are similar to WOA water temperatures during March (Figure 5-12 in the HEC5Q Temperatures section of Appendix D), well above the WOA scenario water temperatures during January and February (Figures 5-10 and 5-11 in the HEC5Q Temperatures section of Appendix D), and well below the WOA scenario water temperatures in all years during April through September in all but 7 percent of years in October (Figures 5-13 through 5-18, and 5-7 in the HEC5Q Temperatures section of Appendix D).

Figure 5.8-19. HEC-5Q Sacramento River Water Temperatures below Colusa Basin Drain under the WOA, COS and proposed action scenarios, June

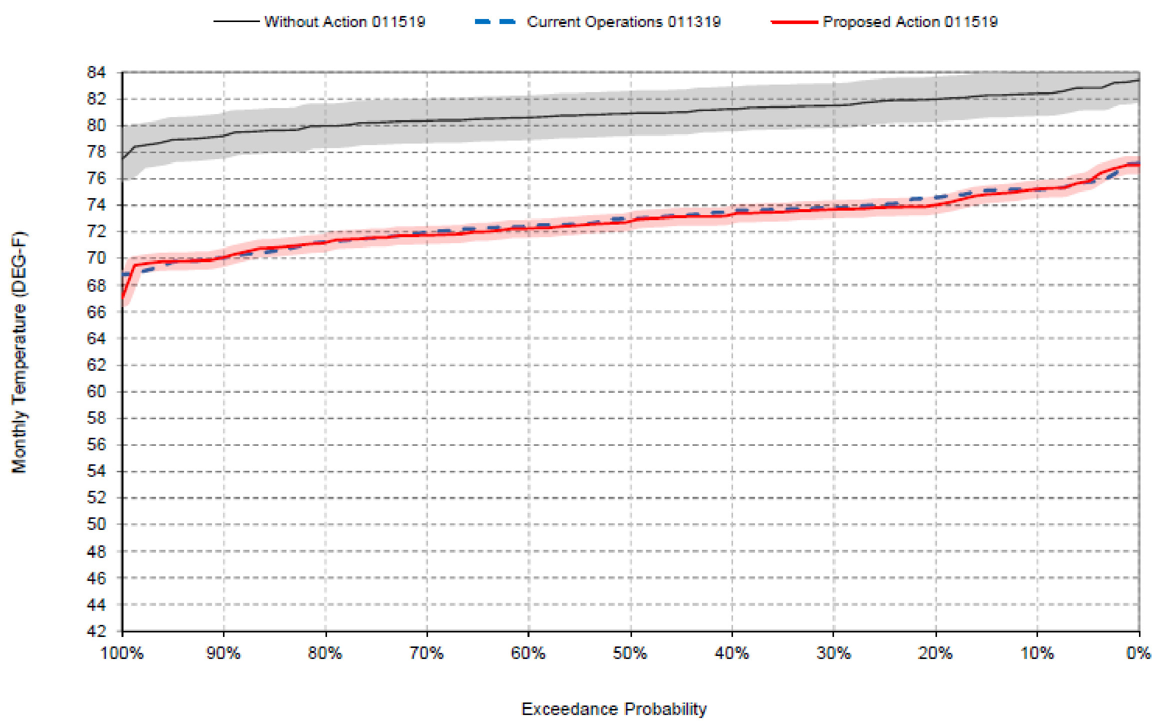


Figure 5.8-20. HEC-5Q Sacramento River Water Temperatures below Colusa Basin Drain under the WOA, COS and proposed action scenarios, August

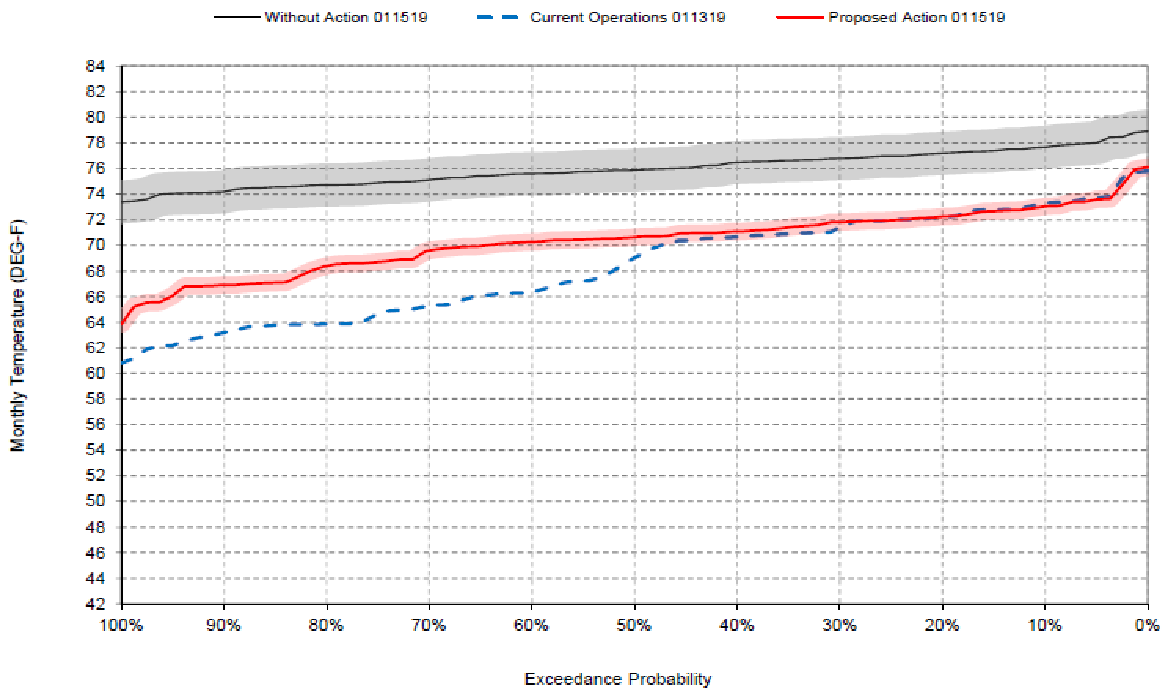


Figure 5.8-21. HEC-5Q Sacramento River Water Temperatures below Colusa Basin Drain under the WOA, COS and proposed action scenarios, September

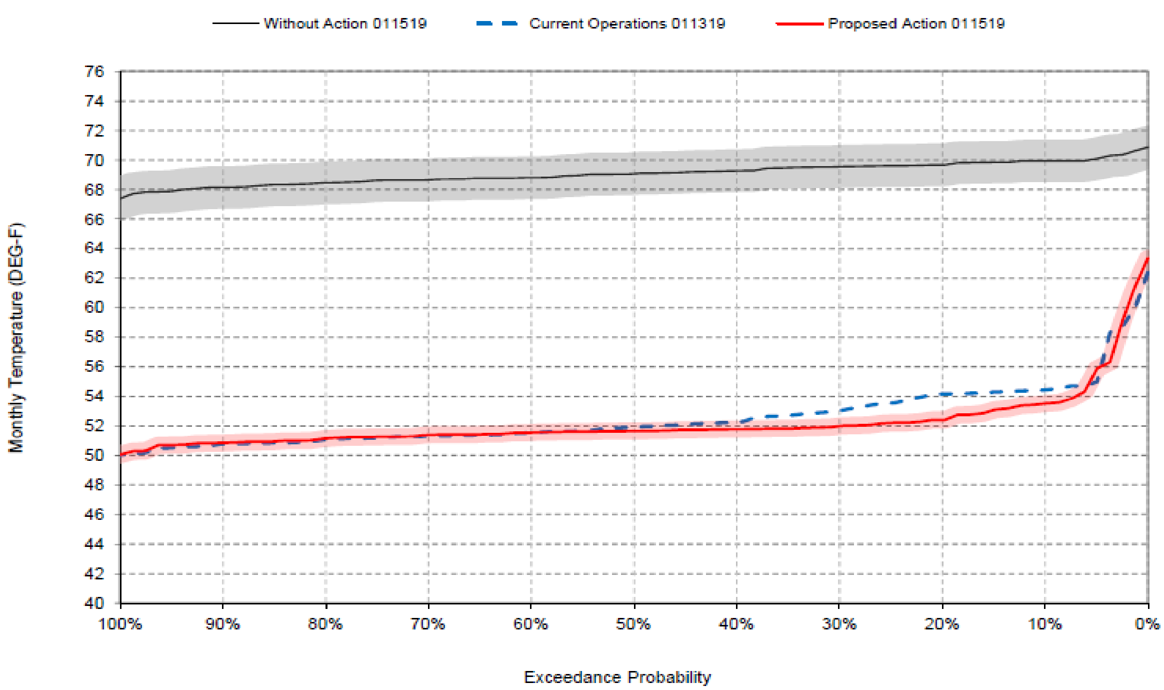


Figure 5.8-22. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the WOA, COS and proposed action scenarios, August

Water temperatures during the January through April period under all three scenarios are suitable for adult spring-run immigrating in the middle Sacramento River or holding in the upper river. However, in May, water temperatures in the middle river below the Colusa Basin Drain are predicted to exceed the threshold for immigrating adults in a large percentage of years under both the proposed action and WOA scenarios, with a greater percentage of years predicted to exceed the threshold under the WOA scenario (Figure 14-14 in the HEC5Q Temperatures section of Appendix D). During June through September, the 68 degrees Fahrenheit threshold is exceeded at Knights Landing during every year under the WOA scenario and in most years under the proposed action and COS, but the exceedances are typically much greater under the WOA scenario (e.g., Figures 14-15 through 14-18 in the HEC5Q Temperatures section of Appendix D). In October, the threshold is exceeded in much lower percentages of years, and the water temperatures are consistently higher for the WOA scenario (Figure 14-7 in the HEC5Q Temperatures section of Appendix D).

At Keswick Dam, the 61 degrees Fahrenheit threshold for holding adults is not exceeded in any years during January through April under any of the scenarios and is exceeded in only 4 percent of years in the WOA scenario in May (Figures 5-10 through 5-14 in the HEC5Q Temperatures section of Appendix D). In June through September, the threshold is exceeded in nearly every year under the WOA scenario, but in only a few years under the proposed action and COS (Figures 5-15 through 5-18 in the HEC5Q Temperatures section of Appendix D). In October, the threshold is exceeded in no years under the WOA scenario and in less than 10 percent of years under the proposed action and COS, although water temperatures under the proposed action and COS are lower than those under the WOA scenario, except in the warmest 8 percent of years (Figure 5-7 in the HEC5Q Temperatures section of Appendix D). During the summer months (June through September), when water temperatures are generally stressful for adult Spring-run Chinook Salmon in the Sacramento River, the water temperatures under the WOA conditions in both the middle and upper Sacramento River would generally be much higher than those under the proposed action or COS. It is unlikely that migrating adult Spring-run Chinook Salmon could survive the elevated water temperatures in the middle Sacramento River predicted for the summer months under the WOA modeling scenario or that eggs of the adult spring-run holding in the upper Sacramento River could survive the predicted high summer water temperatures.

5.8.3.2.5 Adults Holding in Rivers

5.8.3.2.5.1 River Flows

Flows under WOA are generally similar to proposed action and COS flows during February (Figures 15-11 in the CalSim II Flows section of Appendix D), are much higher than proposed action and COS flows during March and April and during May of wetter years (Figures 15-12 through 15-14 in the CalSim II Flows section of Appendix D), and are lower than proposed action and COSflows during June through October (Figures 15-15 through 15-18, and 15-7 in the CalSim II Flows section of Appendix D). In general, higher flows are likely to benefit holding and spawning adult Winter-run by affording better water quality (including cooler water temperatures and higher DO), reduced exposure to pathogens, lower risk from anglers, and a greater area of river bed with suitable attributes for redds (Windell et al. 2017). The proposed action and COS scenarios would have much higher flows than the WOA scenario during summer, when flow is generally low and so more likely to limit Spring-run Chinook Salmon holding and spawning success. Therefore, the proposed action and COS are expected to be beneficial to Spring-run Chinook Salmon relative to the WOA conditions.

Flows during the February through October period would generally be similar between the proposed action and COS modeling scenarios (Figure 15-11 through 15-18, and 15-7; and Tables 15-1 through 15-3, 16-1 through 16-3, and 17-1 through 17-3 in the CalSim II Flows section of Appendix D). The largest differences between these scenarios would occur in June for the upper 60 percent of flows, when proposed action flows would be greater than the COS flows, and in September for the upper 50 percent of flows, when the COS flows would be greater than the proposed action flows. The differences occur over a range of flows from about 9,000 cfs (June) or 7,000 cfs (September) to about 16,000 cfs, all of which are suitable flows for holding and spawning adults (e.g., USFWS 2003), so the differences are not expected to substantially affect the adults.

5.8.3.2.5.2 Water Temperatures

In the upper Sacramento River at Keswick Dam, water temperatures under the proposed action and COS are similar to WOA water temperatures during March (Figure 5-12 in the HEC5Q Temperatures section of Appendix D), well above the WOA scenario water temperatures in February (Figure 5-11 in the HEC5Q Temperatures section of Appendix D), and well below the WOA scenario water temperatures in April through October, except for the warmest Octobers (Figures 5-13 through 5-18, and 5-7 in the HEC5Q Temperatures section of Appendix D). Water temperatures under the WOA scenario are predicted to exceed the 61 degrees Fahrenheit holding threshold in almost all years during June through September, and the 56 and 53.5 degrees Fahrenheit spawning threshold in most years during May through October. In contrast, water temperatures under the proposed action and COS are predicted to exceed the 61 degrees Fahrenheit holding threshold in no years for every month in the February through October period and are rarely predicted to exceed the 56 and 53.5 degrees Fahrenheit thresholds, except for 15 to 75 percent of years during July through October. These results indicate that the proposed action, relative to the WOA, provides a clear benefit to adult Spring-run Chinook Salmon individuals holding and spawning in the upper Sacramento River. In view of the improved water temperature management operations planned for the proposed action, this action is expected to benefit the Spring-run Chinook Salmon adults relative to the WOA.

There are few differences in water temperatures between the proposed action and COS during any of the months that adult Spring-run Chinook Salmon hold and spawn in the upper Sacramento River (Figures 5-11 through 5-18, and 5-7 in the HEC5Q Temperatures section of Appendix D). At Keswick Dam, under the proposed action and COS, the mean water temperatures would be below the 61 degrees Fahrenheit threshold for holding adults for all months from February through October, except for August through October in, at most, 4 percent of years.

5.8.3.3 Spring Pulse Flows

5.8.3.3.1 Egg to Fry Emergence

As described in the proposed action, Reclamation will release pulse flows in the spring if projected storage on May 1 in Shasta Reservoir is above 4 MAF. If Shasta Reservoir total storage on May 1 is projected to be greater than 4 MAF, Reclamation would make a spring pulse release as long as the release would not cause Reclamation to drop into a lower Tier of the Shasta summer temperature management or interfere with the ability to meet other anticipated demands on the reservoir.

Spring pulse releases are not at the time of year of egg incubation, and rather would be timed to attract juvenile Spring-run to move downstream. However, spring pulses could benefit late redds. As indicated by the SAIL Upper River (CM1) conceptual model, flows, combined with other environmental drivers, affect water temperature, DO levels, sedimentation, substrate composition, and other habitat attributes that influence redd quality, which in turn determines egg-to-fry survival. Thus, the spring pulse could benefit late redds by increasing dissolved oxygen in the water for eggs, reducing water temperatures, and flushing fine sediment from spawning gravels. Spring pulses could cause impacts to late eggs emerging from the gravel could be exposed to redd dewatering on the ramp-down side of a spring pulse.

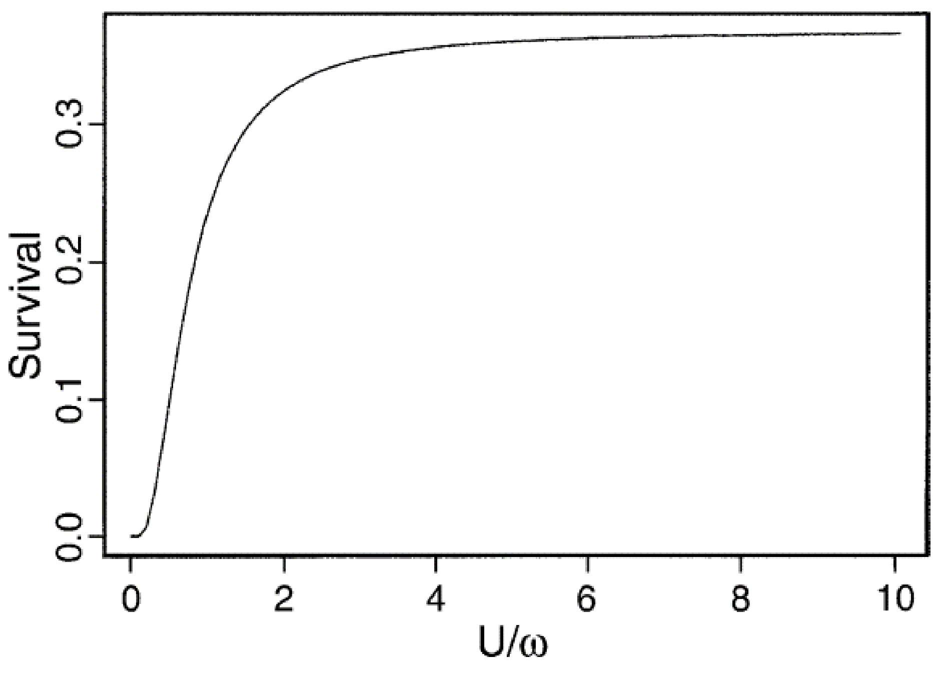
5.8.3.3.2 Rearing to Outmigrating Juveniles

Spring pulse flows would benefit juvenile salmonids by triggering their outmigration (Kjelson et al.,1981). The NMFS Southwest Fisheries Science Center has run statistical models using tagging data from Spring-run Chinook Salmon and Fall-run Chinook Salmon from 2012-2017 and found a significant increase in smolt survival is observed when Sacramento River flow at Wilkins Slough is above 9,100 cfs during the smolts outmigration period (Cordoleani et al, 2019).

One hypothesis may be that decreased travel time leads to decreased interactions with predators. The XT model (Anderson, 2005) provides an estimated equation for survival in rivers based on predation. Anderson's XT model, re-written in terms of mostly physical parameters, is:

$$S = exp\,(-\rho\alpha\sqrt{x^2 + w^2t^2})$$

Where ρ is the predator density, alpha is the cross-sectional area, x is the travel distance, w is the random encounter velocity, and t is the travel time. Increasing flow in the Sacramento River leads to increasing river velocity, which would lead to increasing average migration velocity and decreasing travel time. Figure 5.8-23 below, reproduced from Anderson (2005), shows anticipated survival based on average migration velocity divided by the random component of the encounter velocity, w.



Anderson (2005)

Figure 5.8-23. XT Model Survival vs Average Migration Velocity *U*, divided by the Random Component of the Velocity *w*.

Shown another way, below is a plot of the X-T model for dimensionless travel time units (Figure 5,8-24). As can be seen from the plot below, reduced travel time is highly valuable for increased survival.

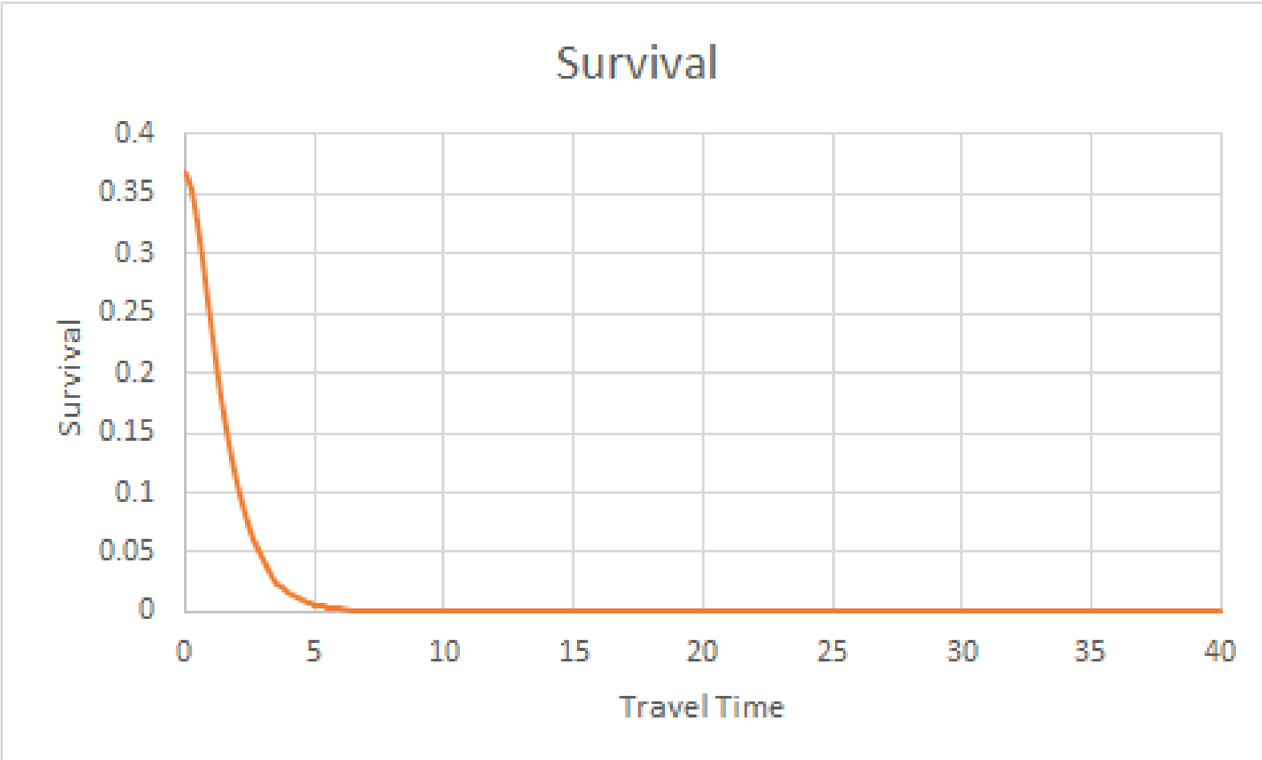


Figure 5.8-24. XT Model for Dimensionless Travel Time Units

Higher flows in the Sacramento River lead to higher velocities and lower travel times, reducing predation.

The random encounter velocity w relates to the predator perception and reaction distance. Reaction distance depends on water clarity and light level (Vogel and Beauchamp, 1999). Water clarity is often measured by Secchi disk depth. The following plots, created from data published in Snider and Titus (2000) and the Fall Mid-water trawl from CDFW, both show an inverse correlation between flow and Secchi depth. As expected, with higher flow, water clarity is less. More sediment is mobilized with higher flows, as higher flows generate more shear stress, as described by the equations of sediment transport (Shields, 1936).

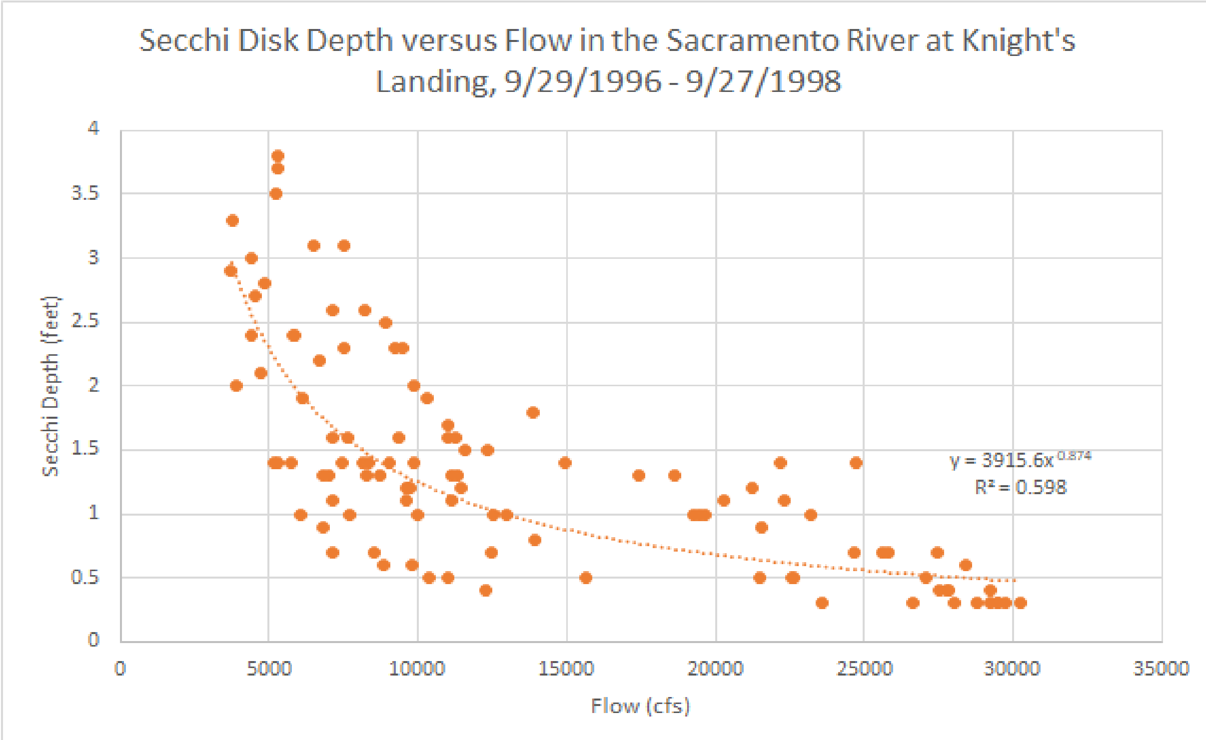


Figure 5.8-25. Turbidity vs. Flow. Data from Snider and Titus, 2000

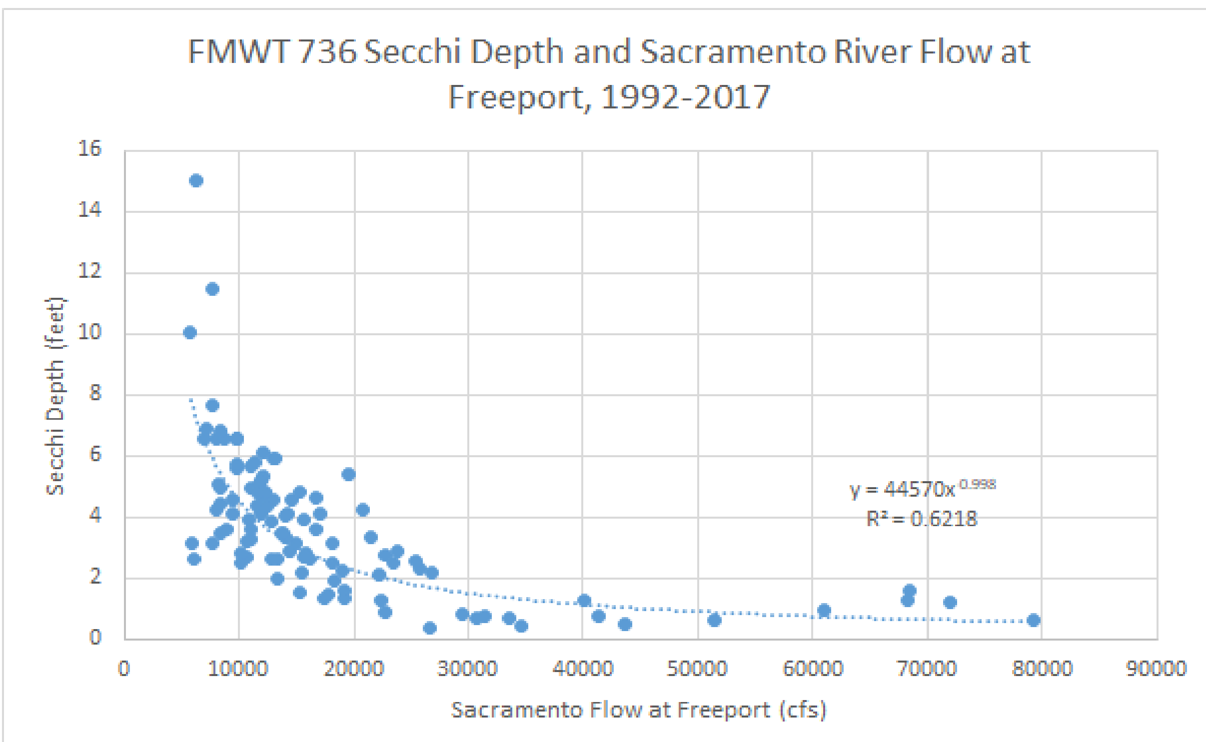


Figure 5.8-26. Turbidity vs. Flow. Data from Fall Mid-water Trawl station 736

Decreased water clarity with higher flows would reduce predator perception distance, which would increase survival according to the XT model.

5.8.3.4 Fall and Winter Refill and Redd Maintenance

Under WOA, fall flows are low. Under the proposed action, Reclamation proposes to adjust fall flows based on Shasta Reservoir storage to avoid dewatering Winter-run and Fall-run Chinook salmon redds and cold water pool impacts. Higher flows than the WOA during this September – November period could benefit rearing Spring-run Chinook Salmon by increasing the inundated area of rearing habitat, and associated food and temperature benefits.

5.8.3.5 Clear Creek Flow Releases

Spring-run Chinook Salmon inhabitat Creek Creek and is designated critical habitat for the species from the downstream of the Whiskeytown Reservoir to the confluence with the Sacramento River. Spring-run Chinook Salmon would be exposed to Reclamation's operation of Whiskeytown Reservoir and Clear Creek releases.

5.8.3.5.1 Egg to Fry Emergence

Under COS, Eggs and emerging fry are exposed to the effects of Whiskeytown temperature controls in Clear Creek, based on the timing of these controls (60°F at IGO gage June 1-September 15; 56°F at IGO gage September 15-October 31) overlapping with the seasonal occurrence of this life stage in Clear Creek (September-November; Table 5.8-1), and the presence of spawning individuals upstream of the IGO gage in Clear Creek (CDFW 2011). Development of incubating Spring-run Chinook Salmon eggs is heavily influenced by water temperature with temperatures < 54°F considered optimal, 54-58°F suboptimal, and water temperatures above 58°F causing chronic to acute stress (Stillwater Sciences 2006).

Effects of egg and fry exposure to Whiskeytown temperature controls in Clear Creek was modeled in HEC 5Q. The proposed action reduces water temperatures in Clear Creek compared to the WOA.

This temperature reduction as compared to WOA would result in an increased likelihood of achieving temperature compliance at IGO, leading to improved survival of incubating Spring-run Chinook Salmon eggs. However, any eggs incubating in Clear Creek prior to September 15 or downstream of the compliance point at IGO could be subjected to water temperatures in the chronic to acute stress range (above 58°F), especially at lower exceedance probabilities (< 50%), and certain water year types. Furthermore, the incubation period (September 15-November) temperature threshold used in this action (56°F at IGO gage) falls within the suboptimal temperature range for incubating Spring-run Chinook Salmon eggs, which could result in less than optimal survival. There are water temperature benefits of the proposed action when compared to WOA. The optimal incubation temperatures for this species are < 54°F.

5.8.3.5.2 Rearing to Outmigrating Juveniles in Rivers

Few, if any, rearing and outmigrating juveniles would be exposed to the effects of spring attraction flows given the likely timing of these flows (May-June [Clear Creek Technical Team 2018]), and the peak timing of this life stage in Clear Creek (November–February; Table 5.8-1). However, rearing juveniles would likely be exposed to the effects of geomorphic flows, which are likely to occur contemporaneously with peak storm flows in Clear Creek after January 1 (to maximize geomorphic effectiveness), since there may be rearing juveniles in Clear Creek throughout the winter, spring, and summer after emergence.

Implementing geomorphic flows that will disperse spawning gravel will minimize project effects to this population. Spawning habitat requirements for salmon are complex and involve the fulfillment of a variety of geomorphic and fluvial conditions. The geomorphic flow augmentation reestablishes sustainable sediment transport downstream of Whiskeytown Dam. This is necessary to support and maintain distinct morphological units such as backwaters, riffles and pools. The ecological goal of gravel augmentation is to create self-sustaining morphological units that have the physical characteristics necessary for the different life stages of salmonids (Pasternak 2010).

Geomorphic flow releases also have the potential to degrade water quality via increased suspended solids and turbidity, leading to direct physiological impacts on rearing and outmigrating juvenile health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), loss of aquatic vegetation providing physical shelter, and reduced foraging ability caused by decreased visibility. The effects of this exposure could also include displacement of rearing fish from suitable habitat, leading to increased predation and exposure to increased water temperatures.

Studies on Clear Creek have shown that the sediment transport threshold generally occurs between 3000–3500 cfs (McBain and Trush 2001, Pittman and Matthews 2004). Events of this magnitude occurred in 50% (26 of 52) of years since Whiskeytown Dam was constructed, while daily average flows > 3000 cfs occur on 0.2% of days since WY 1965 (37 days total). Under WOA, geomorphic flows would occur whenever storage levels get high enough for spilling into the Gloryhole Spillway, but would be unlikely to occur. Proposed geomorphic flows up to the safe release capacity (approximately 900 cfs) represent approximately 30% of the flow needed to transport sediment in the absence of flows from downstream tributaries. As a result, adverse effects associated with geomorphic flow releases are expected to occur with low frequency, and be of low magnitude, compared to COS.

Few, if any, rearing and outmigrating Spring-run Chinook Salmon juveniles would benefit from the effects of Whiskeytown water temperature controls in Clear Creek given the timing of these controls (June 1-September 15 & September 15-October 31), and the peak timing of this life stage in Clear Creek (November–February; Table 5.8-1).

5.8.3.5.3 Adult Migration from Ocean to Rivers

Some migrating adults would be exposed to the effects of geomorphic flows under the proposed action given the likely timing of these flows (contemporaneous with peak storm flows after January 1 through April) and the peak timing of this life stage in Clear Creek (March-September with peak abundance May-June; Table 5.8-1). Exposure to the effects of these high flows could result in adverse effects on migrating adults if improperly shaped, however flows will be developed in coordination with the Clear Creek Implementation Team. Therefore, effects include the potential for stranding leading to increased predation, and degraded water quality from increased discharges of suspended solids and turbidity leading to direct physiological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost) will be avoided and minimized. These flows would be uncontrolled under the WOA conditions, and thus, the species could be exposed to natural flood conditions and adverse effects stated above.

Spring attraction flows would affect a large portion of the migrating adult Spring-run Chinook population in Clear Creek given the likely timing of these flows (May-June [Clear Creek Technical Team 2018]), and the peak timing of this life stage in Clear Creek (May-June; Table 5.8-1). The anticipated time frame for spring attraction flows (May-June) suggests that spring attraction flows are very unlikely to occur during a peak storm flow event. In addition, if occurring outside of a peak storm flow event, the magnitude of spring attraction flows (10 TAF with daily release up to safe release capacity [900 cfs]) would not produce the 3000-3500 cfs needed to transport sediment in Clear Creek (McBain and Trush 2001, Pittman and Matthews 2004). These factors would reduce the likelihood of adverse effects resulting from increases in suspended solids and turbidity, which could lead to physiological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost). Spring attraction flows benefit migrating adult Spring-run Chinook in Clear Creek (Clear Creek Technical Team 2018), and indicate that the number of migrating adults observed and the distance of their upstream migration both increase following spring attraction flows. Adult upstream migrating salmon are attracted to increased flow and cues fish to natal habitats.

Migrating adults would also benefit from Whiskeytown water temperature controls in Clear Creek under the proposed action and COS, based on the starting date of temperature compliance (June 1) and the seasonal timing of this life stage in Clear Creek (peak abundance May-June; Table 5.8-1). The water temperature objective at the IGO gage beginning June 1 is 60°F, well under the 65°F upper bound of the suboptimal range of water temperatures for migrating adult Spring-run Chinook Salmon (Stillwater Sciences 2006), and approximately 3°F cooler than projected water temperatures in June at the IGO gage under the WOA scenario.

5.8.3.5.4 Adult Holding in Rivers

Few, if any, holding adults would be exposed to the effects of geomorphic flows given the likely timing of these flows (contemporaneous with peak storm flows after January 1) and the peak timing of this life stage in Clear Creek (March-September with peak abundance May-July; Table 5.8-1). Exposure to the effects of these high flows could result in adverse effects on holding adults if improperly shaped. Effects include the potential for stranding leading to increased predation, increased water temperature, and degraded water quality from increased discharges of suspended solids and turbidity leading to direct physiological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost). These effects are not anticipated since flows will be shaped in coordination with the Clear Creek Implementation Team. Potential benefits of geomorphic flows included increased gravel mobilization that will increase spawning habitats and create a habitat complexity.

Spring attraction flows would affect a large portion of the holding adult Spring-run Chinook population in Clear Creek given the likely timing of these flows (May-June [Clear Creek Technical Team 2018]), and the peak timing of this life stage in Clear Creek (May-July; Table 5.8-1). These are expected to be beneficial for the species, by increasing cues that will support CV Spring-run to return natal streams. The anticipated timeframe for spring attraction flows (May-June) suggests that they are very unlikely to occur during a peak storm flow event. In addition, if occurring outside of a peak storm flow event, the magnitude of spring attraction flows (10 TAF with daily release up to safe release capacity [900 cfs]) would not produce the 3000-3500 cfs needed to transport sediment in Clear Creek (McBain and Trush 2001, Pittman and Matthews 2004). These factors would reduce the likelihood of any adverse effects resulting from increases in suspended solids and turbidity, which could lead to physiological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost).

Holding adults would also benefit from Whiskeytown water temperature controls in Clear Creek under the proposed action, based on the starting date of water temperature compliance (June 1) and the seasonal timing of this life stage in Clear Creek (peak abundance May-June; Table 5.8-1). The temperature objective at the IGO gage beginning June 1 is 60°F, under the 60.8°F upper limit of the optimal range of water temperatures for holding adult Spring-run Chinook Salmon (Stillwater Sciences 2006), and approximately 3°F cooler than projected water temperatures in June at the IGO gage under the WOA scenario.

5.8.3.6 Feather River

The follow section applies to the Feather River below the FREC boundary.

5.8.3.6.1 Egg to Fry Emergence

5.8.3.6.1.1 Flow Effects

Eggs and emerging fry of Spring-run Chinook would be exposed to the effects of Oroville Dam releases and resulting flows in the High Flow Channel (HFC) of the Feather River downstream of the Oroville Complex FERC boundary, based on the seasonal occurrence of this life stage in the Feather River (September-February; Table 5.8-1; NMFS 2016), minimum instream flow requirements in the HFC (Table 5.8-2), and compliance with Water Rights Decision 1641 (D-1641).

As indicated by the SAIL Upper River (CM1) conceptual model, these flows, combined with other environmental drivers, affect water temperature, DO levels, sedimentation, substrate composition, and other habitat attributes that influence redd quality, which in turn determines egg-to-fry survival. Insufficient flow during this life stage may result in higher water temperatures, lower DO in redds, and redd dewatering, each of which may lead to elevated egg mortality. Insufficient flow may also limit the habitat area available for redd construction, thereby limiting available habitat for this life stage. Excessive flow during this life stage may scour redds, and higher flows may attract spawning adults further upstream into the Low Flow Channel (LFC), where spawning habitat is less abundant, and the effects of superimposition are greater (Sommer et. al. 2001).

Table 5.8-2. Feather River High Flow Channel minimum instream flow requirements

Preceding April – July Unimpaired runoff (Percent of Normal)	High Flow Channel Minimum Instream Flow		
	Oct-Feb (cfs)	March (cfs)	April-Sept (cfs)
55% or greater	1,700	1,700	1,000
Less than 55%	1,200	1,000	1,000

Under the Without Action (WOA) scenario, Lake Oroville would not be operated to control storage or flow releases and no conveyance of water to San Luis Reservoir via the Banks Pumping Plant would be made. Reservoir gates and diversion tunnels would be kept open, resulting in annual storage volumes less than 1,000 TAF (Figure 5.8-27). As a result, there would be limited control of flow or water temperature in the Feather River HFC, which provides habitat for this life stage. Feather River flows under the WOA scenario would be lower in the summer and fall and higher in the winter and spring compared to current operations and the proposed action (Figures 5.8-28 and 5.8-29).

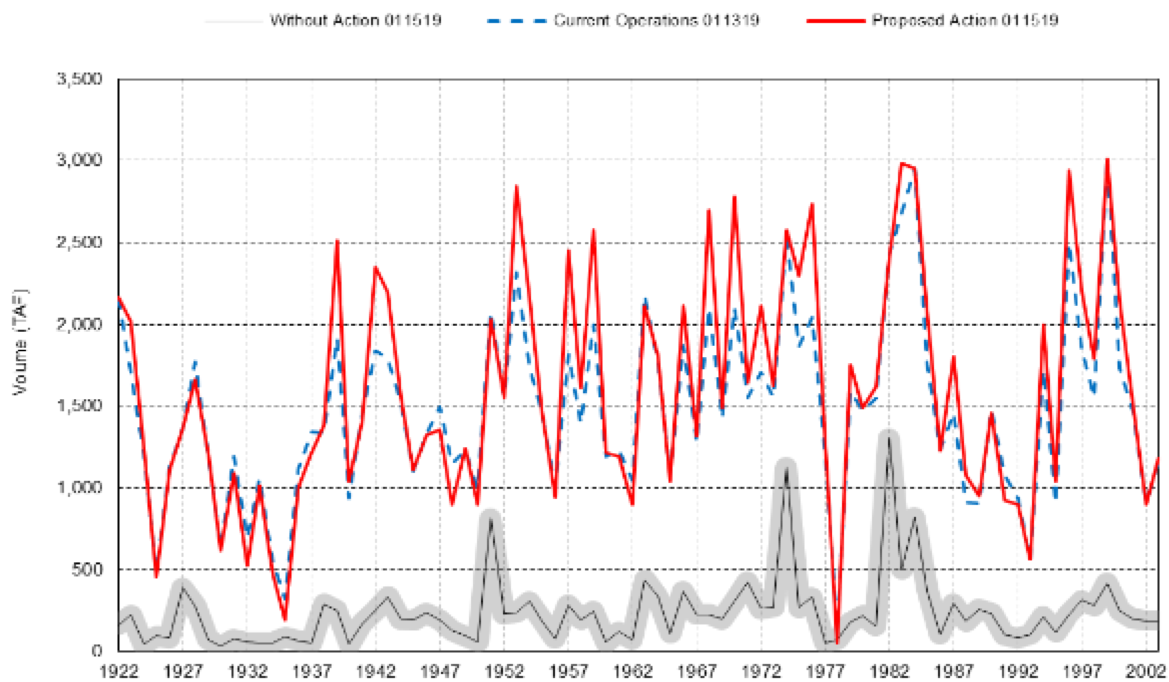


Figure 5.8-27. CalSim II estimates of mean Oroville storage (Thousand Acre-Feet [TAF]) for the period 1923–2002 under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action) scenarios.

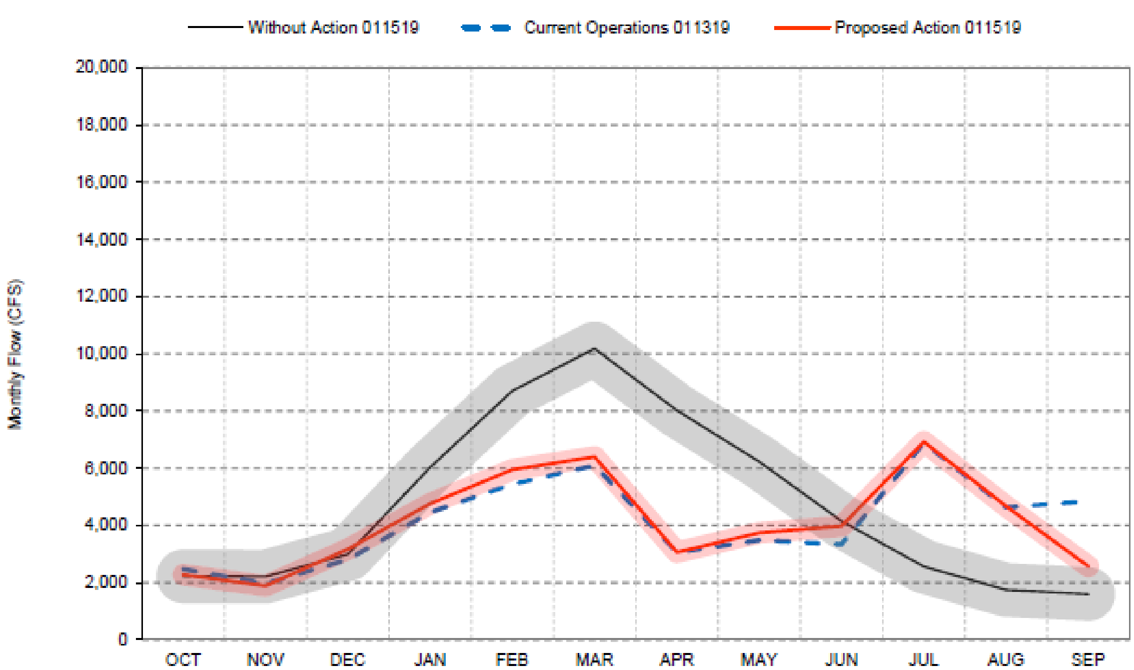


Figure 5.8-28. CalSim II estimates of Feather River long-term average flow below Thermalito Afterbay under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action) scenarios.

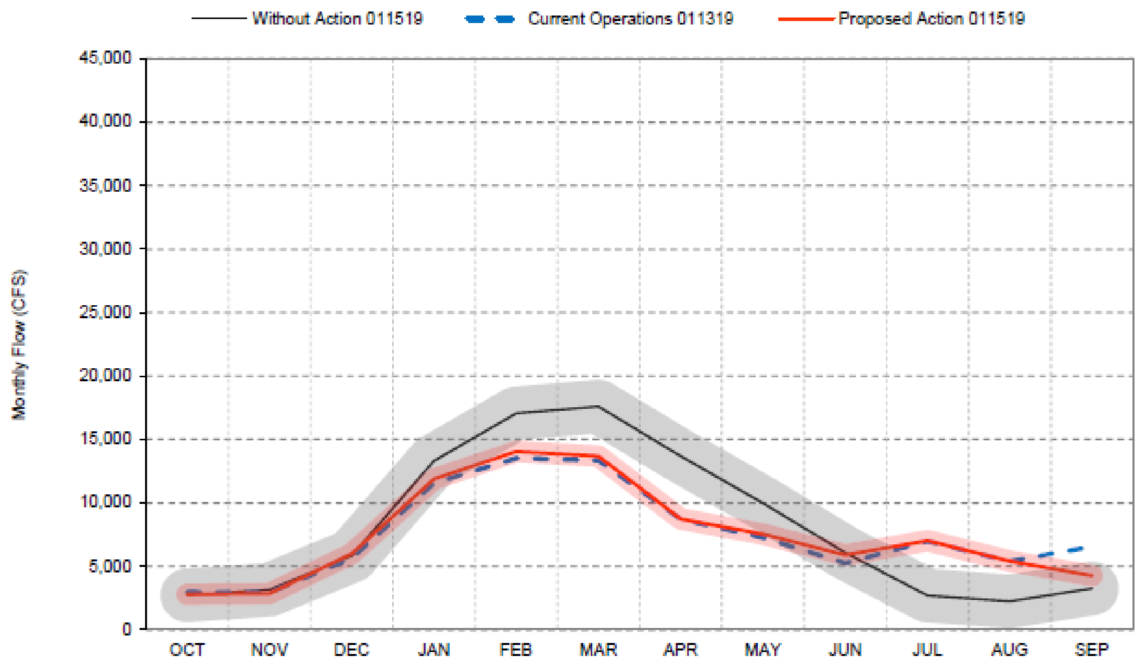


Figure 5.8-29. CalSim II estimates of Feather River mouth long-term average flow under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action) scenarios.

Feather River flows below Thermalito Afterbay under the proposed action and COS scenario would be similar to or higher than flows under the WOA scenarios during the peak seasonal timing of Spring-run Chinook egg incubation (September-November), but would be similar or slightly lower during the months of December to February (Figure 5.8-30). Specifically, higher flows under the COS and proposed action scenarios would occur more frequently in September and October than under the WOA scenario (Figure 5.8-31). Additionally, flows under the proposed action scenario would have a lower likelihood of falling below the required minimum flow stipulated in applicable NMFS/USFWS BOs for October (1,200 – 1,700 cfs, depending on preceding April – July unimpaired runoff) and September (1,000 cfs) (Table 5.8-2 and Figure 5.8-31) as compared to WOA.

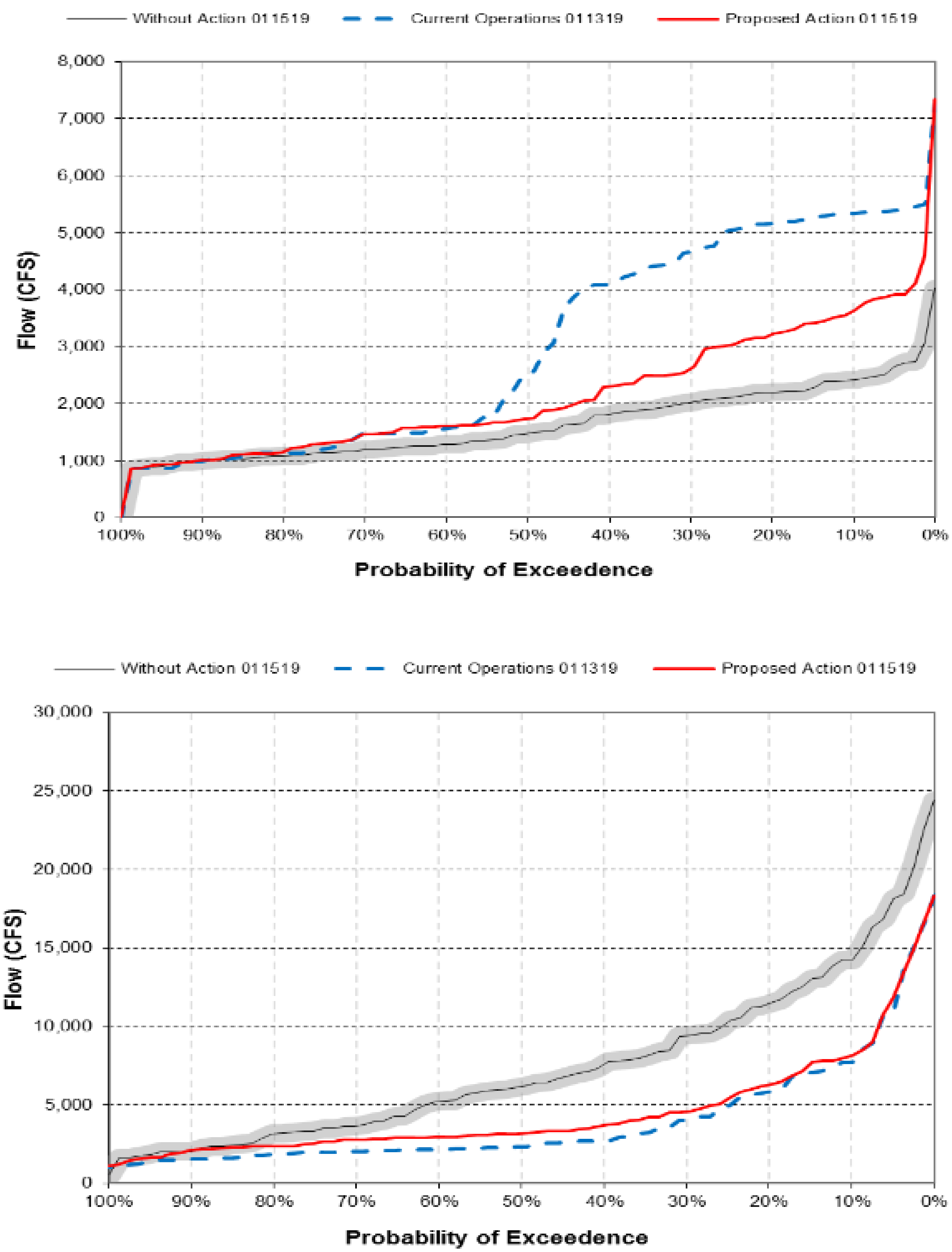


Figure 5.8-30. CalSim II estimates of Feather River flow below the Thermalito Afterbay in September-November and December-February under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action) scenarios.

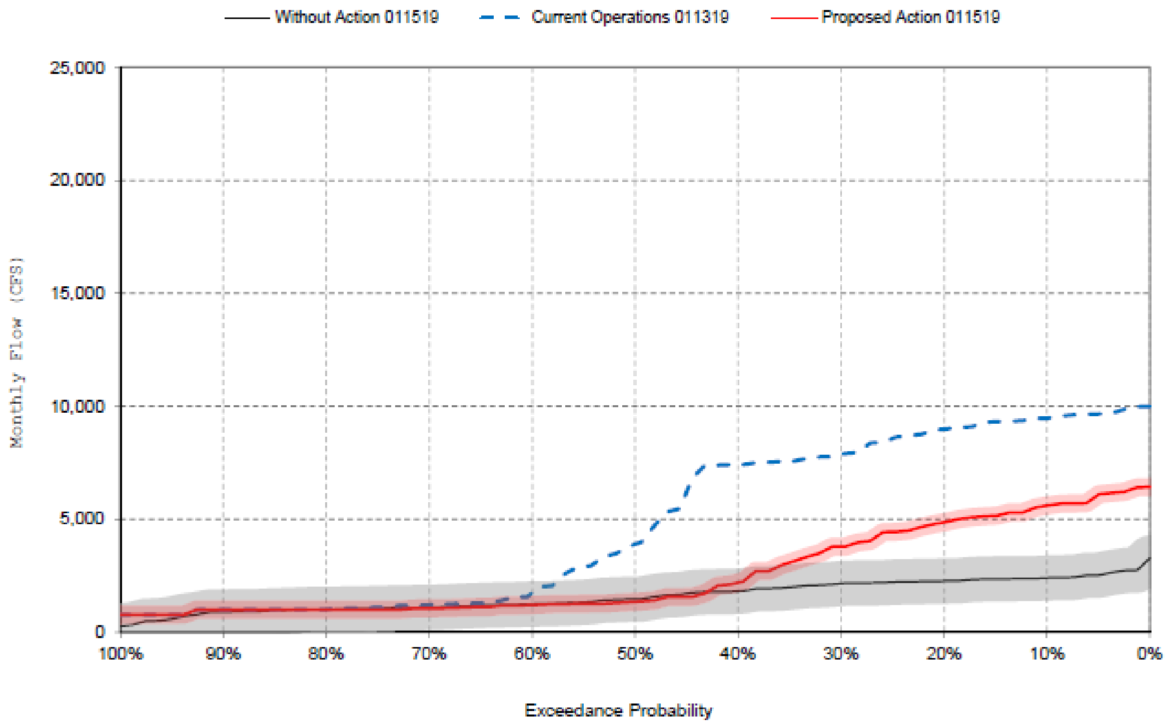


Figure 5.8-31. CalSim II estimates of Feather River flow below the Thermalito Afterbay in September and October under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action) scenarios.

Flows in the Feather River HFC during the egg incubation period would be similar to or higher under the proposed action and COS than under the WOA scenario, and in below normal, dry, and critical water year types, flows are reliably higher under the proposed action scenario than WOA scenario in September and October (Figure 5.8-32). Importantly, CalSim II model output indicates projected flows under the proposed action and COS scenarios would increase the likelihood that September and October minimum instream flow criteria are achieved. Differences in flows between the proposed action and COS are generally small across all months except September (Figures 5.8-28, 5.8-30, and 5.8-31). However, the proposed action is anticipated to result in reliably higher flows than both WOA and COS scenarios during October of below normal, dry, and critically dry years. October is the first month of elevated minimum instream flow criteria in the Feather River HFC and a critical period for Spring-run Chinook egg incubation.

Flows below the minimum requirements (Table 5.8-2) could have a number of adverse effects on this life stage, including higher water temperatures, lower DO in redds, and potential for redd dewatering, all of which may lead to elevated egg mortality. Insufficient flow may also limit the extent of river bed available for redd construction, thereby limiting available habitat for this life stage. Conversely, the predicted flows under the proposed action scenario are considerably lower than under the WOA in January through February (Figure 5.8-28). Although these flows are not expected to effect upstream migration, and therefore superimposition in the Low Flow Channel, the lower flows during this incubation and emergence period could result in reduced redd scouringe. Because the potential adverse effects of low flows on this life stage are anticipated to be less severe, or most beneficial, under the proposed action scenario, flow-related actions under the proposed action scenario are anticipated to produce low- to medium-level population benefits for this life stage.

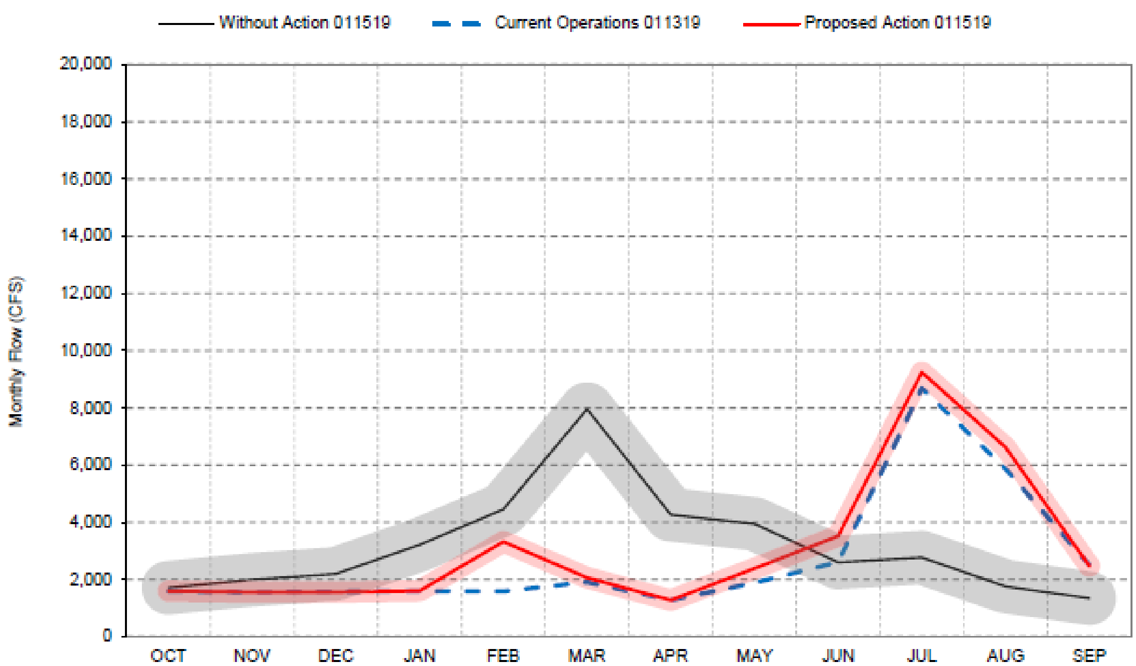


Figure 5.8-32. CalSim II estimates of Feather River flow below Thermalito Afterbay in September and October for below normal water years under the WOA (Without Action), COS (Current Operations), and proposed action scenarios.

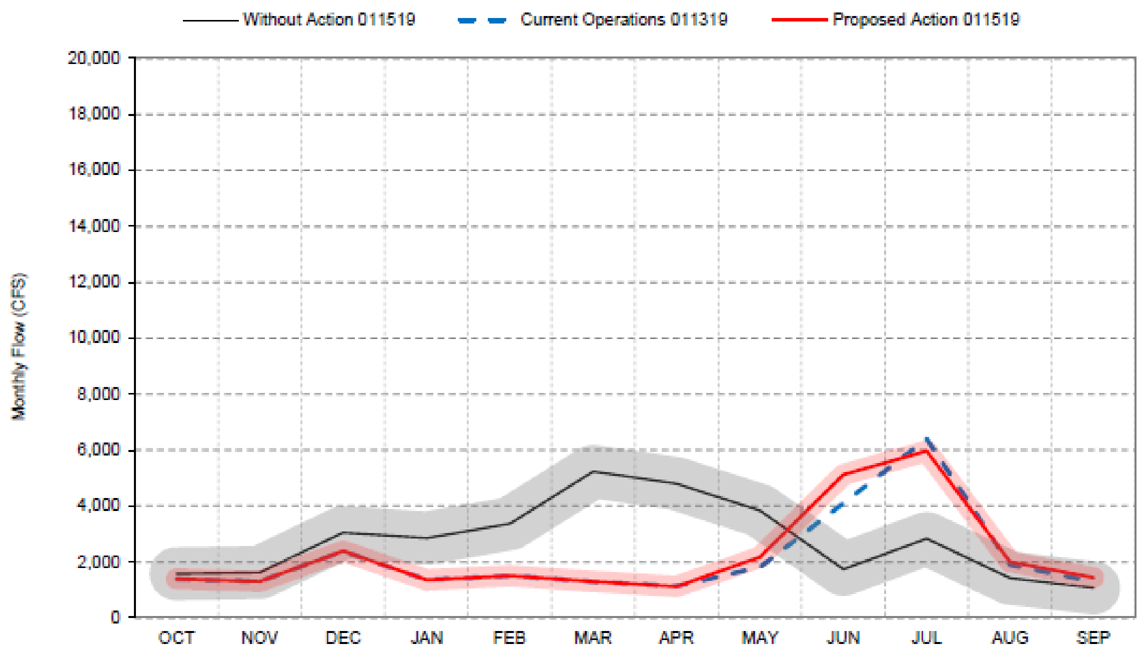


Figure 5.8-33. CalSim II estimates of Feather River flow below Thermalito Afterbay in September and October for dry water years under the WOA (Without Action), COS (Current Operations), and proposed action scenarios.

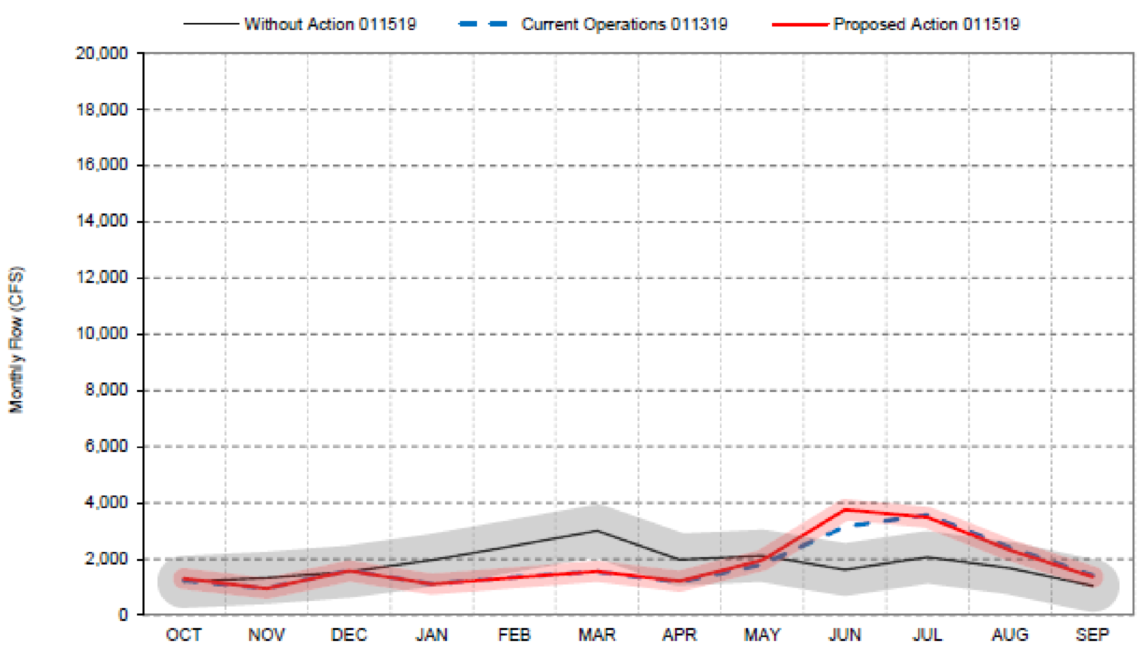


Figure 5.8-34. CalSim II estimates of Feather River flow below Thermalito Afterbay in September and October for critically dry water years under the WOA (Without Action), COS (Current Operations), and proposed action scenarios.

5.8.3.6.1.2 Temperature Effects

Water temperatures, combined with other environmental drivers, have the potential to influence condition and survival of Spring-run Chinook eggs. Effects of elevated water temperatures include an inability to satisfy metabolic demand and acute to chronic physiological stress, eventually leading to egg mortality (Stillwater Sciences 2006, Anderson 2017, Martin et al. 2017). Spring-run Chinook Salmon eggs require temperatures < 54°F for optimal development and survival and 54-58°F for suboptimal development and survival. Temperatures above 58°F may cause chronic to acute stress (Stillwater Sciences 2006).

Water temperatures in the Feather River during summer and fall are heavily influenced by flow releases from Lake Oroville, which are determined by operations and storage releases. Eggs and emerging fry of Spring-run Chinook would be exposed to the effects of operations and water releases that affect water temperatures in the Feather River HFC, based on the seasonal occurrence of this life stage in the Feather River (September-February; Table 5.8-1 & NMFS 2016x), and the timing of the temperature objectives that influence flow releases (Table 5.8-3).

Water temperature objectives would be expected to be met in years when the Oroville Temperature Management Index (OTMI) is greater than 1.35 MAF and would be achieved through a combination of flow releases from Lake Oroville, and operations modifications stipulated in the Oroville Facilities relicensing Settlement Agreement (Article A108.1(b) [(*i*) curtailment of pump-back operation, (*ii*) shutter removal on Hyatt Intake, (*iii*) increase flow releases in the Low Flow Channel up to a maximum of 1,500 cfs]. If OTMI is equal to or less than 1.35 MAF, then a Conference Year is designated, triggering consultation between DWR and NMFS, USFWS, CDFW, and the SWRCB to prepare a strategic plan to manage the coldwater pool to minimize temperature exceedances at the lower FERC project boundary, while maintaining water supply and other legal obligations.

Table 5.8-3. Maximum Daily Mean Water Temperature Objectives for the HFC (NMFS BO and USFWS BO)

Maximum Daily Mean Water Temperature Objectives for the HFC (measured at the downstream FERC project boundary)	
Period	Temperature (°F)
January 1 – March 31	56
April 1 – 30	61
May 1 – 15	64
May 16 – 31	64
June 1 – August 31	64
September 1 – 8	61
September 9 – 30	61
October 1 – 31	60
November 1 – December 31	56

Under the WOA, Lake Oroville would not be operated to control storage or flow releases, and no conveyance of water to San Luis Reservoir via the Banks Pumping Plant would be made. Therefore, there would be limited control of flow or water temperature in the Feather River HFC where Spring-run Chinook egg incubation occurs. Resulting water temperatures under the WOA scenario in the HFC at Gridley Bridge, as modeled by the RecTemp temperature model, would be generally lower during the winter and higher during the summer and fall, with peak annual water temperatures of approximately 78 °F occurring in July and August (Figure 5.8-35).

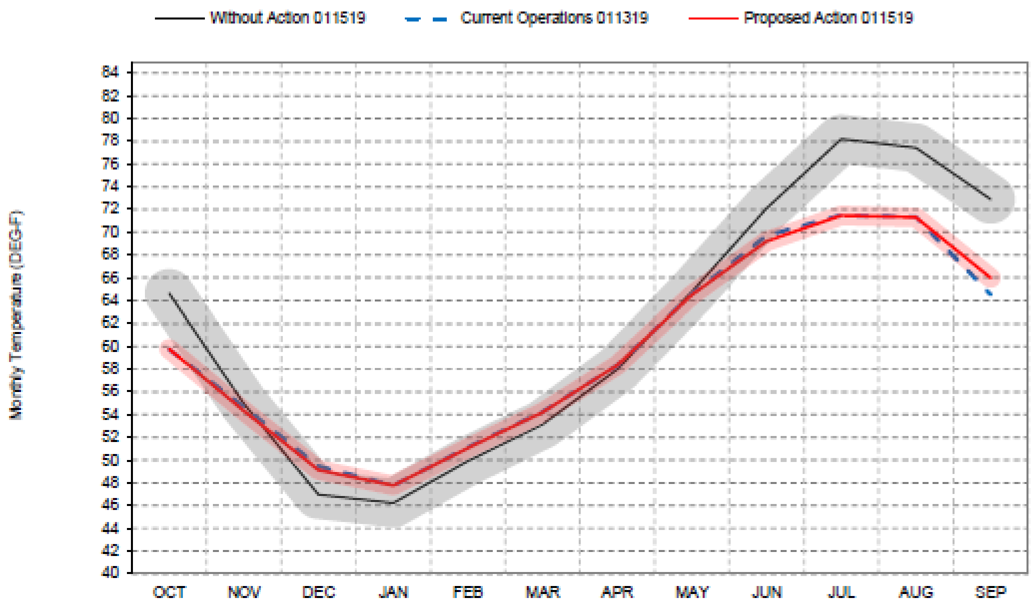


Figure 5.8-35. RecTemp average estimated Feather River water temperatures at Gridley Bridge under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action) scenarios.

Under the proposed action and COS, operations and flow releases would be managed to achieve Feather River HFC temperature objectives, resulting in water temperatures that are generally lower than those estimated under the WOA scenario between June and October, and water temperatures that are roughly equivalent between November and May (Figure 5.8-35). Water temperatures at Gridley Bridge under the WOA scenario would range between 60 and 78 °F in September and October, which is well above levels that may cause chronic to acute stress and would increase the likelihood of temperature-related mortality (Stillwater Sciences 206) during the peak timing of Spring-run Chinook egg incubation. Water temperatures under the proposed action and COS would be appreciably lower than under the WOA during the same period, ranging from approximately 57 to 68 °F; however, would still be suboptimal for development and survival and may also cause chronic to acute stress (Stillwater Sciences 2006). Optimum temperatures for egg incubation are reached after mid-November under all three scenarios (Figure 5.8-35). In addition, modeled water temperatures at Gridley Bridge indicate a higher likelihood of temperature compliance under the proposed action and COS (Table 5.8-3 and Figure 5.8-36 through 41).

Water temperatures exceeding the objectives and the biological thresholds for this life stage of Spring-run Chinook Salmon would have adverse effects on individuals, including acute to chronic physiological stress and increased likelihood of egg mortality. Water temperatures in the Feather River HFC during the egg incubation period under the proposed action and COS are similar to or lower than WOA water temperatures and have a higher likelihood of meeting the temperature objectives during the peak egg incubation period (September–October), which would benefit this life stage. Therefore, potential adverse effects of flow releases and water temperatures would be minimized for this life stage under the proposed action and COS scenarios, which is anticipated to produce low- to medium-level population benefits for this life stage.

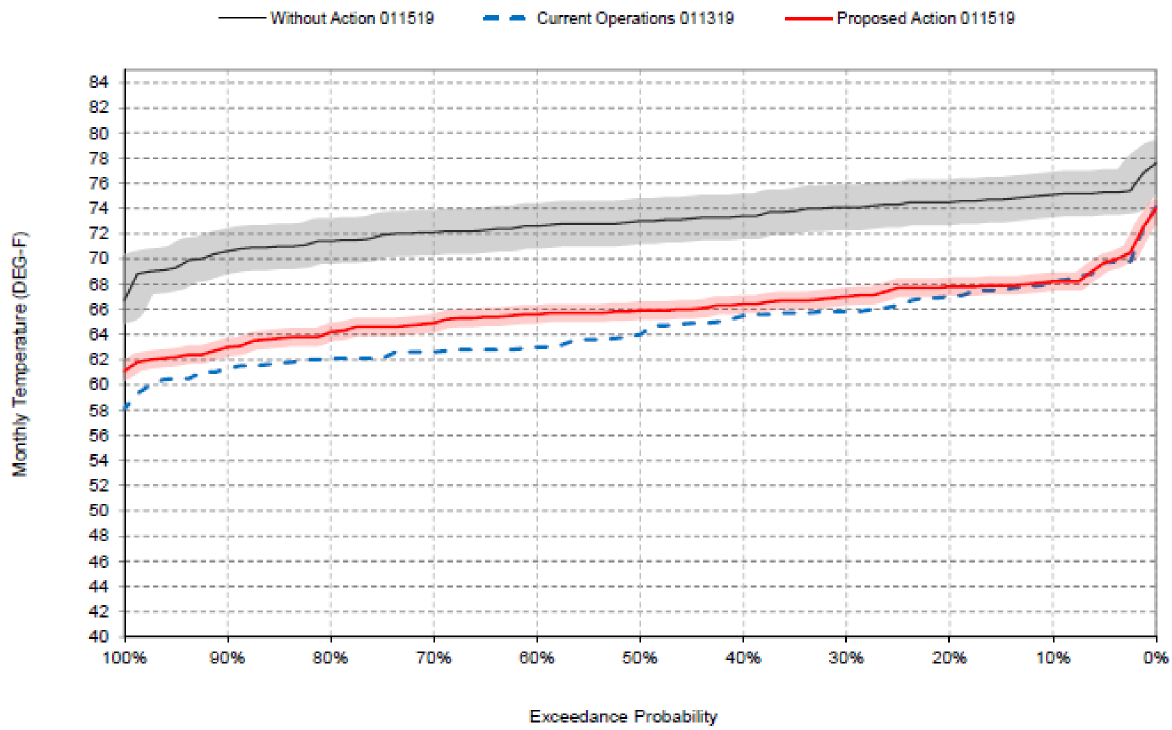


Figure 5.8-36. RecTemp estimates of Feather River water temperature exceedance probabilities at Gridley Bridge in September under the WOA (Without Action), COS (Current Operations), and proposed action scenarios.

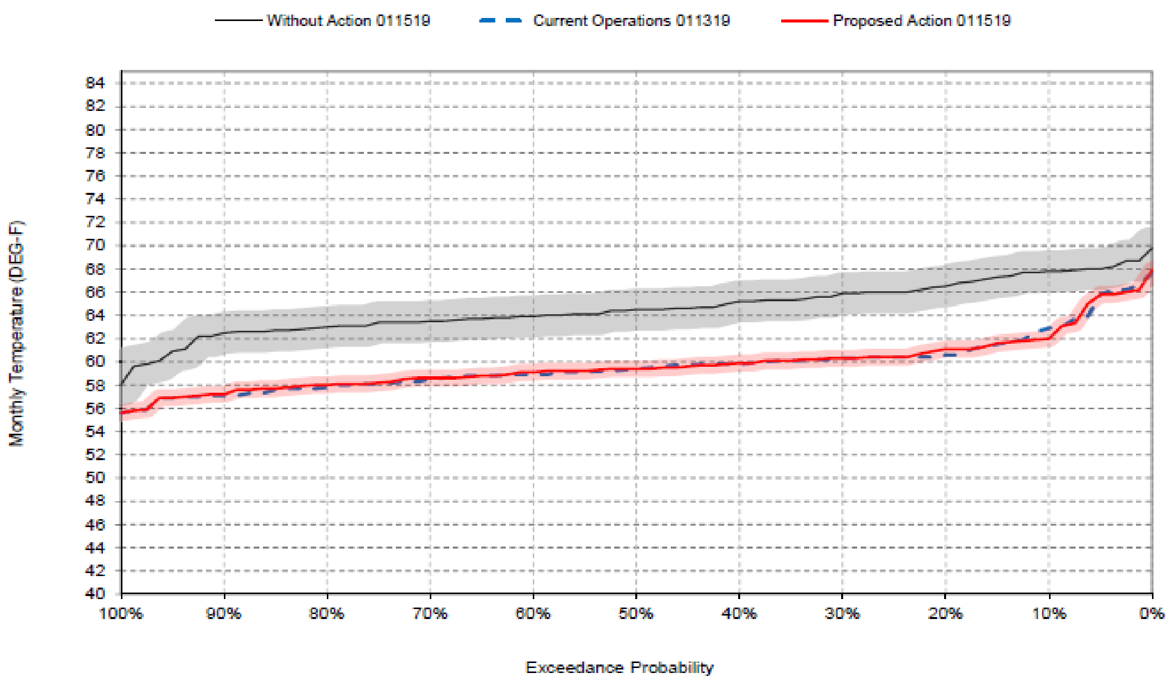


Figure 5.8-37. RecTemp estimates of Feather River water temperature exceedance probabilities at Gridley Bridge in October under the WOA (Without Action), COS (Current Operations), and proposed action scenarios.

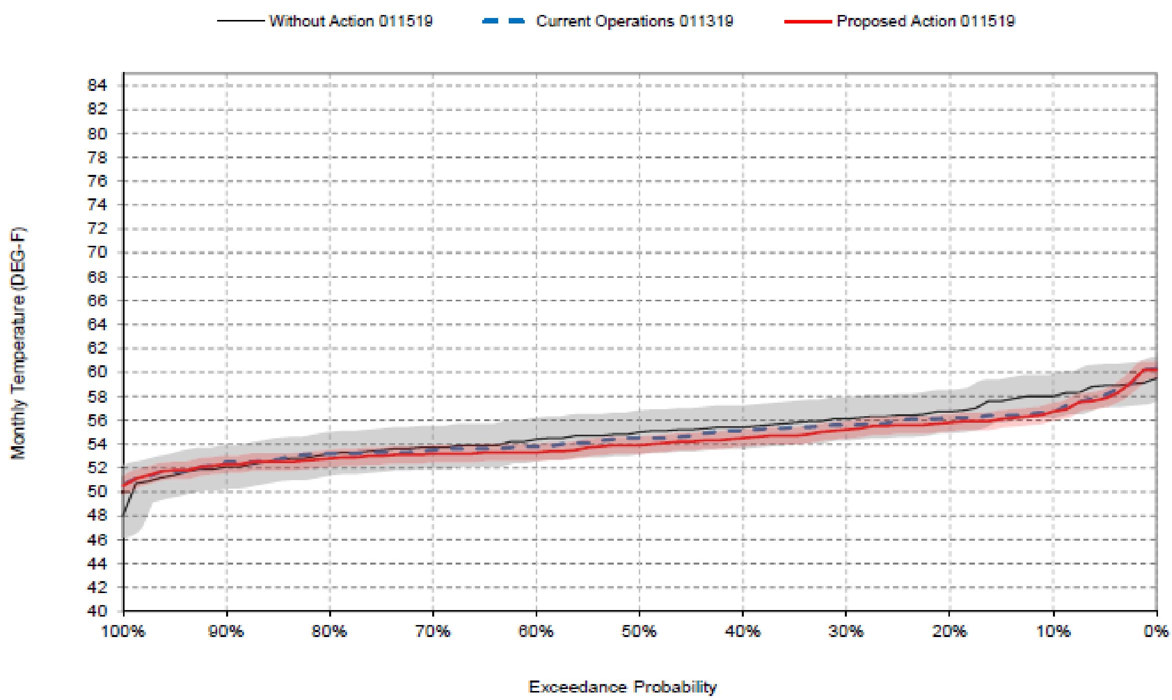


Figure 5.8-38. RecTemp estimates of Feather River water temperature exceedance probabilities at Gridley Bridge in November under the WOA (Without Action), COS (Current Operations), and proposed action scenarios.

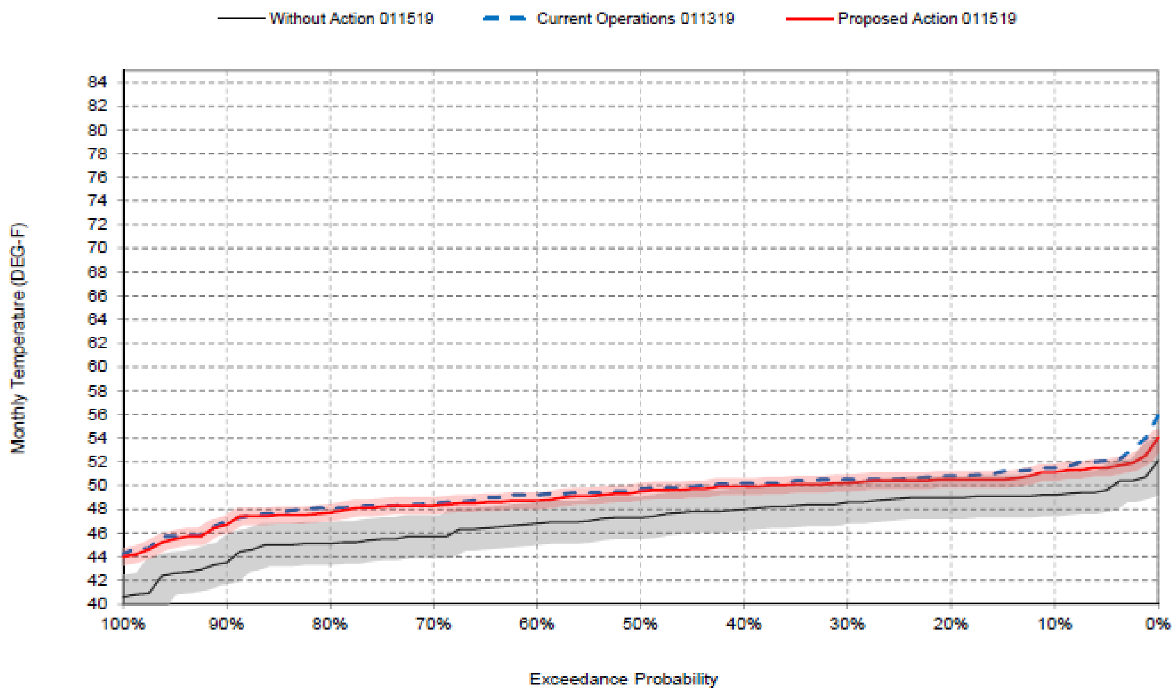


Figure 5.8-39. RecTemp estimates of Feather River water temperature exceedance probabilities at Gridley Bridge in December under the WOA (Without Action), COS (Current Operations), and proposed action scenarios.

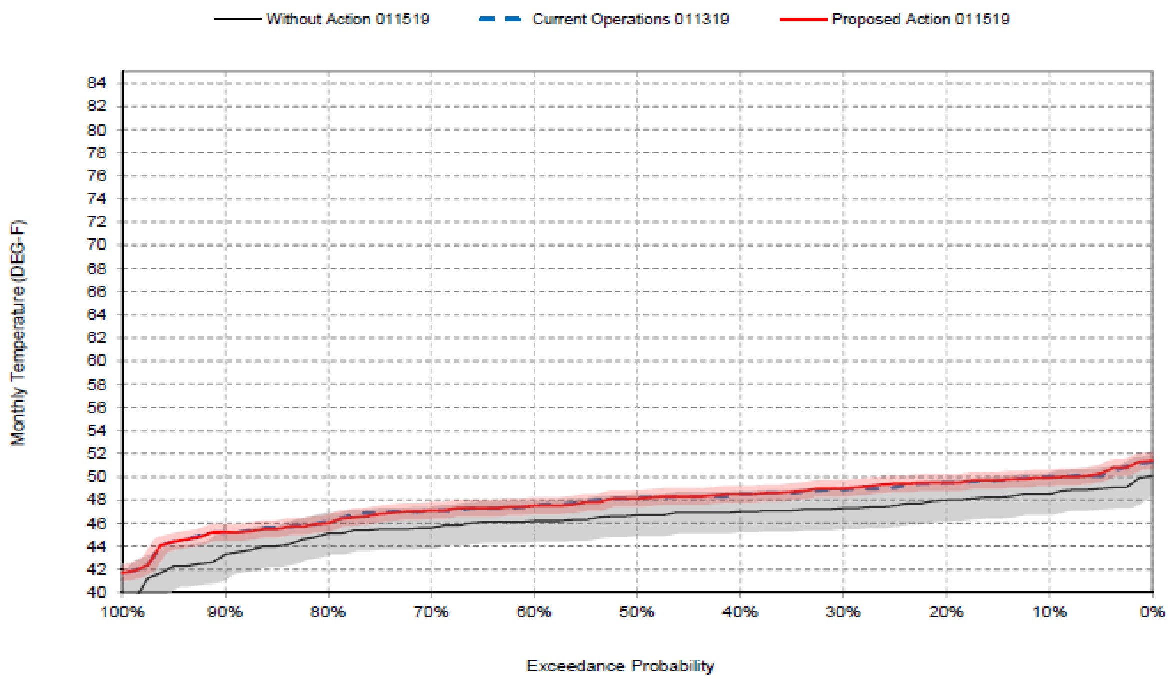


Figure 5.8-40. RecTemp estimates of Feather River water temperature exceedance probabilities at Gridley Bridge in January under the WOA (Without Action), COS (Current Operations), and proposed action scenarios.

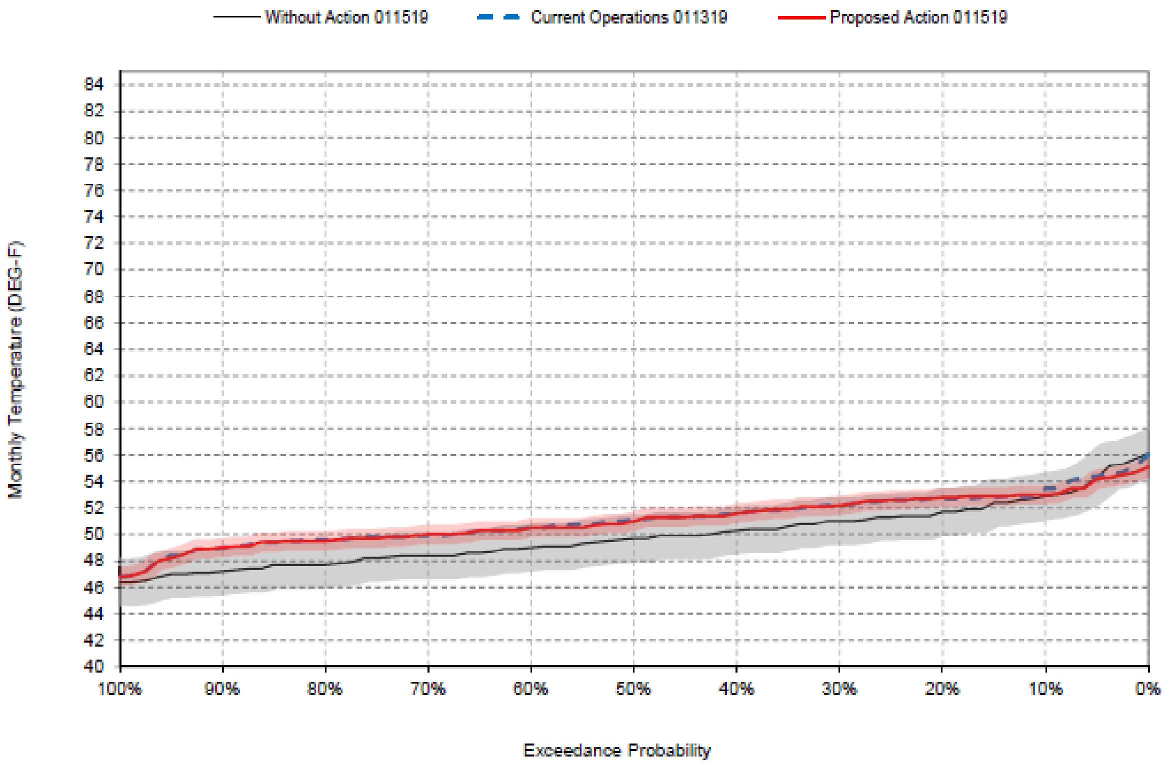


Figure 5.8-41. RecTemp estimates of Feather River water temperature exceedance probabilities at Gridley Bridge in February under the WOA (Without Action), COS (Current Operations), and proposed action scenarios.

5.8.3.6.2 Rearing to Outmigrating Juveniles in Rivers

5.8.3.6.2.1 Flow Effects

Rearing to outmigrating juvenile Spring-run Chinook would be exposed to the effects of Oroville Dam releases and resulting flows in the High Flow Channel (HFC) of the Feather River downstream of the Oroville Complex FERC boundary, based on the seasonal occurrence of this life stage in the Feather River (year-round possible with peak abundance November-May; Table 5.8-1 & NMFS 2016), minimum instream flow requirements in the high flow channel of the Feather River (year-round requirements; Table 3), and compliance with Water Rights Decision 1641 (D-1641).

Under the Without Action (WOA), Lake Oroville would not be operated to control storage or flow releases and no conveyance of water to San Luis Reservoir via the Banks Pumping Plant would be made. Reservoir gates and diversion tunnels would be kept open, resulting in annual storage volumes less than 1,000 TAF (Figure 5.8-27). As a result, there would be limited control of flow or water temperature in the Feather River HFC, which provides habitat for this life stage. Feather River flows under the WOA would approximate uncontrolled flows, with generally lower summer and fall flows and higher winter and spring flows compared to proposed action and COS (Figures 5.8-28 and 5.8-29).

5.8.3.6.2.1.1 Temperature Effects

Water temperatures, combined with other environmental drivers, have the potential to heavily influence condition and survival of rearing individuals. Exposure to the effects of elevated water temperatures can include an increased susceptibility to disease, reduction in growth due to increased metabolic demands, decreased productivity, and eventual mortality. Rearing juvenile Spring-run Chinook require temperatures < 60°F for optimal development and survival, and 60-65°F for suboptimal, with temperatures above 65°F causing chronic to acute stress (Stillwater Sciences 2006).

Water temperatures in the Feather River from November to May are relatively less influenced by flow releases from Lake Oroville than in summer and fall, given the larger flow volumes, and colder air temperatures during these months. Rearing Spring-run Chinook Salmon would be exposed to the effects of water temperature objectives for the Feather River HFC, based on the seasonal occurrence of this life stage in the Feather River (year-round possible with peak abundance November-May; Table 5.8-1 & NMFS 2016x), and the timing of the temperature objectives (year-round objectives; Table 5.8-2).

Water temperature objectives would be expected to be met in years when the Oroville Temperature Management Index (OTMI) is greater than 1.35 MAF and would be achieved through a combination of flow releases from Lake Oroville, and operations modifications stipulated in the Oroville Facilities relicensing Settlement Agreement Article A108.1(b) [(*i*) curtailment of pump-back operation, (*ii*) shutter removal on Hyatt Intake, (*iii*) increase flow releases in the Low Flow Channel up to a maximum of 1,500 cfs]. If OTMI is equal to or less than 1.35 MAF a Conference Year is designated, triggering consultation between DWR and NMFS, USFWS, CDFW, and the SWRCB to prepare a strategic plan to manage the coldwater pool to minimize temperature exceedances at the lower FERC project boundary, while maintaining water supply and other legal obligations.

Under the proposed action and COS operations and flow releases would be managed to achieve Feather River HFC temperature objectives, resulting in water temperatures that are generally lower than those modeled under the WOA from June to October, and water temperatures that are roughly equivalent from November to May (Figure 5.8-31). Temperatures at Gridley Bridge under the proposed action are the same or higher than temperatures under the WOA from November to March, which coincides with the peak seasonal timing of rearing Spring-run Chinook. However, the risk of temperature-related stress and mortality are substantially reduced or not present during this period as temperatures remain well within the optimal range (< 60°F) for this life stage and under the Feather River HFC temperature objectives for these months. However, April and May water temperatures under the COS, and more so the proposed action, are lower than the WOA during a period at moderate risk of temperature-related stress and mortality, increasing the likelihood of temperature-related stress and mortality occurring during juvenile rearing under some conditions of the WOA. As a result, potential adverse effects of water temperature objectives on this life stage are anticipated to be less severe under the proposed action and COS, especially during below normal, dry, and critically dry water year types (Figure 5.8-32). Therefore, water temperature-related actions in these scenarios are anticipated to produce low-level population benefits for this life stage.

5.8.3.6.3 Migrating Adults

5.8.3.6.3.1 Flow Effects

Migrating adult Spring-run Chinook Salmon would be exposed to the effects of Oroville Dam releases and resulting flows in the High Flow Channel (HFC) of the Feather River downstream of the Oroville Complex FERC boundary, based on the seasonal occurrence of this life stage in the Feather River (peak abundance March-June; Table 5.8-1 & NMFS 2016), minimum instream flow requirements in the high flow channel of the Feather River (year-round requirements; Table 5.8-2), and compliance with Water Rights Decision 1641 (D-1641).

As indicated by the SAIL Bay-Delta to Upper River (CM6) conceptual model these flows, combined with other environmental drivers, affect water temperature, DO, stranding, outmigration cues and other habitat attributes that influence the timing, condition and survival of migrating adult Spring-run Chinook Salmon (Johnson et. al., 2016, Windell et. al., 2017). Instream flow from Lake Oroville releases may also heavily influence the strength of navigational cues utilized by migrating adults and the propensity of these fish to stray from migratory pathways leading to high quality spawning habitat.

Feather River flows below Thermalito Afterbay under the proposed action and COS are generally approximate or are significantly lower than flows under the WOA during the peak seasonal timing of Spring-run Chinook adult migration (peak abundance March-June; Table 5.8-1 & NMFS 2016). The likelihood of flows occurring that are less than the minimum instream flow requirements during these months is very low under all scenarios, although some risk exists under the WOA in June of critically dry years, when flows are lower under the WOA than COS and proposed action scenarios (Figure 5.8-30). Differences in flows between the proposed action and COS are less pronounced than differences between the proposed action and WOA during the March to June period, but are still significant, with relatively equal differences across the range of exceedance probabilities.

5.8.3.6.3.1.1 Temperature Effects

Water temperatures, combined with other environmental drivers, have the potential to heavily influence condition and survival of migrating adults. Exposure to the effects of elevated water temperatures can include an increased susceptibility to disease, and physiological stress potentially leading to mortality and altered migration timing and speed. Migrating adult Spring-run chinook require temperatures < 56°F for optimal survival, and 56-65°F for suboptimal, with temperatures above 65°F causing chronic to acute stress (Stillwater Sciences 2006).

Water temperatures in the Feather River during summer are heavily influenced by flow releases from Lake Oroville, which are determined by operations and storage releases. Migrating adult Spring-run Chinook Salmon would be exposed to the effects of water temperature objectives for the Feather River HFC, based on the seasonal occurrence of this life stage in the Feather River (peak abundance March-June; Table 5.8-1 & NMFS 2016), and the timing of the temperature objectives (year-round objectives; Table 5.8-2).

Under the proposed action and COS operations and flow releases would be managed to achieve Feather River HFC temperature objectives, resulting in water temperatures that are generally lower than those modeled under the WOA from June to October, and water temperatures that are roughly equivalent from November to May. Temperatures at Gridley Bridge under the COS and proposed action are the same or lower than temperatures under the WOA from March to June, which coincides with the peak seasonal timing of migrating adult Spring-run Chinook. The risk of temperature-related stress and mortality are present during this period as temperatures are projected to be in or near the suboptimal range (<56-65°F) for this life stage from March to May and potentially above the chronic to acute stress threshold (> 65°F) in June (Figure 5.8-31). Water temperatures under the COS, and more so the proposed action, are lower than the WOA during May and June, a period at moderate to high risk of temperature-related stress and mortality, according to RecTemp model results. As a result, potential adverse effects of water temperature objectives on this life stage are anticipated to be less severe under the COS, and more so the proposed action, especially during below normal, dry, and critically dry water year types (Figure 5.8-32).

5.8.3.6.4 Holding Adults

Holding adult Spring-run Chinook Salmon would be exposed to the effects of Oroville Dam releases and resulting flows in the High Flow Channel (HFC) of the Feather River downstream of the Oroville Complex FERC boundary, based on the seasonal occurrence of this life stage in the Feather River (March-September with peak abundance May-August; Table 5.8-1 & NMFS 2016), minimum instream flow requirements in the high flow channel of the Feather River (year-round requirements; Table 7), and compliance with Water Rights Decision 1641 (D-1641). As indicated by the SAIL Bay-Delta to Upper River (CM7) conceptual model these flows, combined with other environmental drivers, affect water temperature, DO, and other habitat attributes that influence the condition and survival of holding adult Spring-run Chinook Salmon (Johnson et. al., 2016, Windell et. al., 2017).

Feather River flows below Thermalito Afterbay under the proposed action and COS both exceed and are lower than flows under the WOA during the peak seasonal timing of Spring-run Chinook holding (March-September with peak abundance May-August; Table 5.8-1 & NMFS 2016). In particular, proposed action flows are reliably lower than the WOA in May and equal to or higher than the WOA from June to August. The likelihood of flows occurring that are less than the minimum instream flow requirements during these months is very low under all scenarios, and all water year types, except in August and September under the WOA scenario. Under this scenario the likelihood of flows declining below applicable minimum instream flows for the Feather River HFC in August and September is increased under the WOA (Figure 5.8-30). Differences in flows between the proposed action and COS are less pronounced than differences between the proposed action and WOA during the March to September period, but are still significant, with the proposed action projected to be reliably higher in May and June and the COS projected to be reliably higher in September.

Exposure to the effects of differences in flow during this life stage could include variation in water temperature and DO, and the amount and quality of holding habitat used to shelter from predators, and rest during the gamete maturation phase. Proposed Action and COS flows are lower than WOA flows in May, however, proposed action and COS action flows are not anticipated to decline below minimum instream flow standards or to a level that is anticipated to result in substantial loss of suitable holding habitat in the Feather River HFC. Proposed Action and COS flows are predominantly higher than WOA flows from June to August, which is anticipated to result in significant water temperature benefits for holding adults as this period coincides with mid- and late-summer increases in air temperature. These flows are also anticipated to improve the likelihood of adequate holding adult habitat as additional migrants enter the Feather River HFC throughout the summer. As a result, conditions for holding adult Spring-run Chinook will be improved during the majority of the peak seasonal timing of this life stage.

Water temperatures in the Feather River from May to September are heavily influenced by flow releases from Lake Oroville with increased flow releases generally mitigating some of the effects of elevated summer air temperatures on water temperature in the Feather River HFC. Under the WOA, Lake Oroville would not be operated to control storage or flow releases and no conveyance of water to San Luis Reservoir via the Banks Pumping Plant would be made. Therefore, there would be limited control of flow or water temperature in the Feather River HFC where Spring-run Chinook hold prior to spawning. As a result, water temperatures under the WOA in the Feather River HFC at Gridley Bridge as modeled by the RecTemp temperature model become increasingly higher than those projected under the proposed action and as summer progresses from May to September (Figure 5.8-31).

Under the proposed action and COS scenarios operations and flow releases would be managed to achieve Feather River HFC temperature objectives, resulting in water temperatures that are generally lower than those modeled under the WOA from June to October, and water temperatures that are roughly equivalent from November to May. Temperatures at Gridley Bridge under the COS and proposed action are the same or lower than temperatures under the WOA from May to August, which coincides with the peak seasonal timing of holding adult Spring-run Chinook. The risk of temperature-related stress and mortality are present during the majority of this period as temperatures are projected to be at or near the suboptimal range (<60.8-66.2°F) for this life stage from May to August and potentially above the chronic to acute stress threshold (> 66.2°F) in July, August, and September. June to August water temperatures under the COS, and more so the proposed action, are lower than the WOA, a period at high risk of temperature-related stress and mortality, according to RecTemp model results. As a result, potential adverse effects of water temperature objectives on this life stage are anticipated to be less severe under the COS, and more so the proposed action, especially during below normal, dry, and critically dry water year types (Figure 5.8-32).

5.8.3.7 American River Seasonal Operations, including 2017 Flow Management Standard and "Planning Minimum"

Reclamation's proposed action includes a minimum release with flows that range from 500 to 2000 cfs based on time of year and annual hydrology. Reclamation's proposed action also includes a "planning minimum" to preserve storage to protect against future drought conditions and to facilitate the development of the cold water pool when possible and improve habitat conditions for steelhead and Fall-run Chinook salmon. The Flow Management Standard (FMS) also includes the provision for spring pulse flows, with the purpose of providing a juvenile salmonid (Fall-run Chinook salmon and steelhead) emigration cue before relatively low flow conditions and associated unsuitable thermal conditions later in the spring in the river, and downstream in the lower Sacramento River.

Rearing juvenile Spring-run Chinook Salmon may be present in the American River from November to May. The American River corridor downstream of the Watt Street bridge is designated critical habitat for the species.

5.8.3.7.1 Rearing to Outmigrating Juveniles in Rivers

Spring-run Chinook Salmon juveniles may be present in the American River for rearing and exposed to effects of Reclamation's water releases from Folsom Dam during their rearing period. As discussed in the conceptual model, flows affect temperatures. Excessively high water temperatures have been identified as one of the factors threatening Spring-run Chinook Salmon in the Central Valley and a factor for listing of the species. Without Reclamation's proposed action, there would be no Folsom reservoir operations to control storage or releases. The proposed action and COS would result in lower flows below Nimbus Dam during the species rearing period during average water years, with the largest difference in flow between March and May. All three modeled hydrologies (Proposed action, COS, and WOA) indicated flows spike at the beginning of February, between 6,000 cfs and 6,500 cfs. The proposed action and COS result in higher temperatures between November and February. From February to May, all three model runs indicate similar temperatures, however proposed action temperatures are lower than those under WOA.

The implementation of the proposed FMS measures would provide suitable habitat conditions in the lower American River for Chinook Salmon, particularly during drought conditions, and improve conditions for rearing to outmigrating Juveniles.

5.8.3.7.1.1 Stanislaus River Stepped Release Plan

The Stanislaus River is not designated critical habitat for Spring-run Chinook Salmon and while spring-running fish may be present, they are not currently considered part of the listed ESU. However, since no genetic testing has occurred, Reclamation is providing this analysis to ensure future coverage under the ESA if proven to be listed CV Spring-run Chinook Salmon.

A nonessential experimental population of Spring-run Chinook Salmon in the San Joaquin River from Friant Dam downstream to its confluence with the Merced River was designated to allow reintroduction of the species below Friant Dam as part of the San Joaquin River Restoration Program (SJRRP) (78 FR 79622, December 31, 2013). Observations show that spring running Chinook occur in the Stanislaus and Tuolumne Rivers and that these fish would not be considered as experimental under the SJRRP, and as a result, they are addressed in this document.

5.8.3.7.1.1.1 Egg to Fry Emergence

Snorkel surveys (Kennedy and Cannon 2005) conducted between October 2002 and October 2004 on the Stanislaus River identified adults in June 2003 and 2004, as well as observed Chinook fry in December 2003, which would indicate likely spawning timing in late September or October. In addition, monitoring on the Stanislaus since 2003 and on the Tuolumne since 2009, has indicated upstream migration of adult spring-running Chinook Salmon (Anderson et al. 2007), and 114 adults were counted on the video weir on the Stanislaus River between February and June in 2013 with only 7 individuals without adipose fins (FISHBIO 2015). Rotary screw trap (RST) data provided by Stockton U.S. Fish and Wildlife Service (USFWS) corroborates the spring-running Chinook Salmon adult timing by indicating that there are a small number of fry migrating out of the Stanislaus and Tuolumne at a period that would coincide with spring-running Chinook emigration (Franks 2014). Recently emerged fry start to show up at rotary screw traps in late December to mid-January most years and could be indicative of spring-run or fall-run. Chinook.

Under WOA conditions, the lower level river outlets of New Melones Dam would be closed to preserve the integrity of the gate structure and the Flood Control and Industrial gate would be set fully open and assumed to pass a flow of approximately 8,000 cfs. Inflow exceeding this capacity would be stored in New Melones Reservoir until the releases exceed capacity of the outlets. If necessary, the spillway would prevent overtopping of the Dam and to protect the structural integrity of the Dam and related facilities. This spillway is not gated and would naturally flow should the reservoir reach that height. Spring-running Chinook salmon distributions are expected to be similar to WOA as Goodwin Dam would still represent a complete barrier to further upstream migration. WOA water temperatures within the Stanislaus River would represent those of unimpeded flows coming off the western Sierra Nevada that travel through the CVP storage and conveyance facilities on the Stanislaus River that would be operated only to the extent necessary to fulfill flood control operations. Operations of non-CVP facilities would still occur as they are occurring today. Modeled flows below Goodwin Dam are depicted below in Figure 5.8-42. Stanislaus Modeled Flows. The early running Chinook would likely not survive the summer and any that do survive to spawn in early fall would not successfully reproduce due to high water temperature in WOA.

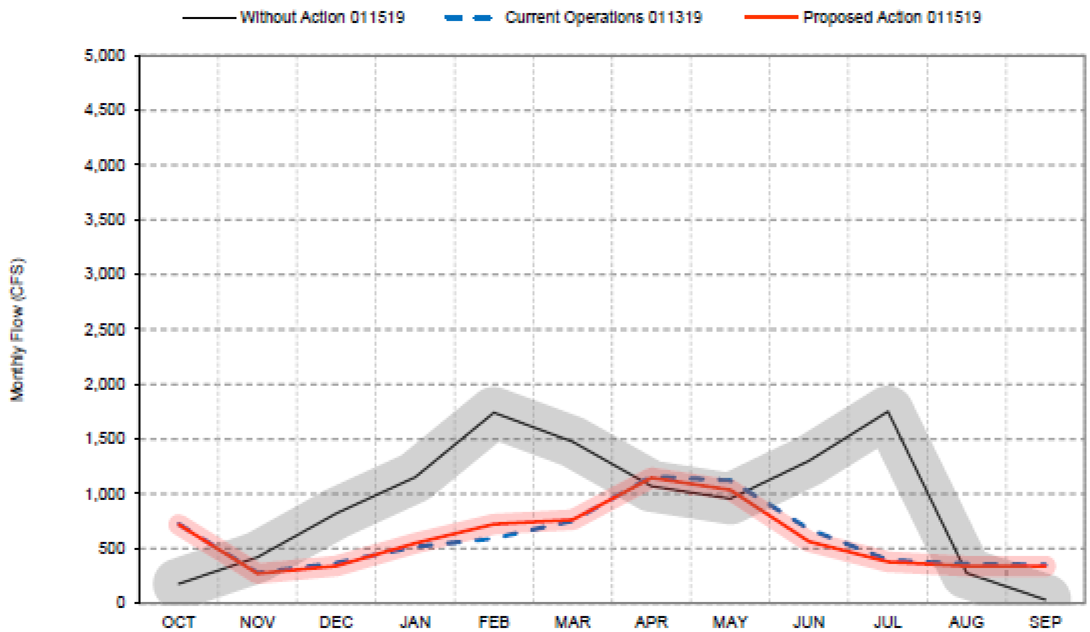


Figure 5.8-42. Modeled flows under WOA, Current Operations Scenario (COS) and Proposed Action Scenario

Current operations of New Melones under the Interim Plan of Operations (IPO), which has been in effect since 1997, were developed prior to completion of current tools to understand hydrology in the Stanislaus River Basin, and the water delivered from New Melones was overallocated in many years and was not able to consistently meet requirements for fish flows, temperature, water quality, dissolved oxygen, and water deliveries. The primary reason for this is that the IPO requires water releases early in the season that have resulted in inadequate water available later in the season to meet water quality and/or flow requirements. Reclamation also currently operate releases from the East Side Division reservoirs to achieve a minimum flow schedule as prescribed by Appendix 2-E of the NMFS 2009 BO.

Under the proposed action, Reclamation proposes to implement the New Melones Stepped Release Plan to create a sustainable operation on the Stanislaus River that strives to meet requirements for fish flows, temperature, water quality, dissolved oxygen, and water deliveries.

Where adult spring-running Chinook Salmon returning to the San Joaquin River are expected to exhibit various life-history patterns on both temporal and spatial scales, the juvenile stage typically exhibits more life-history variability than adults and have a stronger dependence on riverine habitat for successful survival than adults (SJRRP 2010). A review of numerous studies performed for the SJRRP (2010) identified a range of suitable water temperatures for all life stages of salmonids. The findings of this review were compiled into Table 5.8-4: Temperature Objectives for the Restoration of Central Valley Chinook Salmon.

Table 5.8-4. Temperature Objectives for the Restoration of Central Valley Chinook Salmon

Monthly Water Temperature Objectives for the San Joaquin River Restoration Program												
Spring-Run and Fall-Run Chinook Salmon												
Life Stage	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Adult Migration			Optimal: ≤59°F (15°C) Critical: 62.6 – 68°F (17 – 20°C) Lethal: >68°F (20°C)									
Adult Holding (Spring-Run Only)				Optimal: ≤55°F (13°C) Critical: 62.6 – 68°F (17 – 20°C) Lethal: >68°F (20°C)								
Spawning								Optimal: ≤57°F (13.9°C) Critical: 60 – 62.6°F (15.5 – 17°C) Lethal: 62.6°F or greater (17°C)				
Incubation and Emergence								Optimal: ≤55°F (13°C) Critical: 58 – 60°F (14.4 – 15.6°C) Lethal: >60°F (15.6°C)				
In-River Fry/Juvenile	Optimal: ≤60°F (15.6°C), young of year rearing; ≤62.6°F (18°C), late season rearing (primarily spring-run) Critical: 64.4 – 70°F (18-21.1°C) Lethal: >75 °F (23.9°C), prolonged exposure											
Floodplain Rearing*	Optimal: 55 – 68°F (13 – 20°C), unlimited food supply											
Outmigration	Optimal: ≤60°F (15.6°C) Critical: 64.4 – 70°F (18 – 21.1°C) Lethal: >75°F (23.9°C), prolonged exposure											

Sources: EPA 2003, Rich 2007, Pagliughi 2008, Gordus 2009.

Note:

* Floodplain rearing temperatures represent growth maximizing temperatures based on floodplain condition. No critical or lethal temperatures are cited assuming fish have volitional access and egress from floodplain habitat to avoid unsuitable conditions.

Shaded box indicates life stage is

present Key:

°F = degrees Fahrenheit

°C = degrees Celsius

Source: Conceptual Models of Stressors and Limiting Factors for San Joaquin River Chinook Salmon

The New Melones SRP will be implemented similar to current operations with a default daily hydrograph, and the ability to shape monthly and seasonal flow volumes to meet specific biological objectives. The default daily hydrograph is the same as prescribed under current operations for Critical, Dry, and Below Normal water year types; Above Normal and Wet year types follow daily hydrographs for Below Normal and Above Normal year types from 2-E, respectively. As a result, flows would be reduced in Above Normal and Wet year types. This difference between the proposed action and the COS during Above Normal and Wet years, where the minimum release requirement for wetter water year types is reduced from COS to promote storage for potential future droughts and preserve coldwater pool, leads to improved cold water pool performance in droughts, benefiting Spring-running Chinook salmon eggs.

5.8.3.7.2 <u>Rearing to Outmigrating Juveniles</u>

The SRP provides improved cold water pool performance in droughts, but would reduce flow releases in Above Normal and Wet years. As discussed in the conceptual model, lower flows in wet years could result in less inundated rearing habitat, lower outmigration flows, and potentially warmer temperatures, affecting rearing to outmigrating juvenile CV Spring-running Chinook salmon.

5.8.3.8 Alteration of Stanislaus River Dissolved Oxygen Requirement

Under WOA conditions, flow would be uncontrolled through the CVP project facilities and Spring-running Chinook distribution would be similar to currently, as Goodwin Dam would represent a complete barrier to further upstream migration. There would be no temperature management. Early running Chinook spawners would likely not survive the warm water in late summer and fall and would be unable to reproduce.

Current operations are required to meet a year-round dissolved oxygen minimum of 7 mg/L, from June 1 to September 30 at Ripon to protect salmon, steelhead, and trout in the river (CDFW 2018). However, maintaining dissolved oxygen concentrations above 7 mg/L in the Stanislaus River at Ripon is challenging during drought conditions, and, based on recent studies, does not appear to be warranted to protect salmonids in the River (Kennedy and Cannon 2005, Kennedy 2008).

Reclamation proposes to move the compliance location to Orange Blossom Bridge, where the species are primarily located at that time of year. Based on multi-year observations of salmonid abundance in the River Kennedy and Cannon (2005) and Kennedy (2008) found that over-summering juvenile salmonids are primarily found upstream of Orange Blossom Bridge, which is approximately 31 miles upstream from Ripon. Dissolved oxygen monitoring at the Stanislaus River Weir (approximately 15 miles upstream from Ripon) indicates that dissolved oxygen concentrations can be 0.5-1 mg/L higher at this location than those measured at Ripon (Cramer Fish Sciences 2006a-d). Without the proposed action, there would be no water temperature management. Therefore, the proposed temperature compliance point is beneficial to the species, because the majority of salmonid eggs, alevin and/or fry are found in locations where summer dissolved oxygen levels would be expected to be maintained at or near 7 mg/L.

Juvenile spring-run Chinook are found in the Stanislaus River from Goodwin Dam downstream to Oakdale. Because the fish are located primarily at least twice this distance upstream from Ripon, the dissolved oxygen concentration is likely to be at this level or higher where the majority of these fish occur. Additionally, there should be no impact to outmigrating juvenile Spring-run Chinook Salmon since their outmigrations is from November through the end of May (Table 5.8-1). Based on the typical seasonal occurrence of this life stage in the River (mid-January – late June), no adult migrating Spring-run Chinook Salmon would be affected by the relaxation of dissolved oxygen requirements at Ripon (June 1 - September 30). As the majority of adult Chinook Salmon that are holding in the Stanislaus River from March to mid-September (Table 5.8-1) are found in locations where summer dissolved oxygen levels would be expected to be maintained at or near 7 mg/L, holding adult Spring-run Chinook Salmon are not expected to be impacted from this action . Based on the typical seasonal occurrence of this life stage in the Stanislaus River (mid-January – late June), no adult migrating Spring-run Chinook Salmon would be expected to be exposed to the effects of the alteration of dissolved oxygen requirements at Ripon.

5.8.3.9 Bay-Delta Seasonal Operations

Reclamation and DWR propose to operate the C.W. Bill Jones Pumping Plant and the Harvey O. Banks Pumping Plant. These pumping plants affect the hydrodynamics of the south and central Delta resulting in effects to Spring-run Chinook Salmon entrainment, routing and through Delta survival. Hydrodynamic changes associated with river inflows and South Delta exports have been suggested to negatively impact juvenile Chinook Salmon in two distinct ways: 1) “near-field” mortality associated with entrainment to the export facilities, 2) “far-field” mortality resulting from altered hydrodynamics. See Winter-run Chinook salmon effects section for more detail concerning “far-field” and “near-field”.

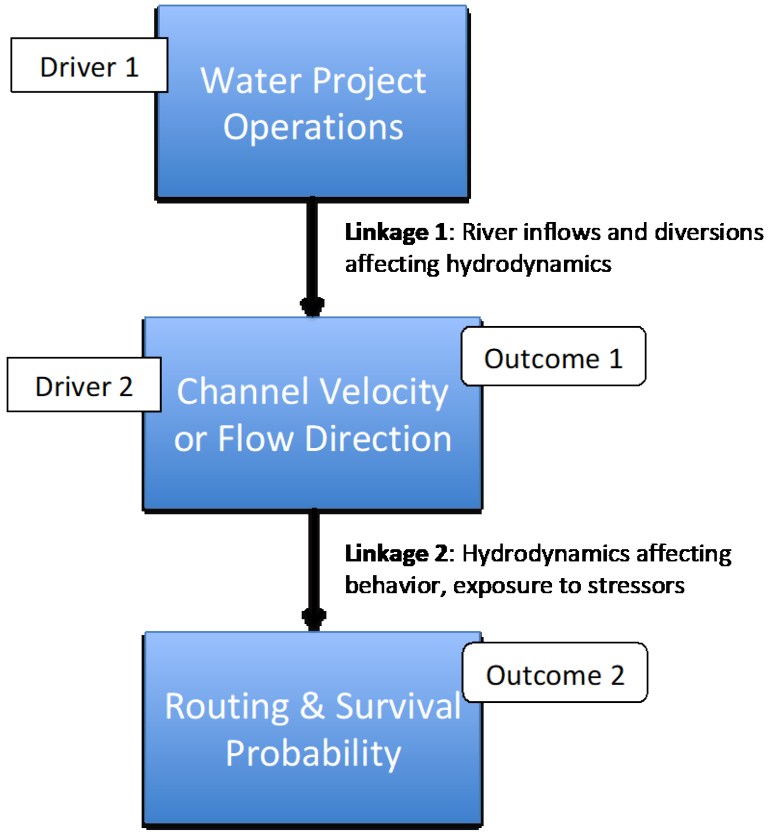


Figure 5.8-43. Conceptual model for far-field effects of water project operations on juvenile salmonids in the Delta. This CM is a simplified version of the information provided by the CAMT SST.

5.8.3.9.1 Entrainment

Among 6.8 million tagged natural origin and 2.8 million tagged hatchery origin Spring-run Chinook Salmon juveniles, entrainment loss averaged less than 0.0005% (Zeug and Cavallo, 2014). As there are no exports under WOA, there is no entrainment risk under WOA. In the December through February, the average total export rate, under the proposed action, is slightly higher difference compared to COS (366 cfs; Figure H-1 – Appendix H, *Bay-Delta Aquatics Effects Figures*) and will therefore have a similar entrainment risk. Total exports proposed in March-June are 1,699 cfs higher than COS (Figure H-2 - Appendix H, *Bay-Delta Aquatics Effects Figures*) when juvenile Spring-run Chinook Salmon are most abundant in the Delta.

According to SacPAS (Appendix F, *Juvenile Salmonid Monitoring, Sampling, and Salvage Timing Summary from SacPAS*), between 0 and 45000 unclipped Spring-run Chinook Salmon are currently salvaged at CVP and SWP fish facilities each year, and between 0 and 9000 clipped Spring-run Chinook Salmon from the Feather River Fish Hatchery. Salvage estimates are made by counting fish for 30 minutes every 2 hours, and multiplying by 4 to obtain the estimate for the number of fish that are entrained into Tracy Pumping Plant or eaten by predators in the canal or fish facility. Entrainment results in harassment and often mortality for juvenile Chinook salmon. Fish that are counted are salvaged and trucked back to the Delta where they are released and may complete their lifecycle.

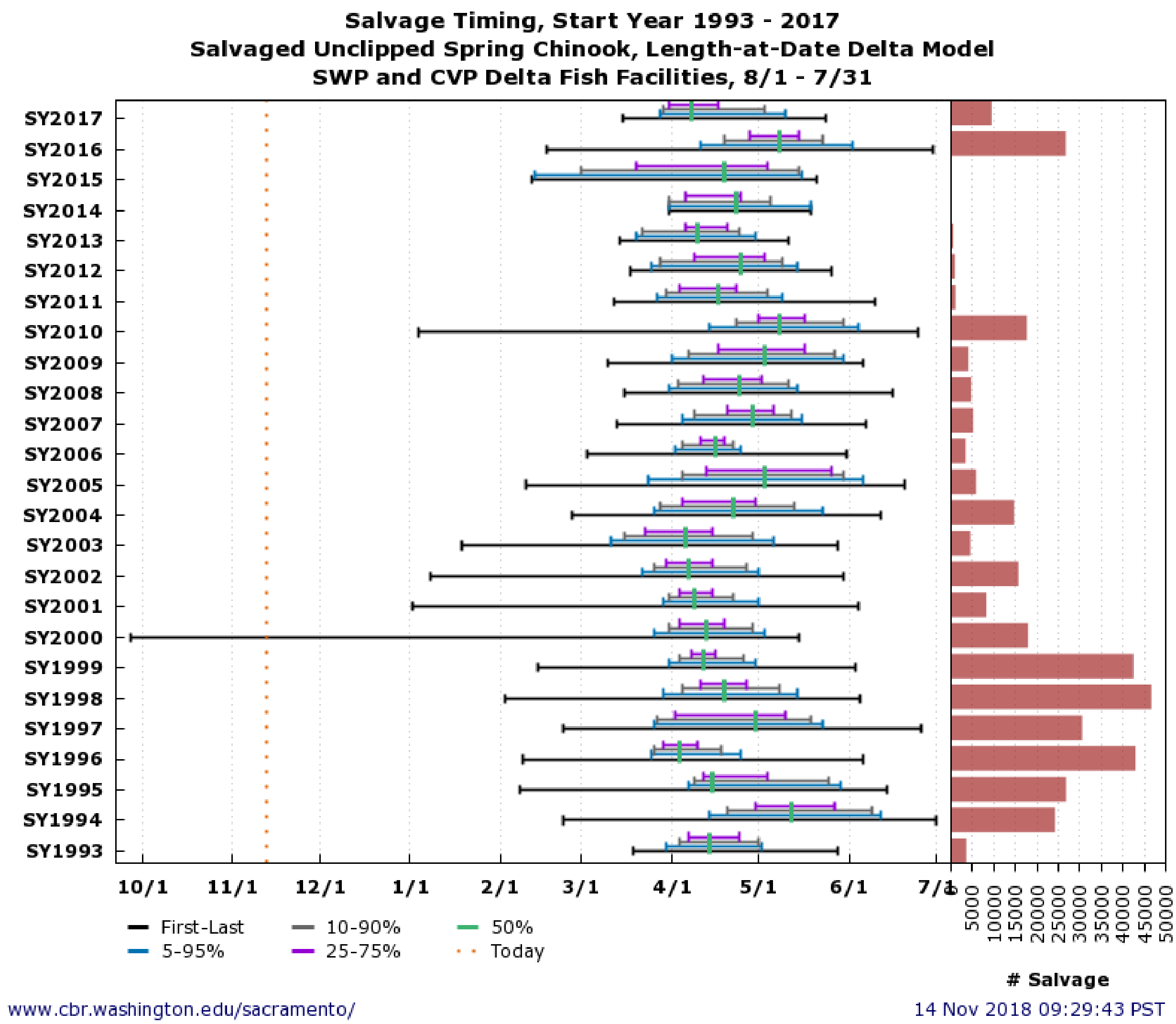


Figure 5.8-44. Salvage Data for Unclipped Spring-run Chinook at SWP and CVP Fish Facilities

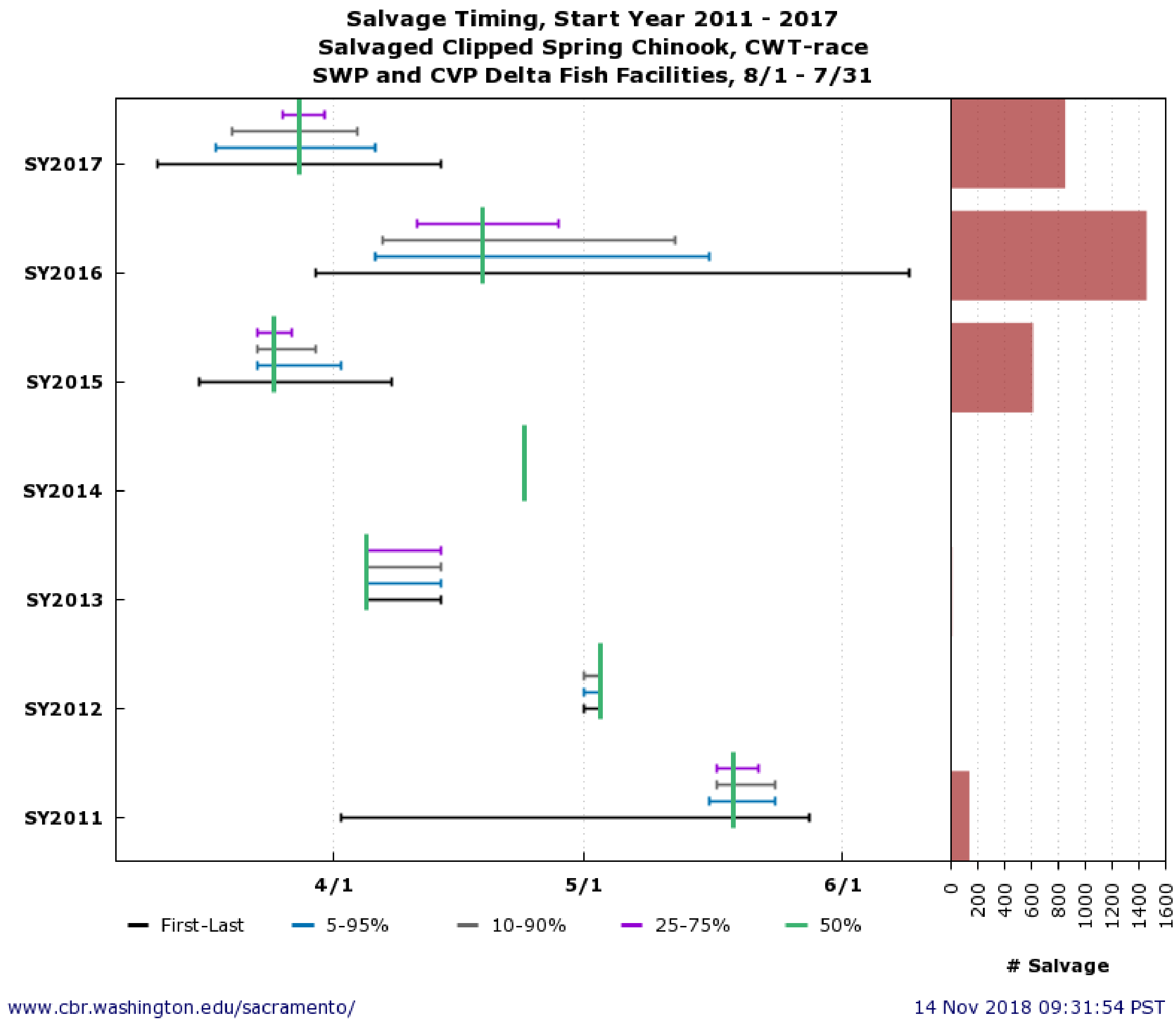


Figure 5.8-45. Salvage Data for Clipped Spring-run Chinook at SWP and CVP Fish Facilities

Although data for juvenile Spring-run Chinook Salmon originating from the San Joaquin River are limited, Zeug and Cavallo (2014) analyzed salvage of San Joaquin River-origin fall run juvenile Chinook Salmon that are found in the Delta at a similar time as Spring-run Chinook Salmon. Salvage of Fall-run Chinook Salmon originating from the San Joaquin River averaged 1.4% and increased with export rate at the CVP and SWP (Zeug and Cavallo 2014). However, there were few observations at export rates greater than 3,000 cfs. Average mortality at the facilities represents < 5% total juvenile mortality for San Joaquin River-origin populations but can range as high as 17.5% (Zeug and Cavallo 2014).

Under WOA, there are no exports and therefore no entrainment. In the December through February period, the proposed action proposes an average total export rate slightly higher than COS (366 cfs; Figure H1) and will, therefore, have a similar entrainment risk. Total exports proposed for proposed action in March-June (1,699 cfs higher than COS; Figure H2) when juvenile Spring-run Chinook Salmon are most abundant in the Delta, will increase entrainment risk relative to COS. Recent acoustic studies of juvenile Fall-run Chinook Salmon in the San Joaquin River revealed that when the Head of Old River

Barrier is out, >60% of fish detected at Chipps Island came through CVP, indicating that salvage is a higher survival route than volitional migration.

5.8.3.9.2 <u>Routing</u>

As stated in the Sacramento Winter-run Chinook effects section, routing of juvenile Chinook Salmon into alternative migration routes is closely related to hydrodynamics (Perry et al. 2015; Cavallo et al. 2015; Steel et al. 2012). Juvenile Spring-run Chinook Salmon are present in the Delta between November and early June with a peak in April (Table 5.8-1). In the December through February period, velocity overlap between proposed action and COS in the Sacramento River main stem between the Sutter-Steamboat and DCC/Georgiana Slough Junctions, was >50% in all water year types (Figure H-3 - Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocities were higher under proposed action in all water year types indicating routing into the interior Delta would be lower relative to COS (Perry et al. 2015). Comparing proposed action to WOA in the Dec-Feb period revealed velocity overlap <50% in Dry, Above Normal and Wet years and <60% in Critical and Below Normal years (Figure H-4 - Appendix H, *Bay-Delta Aquatics Effects Figures*) with higher velocities in the WOA in all water year types. This pattern indicates routing into the interior Delta would be lower under WOA relative to proposed action or COS (Perry et al. 2015). In the March to May period, comparison of the proposed action and COS revealed similar patterns of velocity overlap as described for the December-February period (Figure H-5 - Appendix H, *Bay-Delta Aquatics Effects Figures*) indicating routing into the interior Delta would be lower under the proposed action during March-May. Comparing the proposed action with the WOA in March-May revealed low overlap in Sacramento main stem velocities between the Steamboat-Sutter Junction and the DCC-Georgiana Slough junction (Figure H-6 - Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocities were higher under the WOA indicating routing into the interior Delta under WOA would be lower than proposed action or COS.

Spring-run Chinook Salmon originating from the Sacramento River that enter the interior Delta via Georgiana Slough and the Delta Cross Channel can be exposed to hydrodynamic project effects that could affect routing. Once these fish arrive at the junction of the Mokelumne River and the San Joaquin River, they can move south toward the export facilities or west toward the ocean. In the December-February period analysis of DSM2 data indicates that there is little change to velocities in the region of the junction of the Mokelumne and San Joaquin Rivers between the proposed action and both the COS and the WOA scenarios (Figures H-7 and H-8 - Appendix H, *Bay-Delta Aquatics Effects Figures*). Similar results were obtained when comparing the proposed action to COS and WOA in the March to May period (Figures H-9 and H-10 - Appendix H, *Bay-Delta Aquatics Effects Figures*).

Juvenile Spring-run Chinook Salmon are present in the Delta between November and early June with a peak in April (Table 5.8-1). Early studies using coded wire tags indicated that survival of San Joaquin River-origin juvenile Chinook Salmon was lower in the Old River Route relative to the San Joaquin main stem (Newman 2008). This finding led to strategies designed to keep larger proportions of fish in the San Joaquin River main stem including the Head of Old River rock barrier and non-physical barriers. Recent studies using acoustic technology have indicated that differences in survival among the two routes are not significant (Buchanan et al. 2013; Buchanan et al. 2018). Thus, fish that enter Old River are unlikely to experience reduced survival.

Spring–run Chinook Salmon originating from the San Joaquin River that remain in the San Joaquin River main stem at the Head of Old River are exposed to additional junctions that lead into the interior Delta including; Turner Cut, Columbia Cut, Middle River, Old River, Fisherman’s Cut and False River. In the December-February period analysis of DSM2 data indicates that there is little change to velocities in the region of the junctions with San Joaquin Rivers between the proposed action and both the COS and the

WOA scenarios (Figures H-7 and H-8 - Appendix H, *Bay-Delta Aquatics Effects Figures*). Similar results were obtained when comparing the proposed action to COS and WOA in the March to May period (Figures H-9 and H-10 - Appendix H, *Bay-Delta Aquatics Effects Figures*).

In the December-February period, velocity overlap between proposed action and COS at the Head of Old River was >89% in Critical, Dry and Below Normal water years, >72% in Wet years, and >53% in Above Normal Years (Figure H-7 - Appendix H, *Bay-Delta Aquatics Effects Figures*). When the proposed action was compared to WOA in the December-February period, velocity overlap was >50% in Critical and Dry years and >10% in all other water year types (Figure H-8 - Appendix H, *Bay-Delta Aquatics Effects Figures*). In the March-May period, velocity overlap patterns were similar to comparisons in the December-February period (Figures H-9 and H-10 - Appendix H, *Bay-Delta Aquatics Effects Figures*).

5.8.3.9.3 Through Delta Survival

To examine potential effects of the proposed action, changes in velocity distributions were examined for the Sacramento River at Walnut Grove and Steamboat Slough which are both in this “transitional” region. During the December to February period at Walnut Grove, velocity distributions for proposed action relative to COS were most different in Wet Years (70.9%) with higher velocities in the proposed action. Velocities were also greater for proposed action relative to COS in Dry, Below Normal and Above Normal years although overlap was greater (≥79.6%; Figure H-11 - Appendix H, *Bay-Delta Aquatics Effects Figures*). In Critical Years, velocity distributions were almost identical (95.4%; Figure H-11 - Appendix H, *Bay-Delta Aquatics Effects Figures*). A similar pattern was apparent for the comparison between proposed action and WOA (Figure H-12 - Appendix H, *Bay-Delta Aquatics Effects Figures*); however, overlap was lower for each water year type (37.3 – 68.3%) with higher velocities under WOA relative to proposed action. At Steamboat Slough in the December to February period, there was a similar pattern where velocities under the proposed action were higher than COS in Wet, Above Normal and Below Normal years and similar in Dry and Critical years (Figure H-13 - Appendix H, *Bay-Delta Aquatics Effects Figures*). When proposed action was compared to WOA, overlap was moderate to high with values between 42.6 and 72.6% (Fig H-14 - Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocities were higher under the WOA in all water year types (Figure H-14 - Appendix H, *Bay-Delta Aquatics Effects Figures*).

In the March through May period at Walnut Grove, velocity overlap between the proposed action and COS was ≥78.5% across all water year types with greater velocities under proposed action (Figure H-15 - Appendix H, *Bay-Delta Aquatics Effects Figures*). When proposed action was compared to WOA in the March through May period, velocity overlap was variable among water year types from a low of 14.1% in Wet years to 56.9% in Critical years (Figure H-16 - Appendix H, *Bay-Delta Aquatics Effects Figures*). In all water year types, velocities were greater under the WOA relative to the proposed action. At Steamboat Slough in the March through May period, overlap between the proposed action and COS scenarios was high with all values ≥82.2% and greater velocities under the proposed action (Figure H-17 - Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocity overlap was lower when proposed action was compared to WOA (Figure H-18 - Appendix H, *Bay-Delta Aquatics Effects Figures*). The lowest value occurred in Wet years (19.1%) and highest in Critical years (69.5%).

The small changes in velocity within transitional reaches of the Sacramento River and North Delta between the proposed action and WOA suggest there could be reductions in through Delta survival for Spring-run Chinook Salmon in some water year types under the proposed action.

A recent study by Perry et al. (2018) found that the effect of flow on survival is not uniform throughout the Delta. Relationships between flow and survival were significant only in reaches where flow changes from bi-directional to unidirectional when discharge increases. To examine how effects of the proposed project, changes in velocity distributions were examined for the San Joaquin River at Highway 4 and the Head of Middle River which are both in the "transitional" region of the San Joaquin River. During the December to February period at the San Joaquin River at Highway 4, velocity distributions for proposed action relative to COS exhibited high overlap in Critical, Dry and Below Normal water years (≥95.9%; Figure H-19 - Appendix H, *Bay-Delta Aquatics Effects Figures*). Overlap values were lower in Above Normal and Wet years with values of 84.3% and 87.2% respectively. In these two water year types, velocities were higher under the proposed action relative to COS (Figure H-19 - Appendix H, *Bay-Delta Aquatics Effects Figures*). When the proposed action was compared to WOA, overlap decreased in all water year types with higher velocities under WOA (Figure H-20 - Appendix H, *Bay-Delta Aquatics Effects Figures*). Overlap values ranged from a low of 59.6% in Above Normal years to 83.4% in Critical years (Figure H-20 - Appendix H, *Bay-Delta Aquatics Effects Figures*). At the Head of Middle River during the December-February period, overlap was high between the proposed action and COS in Critical, Dry and Below Normal water years (≥90.1%; Figure H-21 - Appendix H, *Bay-Delta Aquatics Effects Figures*). In Above Normal and Wet years overlap was lower with values of 53.6 and 75.1% respectively. Velocities were higher under the proposed action in these two water year types (Figure H-21 - Appendix H, *Bay-Delta Aquatics Effects Figures*). When the proposed action was compared to WOA, overlap was low in all water year types (≤34.9%) with higher velocities under WOA (Figure H-22 - Appendix I - Appendix H, *Bay-Delta Aquatics Effects Figures*).

Spring flow pulses descibed in the PA to achieve flows >9100 cfs at Wilkins would also provide benefits to spring run in the Delta. Spring run in the Delta would experince greater survival as flow magnitude increases from the flow pulse passing through the Delta (Perry et al. 2018). Spring run Chinook Salmon are in high and moderate abundance in the Delta during the time period when the spring flow pulses are proposed.

In the March-May period in the San Joaquin River at Highway 4, velocity overlap was high between the proposed action and COS (≥83.2%; Figure H-23 - Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocities were lower under the proposed action in Dry, Below Normal and Wet year and higher in Above Normal years (Figure H-23 - Appendix H, *Bay-Delta Aquatics Effects Figures*). Comparing the proposed action and WOA in March-May revealed high overlap in Critical years (92.8%). In other water year types, overlap ranged between 54.5% in Wet years to 78.6% in Dry years with higher velocities under the WOA (Figure H-24 - Appendix H, *Bay-Delta Aquatics Effects Figures*). At the Head of Middle River in the March –May period, overlap between the proposed action and COS was moderate in Above Normal Years (57.7%) and high in all other water year types ≥ 73.0% (Figure H-25 - Appendix H, *Bay-Delta Aquatics Effects Figures*). In Above Normal years, velocities were higher under the proposed action and lower in all other water year types (Figure H-25 - Appendix H, *Bay-Delta Aquatics Effects Figures*). Comparison of the proposed action with WOA in March-May at Head of Middle River revealed overlap >50% in Critical years and overlap <35% in all other water year types (Figure H-26 - Appendix H, *Bay-Delta Aquatics Effects Figures* In all water year types, velocities were higher under the WOA relative to the proposed action.

5.8.3.10 Delta Cross Channel Operations

The Delta Cross Channel may be closed for up to 45 days from November through January for fishery protection purposes. From February 1 through May 20, the gates are closed for fishery protection purposes. Significant amounts of flow and many juvenile Spring-run Chinook Salmon enter the DCC (when the gates are open) and Georgiana Slough, especially during increased Delta pumping. Mortality of juvenile salmon entering the central Delta is higher than for those continuing downstream in the Sacramento River. Juvenile Chinook Salmon which are entrained into an open DCC and transported to the interior Delta have reduced survival (Perry et al. 2010) The gates may also be closed for 14 days from May 21 through June 15 for fishery protection purposes. The peak migration of juvenile Spring-run Chinook Salmon in the Sacramento River past Knights Landing, which is upstream of the DCC, occurs from March-April (Table 5.8-1). Therefore, the DCC is closed to protect the majority of the juvenile Spring-run migration period in the Sacramento River and reduce the proportion of fish exposed to an open DCC.

5.8.3.11 Agricultural Barriers

The agricultural barriers at Middle River and Old River near Tracy can begin operating as early as April 15 but the tide gates are tied open from May 16 to May 31. After May 31, the barriers in Middle River, Old River near Tracy, and Grant Line Canal are permitted to be operational until they are completely removed by November 30.

The proportion of juvenile Spring-run Chinook Salmon exposed to the agricultural barriers (Temporary Barrier Program, TBP) depends on their annual timing of installation and removal. Due to their location, primarily migrants originating from the San Joaquin River would be exposed to the TBP. The peak relative abundance of juvenile Spring-run Chinook Salmon in the Delta is March and April (Table 5.8-1). If the agricultural barriers are operating as early as April 15 then they have the potential to expose a large proportion of the juvenile Spring-run Chinook Salmon migrating down the San Joaquin River. When the Head of Old River barrier is not in place, acoustically tagged juvenile Chinook salmon have demonstrated a high probability of selecting the Old River route (Buchanan 2018), which would expose them to the agricultural barriers. When the agricultural barriers are operating with tidal flap gates down, a significant decline in passage and reach survival of acoustically tagged juvenile Chinook Salmon migrating past the barrier has been observed compared to when the barrier is not present (DWR 2018). When flap gates are tied up, Chinook Salmon passage past the agricultural barrier was improved (DWR 2018). Flap gates tied up on agricultural barriers from May 16 to May 31 would help to reduce the negative effect of the barriers during this period. However, juveniles migrating before or after this period could be exposed to the agricultural barriers with flaps down which apparently decreases passage success and survival (DWR 2018).

5.8.3.12 Contra Costa Water District Rock Slough Intake

As discussed in Section 4.9.5, CCWD’s operations in the proposed action are consistent with the operational criteria specified in separate biological opinions and permits that govern operations at CCWD’s intakes and Los Vaqueros Reservoir (NMFS 1993; NMFS 2007; NMFS 2010; NMFS 2017; USFWS 1993a; USFWS 1993b; USFWS 2000; USFWS 2007; USFWS 2010; USFWS 2017; CDFG 1994; CDFG 2009). Therefore, the operation of the Rock Slough Intake for the proposed action remains unchanged from the current operations.

The Contra Costa Canal Rock Slough Intake is located on a dead-end slough, far from the main migratory route for CV Chinook Spring-run (NMFS 2017), approximately 18 miles from the Sacramento River and 10 miles from the San Joaquin River via the shortest routes. Designated critical habitat for Spring-run Chinook Salmon does not occur within Rock Slough, but is present further to the north in the Delta (NMFS 2017; NMFS 2014). Salmonids are expected to avoid the area of the Rock Slough Intake during certain times of the year based on historical water temperatures, which range from lows of about 45°F in winter (December and January) to over 70°F beginning in May and continuing to October (Reclamation 2016).

Fish monitoring prior to the construction of the Rock Slough Fish Screen (RSFS) indicates the timing and magnitude of CV Spring-run Chinook Salmon presence near the Rock Slough Intake. Since 1994, fish monitoring has been conducted by CDFW and CCWD consistent with the separate biological opinions and permits that govern CCWD's operations. From 1994 through 1999, CDFW conducted fish monitoring at the Rock Slough Intake and in the Contra Costa Canal up to the first pumping plant. Over this 6-year period, CDFW captured a total of 108 juvenile CV Spring-run from March through May (CDFG 2002; NMFS 2017). From 1999-2009, the 11 years prior to construction of the RSFS, CCWD's Fish Monitoring Program collected a total of 11 juvenile CV Spring-run from March through May at the Rock Slough Headworks (Reclamation 2016; NMFS 2017). No adult Spring-run were collected in the vicinity of the Rock Slough Intake from 1994 through 2009 (CDFG 2002; Reclamation 2016; NMFS 2017). No juvenile or adult CV Spring-run have been collected in CCWD's Fish Monitoring Program at the Rock Slough Intake since 2008.

Since construction of the RSFS, operation of the hydraulic rake cleaning system has been shown to trap and kill adult Chinook Salmon and other non-listed fish (Reclamation 2016). From 2011-2018, 47 salmon were recovered at the RSFS (Reclamation 2016, Appendix A; Tenera 2018a), but none of the captured fish were identified as Spring-run Chinook Salmon (NMFS 2017).

5.8.3.12.1 Rearing to Outmigrating Juveniles in the Bay Delta

Due to the location of the Rock Slough Intake near the end of a dead-end slough, far from the main migratory routes (i.e., 10 miles from the San Joaquin River and 18 miles from the Sacramento River), juvenile Spring-run Chinook Salmon are not likely to be in the vicinity of the Rock Slough Intake. However, according to NMFS (2017), juvenile Spring-run can be "drawn" into the south Delta under reverse flows and high CVP and SWP pumping rates.

One indicator of reverse flows is the net flow in OMR. Rock Slough Intake is located on Rock Slough, approximately 3.5 miles west of the junction of Rock Slough and Old River, which is over 12 river miles north of the gates to the SWP Clifton Court Forebay. Given its location, the Rock Slough Intake does not affect net reverse flow in OMR, and any effect that diversions at Rock Slough Intake would have in the OMR corridor would be to increase the northerly (positive) flow away from the Banks and Jones Pumping Plants. For juveniles that migrate down the OMR corridor that are not salvaged at TFCF or Skinner Fish Facility, any effect of Rock Slough Intake diversions would be a positive effect on OMR.

For juveniles that migrate down the mainstem of the Sacramento River or the San Joaquin River and for juveniles that were salvaged, trucked, and released in the western Delta, the potential effect of Rock Slough diversions on the net reverse flow in San Joaquin River may be relevant. The effect of water diversions at Rock Slough Intake on the velocity in the San Joaquin River at Jersey Point is presented in the effects analysis for juvenile Winter-run Chinook Salmon. As detailed in that section, the maximum potential effect of water diversions at Rock Slough Intake (assuming diversions at the maximum permitted capacity of 350 cfs and all water diverted by the Rock Slough Intake comes from the San Joaquin River at Jersey Point) is 0.00625 ft/sec in the San Joaquin River at Jersey Point. For comparison, the velocity threshold for design of fish screens to prevent impingement of salmonids is 0.33 ft/sec, which is 50 times the maximum possible contribution from the Rock Slough diversions.

Recognizing that CCWD owns and operates two additional intakes in the south Delta, we examine the combined effect of all three intakes. CCWD's Old River Intake and Middle River Intake have a physical capacity of 250 cfs at each intake. If CCWD were to divert at all three intakes at the maximum capacity at the same time, total CCWD diversions would be 850 cfs. The corresponding effect on velocity in the San Joaquin River at Jersey Point would be 0.015 ft/sec. The velocity threshold used to protect salmonids from diversions in the vicinity of fish screens (0.33 ft/sec) is over 21 times greater than the maximum possible contribution from CCWD's combined physical capacity. The water diversions at the Rock Slough Intake when combined with diversions at CCWD's Old River Intake and Middle River Intake have a negligible effect on velocity along the migratory path for juvenile Spring-run Chinook Salmon and are not likely to affect the movement of juvenile salmonids.

Nonetheless, even extremely small changes in velocity can affect the movement of neutrally buoyant particles such as phytoplankton. As shown in the Winter-run Chinook Salmon section, the diversions at the Rock Slough Intake could move a neutrally buoyant particle in the San Joaquin River at Jersey Point approximately 540 ft over the course of the day. For comparison, the tidal excursion on the San Joaquin River at Jersey Point during a flood tide (i.e., the distance a particle will travel tidally upstream during a flood tide) is about 34,000 ft on average (or 6.4 miles), which is about 63 times the distance that diversions at Rock Slough could move a particle at the same location over the course of a full day. Therefore, the maximum possible contribution of diversions at Rock Slough on movement of neutrally buoyant particles such as phytoplankton is insignificant in comparison to the tidal excursion and mixing at this location.

5.8.3.12.2 Adults

As discussed for adult Winter-run Chinook salmon, Rock Slough is poor habitat at a dead-end slough, with relatively high water temperature and a prevalence of aquatic weeds. Therefore, adult CV Spring-run Chinook Salmon are not likely to be in the vicinity of the Rock Slough Intake. However, if some adults stray into Rock Slough, the water exiting the Contra Costa Canal on ebb tide may create a false attraction to adult salmon that are migrating upstream (NMFS 2017). The diversion of water at the Rock Slough Intake, which is the subject of this consultation, reduces the false attraction created by the ebb tides existing the Contra Costa Canal.

5.8.3.13 North Bay Aqueduct

The proposed action includes the North Bay Aqueduct (NBA) intake in the North Delta and operation of the Barker Slough Pumping Plant. Listed salmonids may be present in the waterways adjacent to the Barker Slough Pumping Plant (monitoring data is available at). The NBA is located within designated critical habitat for Spring-run Chinook Salmon. There should be no discernable effect to the Spring-run Chinook Salmon due to the operations of the Barker Slough Pumping Facility. This is due to the infrequent presence of Spring-run Chinook Salmon in the monitoring surveys indicating a low risk of entrainment. Further, Barker Slough Pumping Facility fish screens are designed to protect juvenile salmonids per NMFS criteria and should prevent entrainment while greatly minimizing any impingement of fish against the screen.

5.8.3.14 Water Transfers

Under WOA, no pumping and Jones and Banks Pumping Plants would occur and therefore no water transfers would occur through them. Under the proposed action, Reclamation is expanding the transfer window to November from the current July to September. Expanding the transfer window could lead to increased pumping at Jones and Banks Pumping Plants, when capacity is available. The Figures below show when capacity is available under the proposed action and the COS, in terms of exceedances, years in the model period of record, and average by water year types. These values are total available, and are not filtered for the pattern on which water might be acquired for transfer. The pattern of acquisition could decrease these values, as well as reoperation of storage that might be required, or the water cost of meeting D-1641. Prior estimates indicate that approximately 50% of the capacity in the figures below would be useful for water transfers given these timing and upstream considerations. In addition, a 20-30% surcharge on acquisition might be necessary to accommodate the salinity related inefficiencies that arise in operations. Based on the figures below and these additional estimates, expanding the water transfer window could result in an additional approximately 50 TAF of pumping in most yeartypes. As more stored water is available from CVP and SWP reservoirs to pump in wetter yeartypes, most of the available capacity for transfers is in drier yeartypes (Figures 5.8-47 through 5.8-49).

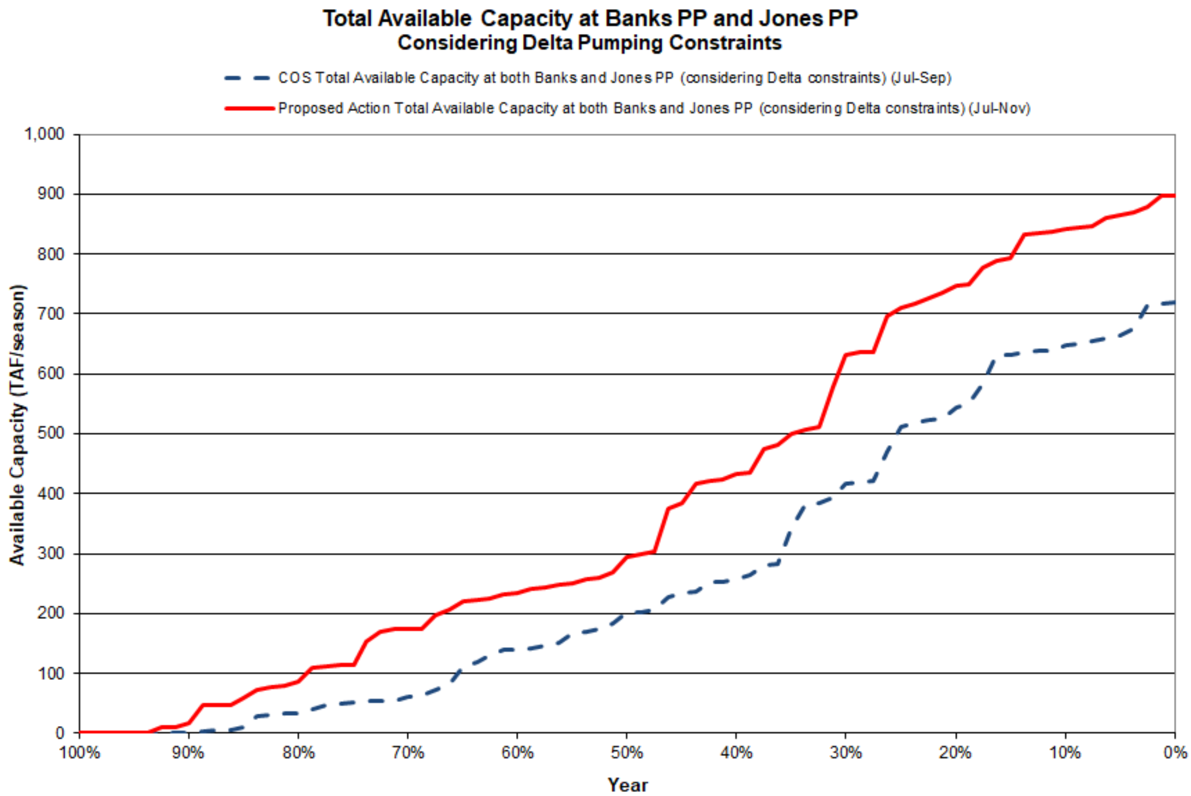


Figure 5.8-46. Exceedance of Available Capacity for Transfers at Jones and Banks under the Proposed Action and COS

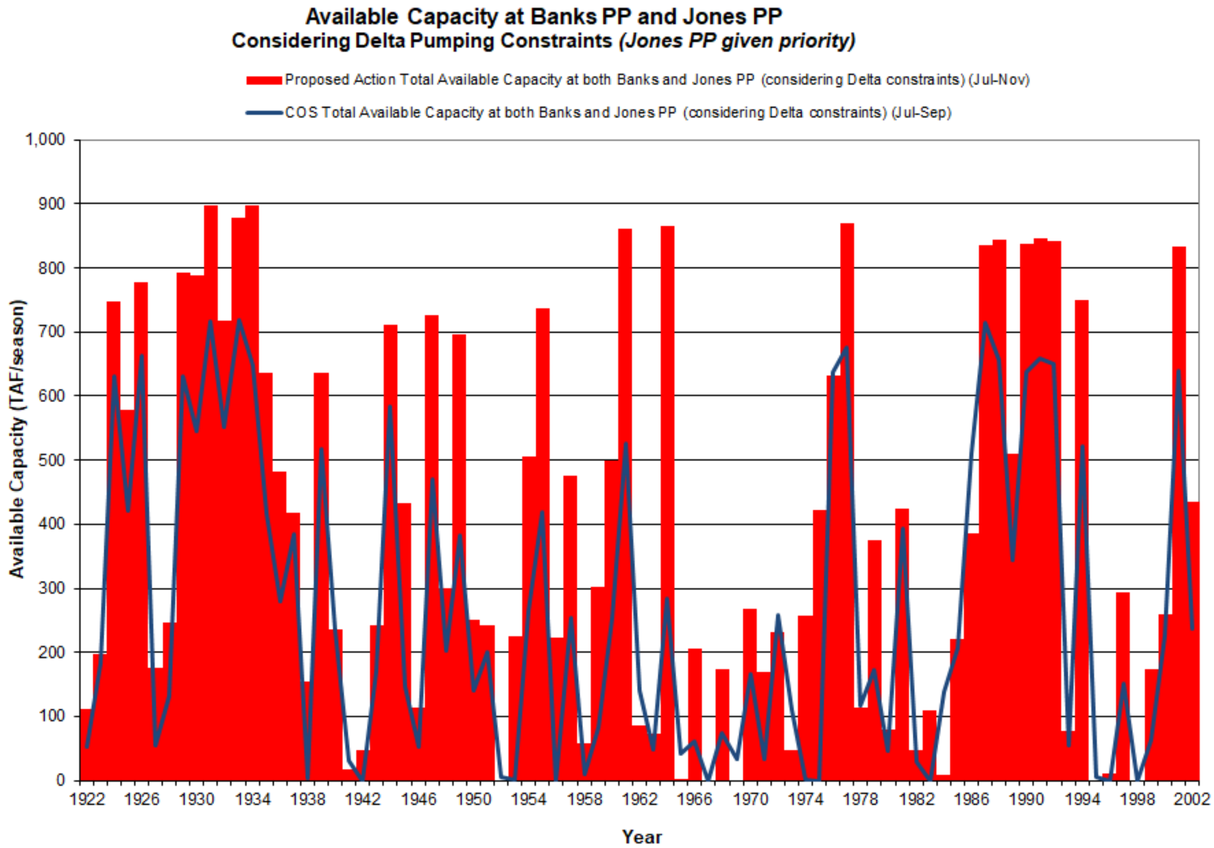


Figure 5.8-47. Modeled annual maximum available capacity for transfers under the proposed action and COS, CalSim period of record (1922-2003)

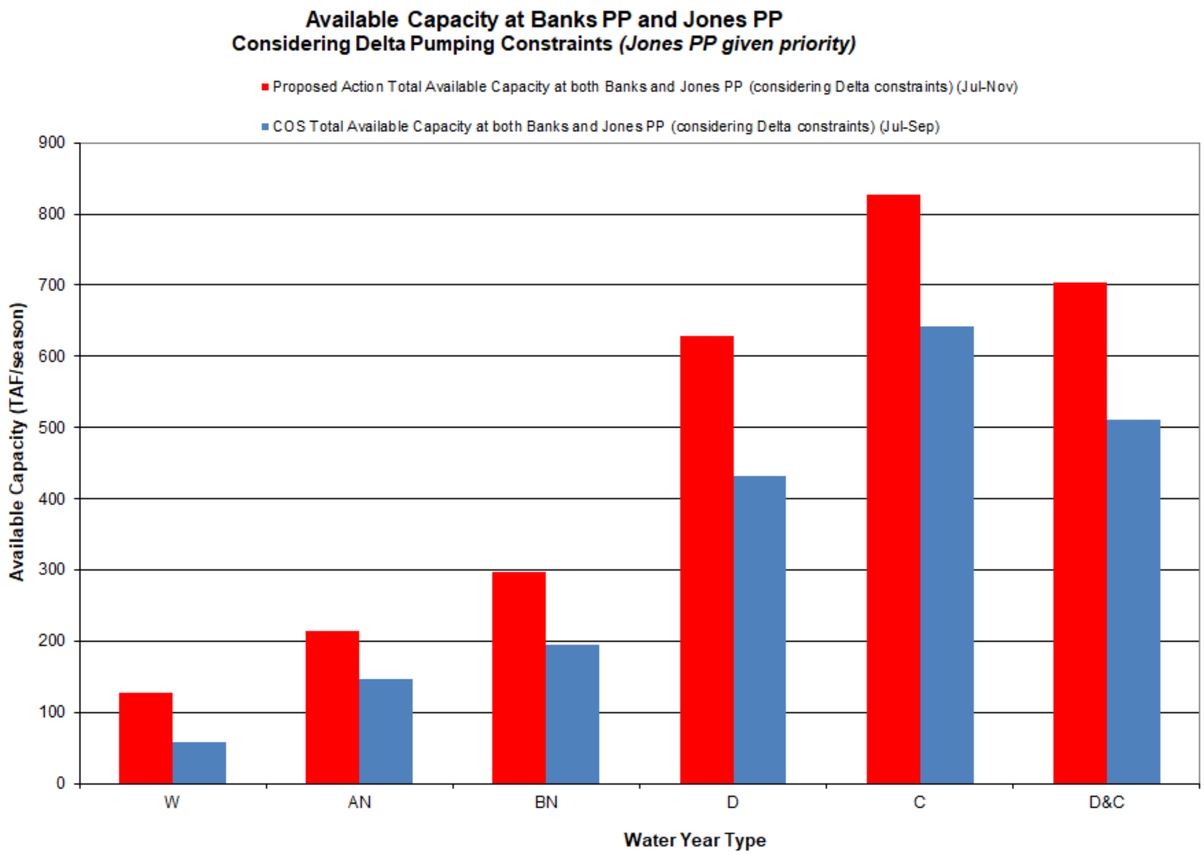


Figure 5.8-48. Water Year Type average available capacity at Jones and Banks Pumping Plants

Egg, aelvin, fry, and adult lifestages of Spring-run Chinook Salmon would not be exposed to the effects of increased water transfers as they do not occur in the Delta during July through November. Juvenile Spring-run Chinook salmon are detected at Chipps Island between December and July with the highest abundance in March-May (Table 5.8-1). Thus, only the very early or late migrants could potential be exposed to water transfers that occur during this time. These early or late migrant juvenile Spring-run Chinook Salmon could be exposed to increased effects of entrainment, routing, and decreased Delta survival (see OMR management section) as a result of the expanded water transfer window. Increased flows during conveyance in the Sacramento River could provide small survival benefits to migrating juveniles (Perry et al. 2018).

5.8.3.15 Clifton Court Forebay Aquatic Weed Control Program

Few if any juvenile Spring-run Chinook Salmon would be expected to be exposed to the Clifton Court Forebay Aquatic Weed Control Program. Juvenile Spring-run are present in the Delta between mid-November and early June with a peak in April (Table5.6-1). The application of aquatic herbicide to the waters of Clifton Court Forebay will occur during the summer months of July and August. Thus, the probability of exposing Spring-run Chinook Salmon to the herbicide is very low. Based on typical water temperatures in the vicinity of the salvage facilities during this period, the temperatures would be incompatible with salmonid life history preferences, generally exceeding 70°F by mid-June.

Mechanical harvesting would occur on an as-needed basis and, therefore, listed salmonids could be exposed to this action, if entrained into Clifton Court Forebay. Potential direct and indirect effects to listed fish species from mechanical weed harvesters include mortality or injury from harvester strikes, entanglement in weeds lifted from the water, reduction of aquatic prey species, and temporary disturbances. Increased boat noise and disturbance of the water during harvesting, the slow speed of the harvester (approximately 2 miles per hour), and beginning harvesting closest to the edge should allow fish to to escape the area proposed for mowing. However, CV Spring-run Chinook Salmon at unlikely to be present and exposed to the adverse effects due to extreme temperatures.

5.8.3.16 Suisun Marsh Operations

5.8.3.16.1 <u>Rearing to Outmigrating Juveniles in Bay-Delta</u>

5.8.3.16.1.1 Suisun Marsh Salinity Control Gates

Operation of the SMSCG from October through May to meet salinity standards set by the State Water Resources Control Board and Suisun Marsh Preservation Agreement provides water quality benefits to Spring-run Chinook Salmon habitat. This beneficial operation coincides with downstream migration of juvenile Spring-run Chinook Salmon (Table 5.8-1). Montezuma Slough provides an alternative route to their primary migration corridor through Suisun Bay. No data are available to estimate the abundance of juvenile Spring run Chinook Salmon in Montezuma Slough thus, the proportion of the total run utilizing this route is unknown. Spring-run Chinook Salmon typically migrate through the estuary several months before spawning, but an extended delay in the estuary may affect their ability to access their natal spawning streams. Spring-run generally utilize high stream flow conditions during the spring snowmelt to assist their upstream migration. Rapid upstream movement may be needed to take advantage of a short duration high stream flow event, particular in dry years when high flow events may be uncommon. If the destination of a pre-spawning adult salmon is among the smaller tributaries of the Central Valley, it may be important for migration to be unimpeded, since access to a spawning area could diminish with receding flows. However NMFS (2009) determined that operation of the SWSCG is unlikely to impede migration of juvenile salmonids or produce conditions that support unusually high numbers of predators.

5.8.3.16.1.2 Roaring River Distribution System

As described by NMFS (2009: 437-438), the Roaring River Distribution System (RRDS)’s water intake (eight 60-inch-diameter culverts) is equipped with fish screens (3/32-inch opening, or 2.4 mm) operated to maintain screen approach velocity of 0.2 or 0.7 ft/s, so that juvenile Spring-run Chinook Salmon would be excluded from entrainment.

5.8.3.16.1.3 Morrow Island Distribution System

The Morrow Island Distribution System (MIDS) diverts water from Goodyear Slough through three 48-inch diameter culverts during high tide. Although the MIDS intakes do not currently have fish screens, its unlikely juvenile CV Spring-run Chinook Salmon will be entrained into the water distribution system, since Spring-run Chinook have not be caught in past surveys. Also, the large size and better swimming ability of juvenile listed salmonids in the Delta allow these fish to avoid entrainment at MIDS. In addition, the location of the MIDS intake on Goodyear Slough further reduces the risk of entrainment. Goodyear Slough is not a migratory corridor Spring-run Chinook Salmon.

5.8.3.16.1.4 Goodyear Slough Outfall

Goodyear Slough Outfall improves water circulation in the marsh. This structure consists of four 48-inch diameter culverts with flap gates designed to drain water from the southern end of Goodyear Slough into Suisun Bay. On flood tides, the gates reduce the amount of tidal inflow into Goodyear Slough. Due to its location and design, Spring-run Chinook Salmon are not likely to encounter this structure or be negatively affected by its operation. Improved water circulation by the operation of the Goodyear Slough Outfall likely benefits juvenile Spring-run Chinook Salmon in Suisun Marsh by improving water quality and increasing foraging opportunities.

5.8.3.17 OMR Management

Delta seasonal operations above describe entrainment in more detail. Restricting OMR flows to -5,000 cfs will reduce or avoid entrainment. Triggers based on salvage that further restrict OMR will further reduce entrainment. Enhanced monitoring and predictive tools will further reduce entrainment while increasing operational flexibility. Figure 5.8-50 shows historical salvage under the COS. Salvage under the proposed action is anticipated to be similar or less.

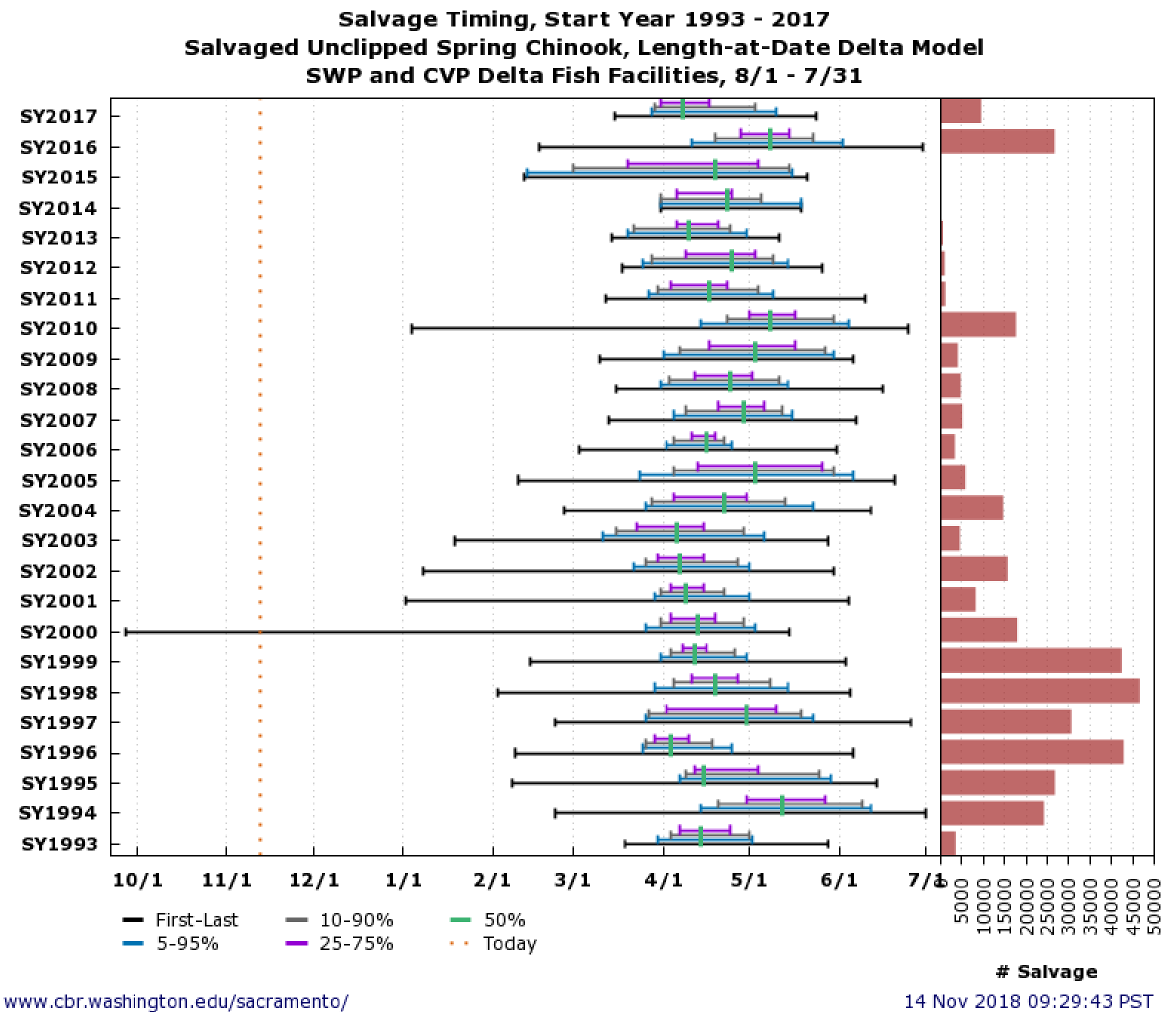


Figure 5.8-49. Salvage of Spring-run Chinook Salmon from 2009 to 2018

5.8.3.18 Operation of a Shasta Dam Raise

Reclamation would operate a raised Shasta Dam consistent with the rest of the proposed action. Therefore, effects described elsewhere in the document would also apply to the operation of a raised Shasta Dam, and there would be no operational changes.

5.8.4 Effects of Conservation Measures

The following are proposed conservation measures that are intended to offset the effects of operations and maintenance. These conservation measures would only occur due to the implementation of the Proposed Action and are beneficial in nature. The following analysis looks at not only at the construction related effects of the measures but also the benefits to the population once completed. Conservation measures would not occur under WOA.

5.8.4.1 Battle Creek Restoration

Under the Proposed Action, Reclamation would accelerate implementation of the Battle Creek Salmon and Steelhead Restoration Project. NMFS and USFWS Biological Opinions were issued in 2005 on this project, and that consultation discusses effects of Battle Creek restoration.

5.8.4.2 Lowering Intakes at Wilkins Slough

5.8.4.2.1 Egg to Fry Emergence

The installation of fish screens near Wilkins Slough would be beneficial to Spring-run Chinook Salmon egg and fry. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning. Additionally, the installation of new diversions and screens that would operate at lower flows would directly benefit fish of all life stages, as the lower fall flows would improve cold water pool for the subsequent summer, and allow greater flexibility for spring pulse flows in the next year. Specifically, operation of diversions with fish screens near Wilkins Slough would improve subsequent water temperatures and increase dissolved oxygen, and decrease entrainment risk.

The egg and fry lifestage of Spring-run Chinook Salmon, as well as the population, would benefit from this action.

Egg and fry of Spring-run Chinook Salmon would not be affected by the construction of a new diversion and screens near Wilkins Slough, based on Spring-run Chinook Salmon spawning from mid- to late-August through early October. Spring-run Chinook Salmon spawn in gravel beds that are often located at the tails of holding pools (OCAP BA 2008). Wilkins Slough does not contain suitable spawning habitat; therefore, effects of construction on Spring-run Chinook Salmon eggs and fry are not anticipated.

5.8.4.2.2 Rearing to Outmigrating Juveniles in Rivers

The installation of fish screens near Wilkins Slough would be beneficial to rearing and emigrating Spring-run Chinook Salmon. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning. Additionally, the installation of new diversions and screens that would operate at lower flows, would directly benefit fish of all life stages.

Outmigrating juvenile Spring-run Chinook Salmon in the Upper Sacramento River would not be affected by the construction of a new diversion and fish screens near Wilkins Slough under the proposed action, based spring-run juveniles emigrating from November through May with peak emigration occurring from May through (Table 5.8-1). Construction of diversions and fish screens near Wilkins Slough would occur during an in-water work window (June 1 to October 1), avoiding the emigration period; therefore effects of construction on emigrating spring-run is not expected.

Juvenile spring-run rear in natal tributaries, the Sacramento River mainstem, nonnatal tributaries to the Sacramento River, and the Delta (DFG 1998 *as cited in* OCAP BA) and emigration timing is highly variable (OCAP BA 2008). If rearing Spring-run Chinook Salmon are present in Wilkins Slough during the June 1 through October 1 in-water work window, individuals may be exposed to temporary disturbances associated with the construction of a cofferdam. Water quality may be temporarily disturbed, in addition the noise associated with construction of the cofferdam may temporarily affect juvenile Spring-run Chinook Salmon. Additionally, fish rescue operations may need be conducted during the period when water within the coffered area needs to be pumped. However, implementation of AMM's identified in the Appendix E, *Avoidance and Minimization Measures* would further minimize any effects to rearing and emigrating Spring-run Chinook Salmon.

5.8.4.2.3 Rearing and Outmigrating Juveniles in the Bay-Delta

Rearing and outmigrating juvenile Spring-run Chinook Salmon in the Bay-Delta would not be affected by the construction of a new diversion and fish screens near Wilkins Slough, based spring-run juveniles emigrating from November through May with peak emigration occurring from March through April (Table 5.8-1). Juvenile fall-run salmon may rear for up to several months within the Delta before ocean entry (Kjelson et al. 1982 *as cited in* OCAP BA). Rearing within the Delta occurs principally in tidal freshwater habitats. Wilkins Slough is located outside of the Bay-Delta; therefore, rearing and outmigrating juveniles located in the Bay-Delta would not affected by construction activities occurring during the inwater construction window from June 1 through October 1.

5.8.4.2.4 Adult Migration

The installation of fish screens near Wilkins Slough would be beneficial to immigrating Spring-run Chinook Salmon. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning. Additionally, the installation of new diversions and screens that would operate at lower flows, would directly benefit fish of all life stages.

Adult Sacramento River spring-run Chinook begin to leave the ocean for their upstream migration in late January to early February based on time of entry to natal tributaries (DFG 1998 *as cited in* OCAP BA 2008). Immigrating Spring-run Chinook Salmon are not expected to be affected by the construction of a new diversion and screens near Wilkins Slough, based spring-run adults immigrating into the Sacramento River Basin between March through June, with a peak from May through June (Table 5.8-1). The implementation of an in-water work window (June 1 and October 1) and other AMM's identified in Appendix E, *Avoidance and Minimization Measures* would further minimize effects on immigrating Spring-run Chinook Salmon.

5.8.4.2.5 Adult Holding

The installation of fish screens near Wilkins Slough would be beneficial to holding Spring-run Chinook Salmon. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning.

Spring-run adults may hold in their natal tributaries for up to several months before spawning (DFG 1998 *as cited in* OCAP BA 2008). Pools in the holding areas need to be sufficiently deep, cool (about 64 F or less), and oxygenated to allow over-summer survival. Suitable holding habitat in Wilkins Slough is not present; therefore, holding Spring-run Chinook Salmon would not be affected by the construction of a new diversion and screens near Wilkins Slough. Implementation of AMM’s identified in Appendix E, *Avoidance and Minimization Measures* would further reduced the likelihood of effects on individuals, and populations.

5.8.4.3 Shasta TCD Improvements

5.8.4.3.1 Egg to Fry Emergence

The ability of the proposed action to better manage the cold water pool and cold water releases would result in increased probability and likelihood of maintaining suitable spawning, incubating and rearing temperatures throughout the season in all but the driest years. Therefore, the improved flow management and temperature regime associated with the Shasta TCD improvements is expected to have high-level population benefits on this life stage of Spring-run Chinook Salmon relative to the WOA and the COS.

5.8.4.3.2 Rearing to Outmigrating Juveniles

There is little difference in water temperatures between the COS and proposed action scenarios during the period of spring-run rearing in the upper Sacramento River, with differences in November the greatest, but less than one degree Fahrenheit difference.

Water temperatures during most years in the November through April period are suitable for juvenile spring-run that rear in and emigrate from the middle Sacramento River under the WOA and the COS and proposed action scenarios, so no adverse effects on the spring-run juveniles are expected for these months. Under all three scenarios during May, however, the 64 degrees Fahrenheit threshold would be exceeded in most years, with the WOA scenario having greater exceedances then the COS and proposed action scenarios, especially in warmer years (Figure SRT_L3_CDmay). These results indicate that water temperature conditions would too warm for juvenile spring-run rearing and emigrating in the middle Sacramento River during May under Without Action conditions, Current Operations, and the Proposed Action, and that conditions would be worse under the Without Action conditions than under the other two scenarios.

5.8.4.3.3 Migrating Adults

High May water temperatures in the middle River are expected for many years under the WOA, and the proposed action improves these temperatures compared to the WOA. As temperatures are still high under the proposed action, Shasta TCD improvements could provide benefits to Reclamation’s ability to meet Sacramento River temperature targets and benefit adult spring-run.

5.8.4.3.4 <u>Holding Adults</u>

The improved flow and temperature management associated with the Shasta TCD improvements is expected to have benefits for holding adult Spring-run Chinook Salmon.

5.8.4.4 Sacramento River Spawning and Rearing Habitat

Spring-run Chinook Salmon juveniles in the Sacramento River would benefit from increased side channel habitat, gravel, and large wood resulting from habitat restoration in the Sacramento River improving their likelihood of rearing success due to an increase in total rearing habitat area and rearing habitat quality. Reclamation estimates that this additional 50 acres of rearing habitat could support the progeny of 5,600 returning adult salmonids based on the relationship shown in the plot below.

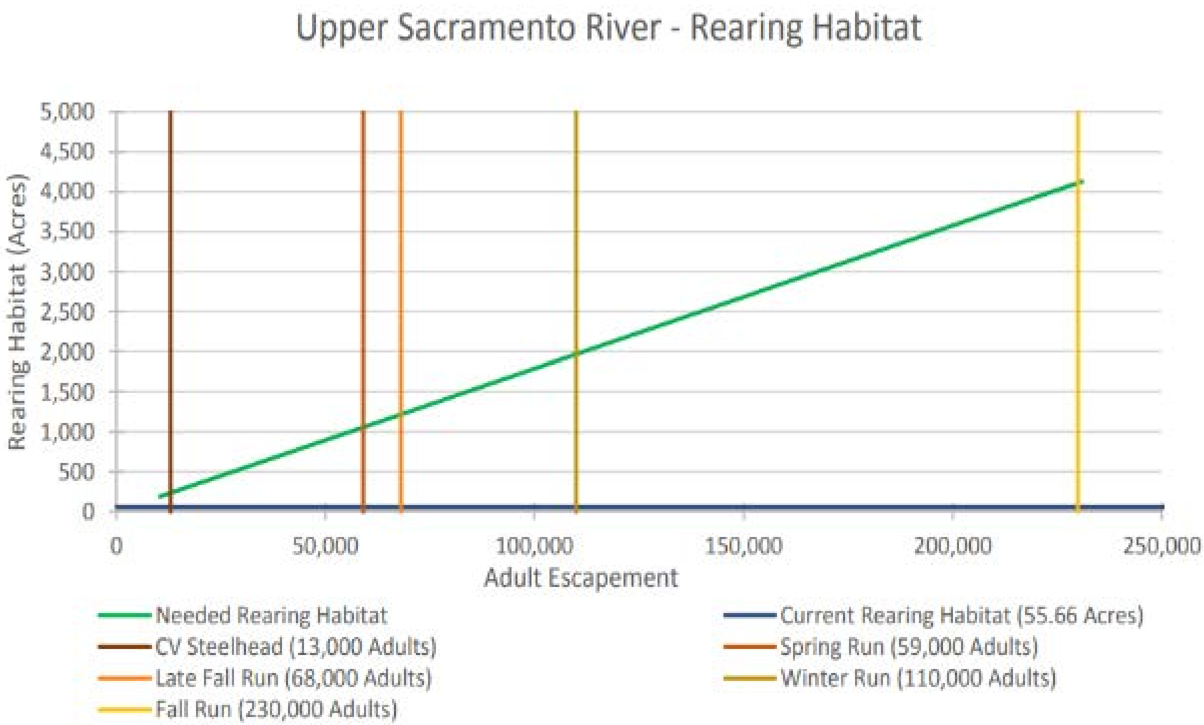


Figure 5.8-50. Adult Escapement and Rearing Habitat on the Upper Sacramento River

Few, if any, rearing and outmigrating juveniles would be exposed to construction of side channel habitat, gravel augmentation, and large wood installation, based on the timing of the in-water work window (July 1-September 30) and peak seasonal occurrence of this life stage in the Sacramento River (November-May; Table 5.8-1). Construction activities in the Sacramento River could result in mortality of this life stage by crushing if heavy equipment entered the stream channel, if individuals were stranded or isolated during dewatering, or if construction otherwise disturbed rearing juvenile habitat during manipulation of gravel, installation of large wood or creation of side channels. Individuals exposed to construction could also experience loss of aquatic habitat, leading to increased predation, increased water temperature, and reduced food availability. Juveniles could also be negatively affected by degraded water quality from contaminant discharge by heavy equipment and soils and increased discharges of suspended solids and turbidity, leading to direct physiological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), loss of aquatic vegetation providing physical shelter, reduced foraging ability caused by decreased visibility, and impeded or delayed migration caused by elevated noise levels from machinery.

However, exposure to these effects would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. There is no overlap of the peak seasonal occurrence of this life stage and the in-water work window. Therefore this action is not anticipated to have negative effects on rearing and outmigrating juvenile Central Valley Spring-run Chinook Salmon.

5.8.4.5 Deer Creek Fish Passage

Deer Creek is a tributary of the Sacramento River with natural production of spring-run Chinook salmon and steelhead trout. There are 3 diversion dams and 4 screened diversion ditches in Deer Creek. Deer Creek Irrigation District Dam (DCID) is the uppermost dam on Deer Creek. DCID is a flashboard dam with a screened diversion. DWR and Reclamation’s installation of a nature-like fishway at this site will provide Spring-run Chinook salmon and other salmonids access to approximately 25 miles of spawning habitat in Deer Creek upstream from the DCID dam.

Few, if any, rearing and outmigrating juveniles would be exposed to construction of the nature-like fishway, based on the timing of the in-water work window (July 1-September 30) and peak seasonal occurrence of this life stage in the Sacramento River (November-May; Table 5.8-1). Construction effects are the same as discussed above for Sacramento River spawning and rearing habitat. Exposure to these effects would be minimized with incorporation of the avoidance and minimization measures.

5.8.4.6 Small Screen Program

A small proportion of the Spring-run Chinook Salmon population would benefit from the Small Screen Program under the proposed action. There may be moderate overlap of the Spring-run Chinook Salmon migration with the main late spring-fall irrigation period for small diversions, and small diversion screening could reduce entrainment of late migrating individuals.

5.8.4.6.1 Egg to Fry Emergence

No egg or fry Spring-run Chinook Salmon would be exposed to fish screens since they remain in the gravel in the rivers. Therefore, there would be no effects from fish screen construction on this life stage.

5.8.4.6.2 Rearing to Outmigrating Juveniles

The operation of fish screens on water diversions under the proposed action would benefit juvenile Spring-run Chinook Salmon by reducing the entrainment of rearing and migrating fish into unscreened or poorly screened diversions. There is the potential for adverse effects to this life stage, including injury or mortality from exposure to screens that are not functioning properly due to lack of maintenance, occlusion, debris accumulation or other factors. However, the risk of this exposure will be minimized under the proposed action since the screens would be designed to meet NMFS and CDFW fish screen criteria and protect this life stage.

Juvenile Spring-run Chinook Salmon may be exposed to the effects of construction of screens on water diversion intakes since they will likely be present during the timing of in-water construction (July 15 – October 15). However, the work area for these projects is small, limiting exposure to construction. Spring-run Chinook Salmon exhibit a stream-type life history where juveniles typically spend a year or more in freshwater before emigrating (NMFS 2009). Thus, juveniles may be present in the Sacramento

River year-round since they reside in freshwater for 12 to 16 months (Table 5.8-1), but some migrate to the ocean as young-of-the-year in the winter or spring months within eight months of hatching (CALFED 2000). Potential short-term adverse effects may include temporary effects to water quality as result from in-water work, resulting in increased turbidity and suspended sediments and sediment deposition in the direct vicinity of the work area, and the temporary displacement of individual fish in the work area. If fish are present in the work area, flowing water will be isolated and fish captured and relocated to an appropriate location in an effort to minimize possible mortality. Juveniles would likely experience increased levels of stress and injury during handling, which could be exacerbated by poor water quality (increased temperatures, low dissolved oxygen saturation), and prolonged periods of holding between capture and release. There may be a minor effect to a small number of individuals, although the risk from these potential effects would be would be minimized through the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures*. In addition, the appropriate conservation measures and handling techniques will be employed to ensure that the stress resulting from handling and transport is short-lived and minor.

5.8.4.6.3 Rearing to Outmigrating Juveniles in the Delta

Operational benefits of screened diversions are the same as for juveniles in rivers above.

Few if any juvenile Spring-run Chinook Salmon rearing and outmigrating in the Bay-Delta are expected to be exposed to the effects of construction of screens on water diversion intakes. Juvenile Sacramento River Spring-run Chinook Salmon primarily from November through early May (NMFS 2014), largely outside of the timing of in-water construction (July 15 – October 15). In addition, the work area for these projects is small, limiting exposure to construction.

5.8.4.6.4 Adult Migration

Operational benefits of screened diversions are the same as for juveniles in rivers above.

Adult Spring-run Chinook Salmon may be exposed to the effects of construction of screens on water diversion intakes based on the timing of in-water construction (July 15 – October 15) and the mid-February to October seasonal occurrence of this life stage in the Sacramento River (Table 5.8-1). Effects are the same as for juveniles above, and would be minimized through AMMs.

5.8.4.6.5 Adult Holding

Operational benefits of screened diversions are the same as for juveniles in rivers above.

Adult Spring-run Chinook Salmon holding in the Sacramento River may be exposed to the effects of construction of screens on water diversion intakes based on the timing of in-water construction (July 15 – October 15), the mid-February to October seasonal occurrence of this life stage in the Sacramento River (Table 5.8-1). However, few fish will potentially be exposed to construction activities due to the localized work areas of these projects and their tendency to remain in deep cold pools in proximity to spawning areas until they are sexually mature and ready to spawn (CDFG 1998; NMFS 2009). Effects are the same as for juveniles above, and would be minimized through AMMs.

5.8.4.7 Adult Rescue

Adult rescue would primarily affect adult Spring-run Chinook Salmon. The operation of adult rescue is targeted towards adult salmonids and sturgeon, including adult Spring-run Chinook Salmon, that become trapped in the Yolo and Sutter bypasses, with the goal of increasing the number of adults returning to spawning areas; therefore, this effort could increase the abundance of Spring-run Chinook Salmon of all life stages in the Sacramento River and its tributaries.

Exposure of this life stage to adult rescue effects would be restricted only to those adult Spring-run Chinook Salmon that become stranded in the Yolo and Sutter Bypasses and subsequently rescued and released to the Sacramento River. Adults that migrate in-river or that do not become stranded in the Yolo and Sutter bypasses would be unaffected by adult rescue activities. The number of adult Spring-run Chinook Salmon that would be expected to be exposed to the effects of adult rescue activities would be based on the abundance of adults that stray into the bypasses and the timing and frequency of stranding events in the bypasses. Individual adult Spring-run Chinook Salmon exposed to adult rescue activities would be at risk of increased stress, injury, and/or mortality, which could vary in intensity depending on the techniques used to capture individuals. Injury and increased stress associated with capture, handling and transport may affect survival of individuals after release. The risk from these potential effects would be minimized through application of AMM8 Fish Rescue and Salvage Plan (Appendix E, *Avoidance and Minimization Measures*). As such, it is concluded that the overall population-level negative effects on this life stage of Spring-run Chinook Salmon from adult rescue activities would be low relative to the without action (no rescue of stranded adult Spring-run Chinook Salmon in Yolo and Sutter bypasses).

Juvenile Spring-run Chinook Salmon occur in the Yolo and Sutter Bypasses when Sacramento River flows overtop the Fremont and/or Tisdale Weirs. Although they are unlikely to occur in the bypasses during periods when flow does not overtop the weirs, ongoing modifications to the Fremont Weir to increase inundation of the Yolo bypass for floodplain rearing would provide juveniles with more consistent access to the Yolo bypass. Therefore, these juveniles could be exposed to the effects of adult rescue activities if they become stranded with adults that are targeted by adult rescue activities. The number of juvenile Spring-run Chinook Salmon that would be expected to be exposed to the effects of adult rescue activities would be based on the timing of proposed adult rescue activities, gear type used to rescue adults, and the typical seasonal occurrence of this life stage in the Yolo and Sutter bypasses. Individual juvenile Spring-run Chinook Salmon exposed to adult rescue activities would be at risk of increased stress, injury, and/or mortality during efforts to capture stranded adults, handling, and transport. Injury and increased stress associated with capture, handling, and transport may reduce disease resistance, swimming ability, and osmoregulatory ability in juveniles, thereby adversely affecting survival of affected individuals after release. Furthermore, the risk of these effects to this life stage may be dependent on fish size (fish collected at a smaller [younger] size may be more susceptible to injury and stress) and timing of collection (fish collected later in the season when water quality conditions [e.g., water temperature] generally are more stressful for fish may make fish more susceptible to injury and stress-related effects). The risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*), and any potential adverse effects on individual juvenile Spring-run Chinook Salmon would be expected to be offset by benefits associated with increased numbers of adult Spring-run Chinook Salmon returning to spawning grounds. As such, it is concluded that the overall population-level negative effects on this life stage of Spring-run Chinook Salmon from adult rescue activities would be low relative to the without action (no rescue of adult Spring-run Chinook Salmon).

Given that this life stage is carried out in the upper Sacramento River and its tributaries and adult rescue activities would occur downstream in the Yolo and Sutter bypasses, there would be no direct effects on this life stage from implementing adult rescue activities.

The operation of adult rescue is targeted towards adult salmonids and sturgeon, including adult Spring-run Chinook Salmon, that become trapped in the Yolo and Sutter bypasses, with the goal of increasing the number of adults returning to spawning areas; therefore, this effort could increase the abundance of Spring-run Chinook Salmon adults holding in the upper Sacramento River and its tributaries.

5.8.4.8 Juvenile Trap and Haul

Juvenile trap and haul would only affect juvenile Spring-run Chinook Salmon. The operation of the juvenile trap and haul is targeted towards juvenile Chinook Salmon, with the goal of increasing the survival of juveniles and, ultimately, returning adults; therefore, this effort could increase the number of Spring-run Chinook Salmon of all lifestages in the Sacramento River and its tributaries.

The number of juvenile Spring-run Chinook Salmon that would be expected to be exposed to the effects of juvenile trap and haul activities would be based on the timing of proposed juvenile trap and haul activities (December 1 to May 31), trapping location and efficiency, and the typical seasonal occurrence of this life stage in the Sacramento River (Table 5.8-1). Individual juvenile Spring-run Chinook Salmon exposed to juvenile trap and haul activities would be at risk of increased stress, injury, and/or mortality. Injury and increased stress associated with handling and transport may reduce disease resistance, swimming ability, and osmoregulatory ability in juveniles, thereby adversely affecting survival of affected individuals after release. Furthermore, the risk of these effects to this life stage may be dependent on fish size (fish collected at a smaller [younger] size may be more susceptible to injury and stress) and timing of collection (fish collected later in the season when water quality conditions [e.g., water temperature] generally are more stressful for fish may make fish more susceptible to injury and stress-related effects). The risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*), and any potential adverse effects on individual juvenile Spring-run Chinook Salmon would be expected to be offset by benefits associated with expected increased survival of the overall brood-year of Spring-run Chinook Salmon. As such, it is concluded that the overall population-level negative effects on this life stage of juvenile Spring-run Chinook Salmon from juvenile trap and haul activities would be low relative to the without action (no trapping and hauling of juvenile Spring-run Chinook Salmon during drought years) and would be potentially offset by benefits (increased juvenile survival and ultimately increased adult escapement) associated with the juvenile trap and haul program.

Because transported juveniles are more likely to have impaired homing behavior as adults, juvenile trap and haul activities may increase the rate of straying by returning adults. Adults that stray into tributaries with unsuitable holding habitat would not be expected to survive or spawn successfully because of the lack of suitable adult holding and/or spawning habitat.

Because juvenile trap and haul would target only wild juveniles during outmigration, adult Spring-run Chinook Salmon holding in rivers would not be directly affected by juvenile trap and haul activities. However, because the purpose of juvenile trap and haul activities is to increase the survival rate of juveniles during drought years, the number of adults holding in rivers potentially would be greater relative to the without action (no trapping and hauling of juvenile Spring-run Chinook Salmon during drought years), as a result of increased juvenile survival and, ultimately, increased adult escapement.

5.8.4.9 Clear Creek Restoration Program

Reclamation proposes to enhance Chinook salmon spawning and rearing habitat within Clear Creek. This action includes placement of large woody debris and gravel augmentation.
This action is expected to enhance habitat complexity, benefiting salmonids that use Clear Creek and improving the habitat conservation value. The benefits from implementation of restoration projects include (1) complex channels and floodplain habitats, and (2) spawning habitat. In some years, over one

hundred Spring-run Chinook Salmon have been observed in Clear Creek, so the restoration is anticipated to have beneficial effects to Spring-run Chinook Salmon spawning and rearing habitat over WOA, where no restoration would occur.

Construction-related effects include increased sedimentation and turbidity. As side channel creation and flood plain enhancement projects are implemented as a part of the restoration, construction-related activities have the potential to result in injury or death to listed fish species. Construction-related effects may include debris falling into the active channel, tools and/or equipment falling into the active channel or noise generated by displaced rock and sediment and the operation of construction machinery.

5.8.4.10 American River Spawning and Rearing Habitat

Spring-run Chinook Salmon juveniles in the American River would benefit from increased side channel habitat, gravel, and large wood resulting from habitat restoration in the American River improving their likelihood of rearing success due to an increase in total rearing habitat area and rearing habitat quality.

Few, if any, rearing and outmigrating juveniles would be exposed to construction of side channel habitat, gravel augmentation, and large wood installation, based on the timing of the in-water work window (July 1-September 30) and peak seasonal occurrence of this life stage in the American River (November-May; Table 5.8-1). Construction activities in the American River could result in mortality of this life stage by crushing if heavy equipment entered the stream channel, if individuals were stranded or isolated during dewatering, or if construction otherwise disturbed rearing juvenile habitat during manipulation of gravel, installation of large wood or creation of side channels. Individuals exposed to construction could also experience loss of aquatic habitat, leading to increased predation, increased water temperature, and reduced food availability. This life stage could also be negatively affected by degraded water quality from contaminant discharge by heavy equipment and soils and increased discharges of suspended solids and turbidity, leading to direct physiological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), loss of aquatic vegetation providing physical shelter, reduced foraging ability caused by decreased visibility, and impeded or delayed migration caused by elevated noise levels from machinery.

However, exposure to these effects would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. There is no overlap of the peak seasonal occurrence of this life stage and the in-water work window. Therefore this action is not anticipated to have negative effects on rearing and outmigrating juvenile Central Valley Spring-run Chinook Salmon.

5.8.4.11 American River Drought Temperature Facility Improvements

Reclamation proposes to evaluate and implement alternative shutter configurations at Folsom Dam to allow temperature flexibility in severe droughts, thereby reducing water temperatures in the lower American River. Juvenile CV Spring-run Chinook Salmon may be present in the lower American River year-round since they reside in freshwater for 12 to 16 months (Table 5.8-1), but some migrate to the ocean as young-of-the-year in the winter or spring months within eight months of hatching (CALFED 2000). Excessively high water temperatures have been identified as one of the factors threatening CV Spring-run Chinook Salmon in the Central Valley and a factor for listing of the species. Juveniles may reside in freshwater for 12 to 16 months, but some migrate to the ocean as young-of-the-year in the winter or spring months within eight months of hatching (CALFED 2000). The implementation of the proposed drought temperature management measures under the proposed action would improve Reclamation’s ability to manage temperatures in the lower American River and improve conditions for this life stage. Therefore, this proposed action may beneficially affect juvenile CV Spring-run Chinook Salmon in the American River by reducing the effects of drought conditions on water temperatures.

5.8.4.12 Stanislaus River Spawning and Rearing Habitat

5.8.4.12.1 Egg to Fry Emergence

Spring running Chinook salmon have the potential to be affected by construction activities associated with the restoration activities in the Stanislaus River. However, benefits from increased habitat complexity due to restoration is expected to offset short-term construction impacts. However, through coordination with the regulatory agencies and implementation of avoidance and minimization measures, including the implementation of an in-water work window from July 15 through October 15, effects to the egg to fry emergence life stage of early spawning Chinook salmon would be avoided by construction activities. Through snorkel surveys, Chinook fry were observed in December 2003 in the Stanislaus River (NMFS 2014), which is outside of the July 15 through October 15 in-water work window, although the eggs may have been spawned within the timing window.

5.8.4.12.2 Rearing to Outmigrating Juveniles in Rivers

The creation of side channel and rearing habitat would increase the quality and quantity of off channel rearing (and spawning areas). The habitat restoration activities would improve the riparian habitat available for juvenile Spring-run Chinook Salmon rearing. The benefit of the habitat restoration activities within the Stanislaus River would yield immediate benefits. Existing riparian vegetation would be increased with the creation of side-channel habitat, providing:

- instream object and overhanging object cover;
- new shaded riverine habitat; and
- additional area for food source.

The creation of side-channel and floodplain rearing habitat would also increase the aquatic habitat complexity and diversity within the Stanislaus River and provide additional predator escape cover. The habitat restoration would result in increased survival of juvenile spring-running Chinook Salmon in the Stanislaus River.

Reclamation will implement an in-water work window from July 15 through October 15. This is outside of the juvenile outmigration period and juveniles would not be expected to be in the river, therefore there would be no effect of spawning and rearing habitat construction on juvenile spring-running Chinook salmon.

5.8.4.12.3 Adult Migration from Ocean to Rivers

Construction activities associated with the restoration activities in the Stanislaus River may potentially affect immigrating Spring-run Chinook Salmon. However, through implementation of avoidance and minimization measures, including the implementation of an in-water work window from July 15 through October 15, immigrating spring-running Chinook Salmon would not be affected by construction activities.

5.8.4.12.4 Adult Holding in Rivers

Additional spawning and rearing habitat is unlikely to benefit Spring-run adults holding in the Stanislaus River as adult holding habitat is generally in the main channel rather than side channels and floodplains.

Construction activities associated with the restoration activities in the Stanislaus River are unlikely to affect adult holding spring-running Chinook salmon in the Stanislaus River. Through implementation of avoidance and minimization measures, including the implementation of an in-water work window from July 15 through October 15, holding spring-running Chinook Salmon would not be affected by construction activities.

5.8.4.13 Lower San Joaquin River Rearing Habitat

Lower San Joaquin Rearing Habitat restoration is expected to result in similar effects as those described above for Stanislaus River Spawning and Rearing Habitat.

5.8.4.14 Suisun Marsh Salinity Control Gates Operation

No Spring-run Chinook Salmon are detected in the Delta between June and October. Therefore, no effects would occur as a result of the Suisun Marsh Salinity Control Gate operation.

5.8.4.15 Summer-Fall Delta Smelt Habitat

No Spring-run Chinook Salmon are detected in the Delta between June and October. Therefore, no effects would occur as a result of the Suisun Marsh Salinity Control Gate operation.

5.8.4.16 Clifton Court Predator Management

Predator control efforts at Clifton Court Forebay under the proposed action could reduce pre-screen loss of juvenile Spring-run Chinook Salmon entrained into Clifton Court Forebay. Spring-run Chinook Salmon are unlikely to be in the area during predator control efforts during the summer in-water work window.

5.8.4.17 Sacramento Deepwater Ship Channel

This action would hydrologically connect the Sacramento River with the Sacramento Deepwater Ship Channel (SDWSC) via the Stone Lock facility from mid-spring to late fall. Juvenile Spring-run Chinook Salmon abundance in the Delta is moderate in March and peaks in April (Table 5.8-1). Juvenile Spring-run Chinook Salmon passing the Stone Lock facility when there is a hydrologic connection between the waterways could potentially be enter into the SDWSC. There are potential benefits to Spring-run Chinook Salmon from this action. Fish entering the SDWSC would not be exposed to entrainment into the interior Delta through the DCC or Georgiana Slough which would provide a benefit if survival rates are similar. However, estimates of salmonid survival in the SDWSC are not available to compare with rates in the Sacramento River route. Also, there is potential for decreased migration time to the ocean and exposure to larger food sources of Liberty Island, but this is currently uncertain.

5.8.4.18 North Delta Food Subsidies/Colusa Basin Drain Study

Provision of north Delta food subsidies by routing Colusa Basin drain water to the Cache Slough area through the Yolo Bypass would occur in summer/fall and therefore would have limited effects on Spring-run Chinook Salmon, who are in the Delta between January – February for adults, and November through June for juveniles, with a peak of juvenile migration from March to April.

5.8.4.19 Suisun Marsh Roaring River Distribution System Food Subsidies Study

Under the proposed action, provision of Suisun Marsh food subsidies through coordination of managed wetland flood and drain operations in Suisun Marsh and draining of RRDS to Grizzly Bay/Suisun Bay in conjunction with reoperation of the SMSCG would occur in summer/fall and therefore would have limited effects on Spring-run Chinook Salmon, who are in the Delta between January – February for adults, and November through June for juveniles, with a peak of juvenile migration from March to April.

5.8.4.20 Tidal Habitat Restoration

A large proportion of juvenile Spring-run Chinook Salmon are expected to benefit from continuing to construct the 8,000 acres of tidal habitat restoration in the Delta under the proposed action. Benefits include increased food availability and quality and refuge habitat from predators. These benefits can manifest in higher growth rates and increased survival through the Delta.

Few if any juvenile Spring-run Chinook Salmon would be expected to be exposed to the effects of construction of 8,000 acres of tidal habitat restoration, based on the timing of in-water construction (August–October) and the typical seasonal occurrence of this life stage in the Delta (Table 5.8-1). There may be some exposure of yearling migrants that enter the Delta in the fall. Individuals being exposed to construction could experience risk of potential effects similar to those suggested in recent restoration projects such as the Lower Yolo Restoration Project (NMFS 2014). This includes the following: temporary loss of aquatic and riparian habitat leading to increased predation, increased water temperature, and reduced food availability; degraded water quality from contaminant discharge by heavy equipment and soils, and increased discharges of suspended solids and turbidity, leading to direct toxicological impacts on fish health/performance, indirect impairment of aquatic ecosystem productivity, loss of aquatic vegetation providing physical shelter, and reduced foraging ability caused by decreased visibility; impediments and delay in migration caused by elevated noise levels from machinery; and direct injury or mortality from in-water equipment strikes or isolation/stranding within dewatered cofferdams. Many of these are elements highlighted in the SAIL conceptual model (Figure 5.6-4). The risk from these potential effects would be minimized through application of AMMs (Appendix E, *Avoidance and Minimization Measures*).

5.8.4.21 Predator Hot Spot Removal

Predator hot spot removal under the Proposed Action is primarily focused on providing positive effects to downstream-migrating juvenile salmonids including Spring-run Chinook Salmon. Although the action would not be limited to existing identified hot spots (e.g., those identified by Grossman et al. 2013), the existing hotspots that may be representative of where removal efforts may be most concentrated are in the primary migratory routes of juvenile Spring-run Chinook. All hotspots are limited in scale relative to overall available habitat and previous research has not found a consistent positive effect of predator removal on juvenile salmon survival (Cavallo et al. 2012, Michel et al. 2017, Sabal et al. 2017).

5.8.4.22 San Joaquin River Scour Hole Predation Reduction

Spring-run Chinook salmon outmigrating from the San Joaquin River are exposed to predation at the junction of the San Joaquin River and Old River. This action would reduce predation at this site, improving juvenile San Joaquin origin Spring-run Chinook salmon survival.

Few Spring-run Chinook Salmon are expected to be exposed to in-water construction impacts due to observance of species protective work windows. Impacts of construction to adjust bathymetry would be minimized in accordance with Appendix E, Avoidance and Minimization Measures.

5.8.4.23 Knight's Landing Outfall Gates Fish Barrier

Reclamation and DWR's fish barrier at the Knight's Landing Outfall Gates would prevent possible entrainment of salmonids into the Colusa Basin Drain. This project would reduce entrainment and therefore increase survival of Spring-run Chinook Salmon adults.

Few Spring-run Chinook Salmon are expected to be exposed to in-water construction impacts due to observance of species protective work windows. Impacts of construction would be minimized in accordance with Appendix E, Avoidance and Minimization Measures.

5.8.4.24 Delta Cross Channel Improvements

Greater operational flexibility and increased gate reliability resulting from improvements to the Delta Cross Channel under the proposed action would reduce the risk of gate failure that could result in higher rates of entrainment of Spring-run Chinook Salmon, if left open. Seasonal closure periods would still be in place to protect Spring-run Chinook Salmon. The DCC is an older structure which requires manual operation and increased use could result in locks braking in either open or closed positions. Migrating Spring-run Chinook Salmon would benefit from faster operations that prevent straying into the central Delta and catastrophic failure of the facility. Improved biological and physical monitoring associated with improvements would likely minimize potentially increased entrainment depending on operations.

Few Spring-run Chinook Salmon are expected to be exposed to in-water construction related improvements to the Delta Cross Channel due to observance of species protective work windows.

5.8.4.25 Tracy Fish Facility Improvements

A number of programmatic actions are proposed to improve salvage efficiency of TFCF, including installing a carbon dioxide injection device to allow remote controlled anesthetization of predators in the secondary channels of the Tracy Fish Facility. These actions could potentially benefit juvenile Spring-run Chinook Salmon through greater salvage efficiency.

Few if any juvenile Spring-run Chinook Salmon would be expected to be exposed to construction of the CO2 injection device proposed for the Tracy Fish Facility Improvements, based on lack of observed salvage during the August–October in-water work window (see figures in Appendix F, *Juvenile Salmonid Monitoring, Sampling, and Salvage Summary from SacPAS:* WR_salvage_unclipped_date, WR_salvage_clipped_date, and WR_salvage_clipped_CWT_race). Risks to these few individuals would be minimized through appropriate AMMs (Appendix E, *Avoidance and Minimization Measures*), the selected in-water work window, and the small scale of the in-water construction. For juvenile Spring-run Chinook Salmon that arrive at the facility, the proposed improvements are likely to increase survival through the facility.

5.8.4.26 Skinner Fish Facility Improvements

Predator control efforts at Skinner Fish Facility under the Proposed Action to reduce predation on listed fishes following entrainment into Clifton Court Forebay could reduce pre-screen loss of juvenile Spring-run Chinook Salmon entrained into Clifton Court Forebay. Spring-run Chinook Salmon are unlikely to be in the area during predator control efforts.

5.8.4.27 Delta Fishes Conservation Hatchery

As with the other proposed construction activities in the Bay-Delta, few if any juvenile Spring-run Chinook Salmon would be expected to be exposed to the effects of construction of the Delta Fishes Conservation Hatchery based on the timing of in-water construction (August–October) and the typical seasonal occurrence of juvenile Spring-run Chinook Salmon in the Delta (Table 5.8-1). There may be some exposure of yearling migrants to in-water and shoreline construction of the hatchery intake and outfall, as illustrated by timing of occurrence in Sacramento seines and trawls (Figures WR_Seines and WR_Sherwood in Appendix F, *Juvenile Salmonid Monitoring, Sampling, and Salvage Summary from SacPAS*). The relatively few individuals occurring near the construction site could be subject to effects similar to those previously described for habitat restoration (e.g., temporary loss of habitat leading to predation, degraded water quality, reduced foraging ability caused by reduced visibility, noise-related delay in migration, and direct effects from contact with construction equipment or isolation/stranding within enclosed areas). The risk from these potential effects would be minimized through application of AMMs (Appendix E, *Avoidance and Minimization Measures*). Potential effects of the Delta Fishes Conservation Hatchery include inadvertent propagation and release of nuisance species and reduced water quality resulting from hatchery discharge. Mitigation and minimization measures detailed in the EIR/EIS for the facility (Horizon Water and Environment 2017) indicate that potential impacts are less than significant. Potential exposure of juvenile Spring-run Chinook Salmon would be restricted to a small spatial area within the primary migration route.

5.8.4.28 Effects of Monitoring

Less than 2% of the estimated Spring-run Chinook Salmon population, as indexed by the Red Bluff Rotary Screw Trap data, is collectively captured by the salmonid monitoring programs that support CVP operations (Table 5.8-5). Because such a small percentage of the estimated Spring-run Chinook Salmon juvenile production is captured in the monitoring programs, the effects of the monitoring programs are not likely to have effects to the Spring-run population.

This page intentionally left blank

Table 5.8-5. Monitoring Programs – Spring-run Chinook Salmon

Species	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Chipps Island Trawl																		
Spring-run Chinook Salmon	1229	3948	889	1880	2085	788	163	429	758	593	761	601	1311	1108	681	3882	1230	
Sacramento Trawl																		
Spring-run Chinook Salmon	197	1008	289	558	532	168	67	224	203	316	269	400	774	46	215	2734	152	
DJFMP Beach Seine Survey																		
Spring-run Chinook Salmon	429	1238	780	579	766	127	72	60	442	923	463	317	409	352	203	187	208	4
CDFW Mossdale Trawl																		
Spring-run Chinook Salmon	419	749	320	965	1042	843	480	385	159	1271	1149	644	296	70	124	1223	529	
EDSM KDTR Trawls																		
Spring-run Chinook Salmon	na	na	na	na	na	na	na	na	na	na	na	na	na	na	2	51	na	
CDFW Bay Study Trawls																		
Chinook Salmon	273	117	327	115	143	115	17	130	157	215	74	134	71	65	62	236	na	
CDFW SKT Study																		
Chinook Salmon	35	1624	1364	348	822	896	603	187	300	244	219	492	632	432	347	565	124	
Totals																		
Spring-run Chinook Salmon	2274	6943	2278	3982	4425	1926	782	1098	1562	3103	2642	1962	2790	1576	1223	8026	2119	
RBDD Rotary Trap or Juvenile Production Estimate (JPE)																		
Spring-run Chinook Salmon RPE	277477	626915	430951	615547	421436	369501	164673	438405	158966	184290	320897							
Percent of Total																		
Spring-run Chinook Salmon	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.02	0.01							

This page intentionally left blank.

5.9 Chinook Salmon, Central Valley Spring-run ESU Critical Habitat

Critical habitat designated for Spring-run Chinook Salmon and potentially affected by the proposed action includes the Feather and Sacramento Rivers, and Clear creek, the as well as portions of the northern Delta. The PBFs essential to the conservation of the Central Valley Spring-run Chinook Salmon ESU and the potential proposed action effects on them are water quantity, floodplain connectivity, water quality, forage, and riparian cover.

5.9.1 Effects of Operations

5.9.1.1 PBF1 – Freshwater Spawning Habitat

The proposed action includes actions to improve spawning habitat for Chinook salmon in the upper Sacramento River, and would likely benefit Spring-run Chinook Salmon spawning habitat. Spawning habitat is also affected by changes in flow and water temperature. As indicated in *Eggs to Fry Emergence*, there would be few major differences between the proposed action and cos in flow and no meaningful difference in water temperature in the spawning portion of Spring-run Chinook Salmon critical habitat during the August through January spawning and egg/alevin incubation period. However, differences between the proposed action and the WOA would be large during the first half of the spawning period, August through October. As described in *Eggs to Fry Emergence* Section, effects of these flow differences are uncertain, with some PBFs of habitat benefited and some negatively affected by the higher flows. Flow is much greater under the proposed action than the WOA during August through October, which is expected to substantially benefit most Spring-run Chinook Salmon spawning habitat PBFs. Proposed action and WOA flows are generally similar during November through January. August through October water temperature under the proposed action is much lower than WOA temperature in almost every year. The proposed action water temperature below Keswick Dam during August and September generally ranges from 10 to 18 degrees Fahrenheit lower than the corresponding WOA temperature, and the proposed action temperature is below critical thresholds for incubating eggs and alevins in most years, while the WOA temperature greatly exceeds these thresholds in every year. From November through January, water temperatures are below critical thresholds for incubating eggs and alevins in every year under both the proposed action and WOA scenarios, although the December and January in the coldest years are potentially low enough to retard egg and alevin development. These results indicate that the proposed action scenario would benefit spawning habitat of Spring-run Chinook Salmon in the Sacramento River.

5.9.1.2 PBF2 – Freshwater Rearing Habitat

As described in *Rearing to Outmigrating Juveniles in the Upper and Middle Sacramento River Section,* there would be few differences between the proposed project and COS in flow in rearing habitat of Spring-run Chinook Salmon and no meaningful difference in water temperature in the upper and middle Sacramento River during the November through May rearing period.

Differences in flow and water temperature would be large between the proposed action and the WOA. Proposed action flow is lower than WOA flow during January through April in most years, especially dry years, but is higher than WOA flow during May of dry years. Proposed action water temperature is much higher than WOA temperature from November through February and is much lower in April and May. The reductions in flow under the proposed action, especially in drier years, would likely have adverse effects on most attributes of spring-run rearing habitat in the Sacramento River. Potential adverse effects include reduced access to riparian and off-channel habitat, greater crowding and competition, and lower prey availability. The temperature differences between the proposed action and the WOA would likely not affect the rearing habitat quality. The temperatures under both the proposed action and WOA would be under critical thresholds for rearing juvenile Spring-run Chinook Salmon in almost all years. Although, the coldest water temperatures under the WOA scenario would potentially cause reduced growth of the juveniles.

5.9.1.3 PBF3 – Freshwater Migration Corridors

As described in *Rearing to Outmigrating Juveniles in the Upper and Middle Sacramento River*, and *Adult Migration from Ocean to Rivers Sections*, proposed action flows during winter and early spring (January through April) would be reduced relative to WOA conditions. Higher, more natural flows under the WOA scenario, including more frequent pulse flows, would have beneficial effects on PBFs of freshwater migratory habitat for juvenile Spring-run Chinook Salmon, including increased migration speeds, access to natural cover and low-velocity refuge habitat, and reduced exposure to predators. However, extremely low flows and higher temperatures under the WOA during May through August in dry and critically dry years would result in severe degradation of migratory habitat for adults. Although the proposed action would have negative effects on migratory habitat for juvenile spring-run in winter and early spring, maintaining 3,250 cfs or more throughout the year would avoid the extremely harsh conditions that would occur in dry and critically dry years under WOA conditions.

5.9.1.4 PBF4 – Estuarine Areas

The Bay/Delta estuarine critical habitat for Spring-run Chinook Salmon is severely degraded by altered hydrologic regimes, poor water quality, reductions in habitat complexity, and competition for food and space with exotic species (NMFS 2014a). Despite its poor condition, the estuarine habitat is of high value for the conservation of the species because it provides the only migratory corridor and area for transition to the ocean environment for juveniles, as well as adults returning to the Sacramento River. Consequently Bay/Delta food resources, water quality, refuge from predators, migratory cues, and other growth and survival factors are critically important. Potential effects of the proposed action compared to the WOA on the estuarine critical habitat of Spring-run Chinook Salmon includes changes in flow that affect hydrodynamics and routing of juvenile spring-run through Delta channels, habitat diversity, and water quality.

Routing through Delta Channels -Flow from the Sacramento, San Joaquin and other rivers tributary to the Delta, and well as tidal flows, affect the hydrodynamic of Delta channels and influence how juvenile spring-run move through the Delta. As described in the Spring-run chinook routing affects analysis, hydrodynamics and flow velocity effects of the proposed action compared to WOA indicate that routing into the interior Delta would be higher relative to the WOA. However, the differences are concerned discountable and would not substantially affect spring-run juveniles. As described in *Spring-run Chinook Salmon- Through Delta Survival section*, the overall effect of the proposed action on through-Delta survival of juvenile Spring-run Chinook Salmon resulting from differences in Delta channel flow velocities is low.

Adult Spring-run Chinook Salmon are present in the Bay/Delta from January through June, with a peak occurrence in January and February. The adults use olfactory cues to find their way through the Delta to the Sacramento River upstream of the Delta, so higher Sacramento River flow may reduce straying to other rivers (Marston et al. 2012; NMFS 2016 Submitted Ch5 EA Draft BA).

Flow in the Sacramento River at Rio Vista and Freeport during the peak period of adult migration through the Delta, January and February, is slightly lower under the PA and COS relative to the WOA (see Figure 32-11 in the CalSim II Flow section of Appendix D), but is more substantially reduced (≤ half) relative of the remaining months, March through June (e.g., Figure 32-11 in the CalSim II Flow section of Appendix D).

Habitat Diversity- Increased habitat diversity potentially enhances food resources, refuge habitat, flow velocity refuge, and other spring-run juvenile growth and mortality factors. Increased flow in the Bay/Delta likely increases habitat diversity. Higher flow results in greater inundation of marshlands surrounding the Delta, Suisun Bay and San Pablo Bay, which potentially improves: 1) foodweb productivity, 2) access of juvenile spring-run to more abundant and more diverse food resources, 3) refuge of the juveniles from predators, and 4) refuge for resting from high velocity flows. Higher flows may also enhance foodweb productivity by transporting nutrients and plankton from productive habitats, including croplands and the Sutter and Yolo bypasses (DWR and Reclamation 2107 Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project EIS/EIR).

During the March and April peak period of juvenile spring-run presence in the Delta, Sacramento River flow at Freeport and Rio Vista, as well as Delta outflow, are substantially lower under the PA and COS relative to the WOA (e.g. Figures 32-11 and 41-12 in the CalSim II Flow section of Appendix D). Flow is also lower under the proposed action in Yolo Bypass flow. Therefore, the proposed action is expected to adversely affect estuarine critical habitat relative to the WOA, with respect to habitat diversity and food resources.

5.9.2 Effects of Conservation Measures

The following analysis of designated critical habitat is programmatic. Though future ESA consultation, these actions will be refined and any potential adverse effects will minimized or avoided. These actions are beneficial in nature and are expected to improve PBFs in the long-term.

5.9.2.1 Lower American River

Spawning Habitat -The PBFs under proposed action for spawning adult Spring-run Chinook Salmon are as follows: no effects to water quantity are anticipated; a temporary increase in turbidity to the water quality is anticipated; and a temporary disturbance to substrate is anticipated. Side channel construction, gravel augmentation, and large wood installation may cause temporary adverse effects but could result long-term beneficial effects to PBFs for Central Valley Spring-run Chinook Salmon critical habitat.

Freshwater Rearing Habitat- The PBFs essential to the conservation of the Central Valley Spring-run Chinook Salmon ESU and the proposed action effects on them are water quantity, floodplain connectivity, water quality, forage, and natural cover. The PBFs under proposed action for rearing Spring-run Chinook Salmon are as follows: no effects to water quantity are anticipated; a temporary disturbance to floodplain connectivity is anticipated; a temporary increase in turbidity to water quality, no effects to forage are anticipated; and increased natural cover. Restoration including side channel construction, gravel augmentation, and large wood installation is beneficial in nature and expected to improve any PBFs for Central Valley Spring-run Chinook Salmon critical habitat.

Freshwater Migration Corridors- The PBFs essential to the conservation of the Central Valley Spring-run Chinook Salmon ESU and the potential proposed action effects on them are passage obstructions, water quality, water quantity, and cover. The PBFs under proposed action for migrating Spring-run Chinook Salmon are as follows: no effects to passage obstructions are anticipated; a temporary increase in turbidity to water quality; no effects to water quantity are anticipated; and a temporary disturbance to cover is anticipated. Side channel construction, gravel augmentation, and large wood installation is not anticipated to result in adverse impacts to any PBFs for Central Valley Spring-run Chinook Salmon critical habitat in the American River.

5.9.2.2 Clear Creek

Spawning Habitat -The PBFs essential to the conservation of the Central Valley Spring-run Chinook Salmon ESU and the potential project effects on them are water quantity and substrate. The PBFs under proposed action for spawning adult Spring-run Chinook Salmon are as follows: no effects to water quantity are anticipated; and a temporary disturbance to substrate is anticipated. Gravel mobilization is anticipated to result in no negative impacts on any PBFs for Central Valley Spring-run Chinook Salmon critical habitat.

Freshwater Rearing Habitat- The PBFs under proposed action for rearing Spring-run Chinook Salmon are as follows: no effects to water quantity are anticipated; potential beneficial effects to floodplain connectivity; temporary increase in turbidity to water quality; no effects on forage are anticipated; and no effects on cover are anticipated. Gravel mobilization is not anticipated to result in impacts to any PBFs for Central Valley Spring-run Chinook Salmon critical habitat.

Freshwater Migration Corridors- The PBFs essential to the conservation of the Central Valley Spring-run Chinook Salmon ESU and the potential proposed action effects on them are passage obstructions, water quality, water quantity, and cover. The PBFs under proposed action for migrating Spring-run Chinook Salmon are as follows: no effects to passage obstructions are anticipated; a temporary increase in turbidity to water quality; no effects to water quantity are anticipated; and no effects to cover are anticipated. Gravel mobilization is not anticipated to result in adverse impacts on any PBFs for Central Valley Spring-run Chinook Salmon critical habitat.

5.10 Steelhead, California Central Valley DPS

The increased summer and fall flows of the proposed action compared to the WOA could have benefits for juvenile CV Steelhead rearing, which occurs year-round. However, the reduced spring flows of the proposed action compared to the WOA are likely to affect rearing and migrating CV Steelhead and their habitat. Effects include a decrease in floodplain and side-channel habitat, reduced foraging conditions, increased competition and predation, higher water temperatures and lower DO, and reduced emigration flows. Operating the temperature control devices on Shasta and Folsom reservoirs has beneficial effects compared to WOA.

The proposed action incorporates information from the Salmonid Scoping Team and the 6-year Steelhead telemetry study to update protections for San Joaquin origin CV Steelhead. Updated science found no difference in survival from routing CV Steelhead into the San Joaquin River mainstem with the installation of HORB to a route through salvage. For Chinook salmon, updated science found a slight benefit in survival to a route through salvage. Similarly, while Vernalis flows improved CV Steelhead survival, improvements were not correlated with exports. Accordingly, the proposed action subsumes protections for CV Steelhead into OMR management. The proposed action continues the telemetry studies to further refine measures for protecting CV Steelhead, and adds a steelhead monitoring collaborative and program.

Several conservation measures proposed for Steelhead would also reduce impacts of lower spring flows on CV Steelhead juveniles. These include pulse flows from Shasta Reservoir, spawning and rearing habitat restoration on the Sacramento and Stanislaus Rivers, cold water pool management on the Sacramento River, predator hot spot removal and the small screen program. Similar to Winter-run Chinook Salmon, OMR management establishes generally protective criteria to avoid entrainment of CV Steelhead, and fish facility improvements can help further reduce the effects of the entrainment from the proposed action.

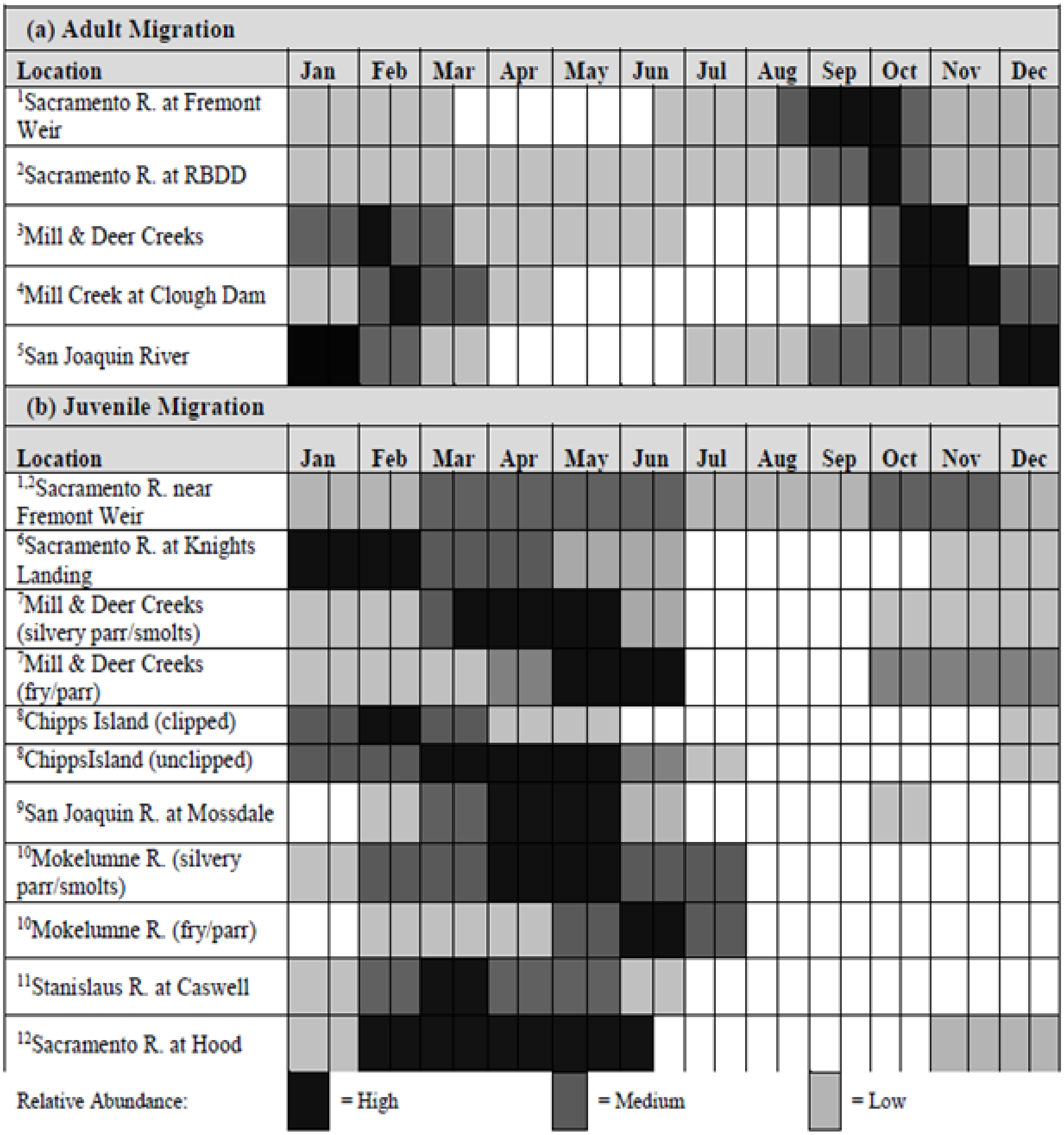
5.10.1 Lifestage Timing

CV Steelhead express a diverse array of life-history strategies including both anadromous and resident (i.e., rainbow trout) life histories. Anadromous and resident life-histories can be adopted by individuals from the same sibling cohort. Although there are general patterns regarding habitat use, migration timing, etc., CV Steelhead can hypothetically be found anywhere within their geographic distribution at all times (NMFS 2009). However, CV Steelhead are a thermally sensitive species like all other salmonids and their distribution and habitat use is generally restricted to waters below 65°F (NMFS 2002); protracted exposure to water temperatures above 75-82°F is likely lethal (Brett et al. 1982; Myrick and Cech 2005). Optimal conditions for CV Steelhead spawning and embryo incubation reportedly occur at water temperatures 52°F (NMFS 2002; SWRCB 2003), temperatures less than 56°F embryo survival has been reported as suitable (NMFS 2009). Water temperatures within the Central Valley and Delta likely control the timing and location of their distribution.

Reservoir releases, combined with other environmental drivers, affect water temperature, DO level, and other habitat attributes that influence the timing, condition and survival of eggs and alevins in the spawning redds. The proportion of eggs surviving to emerge as fry depends largely on the quality of conditions in the redd (Windell et al. 2017). Redd quality is affected by substrate size and composition, flow velocity, temperature, DO, contaminants, sedimentation, and pathogens and diseases. Flow affects sedimentation and gravel composition of the redds and may cause redd scour, stranding or dewatering. For the purposes of this biological assessment, Reclamation is analyzing effects to CV Steelhead in the Sacramento, Feather, American, and Stanislaus Rivers and the Delta.

General life stage timing and location information for CV Steelhead is provided in Table 5.10-1. Additional detail regarding juvenile life stage timing at various monitoring locations is provided in Appendix F – Juvenile Salmonid Monitoring, Sampling, and Salvage Timing Summary from SacPAS. Note that adult abundance timing in the Delta was described by NMFS (2017, p.74) as being high from September to mid-October, medium from mid to late August and mid to late October, and low from mid-June to mid-August and November. This is essentially the same pattern as that suggested for Sacramento River at Fremont Weir in Table 5.10-1, but without the period of low abundance from December to mid-March.

Table 5.10-1. The Temporal Occurrence of Adult (a) and Juvenile (b) CV Steelhead at Locations in the Central Valley (NMFS 2017, Appendix B, p.41).



Sources: [1](Hallock 1957); [2](McEwan 2001); [3](Harvey 1995); [4]CDFW unpublished data; [5]CDFG Steelhead Report Card Data 2007; [6]NMFS analysis of 1998–2011 CDFW data; [7](Johnson and Merrick 2012); [8]NMFS analysis of 1998–2011 USFWS data; [9]NMFS analysis of 2003–2011 USFWS data; [10]unpublished EBMUD RST data for 2008–2013; [11]Oakdale RST data (collected by FishBio LLC) summarized by John Hannon (Reclamation); [12](Schaffter 1980).

Adult CV Steelhead immigration into Central Valley streams typically begins in August and continues into March. Immigration generally peaks during January and February (Table 5.10-1), and then CV

Steelhead hold until flows are high enough in tributaries to enter for spawning (Moyle 2002; McEwan 2001; NMFS 2004). Spawning occurs from December through April, with peaks from January through March in small streams and tributaries where cool, well oxygenated water is available year-round (McEwan 2001). Eggs usually hatch within four weeks, depending on stream temperature, and the yolk sac fry remain in the gravel after hatching for another four to six weeks (CDFG 1996). The majority of CV Steelhead spawn only once but are capable of completing multiple return trips to the ocean and spawning migrations. Post-spawning adults returning to the ocean are referred to as kelts. Juvenile CV Steelhead use the middle Sacramento River as a rearing and migration corridor. Rotary screw trap, beach seine, and trawl data collected during 2004 through 2017 indicate that CV Steelhead may be present year-round in the middle Sacramento River but that the majority occur during January through May (Appendix F, Juvenile Salmonid Monitoring, Sampling, and Salvage Timing Summary from SacPAS). This period encompasses the peak emigration periods of yearling and older juveniles (smolts) from rearing areas in the upper Sacramento River and tributaries upstream of the Delta (Table 5.10-1). Therefore, individuals are present in the proposed action area throughout the year.

Historically adult CV Steelhead maintained several strategies during their migration to natal rivers in preparation for spawning. Some CV Steelhead returned several months prior to spawning to hold over in pools while sexually maturing, others sexually matured in the ocean before returning to freshwater (Williams 2006). Remaining anadromous CV Steelhead predominantly mature in the ocean (McEwan 2001).

5.10.2 Conceptual Model Linkages

CV Steelhead are present in the proposed action area throughout the year. The SAIL conceptual model (Figure 5.6-1) was prepared especially for life stage transitions of Sacramento River Winter-run Chinook Salmon, but the cause and effects relationships it diagrams apply well to the CV Steelhead population in Sacramento River. SAIL life stage transitions are the series in changes in form that an organism undergoes throughout its life cycle. SAIL life stage transitions include egg to larval, larvae to juvenile, juvenile to subadult/adult, adult to spawning, and spawning adult to egg and post-spawn adult period. The SAIL conceptual model prepared for Winter-run Chinook will be referenced throughout this section to explain links between the species and the effects of the actions. The primary differences in the habitat requirements between Winter-run and CV Steelhead are the duration and the time of year that the different life stages use their habitats.

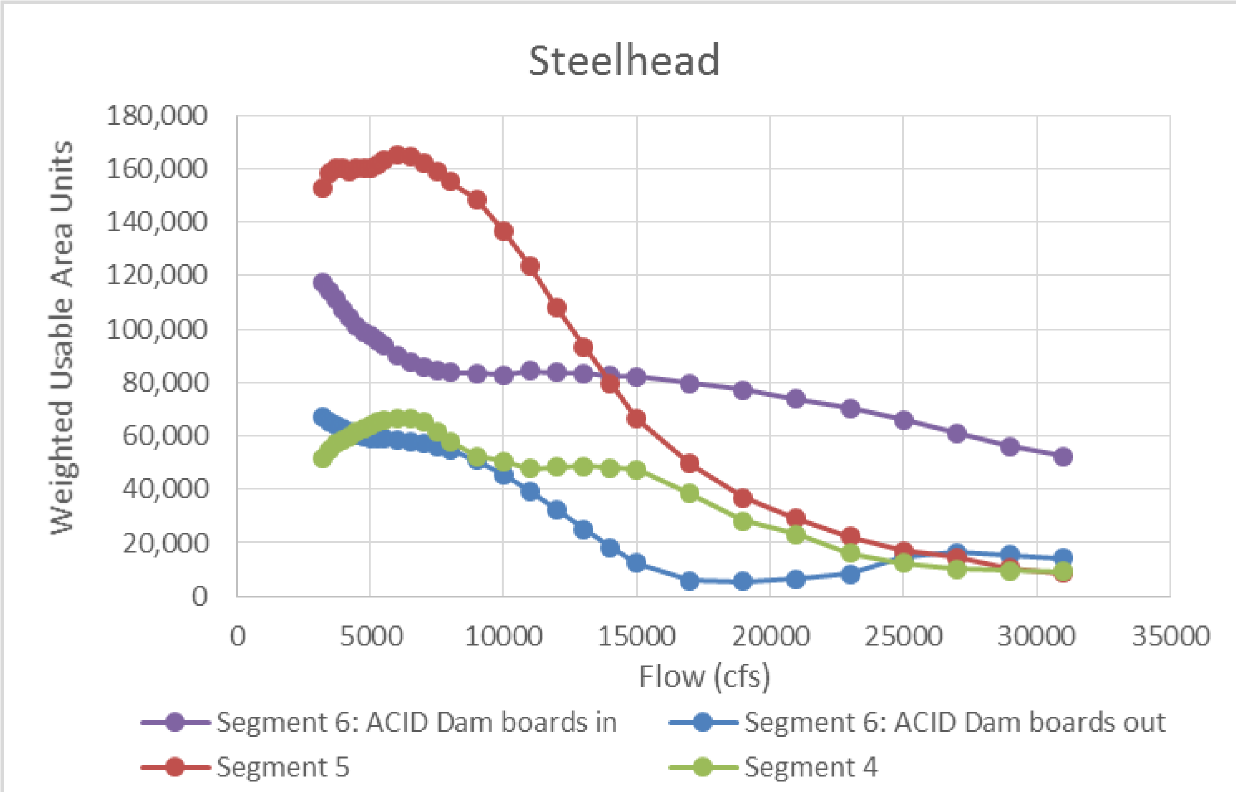
5.10.3 Effects of Operation & Maintenance

5.10.3.1 Sacramento River Seasonal Operations

5.10.3.1.1 <u>Eggs to Fry Emergence</u>

5.10.3.1.1.1 Flow Effects

Central Valley steelhead spawn downstream of dams on every major tributary within the Sacramento and San Joaquin Rivers. On the Sacramento River, steelhead generally spawn where Chinook spawn, between Keswick Dam and Red Bluff Diversion Dam. The effects of flow on available spawning area for CV Steelhead were qualitatively evaluated based on the relationships between flow and weighted usable area (WUA) developed by the USFWS for the Sacramento River between Keswick Dam and Battle Creek (Figure_Steelhead Spawning WUA). These relationships indicate that spawning WUA generally peaks at flows between 3,250 and 7,000 cfs and then declines at higher flows (Figure 5.10-1).



(Source: USFWS 2003)

Figure 5.10-1. Spawning WUA curves for CCV Steelhead in the Sacramento River. Segments 4: Battle Creek to Cow Creek; Segment 5: Cow Creek to the Anderson-Cottonwood Irrigation District (ACID) Dam; Segment 6: ACID to Keswick Dam

The USFWS used Habitat Suitability Criteria (HSC) criteria from the lower American River (USFWS 2000) to model CV Steelhead habitat in the Sacramento River. The USFWS was unable to conduct a transferability test to determine whether the lower American River CV Steelhead HSC are transferable to the Sacramento River, and therefore suggested that the habitat modeling results for CV Steelhead be treated with caution (USFWS 2003).

Under WOA conditions, there would be no Shasta and Keswick reservoir operations to control storage or releases, and no transfer of water from the Trinity River Basin. Under these conditions, flows in the Sacramento River would generally respond to natural seasonal and inter-annual variation in precipitation and runoff. Consequently, flows during the CV Steelhead spawning and incubation period would generally be low initially and then increase with the onset of winter storm events. Under the WOA scenario, CALSIM modeling indicates Keswick releases during November through April would range from 3,250 cfs to 62,650 cfs (Figures 15-8 through 15-13 in the CalSim II Flows section of Appendix D). Based on the CV Steelhead spawning WUA curves for the reaches between Keswick Dam and Battle Creek, flows associated with peak spawning habitat availability (3,250 cfs to 7,000 cfs) would occur most of the time in November (96 percent) and then decline in frequency as flows increase through the winter and spring, occurring about 30 percent of the time in March and April.

Under the proposed action, Keswick releases during the CV Steelhead spawning and incubation period (November through April) would range from 3,250 cfs to 59,000 cfs (Figures 15-8 through 15-13 in the

CalSim II Flows section of Appendix D). Based on the CV Steelhead spawning WUA curves, the largest differences in spawning habitat availability would occur in November when flows within the optimum range (3,250 cfs to 7,000 cfs) are predicted to occur 86 percent of the time under the proposed action scenario and 56 percent of the time under the COS scenario (Figure 15-8 in the CalSim II Flows section of Appendix D). During the peak spawning period (January through March), the frequency of flows associated with peak spawning habitat availability would differ by less than two percent (Figures 15-10 through 15-12 in the CalSim II Flows section of Appendix D). Consequently, the availability of CV Steelhead spawning habitat under the proposed action would be similar except in November when higher flows under the proposed action scenario would reduce the number of years in which flows would be within the optimum range.

Overall, lower winter and spring flows under the proposed action are expected to increase the availability of Steelhead spawning habitat relative to WOA conditions. Compared to the WOA scenario, the proposed action would result in substantially more years in which flows would be within the range of peak spawning habitat availability (3,250 cfs to 7,000 cfs). The largest differences would occur during the peak spawning months (January through March), when flows within the optimum range would occur 63 to 70 percent of the time under and proposed action scenarios versus 29 to 54 percent of the time under the WOA scenario. In addition, lower flows under the proposed action would likely reduce the risk of redd scour and/or dewatering relative to the WOA scenario. If flows are sufficiently high, they can result in excessive depths and flow velocities, resulting in bed scour and loss of existing redds (NMFS 2017). Higher flows may also force adults to build redds in areas that are later dewatered or isolated from the main river channel when flows decline. Therefore, Keswick Dam releases under the proposed action are expected to improve spawning and incubation conditions for CV Steelhead in the upper Sacramento River relative to WOA conditions.

5.10.3.1.1.2 Water Temperature Effects

Proposed action water temperature in the upper Sacramento River apply to the period May 15 to October 31 to provide suitable temperatures for winter-run, spring-run, and fall-run Chinook salmon spawning and incubation life stages. No water temperature requirements have been established for the CV Steelhead spawning and incubation period (November through April) because water temperatures are typically within suitable ranges for these life stages and other species and life stages that are present in the upper Sacramento River during this period. This assumption was evaluated for the WOA and proposed action based on the water temperature modeling results (HEC-5Q) and the recommended criteria developed by USEPA for protection of salmonids (U.S. Environmental Protection Agency 2003) and McCullough et al. (2001). These sources indicate that a water temperature of 53°F provides a reasonable threshold for evaluating the potential for adverse temperature effects based on mean monthly modeling results.

Under the WOA scenario, there would be no Shasta and Keswick reservoir operations to control storage or releases and no transfer of water from the Trinity River Basin. Therefore, there would be no ability to control water temperatures in the upper Sacramento River. Declining solar radiation and air temperatures in October and November consistently result in suitable water temperatures for CV Steelhead spawning and incubation period through the winter and early spring. Under the WOA scenario, exceedance plots of modeled mean monthly water temperatures between Keswick Dam and Red Bluff from November through April indicate that water temperatures would remain below 53°F in all months except April (Figures 5-8 through 5-13 in the HEC5Q Temperatures section of Appendix D).

Under WOA scenario, Sacramento River water would flow through Shasta and Keswick reservoirs, similar to uncontrolled flows, resulting in no control of flow releases or water temperature management within the system. Under the proposed action, the highest elevation gates of the TCD would be used to conserve deeper, colder water for the critical summer months (Figures 5-8 through 5-13 in the HEC5Q Temperatures section of Appendix D). The largest differences in mean monthly water temperatures between the proposed action and COS would be less than 1°F in November and December. Under both scenarios, water temperatures would frequently exceed the 53°F threshold in November but would decrease in December and remain below this threshold through March.

Compared to WOA conditions, water temperatures in the upper Sacramento River under the proposed action would be higher from November through February, similar in March, and lower in April (Figures 5-8 through 5-13 in the HEC5Q Temperatures section of Appendix D). Based on the frequency of years in which water temperatures are predicted to exceed the 53°F threshold, potential adverse effects on CV Steelhead spawning and incubation under the proposed action would occur in November when mean water temperatures below Keswick Dam are predicted to range from 52°F to 58°F between Keswick Dam and Red Bluff (Figure 5-8 in the HEC5Q Temperatures section of Appendix D). However, with higher reservoir storage and water temperature management actions under these scenarios, suitable water temperatures would be maintained through the primary Steelhead spawning and incubation period (January through April). Furthermore, in contrast to the WOA scenario, lower water temperatures under the proposed action would extend the period of suitable incubation temperatures into April (Figure 5-13 in the HEC5Q Temperatures section of Appendix D).

5.10.3.1.2 Rearing to Outmigrating Juveniles

5.10.3.1.2.1 Flow Effects

The effect of flow on available rearing area for CV Steelhead was qualitatively evaluated based on the relationships between flow and weighted usable area (WUA) developed by the USFWS for the Sacramento River between Keswick Dam and Battle Creek (Figure 5.10-2). Rearing habitat WUA for CV Steelhead was not estimated directly by the USFWS but was modeled using the rearing WUA curves for late Fall-run Chinook Salmon because the juvenile rearing period is similar to that of CV Steelhead, and this substitution follows previous practice (e.g., SacEFT model, ESSA 2011). However, the validity of using the late Fall-run Chinook Salmon WUA curves to characterize CV Steelhead rearing habitat is uncertain.

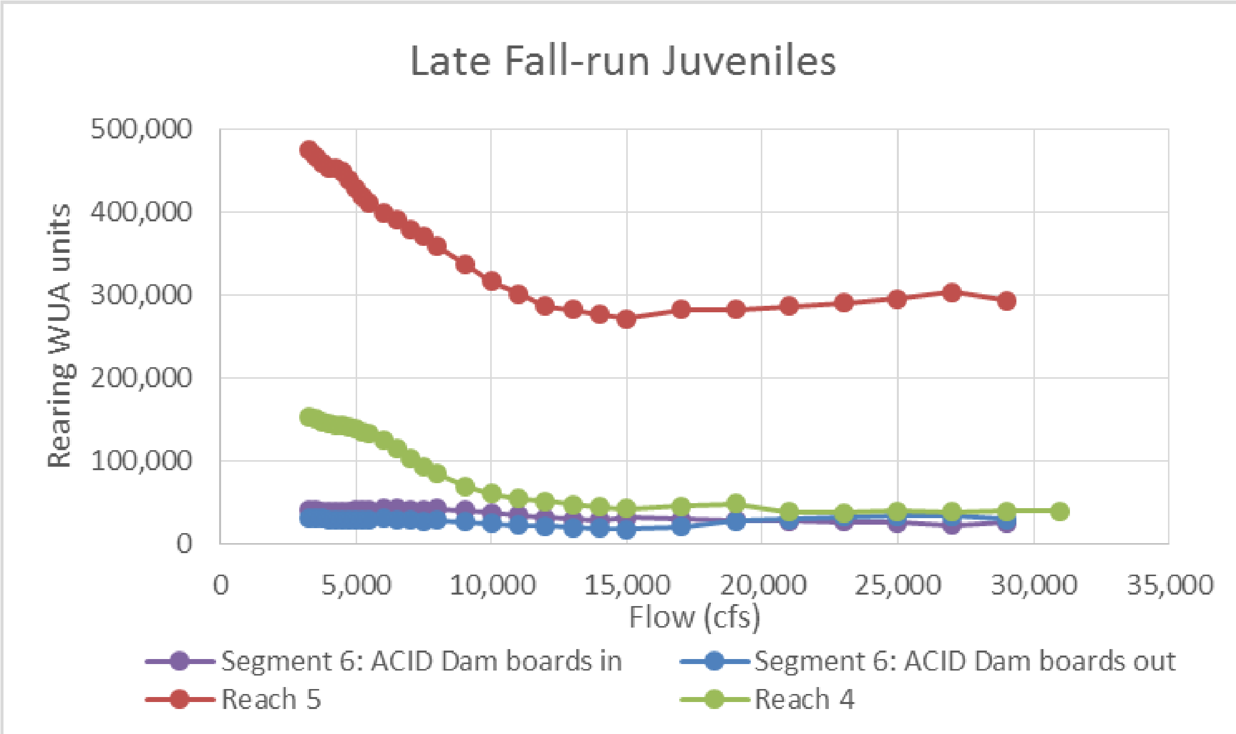


Figure 5.10-2. Rearing WUA curves for late Fall-run Chinook Salmon in the Sacramento River. Segment 4: Battle Creek to Cow Creek; Segment 5: Cow Creek to the Anderson-Cottonwood Irrigation District (ACID) Dam; Segment 6: ACID to Keswick Dam (Source: USFWS 2005).

The relationships indicate that rearing WUA in the upper Sacramento River generally peaks at or below the lowest flow studied (3,250 cfs). Similar to the effects described for Winter-run Chinook Salmon, these low flows would also reduce the quality of rearing habitat through changes in other physical and biological attributes, including high water temperatures, reduced habitat complexity (e.g., reduced side channel and floodplain connectivity), increased crowding and competition, and reduced availability and quality of prey organisms (Windell et al. 2017). Summer water temperatures would be further exacerbated by increased release temperatures due to the lack of cold water storage in Shasta Reservoir under the WOA scenario.

CALSIM modeling indicates that monthly flows in the upper Sacramento River during May through October would frequently drop below 3,250 cfs, especially during the summer of dry and critically dry years. During June through September, Keswick releases under the WOA scenario would be lower than 3,250 cfs in up to 55 percent of the years (Sac R flow below Keswick dam_aug).

Under the proposed action scenario, Shasta and Keswick reservoir operations during summer target flow and water temperature requirements for Winter-run Chinook Salmon and other anadromous fishes. CALSIM modeling indicates that flows of 3,250 cfs or more would be maintained through the spring and summer months. Compared to the COS scenario, modeled flows under the proposed action are higher in June and lower in September (Figures 15-15 through 15-18 in the CalSim II Flows section of Appendix D), but these differences would occur over a range of flows (6,000 to 17,000 cfs) that is not expected to substantially affect rearing habitat for juvenile CV Steelhead. Surrogate WUA for CV Steelhead rearing is reduced at higher flows but remains relatively stable between flows of 6,000 and 17,000 cfs (Figure_Late Fall-run Chinook WUA_Juv).

5.10.3.1.2.2 Water Temperature Effects

CV Steelhead need suitable rearing temperatures throughout the year. The USEPA-recommended 7DADM water temperature for juvenile salmonids in core rearing areas (upper reaches of natal rivers) is 61°F, although this is based on Pacific Northwest fish and hydrology and does not consider the feasibility of operating to 7DADM. Under WOA conditions, monthly mean water temperatures during May through October in the Sacramento River below Keswick Dam would range from about 53°F to 73°F, exceeding the 61°F threshold in 7 percent of years in May and 100 percent of years during June through September (Figures 5-1 through 5-6 in the HEC5Q Temperatures section of Appendix D). Water temperatures during these months would be even higher at downstream locations in the upper Sacramento River. For example, monthly mean temperatures at Bend Bridge are predicted to exceed 70°F in July in all years (Figure 5.10-3). These water temperatures would have sublethal and lethal effects on juvenile CV Steelhead throughout the upper Sacramento River, including reduced growth, delayed smoltification, desmoltification, and physiological stress which can lead to disease and increased predation mortality.

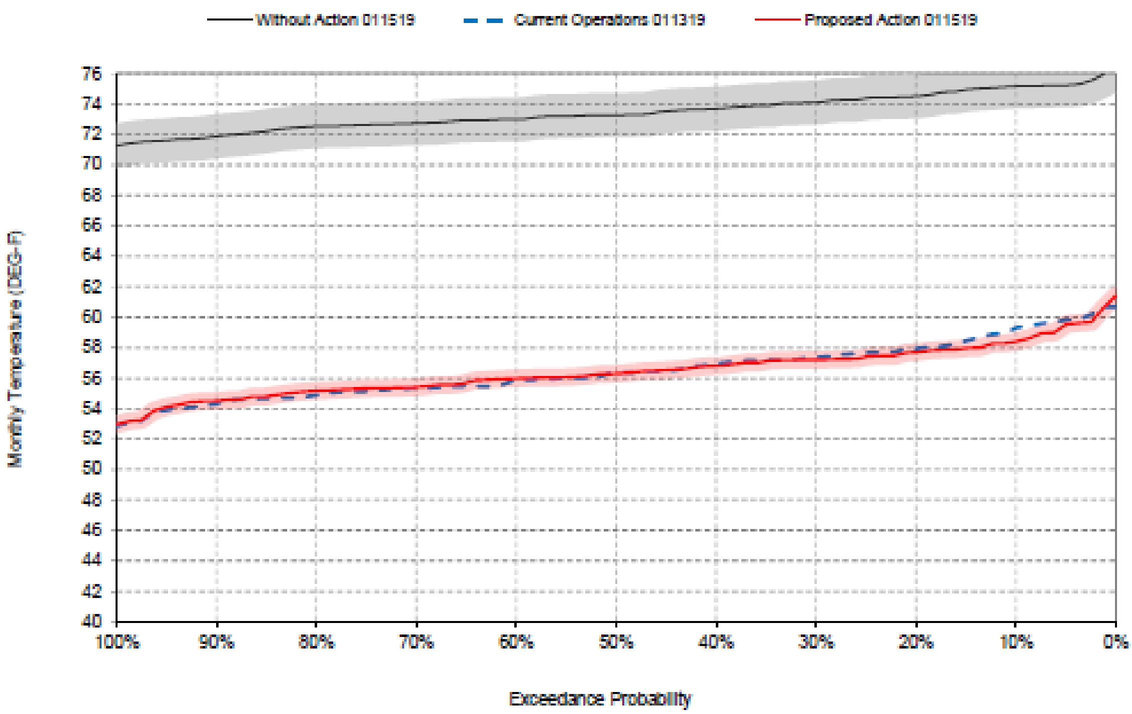


Figure 5.10-3. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the proposed action, WOA, COS, scenarios, July

Water temperatures under the proposed action would be substantially lower than those under the WOA scenario. Monthly mean water temperatures would range from about 46°F to 66°F, exceeding the 61°F threshold in less than 10% of the years in August, September and October. The proposed action would avoid or minimize exposure of juvenile CV Steelhead to sublethal and lethal temperatures, and maintain suitable water temperatures throughout their residence in the upper Sacramento River.

Under the proposed action, summer rearing conditions for juvenile CV Steelhead would be substantially improved relative to WOA conditions. Although Steelhead are adapted to low summer base flows that occurred naturally in their historical spawning and rearing habitat above impassable dams, existing populations in the upper Sacramento River and other tailwater reaches below mainstem dams are dependent on the higher, colder releases from these dams for maintenance of suitable summer rearing conditions.

5.10.3.1.3 Adult Migration from Ocean to Rivers

5.10.3.1.3.1 Flow Effects

Changes in flow potentially affect passage conditions for upstream migration of adults, including the creation of physical barriers and changes in water temperature, dissolved oxygen, and straying, stranding, and disease risk. Very low flows can affect passage by creating physical barriers or poor water quality conditions (e.g., high temperatures and/or low DO) that can block or delay adult migration. Flow thresholds for evaluating passage conditions and related problems for migrating CV Steelhead adults have not been determined for the Sacramento River. A threshold of 3,250 cfs is used in this analysis to evaluate the potential for adverse effects. Flows in the Sacramento River rarely drop below this level, and adults have not been observed experiencing migration difficulties at this flow. As such, it represents a conservative minimum flow above which fish do not experience migration difficulties.

Under WOA conditions, flows during the CV Steelhead immigration period (August through March) would generally be low until the first storm events increase flows in the fall or early winter. Under the WOA scenario, CALSIM modeling indicates that flows in the middle Sacramento River would be very low in August, especially in dry and critically dry years, resulting in poor passage conditions in most years (Figure 19-17 in the CalSim II Flows section of Appendix D). Based on a flow threshold of 3,250 cfs, flows providing suitable passage would occur about half the time in September and October, 90 percent of the time in November, and 100 percent of the time during January through March (Figures 19-12 through 19-18 in the CalSim II Flows section of Appendix D).

Under the proposed action, flows of 3,250 cfs or more would be maintained through the CV Steelhead immigration period in nearly all years (Figures 19-12 through 19-17 in the CalSim II Flows section of Appendix D). In contrast, suitable passage conditions under the WOA scenario would not occur until later in the fall, resulting in potential delays in migration and adverse impacts on migrating adults (e.g., increased exposure to high temperatures resulting in elevated pre-spawning mortality). In dry and critically dry years, suitable passage conditions may not occur until November. Consequently, the proposed action would have beneficial effects on adult CV Steelhead immigration relative to the WOA conditions.

5.10.3.1.3.2 Water Temperature Effects

The USEPA-recommended 7DADM water temperature for adult salmonids during their upstream migration is 68°F, although this is based on Pacific Northwest fish and hydrology and does not consider the operational feasibility of operating to 7DADM. Under WOA conditions, monthly mean water temperatures in the Sacramento River at Knights Landing in August and September would range from about 74°F to 83°F, creating a thermal barrier for upstream migration in all years (Figures 14-17 and 14-18 in the HEC5Q Temperatures section of Appendix D). Based on a threshold of 68°F, suitable water temperature for upstream migration would occur about 95 percent of the time in October, and 100 percent of the time during November through March (Figures 14-7 through 14-12 in the HEC5Q Temperatures section of Appendix D). Consequently, water temperatures under the WOA scenario would be too warm for CV Steelhead upstream migration through September, and suitable water temperatures for upstream migration would be delayed until October or November. In combination with higher flows, the proposed action would be expected to improve immigration conditions for adult CV Steelhead during the early immigration period (August through October) relative to WOA conditions.

5.10.3.1.4 Adult Holding

5.10.3.1.4.1 Flow Effects

Changes in flow potentially affect conditions for holding CV Steelhead adults, including availability of holding habitat (e.g., pools), access to cover, and suitable water temperatures prior to spawning. Flow thresholds for evaluating holding conditions for CV Steelhead adults have not been determined for the Sacramento River. In general, higher flows are likely to benefit holding adults by providing better water quality (including cooler water temperatures and higher DO), reduced exposure to pathogens, and lower risk to anglers or poachers (Windell et al. 2017).

Under WOA conditions, flows during the CV Steelhead holding period (September through November) would generally be low until the first storm events increase flows in the fall or early winter. Under the WOA scenario, CALSIM modeling indicates that median flows in the upper Sacramento River would be 3,350 cfs in September, 3,700 cfs in October, and 4,800 cfs in November. Under the proposed action, flows in the upper Sacramento River in September and October would be substantially higher than those under the WOA scenario in most years (Figures 15-6 and 15-18 in the CalSim II Flows section of Appendix D). Consequently, the proposed action would likely improve holding conditions for adult CV Steelhead relative to WOA conditions, especially in dry and critically dry years.

5.10.3.1.4.2 Water Temperature Effects

The USEPA-recommended 7DADM water temperature for holding adults is 61°F, although this is based on Pacific Northwest fish and hydrology and does not consider the operational feasibility of operating to 7DADM. Under WOA conditions, monthly mean water temperatures in the Sacramento River below Keswick Dam would consistently exceed the 61°F threshold in September (Figure 15-18 in the CalSim II Flows section of Appendix D). Declining water temperatures beginning in September would result in suitable holding temperatures in the upper Sacramento River in October and November (Figures 15-7 and 15-8 in the CalSim II Flows section of Appendix D).

Under the proposed action, water temperatures exceeding the 61°F threshold in the Sacramento River below Keswick Dam during the CV Steelhead holding period would occur about 5 percent of the time in September and October (Figures 15-6 and 15-18 in the CalSim II Flows section of Appendix D). Compared to the COS, water temperatures under the proposed action would be up to 4°F higher in some years in August and September and up to 4°F lower in most years in October, but these differences would be limited to years in which water temperatures are well below the 61°F threshold. Compared to the WOA scenario, the proposed action would substantially improve water temperatures for adult Steelhead during their holding period in the upper Sacramento River. The benefits would occur primarily in September when Keswick Dam releases would consistently be 12°F to 13°F cooler in most years. In combination with higher flows, lower water temperatures under the proposed action would have beneficial effects on holding adults relative to WOA conditions.

5.10.3.2 Whiskeytown Reservoir Operations and Clear Creek Flows

5.10.3.2.1 Eggs to Fry Emergence

Under the proposed action, eggs and emerging fry in Clear Creek are not anticipated to be impacted as they would not be exposed to the effects of Whiskeytown water temperature controls in Clear Creek based on the timing of these controls (60°F at IGO gage June 1-September 15; 56°F at IGO gage September 15-October 31), and the seasonal occurrence of this life stage in Clear Creek (December-April; Table 5.10-1).

Under the proposed action, eggs and emerging fry would be exposed to the effects of Clear Creek geomorphic flows, and potentially spring attraction flows based on the proposed timing of these releases (after January 1 for geomorphic flows; April-June for spring attraction flows [Clear Creek Technical Team 2018]), and the seasonal occurrence of this life stage in Clear Creek (December-April; Table 5.10-1). Potential effects of these flows include increased gravel scour which could displace incubating eggs from redds, resulting in exposure to increased predation, mechanical shock and abrasion, and increased water temperature if transported out of suitable incubation habitat. Geomorphic flows could also temporarily increase suspended solids and turbidity, causing sediment deposition in redds that can reduce hydraulic conductivity through the redd and result in reduced oxygen delivery to eggs, reduced flushing of metabolic waste, and entombment of alevins via a sediment "cap" that prevents or impedes emergence (Everest et al. 1987, Lisle et al. 1989).

Studies on Clear Creek have shown that the sediment transport threshold generally occurs between 3,000–3,500 cfs (McBain and Trush 2001, Pittman and Matthews 2004). Events of this magnitude occurred in 50 percent (26 of 52) of years since Whiskeytown Dam was constructed, while daily average flows > 3,000 cfs occur on 0.2 percent of days since WY 1965 (37 days total). Proposed geomorphic and attraction flows up to the safe release capacity (approximately 900 cfs) under the proposed action represent approximately 30 percent of the flow needed to transport sediment in the absence of flows from downstream tributaries. If geomorphic flows were to achieve their intended effect (gravel mobilization) there may be short-term adverse impacts to incubating Steelhead eggs via redd scour or sediment deposition. However, the total area and overall quality of egg incubation habitat would be increased post gravel mobilization.

5.10.3.2.2 Rearing to Outmigrating Juveniles

Rearing and outmigrating juveniles would be exposed to the effects of geomorphic and spring attraction flows given the likely timing of spring attraction flows (May-June [Clear Creek Technical Team 2018]), geomorphic flows (contemporaneous with peak storm flows after January 1), and the peak timing of this life stage in Clear Creek (year-round; Table 5.10-1). Under the proposed action, some rearing and outmigrating CV Steelhead juveniles would be exposed to the effects of Whiskeytown temperature controls in Clear Creek given the timing of these controls (June 1-September 15 & September 15-October 31), and the peak timing of this life stage in Clear Creek (year-round; Table 5.10-1).

5.10.3.3 Feather River Flows

The DWR proposes flows from Oroville Dam that would affect conditions downstream of the Oroville Complex FERC boundary. These downstream effects are discussed in this section.

5.10.3.3.1 Eggs to Fry Emergence

5.10.3.3.1.1 Flow Effects

Eggs and emerging fry of CV Steelhead would be exposed to the effects of Oroville Dam releases and resulting flows in the High Flow Channel (HFC) of the Feather River downstream of the Oroville Complex FERC boundary, based on the seasonal occurrence of this life stage in the Feather River (December-May; Table 5.10-1 & NMFS 2016), minimum instream flow requirements in the high flow channel of the Feather River (year-round requirements; Table 5-SHCV-1), and compliance with D-1641.

Table 5.10-2. Feather River High Flow Channel Minimum Instream Flow Requirements

Preceding April – July Unimpaired runoff (Percent of Normal)	High Flow Channel Minimum Instream Flow		
	OCT-FEB (cfs)	MAR (cfs)	APR-SEP (cfs)
55% or greater	1,700	1,700	1,000
Less than 55%	1,200	1,000	1,000

Under the WOA scenario, Oroville Dam would not be operated to control storage or flow releases and no conveyance of water to San Luis Reservoir via the Banks Pumping Plant would be made. Reservoir gates and diversion tunnels would be kept open, resulting in annual storage volumes less than 1,000 TAF (Figure 5.10-4). As a result, there would be limited control of flow or water temperature in the Feather River HFC, which provides habitat for this life stage. Feather River flows under the WOA scenario would approximate uncontrolled flows, with generally lower summer and fall flows and higher winter and spring flows compared to the proposed action and COS (Figures 5.10-5 and 5.10-6).

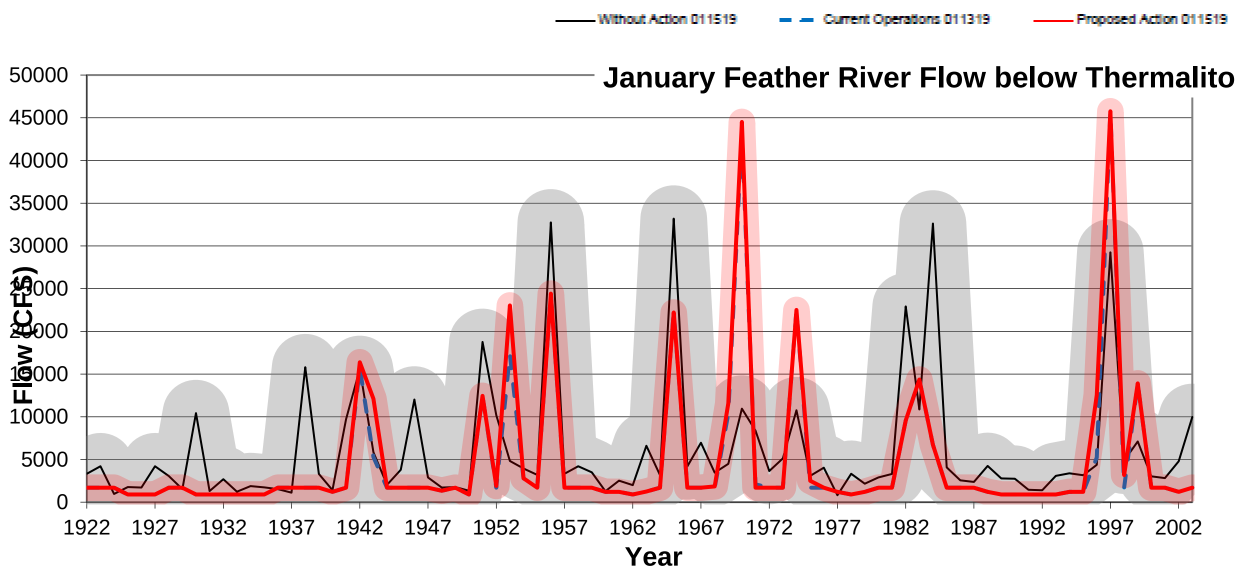


Figure 5.10-4. CalSim II estimates of mean Oroville storage (TAF) for the period 1923–2002 under WOA, COS, and proposed action.

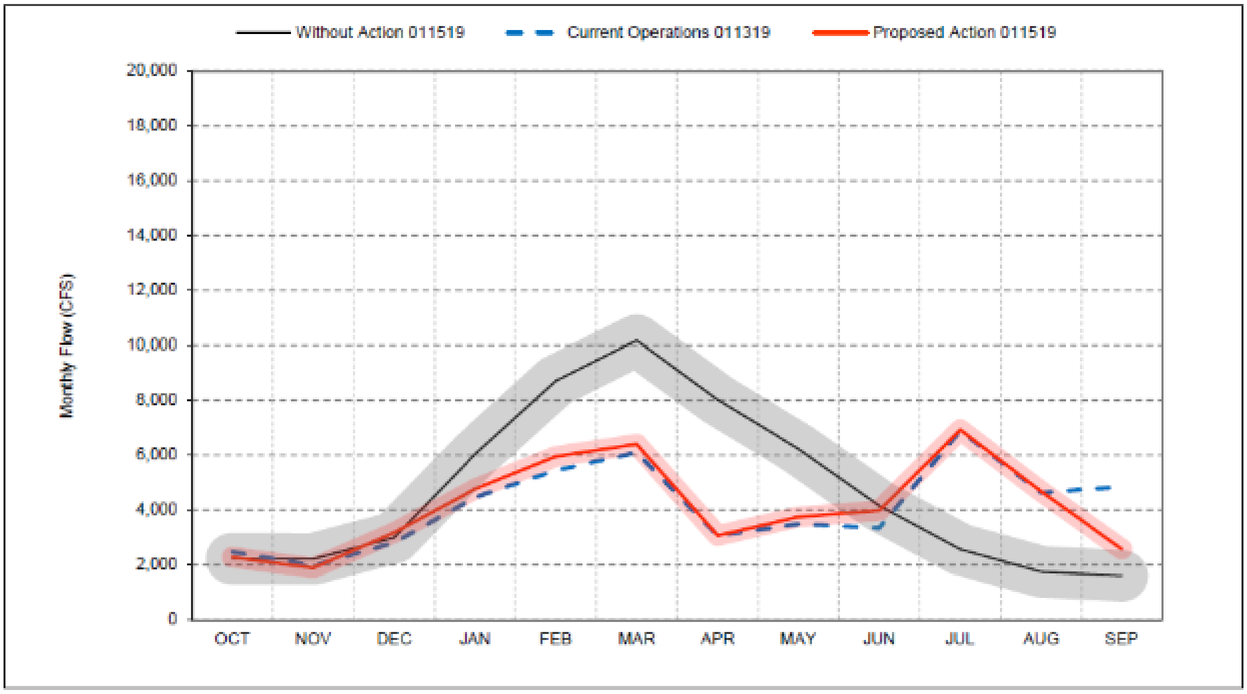


Figure 5.10-5. CalSim II estimates of Feather River long-term average flow below Thermalito Afterbay under the WOA, COS, and proposed action.

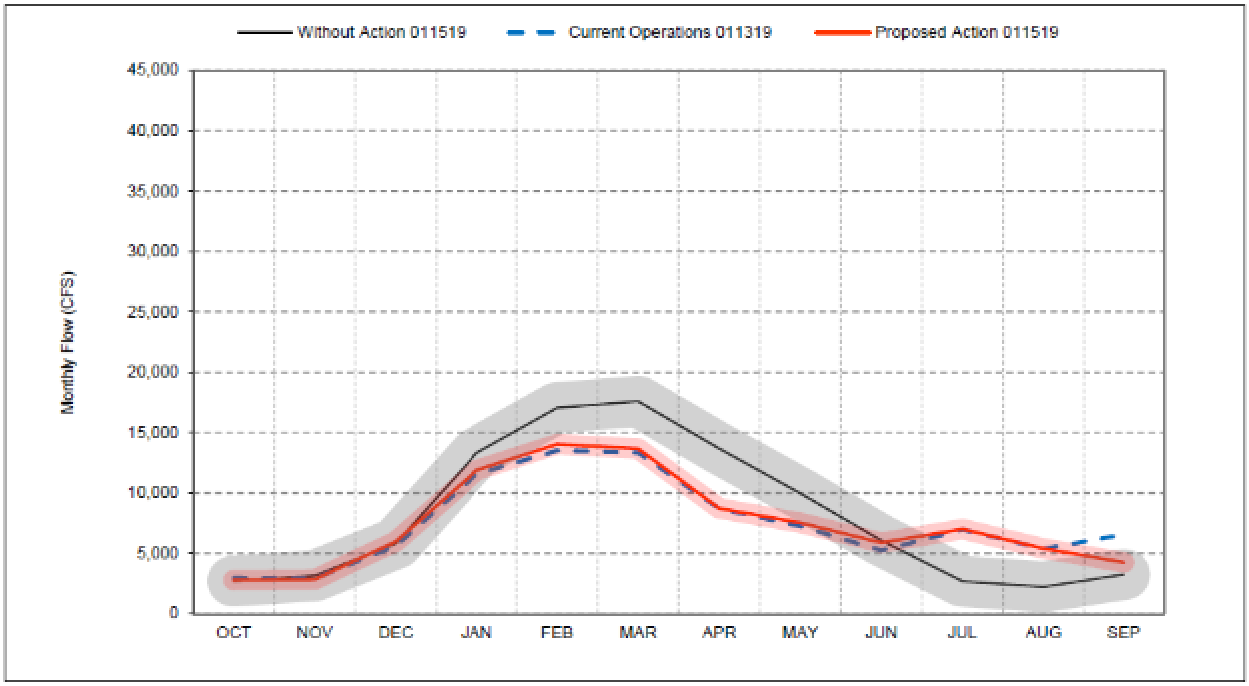


Figure 5.10-6. CalSim II estimates of Feather River mouth long-term average flow under the WOA, COS, and proposed action.

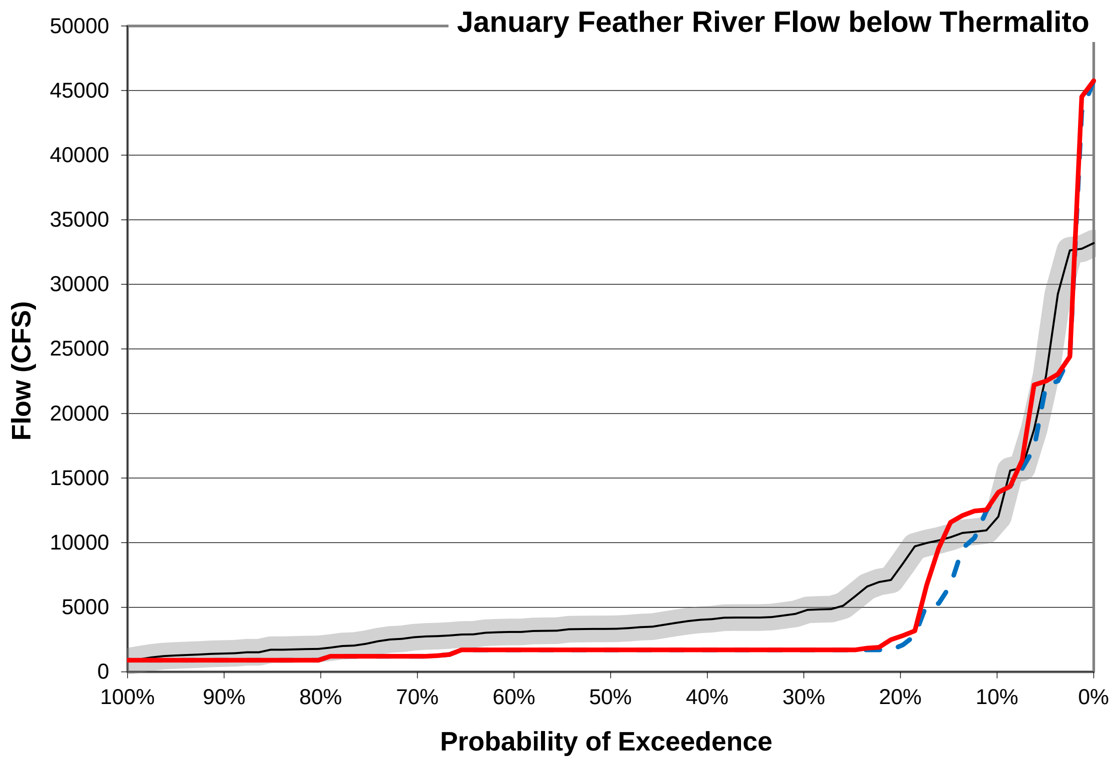


Figure 5.10-7. CalSim II estimates of Feather River flow below the Thermalito Afterbay in December-February under the WOA, COS, and proposed action.

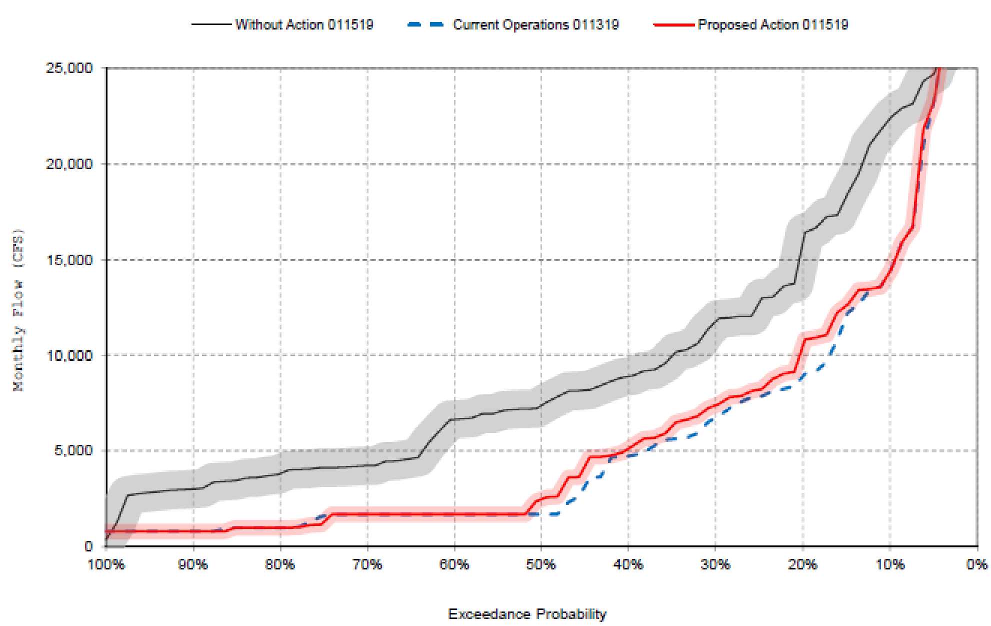


Figure 5.10-8. CalSim II estimates of Feather River flow below the Thermalito Afterbay in March, under the WOA, COS, and proposed action.

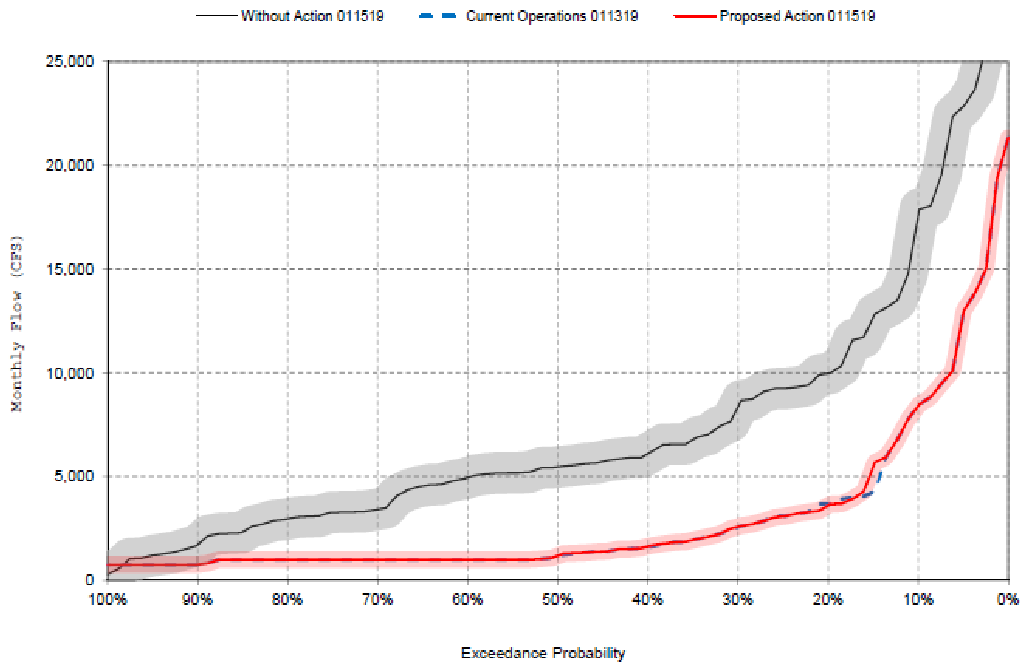


Figure 5.10-9. CalSim II estimates of Feather River flow below the Thermalito Afterbay in April under the WOA, COS, and proposed action.

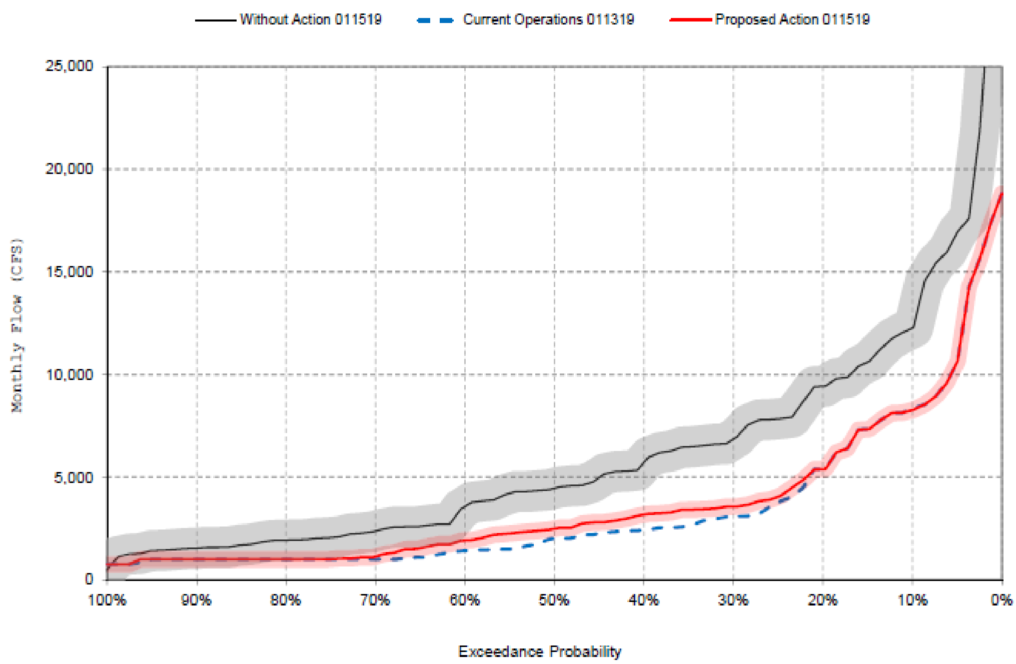


Figure 5.10-10. CalSim II estimates of Feather River flow below the Thermalito Afterbay in May under the WOA, COS, and proposed action.

Feather River flows below Thermalito Afterbay under the WOA are similar or substantially higher than flows under the proposed action during the peak seasonal timing of CV Steelhead egg incubation

(December-May) (Figures 5.10-7 through 5.10-10). Differences in flows between the proposed action and COS are minimal during the December to May period. Flows below the minimum threshold would have a number of negative effects on this life stage, including higher water temperatures, lower DO in redds, and potential for redd dewatering, all of which may lead to elevated egg mortality. Insufficient flow may also limit the extent of river bed available for redd construction, thereby limiting available habitat for this life stage. Conversely, the higher, uncontrolled flows projected to occur during this incubation and emergence period under the WOA could result in redd scouring.

Flows in the Feather River HFC under the proposed action and during the egg incubation period are lower than WOA flows, and in below normal, dry and critical water year types, proposed action flows are substantially lower than WOA flows during December-May (Figures 5.10-11 through 13). CalSim II model output indicates flows projected under the proposed action will likely meet the minimum instream flow criteria during in below normal, dry and critical water year types. In addition, proposed action flows are anticipated to result in reliably higher flows than the COS during the months of April and May, a critical period for CV Steelhead egg incubation. As a result, potential negative effects of low flows on this life stage are anticipated to be reduced under the proposed action compared to the COS. In addition, proposed action flows, although lower than WOA flows during this life stage, are projected to meet or exceed minimum instream flow requirements in the HFC while at the same time minimizing the potential negative effects of high flows.

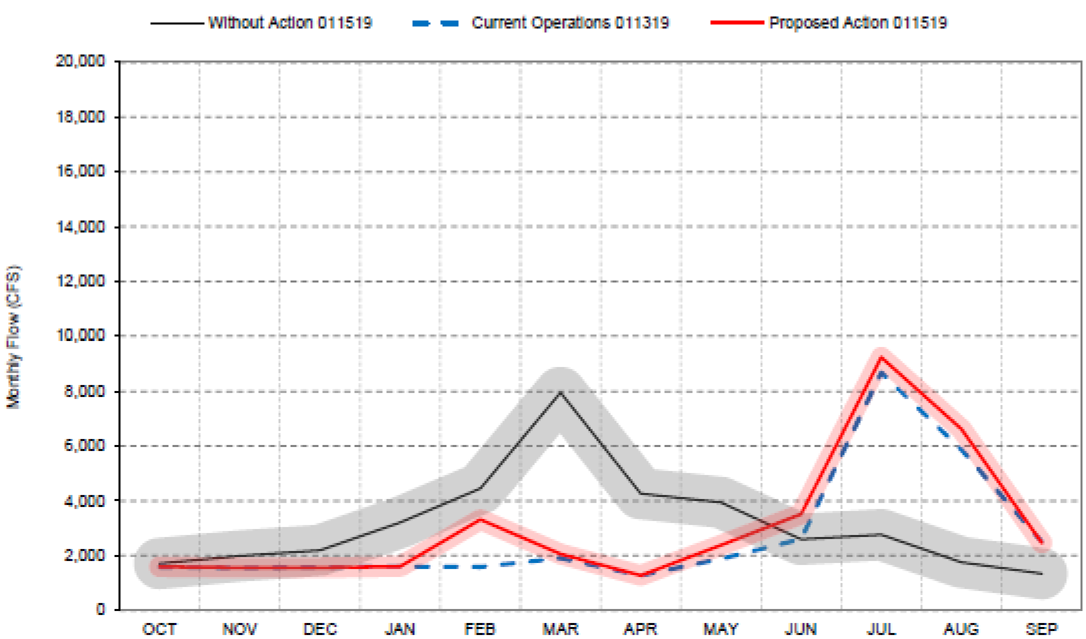


Figure 5.10-11. CalSim II Estimates of Feather River Flow below Thermalito Afterbay for below Normal Water Years under the WOA, COS, and Proposed Action

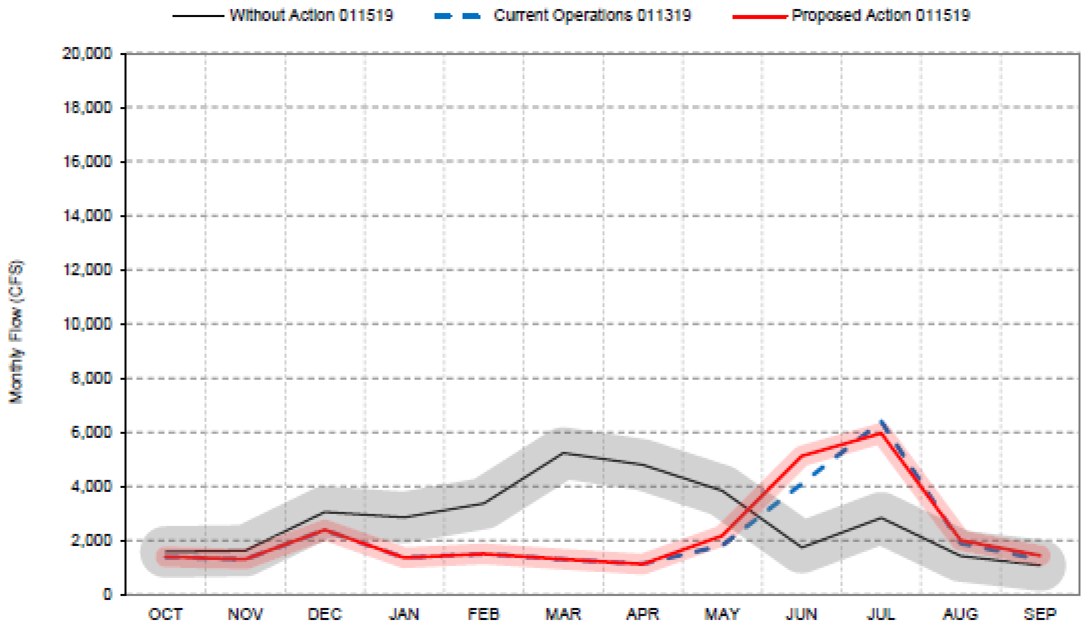


Figure 5.10-12. CalSim II Estimates of Feather River Flow below Thermalito Afterbay for Dry Water Years under the WOA, COS, and Proposed Action

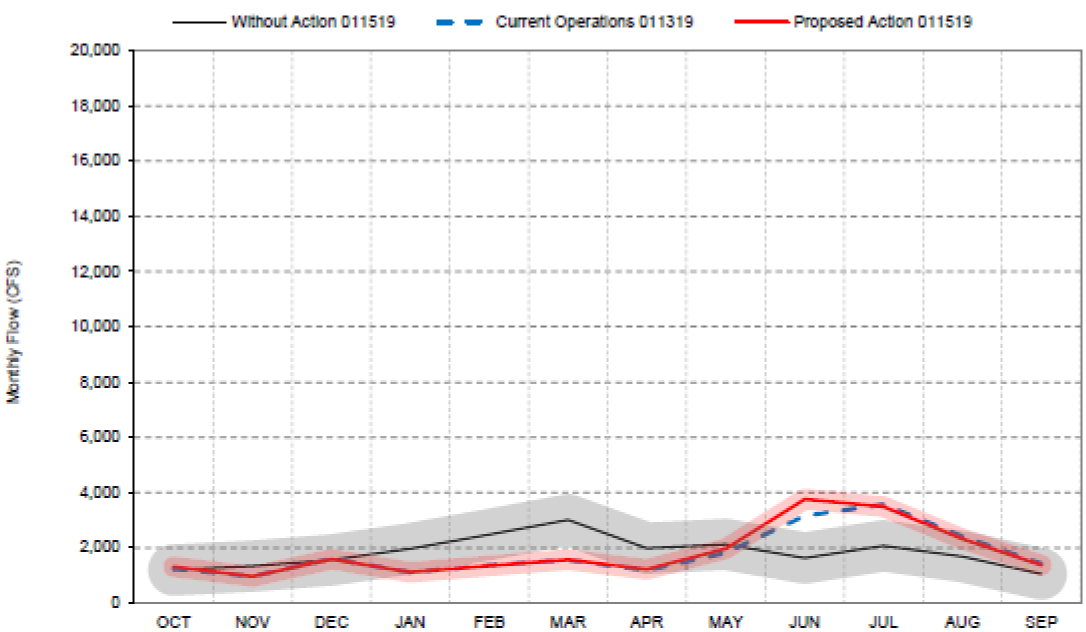


Figure 5.10-13. CalSim II Estimates of Feather River Flow below Thermalito Afterbay for critically Dry Water Years under the WOA, COS, and Proposed Action

5.10.3.3.1.2 Water Temperature Effects

Water temperatures, combined with other environmental drivers, have the potential to heavily influence condition and survival of CV Steelhead eggs. Exposure to the effects of elevated water temperatures include an inability to satisfy metabolic demand, and acute to chronic physiological stress, eventually leading to egg mortality (Stillwater Sciences 2006, Anderson 2017, Martin et al. 2017). CV Steelhead eggs require water temperatures 46-52°F for optimal development and survival, 52-55°F for suboptimal, with temperatures above 55°F causing chronic to acute stress (Stillwater Sciences 2006; U. S. Bureau of Reclamation 2008).

Under the WOA scenario, there would be limited control of flow or water temperature in the Feather River HFC where CV Steelhead egg incubation occurs. Resulting water temperatures under the WOA in the Feather River HFC at Gridley Bridge as modeled by the RecTemp temperature model are generally lower during the winter months, and higher during the summer and fall with peak annual water temperatures of approximately 78 °F occurring in July and August (Figure 5.10-14).

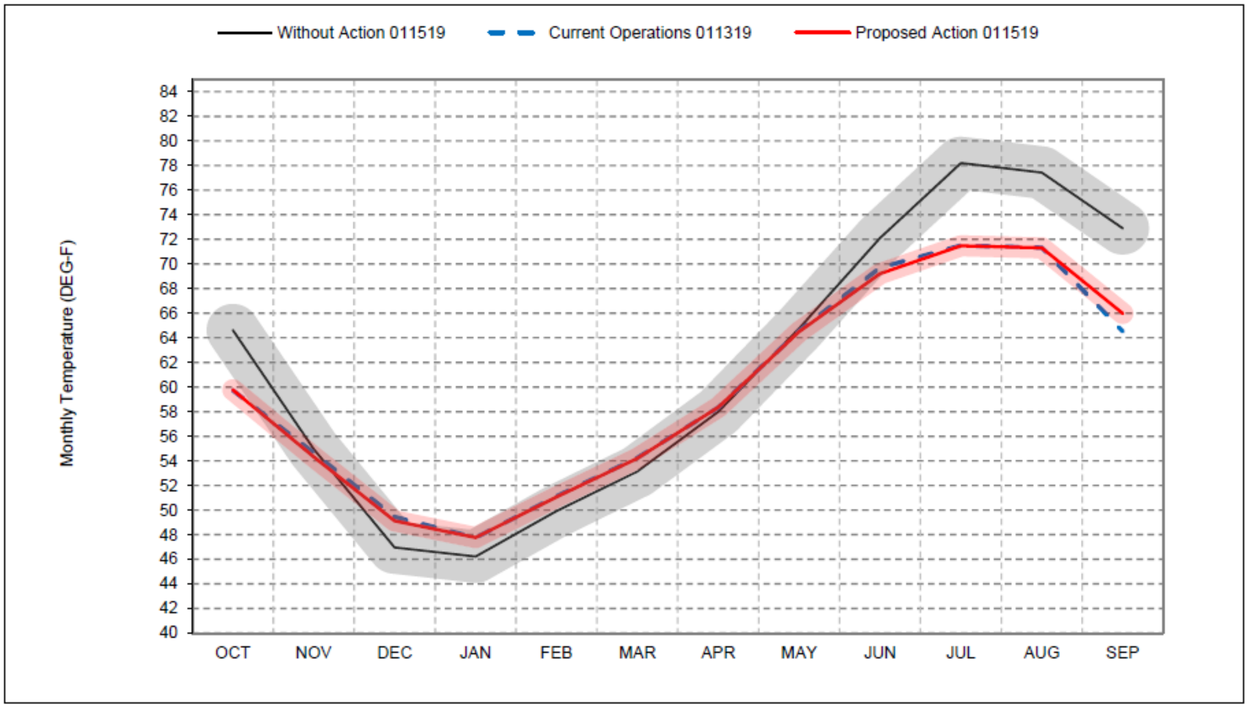


Figure 5.10-14. Long-term Average RecTemp Estimates of Feather River Water Temperature at Gridley Bridge under the WOA, COS, and Proposed Action

Under the proposed action, operations and flow releases would be managed to achieve Feather River HFC temperature objectives, resulting in water temperatures that are generally lower than those modeled under the WOA from June to October, and water temperatures that are roughly equivalent from November to May (Figure 5.10-14). Water temperatures at Gridley Bridge under the WOA scenario are slightly higher than the proposed action during April and May, which coincides with the later part of the seasonal timing of CV Steelhead egg incubation and are slightly lower during the months of December to March when the risk of temperature-related stress and mortality are substantially reduced (Figures 5.10-15 through 18). Under most conditions near or above the 55°F threshold, the proposed action scenario would decrease the likelihood of temperature-related stress and mortality occurring during the period of egg incubation. In addition, modeled water temperatures at Gridley Bridge under the proposed action indicate better likelihood of water temperature compliance at the compliance point (lower FERC project boundary).

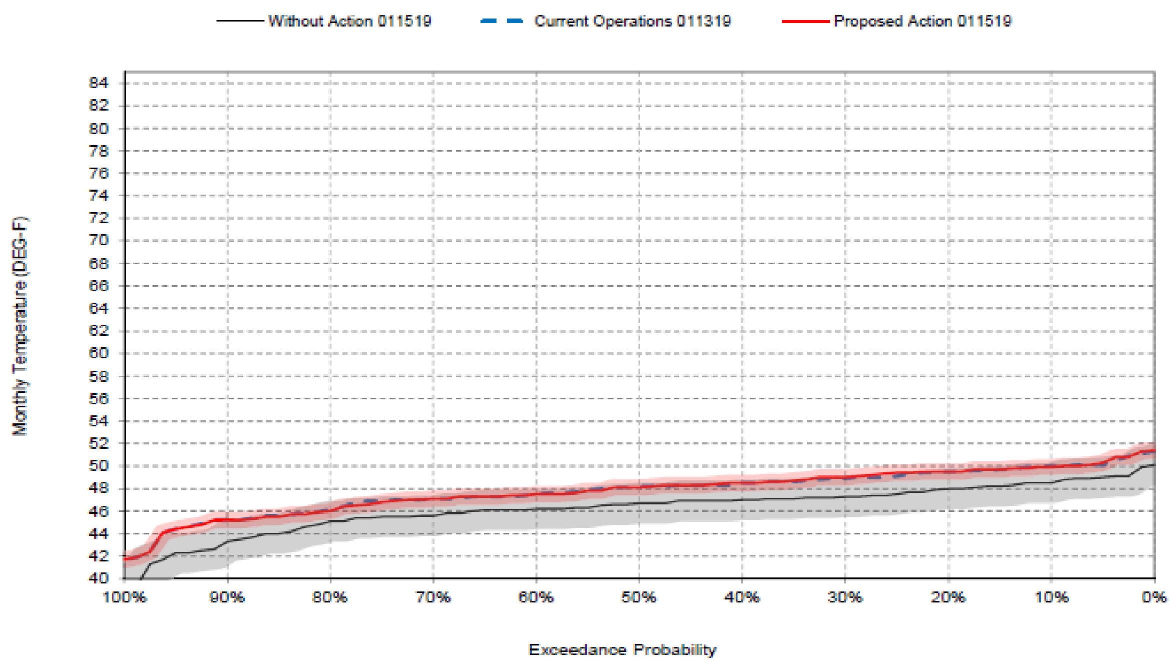


Figure 5.10-15. RecTemp Estimates of Feather River water Temperature at Gridley Bridge under the WOA, COS, and Proposed Action for January

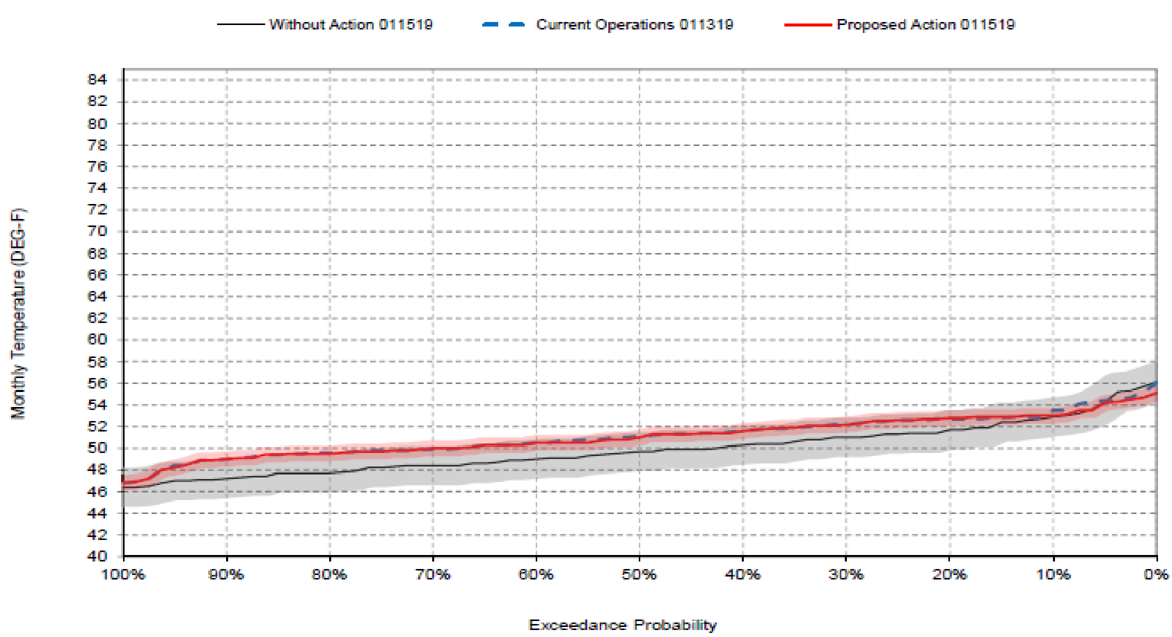


Figure 5.10-16. RecTemp Estimates of Feather River water Temperature at Gridley Bridge under the WOA, COS, and Proposed Action for February

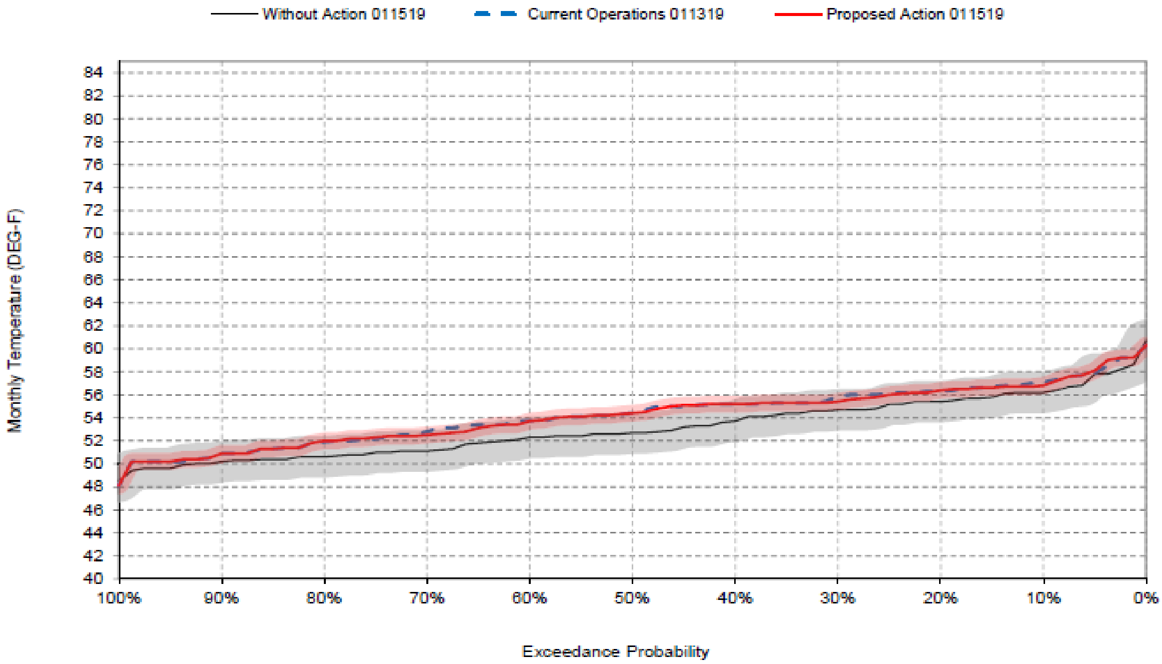


Figure 5.10-17. RecTemp Estimates of Feather River water Temperature at Gridley Bridge under the WOA, COS, and Proposed Action for March

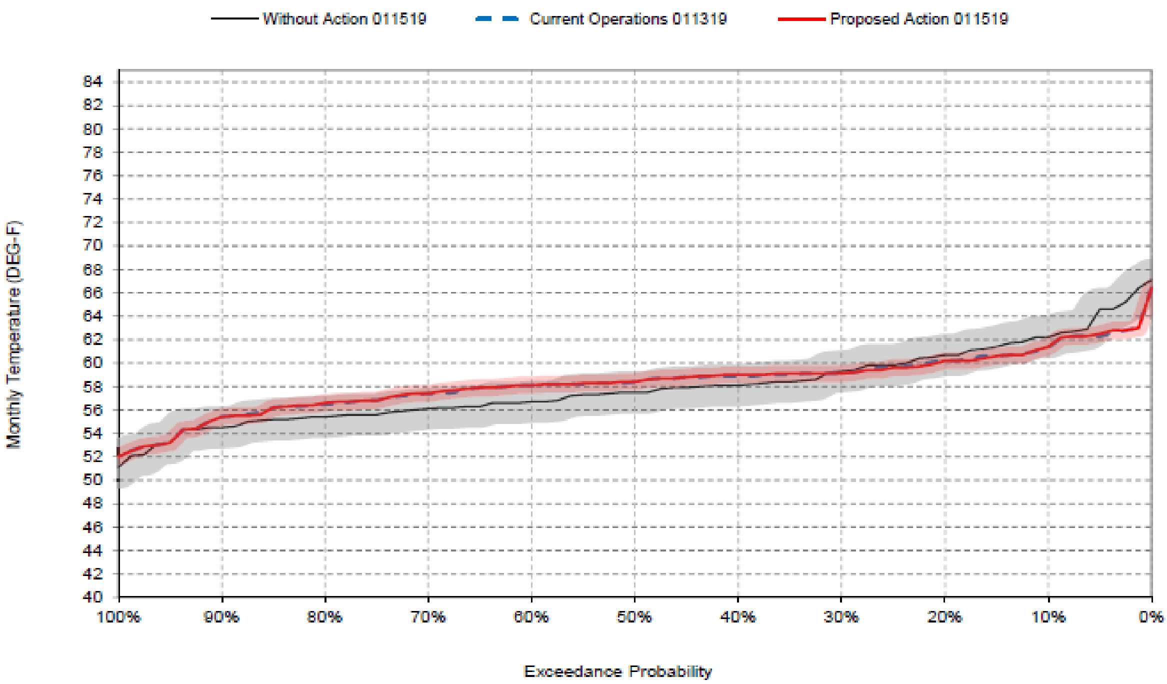


Figure 5.10-18. RecTemp Estimates of Feather River water Temperature at Gridley Bridge under the WOA, COS, and Proposed Action for April

Water temperatures exceeding the objectives and biological thresholds for this life stage of CV Steelhead would have a number of negative impacts on individuals, including acute to chronic physiological stress, potentially leading to egg mortality. Water temperatures in the Feather River HFC under the proposed action during the egg incubation period are similar to or lower than WOA water temperatures. Importantly, RecTemp model output indicates water temperatures projected under the proposed action will increase the likelihood that December to May temperature objectives are met. As a result, potential negative effects on this life stage are anticipated to be minimized under the proposed action.

5.10.3.3.2 Rearing to Outmigrating Juveniles

5.10.3.3.2.1 Flow Effects

Feather River flows below Thermalito Afterbay under the WOA generally approximate or are significantly higher than flows under the proposed action during the peak seasonal timing of CV Steelhead juvenile rearing (January-May; Figure 5.10-7 through 10). The likelihood of flows occurring that are less than the minimum instream flow requirements during these months is very low under all scenarios. Differences in flows between the proposed action and COS are less pronounced than differences between the proposed action and WOA during the January to May period, with relatively equal differences across the range of exceedance probabilities.

Lower proposed action flows in winter and spring could have both positive and negative effects on rearing juvenile CV Steelhead. Flows can modulate water temperature and DO concentration leading to changes in contaminant toxicity, pathogen virulence, food availability, bioenergetics and disease susceptibility. In addition, river stage and flow velocity may affect habitat connectivity, and availability which in turn may influence food availability, predation, crowding, entrainment and stranding risk, and can potentially affect cues that stimulate outmigration (Windell et al. 2017, Moyle 2002). These adverse effects of low flow are generally mitigated by flow increases, but there can be adverse effects of high flows including higher stranding risk resulting from increased use of floodplain habitat and greater flow fluctuations, and higher contaminant loading from stormwater runoff.

The differences in flows between the proposed action and WOA scenario are likely to suggest beneficial impacts to rearing individuals and their habitat. Lower proposed action flows from January to May could result in both positive and negative effects on rearing CV Steelhead. Impactss include a decrease in floodplain and side-channel habitat, reduced foraging conditions, increased competition and predation, higher water temperatures and higher DO, and reduced emigration flows. Beneficial effects are anticipated to be an reduced stranding risk resulting from reduced use of floodplain habitat and smaller flow fluctuations, and reduced contaminant loading from stormwater runoff. The comparative magnitude of positive and negative effects of lower flows under the proposed action compared to the WOA are difficult to quantify; however, potential adverse effects of lower flows from January to May are anticipated to be minimal since projected flows during this period remain well in excess of all applicable minimum instream flows for the Feather River HFC.

5.10.3.3.2.2 Water Temperature Effects

Water temperatures, combined with other environmental drivers, have the potential to heavily influence condition and survival of rearing individuals. Exposure to the effects of elevated water temperatures can include an increased susceptibility to disease, reduction in growth due to increased metabolic demands, decreased productivity, and eventual mortality. Rearing juvenile CV Steelhead require temperatures < 65°F for optimal development and survival, and 65-68°F for suboptimal, with temperatures above 68°F causing chronic to acute stress (Stillwater Sciences 2006). Water temperatures in the Feather River from

November to May are relatively less influenced by flow releases from Lake Oroville than in summer and fall, given the larger flow volumes, and colder air temperatures during these months.

Under the proposed action, operations and flow releases would be managed to achieve Feather River HFC temperature objectives, resulting in water temperatures that are generally lower than those modeled under the WOA from June to October, and water temperatures that are roughly equivalent from November to May (Figures 5.10-11 through 13). Water temperatures at Gridley Bridge under the proposed action are the same or higher than water temperatures under WOA from January to May, which coincides with the peak seasonal timing of rearing CV Steelhead. However, the risk of temperature-related stress and mortality are substantially reduced or not present during this period as water temperatures remain well within the optimal range (< 65°F) for this life stage and under the Feather River HFC temperature objectives for these months. Additionally, summer water temperatures under the proposed action are lower than the WOA during a period at moderate risk of water temperature-related stress and mortality, decreasing the likelihood of water temperature-related stress and mortality occurring during juvenile rearing under some conditions of the WOA. As a result, potential negative effects of water temperature objectives on this life stage are anticipated to be less severe under the proposed action, especially during below normal, dry, and critically dry water year types (Figure 5.10-14).

5.10.3.3.3 Adult Migration from Oceans to Rivers

5.10.3.3.3.1 Flow Effects

As indicated by the SAIL Bay-Delta to Upper River (CM6) conceptual model these flows, combined with other environmental drivers, affect water temperature, DO, stranding, outmigration cues and other habitat attributes that influence the timing, condition and survival of migrating adult CV Steelhead (Johnson et. al., 2016, Windell et. al., 2017). Instream flow from Oroville Dam releases may also heavily influence the strength of navigational cues utilized by migrating adults and the propensity of these fish to stray from migratory pathways leading to high quality spawning habitat.

Feather River flows below Thermalito Afterbay under the WOA generally approximate or are significantly lower than flows under the proposed action during the peak seasonal timing of CV Steelhead adult migration (September and October; Table 5.10-1 & NMFS 2016). The likelihood of flows occurring that are less than the minimum instream flow requirements during these months is low under all scenarios, although some risk exists under the WOA in September and October of critically dry years, when flows are lower under the WOA than the proposed action. (Figure 5.10-7 through 10).

Modeled flows under the proposed action during this period are higher than WOA flows, and are not anticipated to decline below minimum instream flow standards, or to a level that results in increased passage or barrier issues in the Feather River HFC. Lower WOA flows from September to October could result in both positive and negative effects on migrating adult CV Steelhead. Negative effects include a decrease in floodplain and side-channel habitat, increased competition and predation, higher water temperatures and lower DO, and diminished immigration flows. Positive effects are anticipated to be a reduced stranding risk resulting from reduced floodplain access. Because the proposed action produces only modest flow increases compared to the WOA, the proposed action is anticipated to result in the benefits listed above without dramatically increasing stranding risk.

5.10.3.3.3.2 Water Temperature Effects

Water temperatures, combined with other environmental drivers, have the potential to heavily influence condition and survival of migrating adults. Exposure to the effects of elevated water temperatures can include an increased susceptibility to disease, and physiological stress potentially leading to mortality and altered migration timing and speed. Migrating adult CV Steelhead require temperatures < 52°F for optimal survival, and 52-70°F for suboptimal, with temperatures above 70°F causing chronic to acute stress (Stillwater Sciences 2006).

Under the proposed action, operations and flow releases would be managed to achieve Feather River HFC temperature objectives, resulting in water temperatures that are generally lower than those modeled under the WOA from September to October, and water temperatures that are roughly equivalent from November to March. Water temperatures at Gridley Bridge under the proposed action are substantially lower than temperatures under the WOA from September to October, which coincides with the peak seasonal timing of migrating adult CV Steelhead. The risk of water temperature-related stress and mortality are present during this period as water temperatures are projected to be in or near the suboptimal range (52-70°F) for this life stage in October and potentially above the chronic to acute stress threshold (> 70°F) under the WOA in September (Figure 5.10-14). Water temperatures under the proposed action are slightly higher than the WOA during November to March, a period at a moderate risk of water temperature-related stress and mortality, according to RecTemp model results. As a result, potential adverse effects of water temperature objectives on this life stage are anticipated to be reduced under the proposed action, especially during below normal, dry, and critically dry water year types (Figure 5-SHCV-6).

5.10.3.3.4 Adult Holding

5.10.3.3.4.1 Flow Effects

Feather River flows below Thermalito Afterbay under the WOA equal or exceed flows under the proposed action during the peak seasonal timing of CV Steelhead holding (December-March; Table 5.10-1 & NMFS 2016). In particular, WOA flows are reliably higher than the proposed action in January through March. The likelihood of flows occurring that are less than the minimum instream flow requirements during these months is very low under all scenarios, and all water year types. Differences in flows between the proposed action and COS are minimal during the December to March period.

Exposure to the effects of differences in flow during this life stage could include variation in water temperature and DO, and the amount and quality of holding habitat used to shelter from predators, and rest during the gamete maturation phase. Proposed action flows are lower than WOA flows in January through March; however, proposed action flows are not anticipated to decline below minimum instream flow standards or to a level that is anticipated to result in substantial loss of suitable holding habitat in the Feather River HFC. As a result, conditions for holding adult CV Steelhead will be minimally impacted during the majority of the peak seasonal timing of this life stage.

5.10.3.3.4.2 Water Temperature Effects

Water temperatures, combined with other environmental drivers, have the potential to heavily influence condition and survival of holding adults. Exposure to the effects of elevated water temperatures can include an increased susceptibility to disease, and physiological stress potentially leading to mortality and delayed or poor gamete maturation. Holding adult CV Steelhead require water temperatures < 52°F for optimal survival, and 52-70°F for suboptimal, with temperatures above 70°F causing chronic to acute stress (Stillwater Sciences 2006).

Water temperatures under the WOA in the Feather River HFC at Gridley Bridge as modeled by the RecTemp temperature model are slightly lower than those projected under the proposed action during

December to March (Figure 5-SHCV-4). Under the proposed action, water temperatures are slightly higher but within the optimal range during the peak seasonal timing of holding adult CV Steelhead. The risk of temperature-related stress and mortality is negligible during this period, as water temperatures are projected to be at or near the suboptimal range (<60.8-66.2°F) for this life stage only during March, the end of the peak seasonal timing of holding adult CV Steelhead. As a result, potential negative effects of water temperature on this life stage are not anticipated under the proposed action, even during below normal, dry, and critically dry water year types (Figure 5.10-11 through 13).

5.10.3.4 American River Seasonal Operations

5.10.3.4.1 <u>Eggs to Fry Emergence</u>

Under the proposed action, Reclamation proposes to adopt the minimum flow schedule and approach proposed by the Water Forum in the 2017 Flow Management Standard (FMS). Under the WOA, the 2017 FMS would not be implemented. The 2017 FMS includes a Minimum Release Requirement (MRR) with flows that range from 500 to 2000 cfs based on time of year and annual hydrology. The objective of the planning minimum is to preserve storage to protect against future drought conditions, and to facilitate the development of the cold water pool when possible to improve habitat conditions for CV Steelhead and Fall-run Chinook Salmon.

Cool water temperatures are important for embryo survival. Water temperatures reportedly must be between 41°F and 55.4°F for maximum survival (Moyle 2002). In addition, redd dewatering protective adjustments were included in the 2017 FMS to limit potential redd dewatering due to reductions in the MRR during the January through May period coincident with the embryo incubation period. The embryo incubation and alevin development period for CV Steelhead follows the December through April spawning period. Eggs usually hatch within four weeks, depending on stream temperature, and the yolk sac fry remain in the gravel after hatching for another four to six weeks (CDFG 1996). Under the proposed action, the implementation of the proposed 2017 FMS measures would provide habitat conditions in the lower American River tailored for salmonids, particularly during drought conditions and improve conditions for this life stage relative to WOA.

5.10.3.4.2 <u>Rearing to Outmigrating Juveniles</u>

Under the proposed action, the planning minimum would preserve storage when compared to WOA and COS. In addition to the MRR flows, the 2017 FMS under the proposed action includes the following water temperature objectives to provide suitable water temperatures for salmonids:

- 65°F from mid-May to mid-October to provide suitable conditions for juvenile CV Steelhead rearing in the lower American River
- 60°F or less by October 1 to provide suitable conditions for Fall-run Chinook Salmon holding and early spawning (also benefits CV Steelhead)
- 56°F or less by November 1 to provide suitable conditions for Fall-run Chinook Salmon spawning and embryo incubation (also benefits CV Steelhead)

The 2017 FMS also includes the provision for spring pulse flows, with the purpose to provide a juvenile salmonid emigration cue before potentially lower flow conditions and associated unsuitable thermal conditions later in the spring in the river, and downstream in the lower Sacramento River.

The implementation of the proposed 2017 FMS measures under the proposed action would provide suitable habitat conditions in the lower American River for CV Steelhead, particularly during drought conditions and improve conditions for this life stage. The proposed action would likely beneficially affect this life stage of CV Steelhead in the American River when compared to the WOA and COS scenarios.

5.10.3.5 Delta Seasonal Operations

5.10.3.5.1 Entrainment

ICF (2018) analyzed salvage of CV Steelhead at the CVP and SWP between 2003 and 2017 and found that salvage increased with export rate and decreased with San Joaquin River flow. Salvage also decreased with OMR flow. However, OMR is a comprised of both exports and San Joaquin River flow which complicates attempts to understand individual effects.

Average total exports for months when juvenile CV Steelhead are present in the Delta indicate zero entrainment risk under the WOA. In the December through February period, proposed action proposes an average total export rate slightly higher than COS (366 cfs; Figure H1 – Appendix H – Bay-Delta Aquatics Effects Figures) and will therefore have a similar entrainment risk. Total exports proposed for proposed action in March-June (1,699 cfs higher than COS; Figure H2 – Appendix H – Bay-Delta Aquatics Effects Figures) when juvenile CV Steelhead are most abundant in the Delta at Chipps Island (Table 5.10-1), will increase entrainment risk relative to COS.

5.10.3.5.2 Routing

Routing of juvenile CV Steelhead into alternative migration routes is closely related to hydrodynamics (Perry et al. 2015; Cavallo et al. 2015; Steel et al. 2012). Changes to hydrodynamics in Delta channels resulting from the proposed action were evaluated using DSM2. Juvenile CV Steelhead are present in the Sacramento River at Hood upstream of the first distributary junctions between November and early June with peak abundance from February to early June (Table 5.10-1). In the December through February period, velocity overlap between proposed action and COS in the Sacramento River main stem between the Sutter-Steamboat and DCC/Georgiana Slough Junctions, was >50% in all water year types (Figure H-3 – Appendix H – Bay-Delta Aquatics Effects Figures).

Comparing proposed action to WOA in the December-February period revealed velocity overlap <50% in Dry, Above Normal and Wet years and <60% in Critical and Below Normal years (Figure H4 – Appendix H – Bay-Delta Aquatics Effects Figures) with higher velocities in the WOA in all water year types. This pattern indicates routing into the interior Delta would be lower under WOA relative to proposed action or COS (Perry et al. 2015). In the March to May period Comparison of the proposed action and COS revealed similar patterns of velocity overlap as described for the December-February period (Figure H5 – Appendix H – Bay-Delta Aquatics Effects Figures) indicating routing into the interior Delta would be lower under the proposed action during March-May. Comparing the proposed action with the WOA in March-May revealed low overlap in Sacramento River mainstem velocities between the Steamboat-Sutter Junction and the DCC-Georgiana Slough junction (Figure H6 – Appendix H – Bay-Delta Aquatics Effects Figures).

5.10.3.5.3 Through Delta Survival

A recent study by Perry et al. (2018) found that the effect of flow on survival is not uniform throughout the Delta. Relationships between flow and survival were significant only in reaches where flow changes from bi-directional to unidirectional when discharge increases. To examine potential effects of the proposed action, changes in velocity distributions were examined assuming a positive correlation between discharge and mean water column velocity for the Sacramento River at Walnut Grove and Steamboat Slough, which are both in this “transitional” region. During the December-February period at Walnut

Grove, velocity distributions for proposed action relative to COS were most different in Wet Years (70.9%) with higher velocities in the proposed action. Velocities were also greater for proposed action relative to COS in Dry, Below Normal and Above Normal years although overlap was greater (≥79.6%; Figure H11 – Appendix H – Bay-Delta Aquatics Effects Figures). In Critical Years, velocity distributions were almost identical (95.4%; Figure H11 – Appendix H – Bay-Delta Aquatics Effects Figures). A similar pattern was apparent for the comparison between proposed action and WOA (Figure H12 – Appendix H – Bay-Delta Aquatics Effects Figures); however, overlap was lower for each water year type (37.3 – 68.3%) with higher velocities under WOA relative to proposed action. At Steamboat Slough in the December-February period, there was a similar pattern where velocities under the proposed action were higher than COS in Wet, Above Normal and Below Normal years and similar in Dry and Critical years (Figure H13 – Appendix H – Bay-Delta Aquatics Effects Figures).

When the proposed action was compared to WOA, overlap was moderate to high with values between 42.6% and 72.6% (Figure X14 – Appendix H – Bay-Delta Aquatics Effects Figures). Velocities were higher under the WOA in all water year types (Figure H14 – Appendix H – Bay-Delta Aquatics Effects Figures). Results of this analysis indicate that through delta survival between December-February would be higher under the proposed action relative to COS, but potentially reduced survival relative to WOA.

When comparting the proposed action to WOA in the March through May period, velocity overlap was variable among water year types from a low of 14.1 percent in Wet years to 56.9 percent in Critical years (Figure H16 – Appendix H – Bay-Delta Aquatics Effects Figures). In all water year types, velocities were less under the proposed action relative to the WOA. Velocity overlap was lower in March through May at Steamboat Slough when proposed action was compared to WOA (Figure H18 – Appendix H – Bay-Delta Aquatics Effects Figures). The lowest value occurred in Wet years (19.1%) and highest in Critical years (69.5%). These results indicate that survival under the proposed action may be reduced due to lower water velocity compared to WOA assuming water velocity scales positively and linearly with discharge.

In the March through May period at Walnut Grove, velocity overlap between the proposed action and COS was ≥78.5 percent across all water year types with greater velocities under proposed action (Figure H15 – Appendix H – Bay-Delta Aquatics Effects Figures). At Steamboat Slough in the March through May period, overlap between the proposed action and COS scenarios was high with all values ≥82.2 percent (Figure H17 – Appendix H – Bay-Delta Aquatics Effects Figures). The small changes in velocity within transitional reaches of the Sacramento River and North Delta between the proposed action and COS suggest there could be small improvements associated with the proposed action in through Delta survival in some water year types. There would potentially be a reduction in survival under the proposed action when compared to the WOA.

5.10.3.6 Delta Cross Channel Operations

Under WOA, the Delta Cross Channel would be closed, and fish would not be entrained into the central Delta. Significant flow and many juvenile CV Steelhead enter the central Delta when the DCC gates are open. Mortality of juvenile CV Steelhead entering the central Delta is higher than for those continuing downstream in the Sacramento River. The peak migration of juvenile CV Steelhead in the Sacramento River past Knights Landing, which is upstream of the DCC, occurs from January-February (Table 5.10-1). Therefore under the proposed action, the continued operation of the DCC to protect the majority of the juvenile CV Steelhead during their migration period in the Sacramento River would reduce the proportion of fish exposed to an open DCC and result in beneficial impacts to this life stage when compared to the COS. Under WOA conditions, the DCC would remain closed, which is more protective of this life stage; however, DCC operations under the proposed action attempt to minimize the potentially negative effects compared to WOA by closing the DCC gates during peak migration periods.

5.10.3.7 Agricultural Barriers

The Temporary Barriers Project (TBP) consists of three rock barriers across south Delta channels to improve water levels for agricultural diversions and one rock barrier to improve San Joaquin River salmonid migration in the south Delta. The temporary rock barriers are installed and removed at Middle River near Victoria Canal, Old River near Tracy, Grant Line Canal near Tracy Boulevard Bridge, and the head of Old River. The TBP is operated based on San Joaquin River flow conditions. The agricultural barriers at Middle River and Old River near Tracy can begin operating as early as April 15 but the tide gates are tied open from May 16 to May 31. After May 31, the barriers in Middle River, Old River near Tracy, and Grant Line Canal are permitted to be operational until they are completely removed by November 30. The Head of Old River Barrier is only installed from September 16 to November 30 to improve flow and DO conditions in the San Joaquin River for the immigration of adult fall-run Chinook Salmon.

5.10.3.7.1 Rearing to Outmigrating Juveniles

The proportion of juvenile CV Steelhead exposed to the TBP depends on their annual timing of installation and removal. Due to their location, primarily juvenile CV Steelhead migrants originating from the San Joaquin River would be exposed to the TBP. The peak relative abundance of juvenile CV Steelhead in the San Joaquin River in the vicinity of the TBP (Mossdale) occurs in April and May (Table 5.10-1). If the agricultural barriers are operating as early as April 15, there is potential exposure to a large proportion of the juvenile CV Steelhead migrating down the San Joaquin River.

When the Head of Old River barrier is not in place, acoustically tagged juvenile CV Steelhead have demonstrated a high probability of selecting the Old River route (Buchanan 2018[PC1]), which would expose them to the agricultural barriers. When the agricultural barriers are operating with tidal flap gates down, a significant decline in passage and reach survival of acoustically tagged juvenile CV Steelhead migrating past the barrier has been observed compared to when the barrier is not present (DWR 2018). When flap gates are tied up, CV Steelhead passage past the agricultural barrier was improved (DWR 2018). Therefore, although the proposed action does not include HORB, which could result in negative impacts to CV Steelhead juvenile migration, the improvements to the agricultural barriers (including flap gates tied up from May 16 to May 31) would help to reduce the negative effect of the barriers on migrating juvenile CV Steelhead during this period relative to COS. However, juvenile CV Steelhead migrating before or after this period could be exposed to the agricultural barriers with flaps down, which apparently decreases passage success and survival (DWR 2018). Therefore, the potential negative effects of the agricultural barriers under the proposed action on juvenile CV Steelhead depends on when they are installed and whether or not the flap gates are down.

5.10.3.8 Contra Costa Water District Rock Slough Intake

CCWD’s operations in the proposed action are consistent with the operational criteria specified in separate biological opinions and permits that govern operations at CCWD’s intakes and Los Vaqueros Reservoir (NMFS 1993; NMFS 2007; NMFS 2010; NMFS 2017; USFWS 1993a; USFWS 1993b; USFWS 2000; USFWS 2007; USFWS 2010; USFWS 2017; CDFG 1994; CDFG 2009). The subject of this consultation is the actual diversion of water through the Rock Slough Intake, covered under the NMFS 2009 biological opinion on the long-term coordinated operations of the CVP and SWP. However, since the 2009 biological opinion, the Rock Slough Fish Screen has been built, and entrainment of salmonids resulting from diverting water into the Rock Slough intake has been fully avoided. Adverse effects of fish screen operation are covered under the NMFS 2017 biological opinion.

The Contra Costa Canal Rock Slough Intake is located on a dead-end slough, far from the main migratory route for CV Steelhead (NMFS 2017), approximately 18 miles from the Sacramento River via the shortest route. Fish monitoring prior to the construction of the Rock Slough Fish Screen (RSFS) indicates the timing and magnitude of CV Steelhead presence near the Rock Slough Intake. Since 1994, fish monitoring has been conducted by CDFW and CCWD consistent with the separate biological opinions and permits that govern CCWD's operations. From 1994 through 1996, CDFW conducted fish monitoring at the Rock Slough Intake and in the Contra Costa Canal up to the first pumping plant. Over this period, CDFW captured a total of 36 juvenile CV Steelhead from February to May (CDFG 2002; NMFS 2017). In the 11 years prior to construction of the RSFS (1999-2009), CCWD's Fish Monitoring Program collected a total of 15 juvenile CV Steelhead at the Rock Slough Headwords (Reclamation 2016; NMFS 2017). In addition, one adult CV Steelhead (622 mm FL, adipose fin intact) was collected and released during fish rescue efforts in November 2009, for the construction of the RSFS (Reclamation 2016). Since construction of the RSFS, one ad-clipped CV Steelhead was collected at the RSFS facility (April 24, 2012) by operation of the hydraulic rake cleaning system (Reclamation 2016; Tenera 2018a). Based on the size, the CV Steelhead was likely a hatchery released smolt (Reclamation 2016, Appendix A).

On July 3, 2017, NMFS issued a biological opinion (NMFS 2017) that considered improvements to the RSFS facility including the hydraulic rake cleaning system, operations and maintenance (O&M) of the RSFS and associated appurtenances, and administrative actions such as the transfer of O&M activities from Reclamation to CCWD. NMFS determined that the O&M of RSFS may result in the incidental take of juvenile CV Steelhead and provided an incidental take limit based upon the number of listed fish collected in the pre and post-construction RSFS monitoring (NMFS 2017). The incidental take provided in NMFS 2017 is 10 juvenile and 10 adult CV Steelhead per year.

5.10.3.8.1 Rearing to Outmigrating Juveniles

Due to the location of the Rock Slough Intake near the end of a dead-end slough, far from the main migratory routes, juvenile CV Steelhead are not likely to be in the vicinity of the Rock Slough Intake. However, according to NMFS (2017), juvenile salmonids can be "drawn" into the south Delta under reverse flows and high CVP and SWP pumping rates. One indicator of reverse flows is the net flow in OMR. Rock Slough Intake is located on Rock Slough, approximately 3.5 miles west of the junction of Rock Slough and Old River, which is over 12 river miles north of the gates to the SWP Clifton Court Forebay. Given its location, the Rock Slough Intake does not affect OMR, and any effect that diversions at Rock Slough Intake under the proposed action would have in the OMR corridor would be to increase the northerly (positive) flow away from the Banks and Jones Pumping Plants. For juveniles that migrate down the Old and Middle River corridor that are not salvaged at TFCF or Skinner Fish Facility, any effect of Rock Slough Intake diversions would be a positive effect on OMR.

For juveniles that migrate down the mainstems of the Sacramento or San Joaquin Rivers and for juveniles that were salvaged, trucked, and released in the western Delta, the potential effect of Rock Slough diversions on the net reverse flow in San Joaquin River may be relevant. The effect of water diversions at Rock Slough Intake on the velocity in the San Joaquin River at Jersey Point is presented in the effects analysis for juvenile Winter-run. As detailed in that section, the maximum potential effect of water diversions at Rock Slough Intake (assuming diversions at the maximum permitted capacity of 350 cfs and all water diverted by the Rock Slough Intake comes from the San Joaquin River at Jersey Point) is 0.00625 ft/sec in the San Joaquin River at Jersey Point. For comparison, the velocity threshold for design of fish screens to prevent impingement of salmonids is 0.33 ft/sec, which is 50 times the maximum possible contribution from the Rock Slough diversions.

Recognizing that CCWD owns and operates two additional intakes in the south Delta, the combined effect of all three intakes was examined. CCWD's Old River Intake and Middle River Intake have a physical capacity of 250 cfs at each intake. If CCWD were to divert at all three intakes at the maximum capacity at the same time, total CCWD diversions would be 850 cfs. The corresponding effect on velocity in the San Joaquin River at Jersey Point would be 0.015 ft/sec. The velocity threshold used to protect salmonids from diversions in the vicinity of fish screens (0.33 ft/sec) is over 21 times greater than the maximum possible contribution from CCWD's combined physical capacity. The water diversions at the Rock Slough Intake when combined with diversions at CCWD's Old River Intake and Middle River Intake have a negligible effect on velocity along the migratory path for juvenile CV Steelhead.

Nonetheless, even extremely small changes in velocity can affect the movement of neutrally buoyant particles such as phytoplankton. As shown in the Winter-run section, the diversions at the Rock Slough Intake could move a neutrally buoyant particle in the San Joaquin River at Jersey Point approximately 540 ft over the course of the day. For comparison, the tidal excursion on the San Joaquin River at Jersey Point during a flood tide (i.e., the distance a particle will travel tidally upstream during a flood tide) is about 34,000 ft on average (or 6.4 miles), which is about 63 times the distance that diversions at Rock Slough could move a particle at the same location over the course of a full day. Therefore, the maximum possible contribution of diversions at Rock Slough on movement of neutrally buoyant particles such as phytoplankton is insignificant in comparison to the tidal excursion and mixing at this location. Although the diversions at Rock Slough Intake are not likely to impact juvenile CV Steelhead, the aggregate effect of all water diversions in the Delta, including exports at Jones and Banks Pumping Plants can affect channel velocity.

5.10.3.8.2 Adult Holding

Rock Slough is a relatively slow flowing, tidal waterway which ends at the Rock Slough Extension, approximately 1,700 feet upstream from the Rock Slough Intake. Rock Slough is poor habitat with relatively high water temperature and a prevalence of aquatic weeds. Due to the location of the Rock Slough Intake near the end of a dead-end slough, far from the main migratory routes, and due to the poor quality of habitat within the slough, adult CV Steelhead are not likely to be in the vicinity of the Rock Slough Intake. However, if some adults stray into Rock Slough, the water exiting the Contra Costa Canal on ebb tide may create a false attraction to adult CV Steelhead that are migrating upstream (NMFS 2017).

NMFS has advised Reclamation that salmonids will likely be less attracted to the area near the intake if tides can be reduced (Reclamation 2016). As illustrated in NMFS 2017 (Figure 10), water diversions at the Rock Slough Intake reduce the ebb tidal flows through the RSFS. Thus, the diversion of water at the Rock Slough Intake under the proposed action, which is the subject of this consultation, reduces the false attraction created by the ebb tides existing the Contra Costa Canal. Furthermore, it is worth noting that the ebb tidal flow in Rock Slough will be substantially reduced when the Contra Costa Canal is encased in a pipeline. This ongoing, multi-phased project (the Canal Replacement Project) is being conducted as a separate action by CCWD and has undergone separate environmental review. Completion of the Canal Replacement Project will result in tidal flows being significantly reduced at the Rock Slough Intake. Modeling of the area indicates that with only the first two phases complete, ebb flows reach up to 160 cfs, but with the Contra Costa Canal fully encased, ebb flows would be greatly muted to about 10 cfs. Although the likelihood that adult CV Steelhead will be present near the Rock Slough Intake is low, a small number of fish could stray into Rock Slough, or be attracted by the flows exiting the Contra Costa Canal on ebb tides.

5.10.3.9 North Bay Aqueduct

Under the proposed action, there would be no changes to operational criteria at the NBA's BSPP relative to current operations and WOA. Juvenile CV Steelhead could occur in the vicinity of the BSPP; however, the fish screens used at the facility are designed to protect juvenile salmonids per NMFS criteria and should prevent entrainment and greatly minimize impingement of fish against the screen itself (NMFS 2009). In addition, the location of the facility is well off the typical migration corridor of juvenile CV Steelhead (NMFS 2009: 417). No juvenile CV Steelhead have been captured during CDFW monitoring surveys from 1996 to 2004 (http://www.delta.dfg.ca.goc/data/nba).

5.10.3.10 Water Transfers

CV Steelhead juveniles could be exposed to increased entrainment, predation, and decreased through-Delta survival as a result of the expanded transfer window under the proposed action, but as the peak of the juvenile outmigration is in the spring, effects are anticipated to be minimal. No other lifestages of CV Steelhead would co-occur in time and space with water transfers from the Delta.

5.10.3.11 Clifton Court Forebay Aquatic Weed Program

Under the proposed action, the application of aquatic herbicide to the waters of CCF will occur during the summer months of July and August. Juvenile CV Steelhead abundance in the Delta peaks between March and May (Table 5.10-1). Based on typical water temperatures in the vicinity of the salvage facilities during this period, the water temperatures would be incompatible with salmonid life history preferences, generally exceeding 70°F by mid-June. As such, it is unlikely that juvenile CV Steelhead would be rearing near this location after mid-June and the potential application of aquatic herbicide would only occur well after the peak outmigration period (Table 5.10-1) and therefore CV Steelhead are not expected to be exposed to herbicide application activities.

Mechanical harvesting would occur on an as-needed basis and therefore listed salmonids could be exposed to this action, if entrained into the CCF. Potential direct and indirect effects to listed fish species from mechanical weed harvesters include mortality or injury from harvester strikes, entanglement in weeds lifted from the water, reduction of aquatic prey species, and temporary disturbances. Increased boat noise and disturbance of the water during harvesting, the slow speed of the harvester (approximately 2 miles per hour), and beginning harvesting closest to the edge should allow fish to escape the area proposed for mowing. However, CV Steelhead are unlikely to be present and exposed to the adverse effects due to extreme temperatures.

5.10.3.12 Suisun Marsh Salinity Control Gates

Operation of the SMSCG from October through May under the proposed action coincides with downstream migration of juvenile CV Steelhead (Table 5.10-1). Montezuma Slough provides an alternative route to their primary migration corridor through Suisun Bay. No data are available to estimate the abundance of juvenile CV Steelhead thus, the proportion of the total run utilizing this route is unknown. However NMFS (2009) determined that operation of the SWSCG is unlikely to impede migration of juvenile salmonids or produce conditions that support unusually high numbers of predators.

5.10.3.12.1 Roaring River Distribution System

Under the proposed action, the Roaring River Distribution System water diversion intake is equipped with fish screens (3/32-inch opening, or 2.4 mm) operated to maintain screen approach velocity of 0.2 ft/s from mid-September to mid-October (for Delta Smelt protection) or 0.7 ft/s, excluding juvenile CV Steelhead from entrainment (NMFS 2009: 437).

5.10.3.12.2 <u>Morrow Island Distribution System</u>

The MIDS diverts water from Goodyear Slough through three 48-inch diameter culverts during high tide. Although the MIDS intakes do not currently have fish screens, it is unlikely juvenile CV Steelhead will be entrained into the water distribution system because CV Steelhead have not been caught in past surveys. Also, the large size and better swimming ability of juvenile listed salmonids in the Delta allow these fish to avoid entrainment at MIDS. In addition, the location of the MIDS intake on Goodyear Slough further reduces the risk of entrainment. Goodyear Slough is not a migratory corridor for CV Steelhead. The operation of the MIDS under the proposed action would not impact CV Steelhead.

5.10.3.12.3 <u>Goodyear Slough Outfall</u>

Goodyear Slough Outfall improves water circulation in the Suisun Marsh. This structure consists of four 48-inch diameter culverts with flap gates designed to drain water from the southern end of Goodyear Slough into Suisun Bay. On flood tides, the gates reduce the amount of tidal inflow into Goodyear Slough. Due to its location and design, CV Steelhead are not likely to encounter this structure or be negatively affected by its operation. Improved water circulation by the operation of the Goodyear Slough Outfall likely benefits CV Steelhead in Suisun Marsh by improving water quality and increasing foraging opportunities.

5.10.3.13 OMR Management

As shown in Figure 5.10-20 below, at CVP and SWP fish facilities in the Delta, between 0 and approximately 5000 juvenile CV Steelhead have been historically salvaged. Between 2010-2018, steelhead loss has ranged between 157 to 2852 fish. Exports are expected to increase slightly under the proposed action, and therefore salvage of CV Steelhead is also expected to increase under the proposed action. Restricting OMR flows to -5,000 cfs will reduce or avoid entrainment. Triggers based on salvage that further restrict OMR will further reduce entrainment. Enhanced monitoring and predictive tools will further reduce entrainment while increasing operational flexibility. OMR management under the proposed action will reduce the entrainment effects of the proposed action on CV Steelhead. Please see Delta seasonal operations –entrainment –for more details.

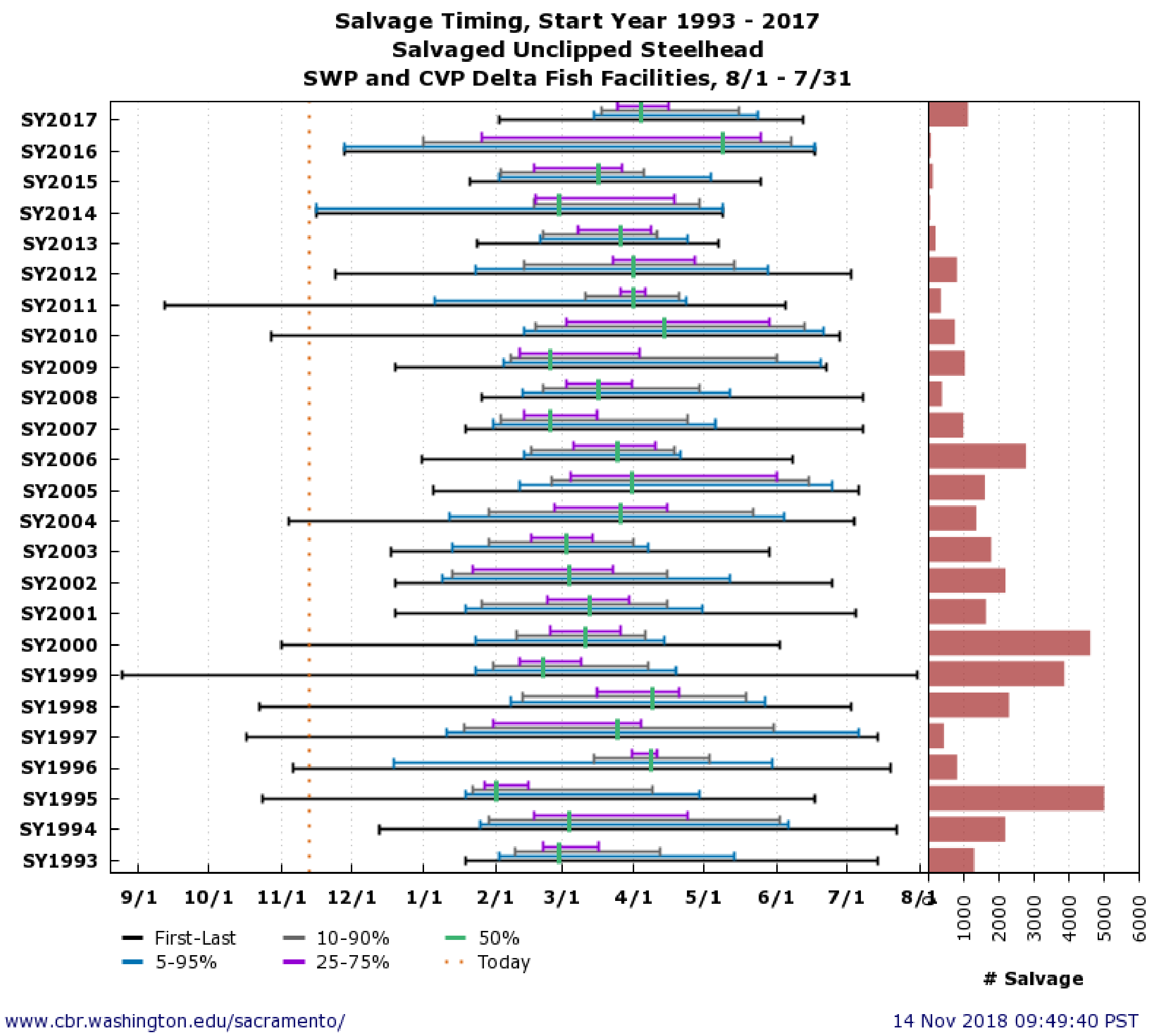


Figure 5.10-19. Sac PAS Salvage Unclipped Steelhead

5.10.3.14 Stanislaus River Operations - Stepped Release Plan

CV Steelhead in the Stanislaus River are found mostly in the reach from Goodwin Dam downstream to Oakdale (Kennedy 2008). Under the WOA, CV Steelhead distribution would be similar to the proposed action and COS as Goodwin Dam would still represent a complete physical barrier to further upstream migration. Steelhead on the Stanislaus River generally move upstream to spawn between July and March, and juvenile steelhead outmigrate between January and June (NMFS, 2014).

Under the proposed action, Reclamation proposes to implement the New Melones Stepped Release Plan to create a sustainable operation on the Stanislaus River that strives to meet requirements for fish flows, temperature, water quality, dissolved oxygen, and water deliveries.

5.10.3.14.1 River Flow

Modeled flows below Goodwin Dam are depicted below in Figure 5.10-21. Stanislaus Modeled Flows. Under WOA conditions, flows are highest in February and July. Flows drop below 500 cfs from August to October. August and September flows are often 0 cfs (see Figure below). April and May flows range from 0 cfs in the driest years to over 1,400 cfs in the wettest.

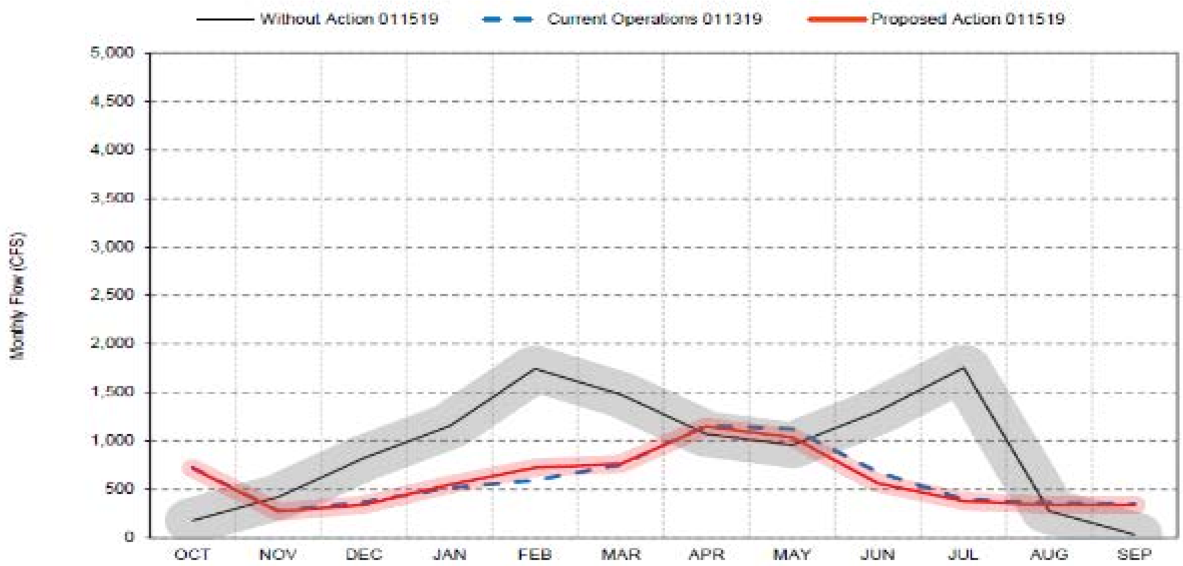


Figure 5.10-20. Stanislaus River Flow below Goodwin Dam under WOA, Current Operations Scenario (COS) and Proposed Action Scenario

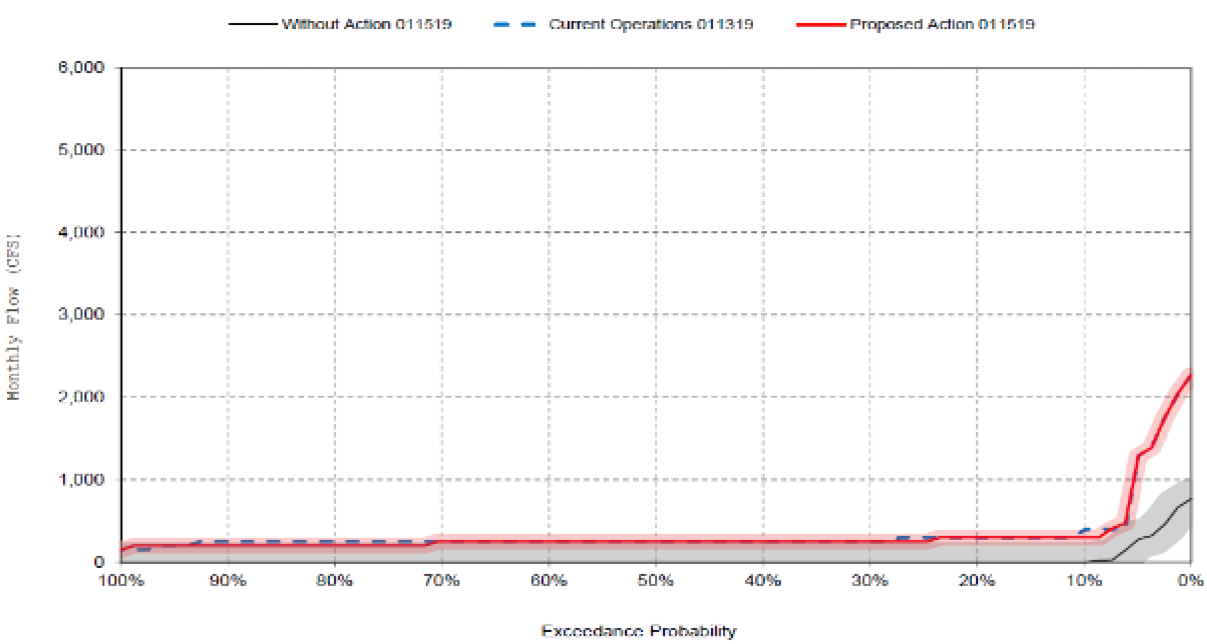


Figure 5.10-21. Stanislaus River Flows below Goodwin Dam, September Exceedance

Under the proposed action, flows are at least 200 cfs year-round in all water year types. As compared to WOA, the proposed action has lower flows in November to March and some wet June and July's (late snowmelt runoff). The proposed action has higher flows than WOA in April through October of most years.

5.10.3.14.2 Water Temperature

The Stepped Release Plan promotes increased storage at New Melones Reservoir. Over time, increased total storage would promote the development of a larger cold water pool. Recognizing that there is no ability for Reclamation to release water from different depths at New Melones, increased water depth above the static intake structure would function like a thermal cap, keeping the water below cooler. More cold water in New Melones Reservoir may lower water temperatures downstream of Goodwin Dam, which would benefit CV Steelhead in all life stages in the lower Stanislaus River.

As can be seen in Figure 5.10-23 below, the proposed action greatly decreases water temperatures in May through October as compared to WOA, and the proposed action increases temperatures between December and March as compared to WOA.

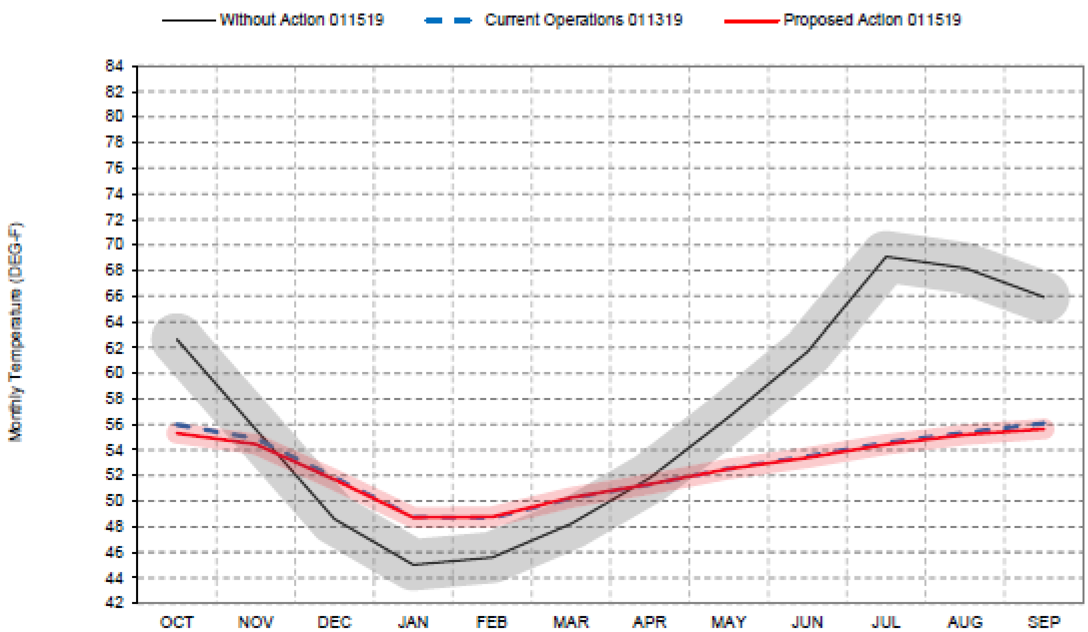


Figure 5.10-22. Stanislaus River below Goodwin Dam, Long-term Average Temperatures by Month

5.10.3.14.3 Egg to Fry Emergence (January – March)

A water temperature of 53°F provides a reasonable threshold for evaluating the potential for adverse temperature effects to spawning and egg incubation (USEPA, 2003). This reference, however, is based on Pacific Northwest fish.

Under the WOA, temperatures in the Stanislaus River below Goodwin Dam are below 53 degrees Fahrenheit between January and March in all years. Under the proposed action, temperatures are also below 53 degrees in all years, although temperatures are a few degrees higher than WOA. Therefore, proposed action is not anticipated to have impacts on the egg to fry emergence lifestage.

5.10.3.14.4 Juveniles (January – June)

Under WOA, flows in March, the peak of juvenile outmigration, range from 121 cfs to 2,380 cfs. Under the proposed action, flows during this period range from 200 cfs to 1,528 cfs. Higher flows in March under the proposed action would benefit rearing and outmigrating juvenile CV Steelhead by increasing the inundated area of rearing habitat, stimulating food production and primary productivity, increasing cover and habitat complexity, and increasing ability to avoid predators.

For juvenile rearing and outmigrating temperatures, the USEPA recommends 61 degrees Fahrenheit, although this is based on Pacific Northwest fish. Under WOA, approximately 50% of June months would exceed this threshold. Under the proposed action, all months between January and June are modeled to have Stanislaus River water temperatures below 61 degrees Fahrenheit. This would be a slight benefit of the proposed action to outmigrating juvenile CV Steelhead, avoiding temperature stress for the last outmigrats.

5.10.3.14.5 Migrating Adults (July – March)

During July through March, the WOA has flows ranging from 0 cfs in most Augusts and Septembers to approximately 6,800 cfs in occasional wetter July months. Under WOA, CV Steelhead adults would not be able to migrate up to spawning habitat below Goodwin Dam in August or September, or approximately half of July months. The proposed action flows during the CV Steelhead adult migration window range from a minimum of 200 cfs during the summer to approximately 1,500 cfs in some March months. Under the proposed action, CV Steelhead adults would be able to reach the spawning grounds in all months due to minimum 200 cfs flows. The proposed action benefits CV Steelhead by allowing adult migration during their entire window.

The USEPA-recommended 7DADM water temperature for holding adults is 68°F. Although this is based on Pacific Northwest fish and hydrology and does not consider the operational feasibility of operating to 7DADM, it is appropriate for comparison to monthly averaged temperature model results. Under the WOA, temperatures during the adult migration window for CV Steelhead on the Stanislaus River below Goodwin Dam range from 43.6 degrees in January in some years to 72 degrees in some July months. In the without action, temperatures would be above 68 degree Fahrenheit migrating adult threshold in 70% of July months, 60% of August months, 30% of September months, and then is below 68 degrees for the rest of the adult migration window. Temperatures would be below the 61 degrees Fahrenheit adult holding threshold in the without action in November through March in all years under the Without Action. Under the proposed action, temperatures would be below 68 degrees and below 61 degrees from July through March in all water years. The largest differences between the WOA and the proposed action are in January, where the proposed action is up to 4 degrees Fahrenheit warmer than WOA but still below CV Steelhead temperature thresholds, and in September, where the WOA is 12 degrees Fahrenheit warmer than the proposed action and exceeds adult migration as well as adult holding temperatures. Therefore, the proposed action also provides a temperature benefit to CV Steelhead, by providing optimal temperatures during their entire adult migration window.

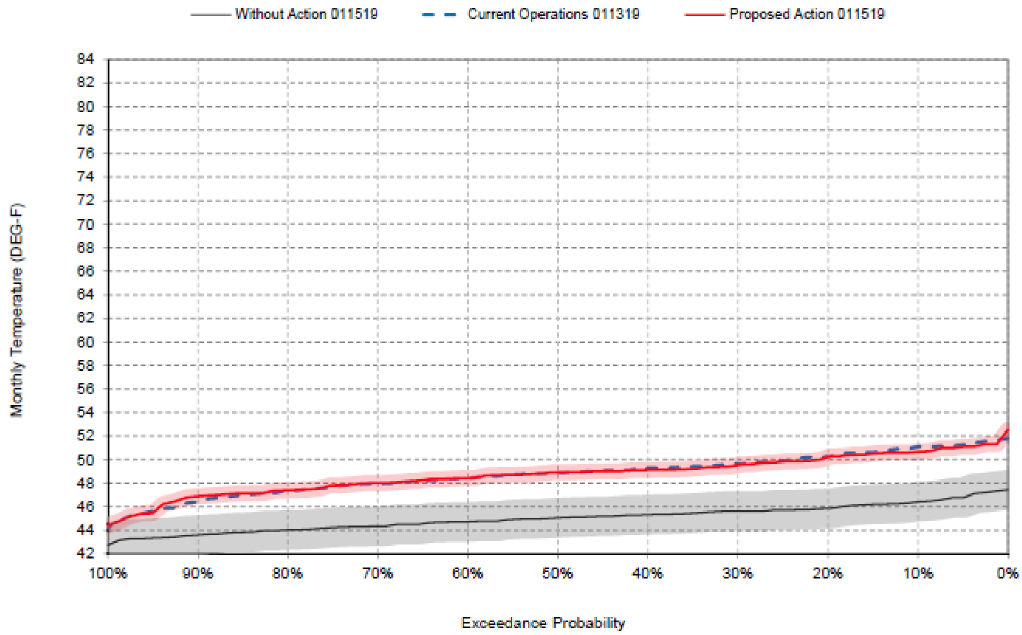


Figure 5.10-23. Exceedance Probability of January Temperatures below Goodwin Dam

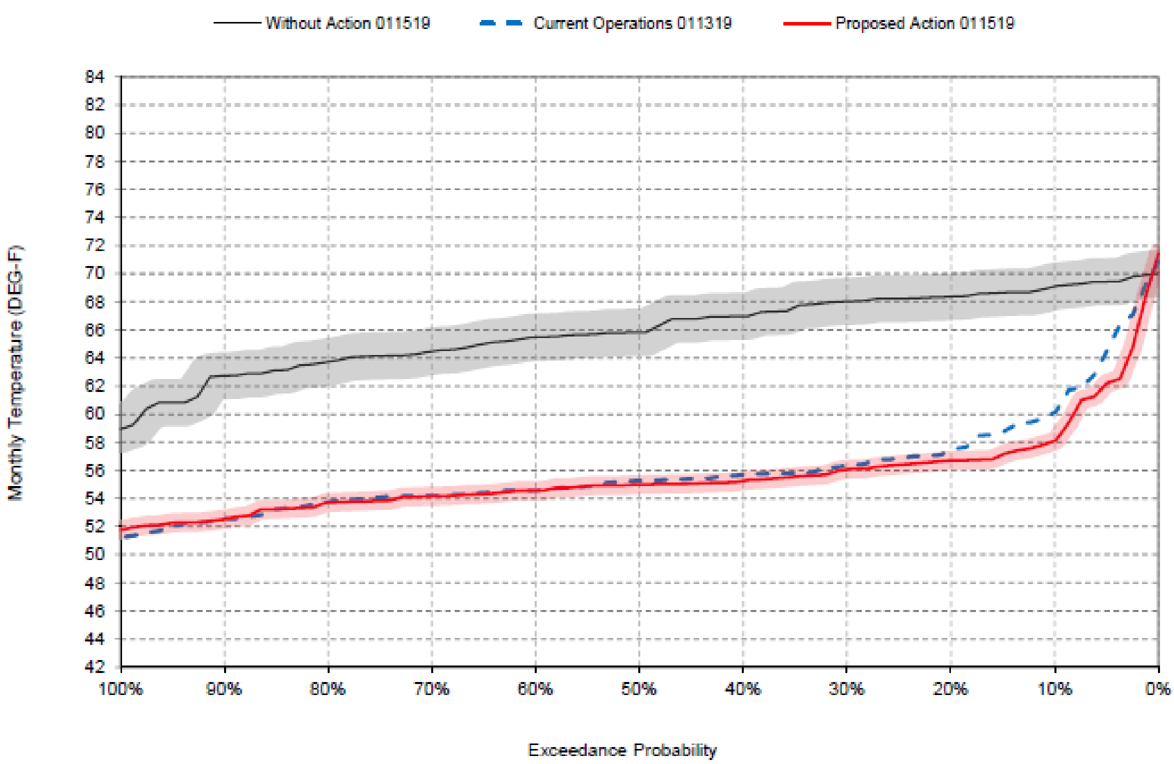


Figure 5.10-24. Exceedance Probability of September temperatures in the Stanislaus River below Goodwin Dam

5.10.3.15 Stanislaus River Dissolved Oxygen

Reclamation currently operates to meet a DO requirement on the lower Stanislaus River of 7.0 mg/L at Ripon from June 1 to September 30. Under the proposed action, Reclamation would operate to meet the same DO requirement at Orange Blossom Bridge, approximately 31 miles upstream from Ripon, where salmonids are primarily located at that time of year.

5.10.3.15.1 Rearing to Outmigrating Juveniles

Based on multi-year observations of salmonid abundance in the Stanislaus River, Kennedy and Cannon (2005) and Kennedy (2008) found that over-summering juvenile salmonids are primarily found upstream of Orange Blossom Bridge. Dissolved oxygen monitoring at the Stanislaus River Weir (approximately 15 miles upstream from Ripon) indicates that DO concentrations can be 0.5-1 mg/L higher at this location than those measured at Ripon (Cramer Fish Sciences 2006a-d). Because the fish are generally located at least twice this distance upstream, the DO concentration there is likely to be higher than at the Stanislaus River Weir. The majority of juvenile CV Steelhead are found at locations where summer DO levels would meet or exceed 7 mg/L.

5.10.3.15.2 Adult Migration from Ocean to Rivers

Based on the typical seasonal occurrence of this life stage in the Stanislaus River (mid-January to late June), adult migrating CV Steelhead would not be expected to be exposed to the effects of altering the DO requirements at Ripon.

5.10.4 Effects of Conservation Measures

The following are proposed conservation measures that are intended to offset the effects of operations and maintenance. These conservation measures would only occur due to the implementation of the proposed action and are beneficial in nature. The following analysis looks not only at the construction related effects of the measures, but also the benefits to the population once completed. Conservation measures would not occur under WOA conditions.

5.10.4.1 Lowering Intakes Near Wilkins Slough

5.10.4.1.1 Eggs to Fry Emergence

The installation of fish screens near Wilkins Slough would be beneficial to CV Steelhead. The installation of new diversions and screens that would operate at lower flows would indirectly benefit fish of all life stages. Specifically, operation of diversions near Wilkins Slough at lower flows could increase Shasta and Trinity water storage and cold-water pool. As a result, additional water may be available for Keswick releases to:

- Improve water temperatures and dissolved oxygen during egg incubation;
- Improve water quality, and subsequently increase redd quality and decrease the risks of pathogens and disease; and
- Reduce the risks of redd dewatering and stranding.

Adult migration from the ocean to spawning grounds occurs during much of the year, with peak migration occurring in the fall or early winter. Migration through the Sacramento River mainstem begins in July, peaks at the end of September, and continues through February or March (OCAP BA 2008). In the upper

Sacramento River spawning occurs between November 15 through April, peaking in November through December and during April. Fry are present for another four to six weeks within the gravel (OCAP BA 2008) prior to moving into shallow protected areas associated with the stream margin (OCAP BA 2008). Wilkins Slough does not contain suitable spawning habitat; therefore, CV Steelhead are not likely to spawn there and subsequently there is a very low potential for eggs and fry to be present. The lack of suitable habitat, implementation of an in-water work window (June 1 through October 1), and other AMM's identified in Appendix E minimizes the potential for CV Steelhead egg and fry to be affected by the action.

5.10.4.1.2 <u>Rearing to Outmigrating Juveniles</u>

The fish screens would directly benefit rearing and outmigrating juvenile Steelhead by reducing mortality risks from entrainment, thus increasing the survival of rearing and outmigrating juveniles, and in turn potentially increasing successful CV Steelhead recruitment. The installation of new diversions and screens that operate at lower flows would indirectly benefit rearing and outmigrating juvenile CV Steelhead. Specifically, this action could increase Shasta and Trinity water storage. As a result, additional water may potentially be available for Keswick releases and spring pulse flows that would:

- Provide access to floodplains, side channels, and refuge habitat;
- Decrease predation risks to outmigrating juveniles; and
- Increase emigration cues.

CV Steelhead rear year-round in the upper Sacramento River basin (OCAP BA 2008). Construction activities have the potential to affect rearing CV Steelhead that move downstream and through Wilkins Slough. Rearing CV Steelhead have the potential to be exposed to temporary increases to turbidity and associated decrease in DO, underwater noise associated with construction of a cofferdam for in-water work. Additionally, the installation of a cofferdam (if needed) increase the risk of mortality of Steelhead through fish rescue operations required to remove fish from the dewatered work area. Implementation of an in-water work window (June 1 through October 1), and other AMM's identified in Appendix E, aim to minimize the duration and likelihood of these potentially adverse effects to rearing CV Steelhead.

CV Steelhead emigrate downstream from the Upper Sacramento River basin between November and July, with peak emigration occurring January through March. Construction activities would not affect emigrating Steelhead as an in-water work window (June 1 through October 1) would be implemented, in addition to other standard AMM's.

5.10.4.1.3 <u>Adult Migration from Ocean to Rivers</u>

The installation of new diversions and screens near Wilkins Slough that would operate at lower flows would indirectly benefit migrating adult CV Steelhead. Specifically, this action could increase Shasta and Trinity water storage and cold-water pool. As a result, additional water may potentially be available for Keswick releases that would:

- Decrease water temperatures and increase DO during adult migration;
- Decrease the risks of disease and pathogens;
- Decrease concentrations of contaminants; and
- Increase migration cues and decrease straying.

Adult CV Steelhead migrate from the ocean to spawning grounds during much of the year, with peak migration occurring in the fall or early winter. Migration through the Sacramento River mainstem begins in July, peaks at the end of September, and continues through February or March (OCAP BA 2008). Implementation of an in-water work window (June 1 through October 1) would reduce the effects on migrating Steelhead; however, the onset of in-water work would occur prior to the peak of migration (end of September). Any CV Steelhead that may be present in Wilkins Slough during the onset of in-water construction activities may be exposed to temporary increases in turbidity and associated DO, and underwater noise associated with the construction of a cofferdam. Additionally, fish rescue activities may need to occur, thus increasing the risk of survival associated with moving fish within the coffered area to the mainstem of the slough. Reclamation will coordinate with the resource agencies prior to the onset of construction activities to determine if any other AMM's are required.

5.10.4.1.4 Adult Holding

Historically adult CV Steelhead maintained several strategies during their migration to natal rivers in preparation for spawning. Some CV Steelhead return several months prior to spawning and hold over in pools while sexually maturing, others sexually matured in the ocean before returning to freshwater (Williams 2006). The former life-history strategy required suitable cold-water habitat for holding. However, anadromous CV Steelhead predominantly mature in the ocean (McEwan 2001) and do not hold prior to maturation and spawning. Wilkins Slough does not contain suitable habitat (cold water) for holding nor is this a common life-history strategy expressed in CV Steelhead. Therefore, construction activities are not anticipated to affect holding CV Steelhead due to implementation of an in-water work window (June 1 through October 1) and other AMM's identified in Appendix E.

5.10.4.2 Shasta TCD Improvements

5.10.4.2.1 Eggs to Fry Emergence

Water temperature has a major influence on CV Steelhead, directly affecting survival, growth rates, distribution, and developmental rates (NMFS 2009). Steelhead embryo incubation period (i.e., January through May) occurs in the winter and spring following spawning. The implementation of the proposed Shasta TCD would improve Reclamation's ability to manage temperatures in the Sacramento River and meet water temperature requirements for CV Steelhead, improving conditions for this life stage. Therefore, this action would have high-level population benefits on this life stage of CV Steelhead.

5.10.4.2.2 Rearing to Outmigrating Juveniles

Water temperature can affect juvenile rearing and outmigration and adult immigration and holding within the Sacramento River. CV Steelhead can be found where daytime water temperatures range from nearly 32°F to 81°F in the summer, although mortality may result at extremely high (i.e., > ~73°F) water temperatures if the fish have not been gradually acclimated (Moyle 2002). Juvenile CV Steelhead in northern California rivers reportedly exhibited increased physiological stress, increased agonistic activity, and a decrease in forage activity after ambient stream temperatures exceeded 72°F (Nielsen et al. 1994). Since juvenile CV Steelhead rear in streams for 1-3 years and are present year round (Table 5.10-1), they would be affected by the effects of drought related excessively high water temperatures. The implementation of the proposed Shasta TCD would improve Reclamation's ability to manage temperatures in the Sacramento River and meet water temperature requirements for CV Steelhead.

5.10.4.2.3 Adult Migration from Ocean to Rivers

Adult CV Steelhead are affected by excessively high water temperatures due to their presence within the Sacramento River in the summer and fall. The implementation of this action would improve Reclamation’s ability to manage temperatures in the Sacramento River and meet water temperature requirements for CV Steelhead, improving conditions for this life stage.

5.10.4.2.4 Adult Holding

As discussed above, the implementation of the proposed Shasta TCD would improve Reclamation’s ability to manage temperatures in the Sacramento River and meet water temperature requirements for CV Steelhead, improving conditions for this life stage.

5.10.4.3 Sacramento River Spawning and Rearing Habitat

The creation of side channel and rearing habitat under the proposed action would increase the quality and quantity of off channel rearing and spawning areas in the Sacramento River. These habitat restoration activities would improve the riparian habitat available for emerging CV Steelhead fry, providing an overall benefit to the species.

Based on the proposed in-water work windows for the upper Sacramento River (AMM2), CV Steelhead adults, eggs, and alevins would be subject to potential adverse effects from proposed spawning (e.g, gravel augmentation) and rearing habitat (e.g., side channel) restoration projects in the upper Sacramento River. Construction activities could result in mortality of eggs and alevins by crushing if heavy equipment enters the stream channel or otherwise disturbs existing redds during in-water activities. Eggs and alevins could also be negatively impacted by increases in suspended sediment, turbidity, and contaminant exposure risk, leading to indirect impacts on individuals from reductions in habitat quality in the redd (e.g., reduced flow and dissolved oxygen from increases in sediment deposition) or direct impacts from sublethal and lethal exposures to contaminants.

Although these potential effects may be unavoidable, exposure of the CV Steelhead population to construction effects would be low based on the limited extent of proposed restoration projects relative to the overall distribution of spawning adults, and the implementation of other AMMs described in Appendix E. These measures include AMM1, which requires worker awareness training, AMM2, which specifies monitoring oversight by a qualified biologist, and AMM3-5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention and containment.

5.10.4.4 Deer Creek Fish Passage

Deer Creek is a tributary of the Sacramento River with natural production of steelhead. DWR and Reclamation’s installation of a nature-like fishway at the DCID diversion dam will provide steelhead access to approximately 25 miles of spawning habitat in Deer Creek upstream from the DCID dam.

Construction effects are the same as discussed above for Sacramento River spawning and rearing habitat. Exposure to these effects would be minimized with incorporation of the avoidance and minimization measures.

5.10.4.5 Small Screen Program

5.10.4.5.1 Egg to Fry Emergence

CV Steelhead in the egg-to-emergence life stage would not be expected to be exposed to the effects of operation or construction of screens on water diversion intakes based on the seasonal occurrence of this life stage in the Sacramento River, and the geographic location of redds away from diversions. This life stage occurs over a 2-2.5 month period from mid-February through June following the December to April Steelhead spawning period (NMFS 2009), which is outside of the timing of the in-water construction (August–October).

5.10.4.5.2 Rearing to Outmigrating Juveniles in the Rivers

The operation of fish screens on water diversions under the proposed action would benefit juvenile CV Steelhead by reducing the entrainment of rearing and migrating fish into unscreened or poorly screened diversions. There is the potential for negative impacts to this life stage, including injury or mortality from exposure to screens that are not functioning properly due to lack of maintenance, occlusion, debris accumulation or other factors. However, the risk of this exposure will be minimized since the screens would be designed to meet NMFS and CDFW fish screen criteria and protect this life stage.

Juvenile CV Steelhead rearing and outmigrating in the Sacramento River may be exposed to the effects of construction of screens under the proposed action since juvenile CV Steelhead spend one to three years in freshwater prior to migration to the ocean (CDFG 1996). Juvenile CV Steelhead may be found in the work area of these projects. Potential short-term negative impacts may include temporary effects to water quality as result from in-water work, resulting in increased turbidity and suspended sediments and sediment deposition in the direct vicinity of the work area, and the temporary displacement of individual fish in the work area. If fish are present in the work area, flowing water will be isolated and fish captured and relocated to an appropriate location in an effort to minimize possible mortality. CV Steelhead juveniles would likely experience increased levels of stress and injury during handling, which could be exacerbated by poor water quality (increased temperatures, low dissolved oxygen saturation), and prolonged periods of holding between capture and release. There may be a minor effect to a small number of individuals, although the risk from these potential effects would be minimized through the implementation of general avoidance and minimization measures identified in Appendix E. In addition, the appropriate conservation measures and handling techniques will be employed to ensure that the stress resulting from handling and transport is short-lived and minor.

5.10.4.5.3 Rearing to Outmigrating Juveniles in the Bay Delta

Fish screens under the proposed action would also benefit this lifestage in the same ways described above. Juvenile CV Steelhead outmigrating in the Bay-Delta may be exposed to the effects of construction of screens since they migrate downstream during most months of the year, with a peak emigration period in the spring and a smaller peak in the fall (Hallock et al. 1961). Juvenile CV Steelhead may be found in the work area of these projects; however, AMMs would minimize impacts.

5.10.4.5.4 Adult Migration

The operation of fish screens on water diversions under the proposed action would benefit adult migrating CV Steelhead by reducing the entrainment of rearing and migrating fish into unscreened or poorly screened diversions. Adult CV Steelhead may be exposed to the effects of construction of screens on water diversion intakes associated with the proposed action based on the overlap of timing of in-water construction (July 15 – October 15) and the timing this life stage in the Sacramento River. AMMs would minimize effects.

5.10.4.5.5 Adult Holding

The operation of fish screens on water diversions under the proposed action would benefit CV Steelhead by reducing the entrainment of rearing and migrating fish into unscreened or poorly screened diversions. Adult CV Steelhead holding in the Sacramento River may be exposed to the effects of construction of screens on water diversion intakes associated with the proposed action due the overlap of the timing of in-water construction (August–October), and the seasonal occurrence of this life stage in the Sacramento River. AMMs would minimize effects.

5.10.4.6 Adult Rescue

The operation of adult rescue is targeted towards adult salmonids and sturgeon, including adult CV Steelhead, that become trapped in the Yolo and Sutter bypasses, with the goal of increasing the number of adults returning to spawning areas; therefore, this effort could increase the number of CV Steelhead of all lifestages in the Sacramento River and its tributaries.

5.10.4.6.1 Egg to Fry Emergence

Given that this life stage is carried out in gravel substrates and adult rescue activities would occur downstream of CV Steelhead spawning areas in the Sacramento River and its tributaries, there would be no direct effects on this life stage from implementing adult rescue activities.

5.10.4.6.2 Rearing to Outmigrating Juveniles in Rivers

Although CV Steelhead are less likely to use floodplain habitat, including the Yolo and Sutter bypasses, than Chinook salmon, there is a potential for juveniles to occur in the Yolo and Sutter Bypasses when Sacramento River flows overtop the Fremont and/or Tisdale Weirs. Although they are unlikely to occur in the bypasses during periods when flow does not overtop the weirs, proposed modifications to the Fremont Weir to increase inundation of the Yolo bypass for floodplain rearing would provide juveniles with more consistent access to the Yolo bypass. Therefore, these juveniles could be exposed to the effects of adult rescue activities if they become stranded with adults that are targeted by adult rescue activities.

The number of juvenile CV Steelhead that would be expected to be exposed to the effects of adult rescue activities would be based on the timing of proposed adult rescue activities, gear type used to rescue adults, and the typical seasonal occurrence of this life stage in the Yolo and Sutter bypasses. Individual juvenile CV Steelhead exposed to adult rescue activities would be at risk of increased stress, injury, and/or mortality during efforts to capture stranded adults, handling, and transport. Injury and increased stress associated with capture, handling, and transport may reduce disease resistance, swimming ability, and osmoregulatory ability in juveniles, thereby adversely affecting survival of affected individuals after release. Furthermore, the risk of these effects to this life stage may be dependent on the timing of collection, as fish collected later in the season when water quality conditions (e.g., water temperature) generally are more stressful for fish may make juveniles more susceptible to injury and stress-related effects. The risk from these potential effects would be minimized through application of AMM8, and any potential adverse effects on individual juvenile CV Steelhead would be expected to be offset by benefits associated with increased numbers of adult CV Steelhead returning to spawning grounds. As such, the overall population-level negative effects on this life stage of CV Steelhead from adult rescue activities would be low relative to WOA conditions (i.e., no rescue of adult CV Steelhead in Yolo and Sutter bypasses).

5.10.4.6.3 Rearing to Outmigrating Juveniles

Given that this life stage is carried out in the Bay-Delta and adult rescue activities would occur upstream in the Yolo and Sutter bypasses, there would be no direct effects on this life stage from implementing adult rescue activities.

5.10.4.6.4 Adult Migration from Ocean to Rivers

Exposure of this life stage to adult rescue effects would be restricted only to those adult CV Steelhead that become stranded in the Yolo and Sutter bypasses and subsequently rescued and released to the Sacramento River. Adults that migrate in-river or that do not become stranded in the Yolo and Sutter bypasses would be unaffected by adult rescue activities. The number of adult CV Steelhead that would be expected to be exposed to the effects of adult rescue activities would be based on the abundance of adults that stray into the bypasses and the timing and frequency of stranding events in the bypasses. Individual adult CV Steelhead exposed to adult rescue activities would be at risk of increased stress, injury, and/or mortality, which could vary in intensity depending on the techniques used to capture individuals. Injury and increased stress associated with capture, handling and transport may affect survival of individuals after release. The risk from these potential effects would be minimized through application of AMM8. As such, it is concluded that the overall population-level negative effects on this life stage of CV Steelhead from adult rescue activities would be low relative to WOA conditions (i.e., no rescue of stranded adult CV Steelhead in Yolo and Sutter bypasses).

5.10.4.6.5 Adult Holding

Given that this life stage is carried out in the upper Sacramento River and its tributaries and adult rescue activities would occur downstream in the Yolo and Sutter bypasses, there would be no direct effects on this life stage from implementing adult rescue activities.

5.10.4.7 Juvenile Trap and Haul

The operation of juvenile trap and haul is targeted towards juvenile CV Steelhead, with the goal of increasing the survival of juveniles and, ultimately, returning adults. This effort could increase the number of CV Steelhead of all lifestages in the Sacramento River and its tributaries.

5.10.4.7.1 Egg to Fry Emergence

Given that this life stage is carried out in gravel substrates and temporary juvenile collection weirs would be placed downstream of CV Steelhead spawning areas in the Sacramento River and its tributaries, there would be no direct effects on this life stage from implementing juvenile trap and haul activities.

5.10.4.7.2 Rearing to Outmigrating Juveniles in Rivers

The number of juvenile CV Steelhead that would be expected to be exposed to the effects of juvenile trap and haul activities would be based on the timing of proposed juvenile trap and haul activities (December 1 to May 31), trapping location and efficiency, and the typical seasonal occurrence of this life stage in the Sacramento River (Table 5.10-1). Individual juvenile CV Steelhead exposed to juvenile trap and haul activities would be at risk of increased stress, injury, and/or mortality. Injury and increased stress associated with handling and transport may reduce disease resistance, swimming ability, and osmoregulatory ability in juveniles, thereby adversely affecting survival of affected individuals after release.

Furthermore, the risk of these effects to this life stage may be dependent on fish size (fish collected at a smaller [younger] size may be more susceptible to injury and stress) and timing of collection (fish collected later in the season when water quality conditions [e.g., water temperature] generally are more stressful for fish may make fish more susceptible to injury and stress-related effects). The risk from these potential effects would be minimized through application of AMM8, and any potential adverse effects on individual juvenile CV Steelhead would be expected to be offset by benefits associated with expected increased survival of the overall brood-year of CV Steelhead. As such, it is concluded that the overall population-level negative effects on this life stage of juvenile CV Steelhead from juvenile trap and haul activities would be low relative to WOA conditions (i.e., no trapping and hauling of juvenile CV Steelhead during drought years) and would be potentially offset by benefits (i.e., increased juvenile survival and ultimately increased adults returning to spawn) associated with the juvenile trap and haul program.

5.10.4.7.3 Rearing to Outmigrating Juveniles in Bay-Delta

Exposure of this life stage to trap and haul effects would be restricted only to those juvenile CV Steelhead trapped in the Sacramento River and subsequently released to the lower Sacramento River and/or Bay-Delta. Wild juveniles that migrate in-river to the Bay-Delta (either before December 1 or that avoid capture by the temporary juvenile collection weirs after December 1) would not be affected by juvenile trap and haul activities. Potential effects associated with juvenile trap and haul on this life stage would be same as those described for Winter-run Chinook Salmon juveniles. The risk from these potential effects would be minimized through application of AMM8, and any potential adverse effects on individual juvenile CV Steelhead would be expected to be offset by benefits associated with expected increased survival of the overall brood-year of CV Steelhead. As such, the overall population-level negative effects on this life stage of juvenile CV Steelhead from juvenile trap and haul activities would be low relative to WOA conditions.

5.10.4.7.4 Ocean Juvenile to Ocean Adult

Exposure of this life stage to trap and haul effects would be restricted only to those juvenile CV Steelhead trapped in the Sacramento River and subsequently released to the lower Sacramento River and/or Bay-Delta, and that enter the ocean. Wild juveniles that migrate in-river to the ocean would not be affected by juvenile trap and haul activities. The overall population-level negative effects on this life stage of juvenile CV Steelhead from juvenile trap and haul activities would be low relative to WOA conditions.

5.10.4.7.5 Adult Migration from Ocean to Rivers

Exposure of this life stage to trap and haul effects would be restricted only to those adult CV Steelhead that were trapped in the Sacramento River as juveniles and subsequently released to the lower Sacramento River and/or Bay-Delta as part of the juvenile trap and haul program. Ocean adults that had out-migrated in-river as juveniles would not be affected by juvenile trap and haul activities. Because transported juveniles are more likely to have impaired homing behavior as adults, juvenile trap and haul activities may increase the rate of straying by returning adults. Adults that stray into tributaries with suitable habitat may compete with native-run adults for spawning space, excavate or superimpose their redds on the redds of native-run fish, or spawn with native-run fish, thereby introducing genes from neighboring populations that have strayed into the river. However, it is concluded that the overall population-level negative effects on this life stage of adult CV Steelhead from juvenile trap and haul activities would be low relative to

WOA conditions and would be potentially offset by benefits (i.e., increased juvenile survival and ultimately increased adult escapement) associated with the juvenile trap and haul program.

5.10.4.7.6 Adult Holding

Because juvenile trap and haul would target only wild juveniles during outmigration, adult CV Steelhead holding in rivers would not be directly affected by juvenile trap and haul activities. However, because the purpose of juvenile trap and haul activities is to increase the survival rate of juveniles during drought years, the number of adults holding in rivers potentially would be greater relative to the WOA conditions as a result of increased juvenile survival and, ultimately, increased adult spawners.

5.10.4.8 Spawning and Rearing Habitat (American River)

5.10.4.8.1 Eggs to Fry Emergence

Eggs and emerging fry would benefit from increased side channel habitat, gravel, and large wood resulting from habitat restoration in the American River. Effects include an increase in total spawning habitat area, improved intragravel incubation conditions and reduced likelihood of redd superimposition. Therefore, this action would benefit this life stage of CV Steelhead.

No eggs and emerging fry would be exposed to construction of side channel habitat, gravel, gravel augmentation, and large wood installation, based on the timing of the in-water work window (July 1-September 30) and seasonal occurrence of this life stage in the American River (December-April; Table 5.10-1). CV Steelhead spawn as early as December and as late as early April with the peak in February. All fry are out of the gravel before July when construction could begin. There would be no impact from construction to this lifestage in the American River.

5.10.4.8.2 Rearing to Outmigrating Juveniles

Rearing and outmigrating individuals would benefit from increased side channel habitat, gravel, and large wood resulting from habitat restoration in the American River. Effects include an improved likelihood of rearing success due to an increase in total rearing habitat area, and rearing habitat quality.

Rearing and outmigrating juveniles could be exposed to construction of side channel habitat, gravel augmentation, and large wood installation. Juvenile CV Steelhead grow quickly in the American River and young of the year are 100 mm or larger by the time construction activity starts in the summer. These fish are often attracted by the disturbance from construction activity and are able to swim quickly to desirable locations when in close proximity to construction activities. Construction activities in the American River could result in mortality of this life stage if crushed by heavy equipment, if individuals were stranded or isolated during dewatering. This life stage could be negatively affected by degraded water quality from contaminant discharge by heavy equipment and discharges of suspended solids and turbidity, leading to direct physiological impacts on fish health/performance (e.g., reduced ability to take in oxygen, increasing metabolic cost), and reduced foraging ability caused by decreased visibility. Outmigration timing does not overlap with construction activities so there would be no effect on outmigrating juvenile CV Steelhead.

Construction activities are temporary and exposure to effects would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. Exposure would be further minimized by implementing AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention, and containment. With application of AMM 1–5, the temporary, adverse effects that may result from the proposed construction activities would be minimized.

5.10.4.8.3 Adult Migration from Ocean to Rivers

Completion of restoration activities would increase the number of CV Steelhead of all life stages within the CVP watershed. Early migrating CV Steelhead adults may be exposed to construction of side channel habitat, gravel augmentation, and large wood installation, based on the timing of the in-water work window (July 1-September 30) and seasonal occurrence of this life stage in the American River. Adult CV Steelhead are strong swimmers and able to avoid construction activities in the American River. Migrating adults could be negatively affected by degraded water quality from contaminant discharge by heavy equipment, and increased discharges of suspended solids and turbidity, leading to direct physiological or physiological impacts on fish health/performance (e.g., reduced ability to take in oxygen, increasing metabolic cost), loss of aquatic vegetation providing physical shelter, and delay in migration caused by elevated noise levels from machinery.

Construction activities are temporary and exposure to effects would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. Exposure would be further minimized by implementing AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention and containment. With application of AMM 1–5, the temporary, adverse effects that may result from the proposed construction activities would be minimized.

5.10.4.8.4 Adult Holding

Generally CV Steelhead do not hold over during the summer months though if present, holding adults could be exposed to construction of side channel habitat, gravel augmentation, and large wood installation based on the timing of the in-water work window (July 1-September 30). Holding pools are typically in deep water near mid-channel and away from shallower riffles, pool tails, and channel margins where most gravel augmentation and side channel construction would occur. When construction activities in the American River occur near holding pools, holding adults could be displaced, injured, or killed by heavy equipment strikes or disturbance of suitable habitat during manipulation of gravel or creation of side channels. Adult CV Steelhead are strong swimmers and able to avoid construction activities. Holding adults could be negatively affected by degraded water quality from contaminant discharge by heavy equipment and increased discharges of suspended solids and turbidity, leading to direct toxicological or physiological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost).

Exposure to effects would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. Exposure would be further minimized by implementing AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention and containment. With application of AMM 1–5 the temporary, negative effects that may result from construction of side channel habitat, gravel augmentation, and large wood installation would affect few if any holding adult CV Steelhead. Completion of restoration activities would increase the number of CV Steelhead of all life stages within the CVP watershed.

5.10.4.9 Drought Temperature Facility Improvements (American River)

Under the proposed action, Reclamation proposes to evaluate and implement alternative shutter configurations at Folsom Dam to allow temperature flexibility in severe droughts, thereby reducing water temperatures in the lower American River. Water temperature is perhaps the physical factor with the greatest influence on CV Steelhead, directly affecting survival, growth rates, distribution, and developmental rates (NMFS 2009). Warm water temperatures have been identified as a key stressor for CV Steelhead in the American River, particularly below dams, affecting juvenile rearing and outmigration and adult immigration and holding. Since juvenile CV Steelhead rear in streams for one to three years and are present year round (Table 5.10-1), they would be affected by drought related excessively high water temperatures. The implementation of the proposed drought temperature management measures would improve Reclamation's ability to manage water temperatures in the lower American River and meet water temperature requirements for CV Steelhead during drought conditions and improve conditions for all life stages.

5.10.4.10 Spawning and Rearing Habitat (Stanislaus River)

5.10.4.10.1 Eggs to Fry Emergence

Juvenile CV Steelhead occur in the Stanislaus River, but those individuals may assume a resident life history that is not ESA protected like the anadromous life history of CV Steelhead. *O. mykiss* only become CV Steelhead upon outmigrating to the ocean. The weir on the Stanislaus River has counted only 82 CV Steelhead (i.e., O. mykiss longer than 16 inches) during escapement monitoring from 2003 to 2017 (no spring monitoring occurred in 2006 and 2008; Figure 5.10-26) (FishBio2012). These fish were categorized based on length, which is a standard practice. *O. mykiss* that have reared in the ocean and become CV Steelhead are generally much larger than their resident counterpart that reared only in freshwater. The individuals detected on the Stanislaus River did not receive additional testing to determine if the individuals completed an anadromous life history or not. While less common, larger resident *O. mykiss* can occur; so, there remains a degree of uncertainty as to determining resident or CV Steelhead origins.

Habitat restoration activities would directly benefit CV Steelhead, increasing the quantity and quality of spawning habitat in the Stanislaus River. Additionally, the created side channel and floodplain habitat would provide additional refuge for outmigrating juvenile CV Steelhead.

Construction activities associated with spawning and rearing habitat restoration under the proposed action are not expected to result in any direct effects to CV Steelhead eggs or emerging fry, based on timing of in-water construction (July 15 through October 15), typical seasonal occurrence of this life stage in the Stanislaus River (December through June), and implementation of general avoidance and minimization measures.

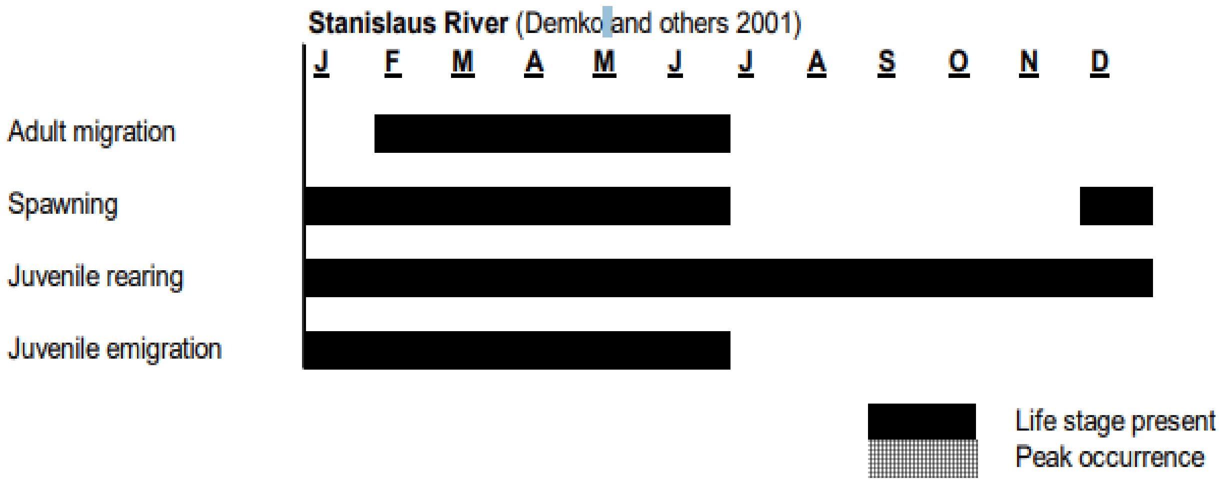


Figure 5.10-25. Stanislaus River Weir *O. mykiss* Passage (FishBio 2012)

5.10.4.10.2 <u>Rearing to Outmigrating Juveniles</u>

The creation of side channel and rearing habitat under the proposed action would increase the quality and quantity of off channel rearing and spawning areas in the Stanislaus River. The habitat restoration activities would improve the riparian habitat available for juvenile CV Steelhead rearing. Habitat restoration activities within the Stanislaus River would yield benefits including increasing existing riparian vegetation, providing instream and overhanging object cover, new shaded riverine habitat, and additional area for food production.

The creation of side-channel and floodplain rearing habitat would also increase the aquatic habitat complexity and diversity within the Stanislaus River and provide additional predator escape cover. The creation of side channel and floodplain habitat would increase the quality and quantity of rearing habitat available to CV Steelhead. Reclamation expects that the creation of 50 acres of side channel and floodplain habitat, would support the progeny of 2,800 adult salmon. The habitat restoration would result in an overall benefit to the CV Steelhead.

Construction activities associated with spawning and rearing habitat construction are not expected to result in impacts to CV Steelhead juveniles, based on timing of in-water construction (July 15 through October 15), typical seasonal occurrence of this life stage in the Stanislaus River (December through June), and implementation of general avoidance and minimization measures.

5.10.4.10.3 <u>Adult Migration from Ocean to Rivers</u>

The creation of side channel and floodplain habitat under the proposed action would increase the quality and quantity of spawning available. Additionally the placement of additional spawning gravel would create an additional 34 acres of spawning habitat available to immigrating CV Steelhead. The habitat restoration would result in an overall benefit to CV Steelhead.

Construction activities associated with habitat restoration under the proposed action will not affect immigrating CV Steelhead. Construction activities would occur during an in-water work window of July 15 through October 15, when the species is not present in the Stanislaus River. No effects would occur on CV Steelhead individuals and/or populations during this life stage.

5.10.4.10.4 Adult Holding

The construction activities under the proposed action associated with spawning habitat restoration are not expected to affect adults holding in the Stanislaus River due to the implementation of general avoidance and minimization measures. The habitat restoration activities would increase the quality and quantity of off channel habitat areas available for CV Steelhead.

5.10.4.11 Stanislaus River Temperature Management Study

As part of the proposed action, Reclamation will study approaches to improving temperature for listed species on the lower Stanislaus River, to include evaluating the utility of conducting temperature measurements/profiles in New Melones Reservoir. This study will help inform operational abilities to control temperature in the Stanislaus River, which could benefit fish in the future.

5.10.4.12 Lower SJR Habitat

Lower San Joaquin Rearing Habitat restoration is expected to result in similar effects as those described above for Stanislaus River Spawning and Rearing Habitat.

5.10.4.13 Suisun Marsh Salinity Control Gates Operation

CV Steelhead juveniles are in the Delta in the spring. Reclamation proposes to operate the Suisun Marsh Salinity Control Gate between June to October. The last few CV Steelhead juveniles could possibly benefit from increased food production due to this action in the Delta.

5.10.4.14 Summer-Fall Delta Smelt Habitat

CV Steelhead juveniles are in the Delta in the spring. Reclamation proposes to conduct actions for Summer-Fall Delta Smelt Habitat in the fall, as adult CV Steelhead are migrating upstream. Summer-Fall Delta Smelt Habitat actions are unlikely to affect adult CV Steelhead.

5.10.4.15 Clifton Court Predator Management

Clifton Court predator management under the proposed action could reduce pre-screen loss of juvenile CV Steelhead entrained into CCF; therefore, providing a benefit for all life stages of CV Steelhead.

5.10.4.16 San Joaquin Steelhead Telemetry Study

The San Joaquin Steelhead telemetry study under the proposed action would include inserting acoustic tags into San Joaquin origin juvenile CV Steelhead to track them as they move through the south Delta. Acoustic arrays would monitor their presence. This study would help fill a gap in knowledge related to CV Steelhead survival on the San Joaquin River. Only the juvenile lifestage of CV Steelhead would be affected by the study, as they are the only lifestage of fish that would be tagged. Tagged fish could have mortality associated with surgery to insert the tag, shock, and reduced swimming leading to increased predation as a result of the acoustic tag in their stomach cavity.

5.10.4.17 Sacramento Deepwater Ship Channel Food Study

Moderate to high proportions of CV Steelhead are expected to be exposed to the Sacramento Deepwater Ship Channel (SDWSC) conservation measure under the proposed action. This conservation measure would hydrologically connect the Sacramento River with the SDWSC via the Stone Lock facility from mid-spring to late fall (Wood Rodgers 2018), allowing food to enter the Delta and an alternate migration pathway. Juvenile CV Steelhead abundance in the Delta peaks in February through May (Table 5.10-1). Juvenile CV Steelhead passing the Stone Lock facility when there is a hydrologic connection between the waterways could potentially be entrained into the SDWSC. Estimates of salmonid survival in the SDWSC are not available to compare with rates in the Sacramento River route. However, fish entering the SDWSC would not be exposed to entrainment into the interior Delta through the DCC or Georgiana Slough which would provide a benefit if survival rates are similar.

No CV Steelhead are expected to be exposed to the Sacramento Deepwater Ship Channel construction, as the in-water work window does not overlap with their occurrence in the Delta.

5.10.4.18 North Delta Food Subsidies/Colusa Basin Drain Study

Provision of north Delta food subsidies by routing Colusa Basin drain water to the Cache Slough area through the Yolo Bypass would occur in summer/fall, and does not overlap in time or space with juvenile CV Steelhead occurrence in the Delta. There would not be any effect to CV Steelhead adults.

5.10.4.19 Suisun Marsh Roaring River Distribution System Food Subsidies Study

Under the proposed action, provision of Suisun Marsh food subsidies through coordination of managed wetland flood and drain operations in Suisun Marsh and draining of RRDS to Grizzly Bay/Suisun Bay in conjunction with reoperation of the SMSCG would occur in summer/fall and therefore would have limited effects on CV Steelhead juveniles, who are in the Delta between December and July. The action is not expected to have any effect on CV Steelhead adults.

5.10.4.20 Tidal Habitat Restoration

A large proportion of juvenile CV Steelhead are expected to benefit from 8,000 acres of tidal habitat restoration in the Delta under the proposed action. Tidal habitat restoration is expected to benefit juvenile CV Steelhead in several aspects represented by the Winter-run Chinook salmon conceptual model (Figure 5.6-4) including, increased food availability and quality and refuge habitat from predators. These benefits can manifest in higher growth rates and increased survival through the Delta; however, the Delta only represents a small fraction of the total migration route.

Few if any juvenile CV Steelhead would be expected to be exposed to the effects of construction of 8,000 acres of tidal habitat restoration, based on the timing of in-water construction (August–October) and the typical seasonal occurrence of this life stage in the Delta (Table 5.10-1). There may be exposure of a few late migrants, as illustrated by timing of occurrence in Chipps mid-water trawls (Table 5.10-1). Individuals being exposed to construction could experience risk of potential effects similar to those suggested in recent restoration projects such as the Lower Yolo Restoration Project (NMFS 2014). This includes temporary loss of aquatic and riparian habitat leading to increased predation, increased water temperature, and reduced food availability; degraded water quality from contaminant discharge by heavy equipment and soils, and increased discharges of suspended solids and turbidity, leading to direct toxicological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), loss of aquatic vegetation providing physical shelter, and reduced foraging ability caused by decreased visibility; impediments and delay in migration caused by elevated noise levels from machinery; and direct injury or mortality from in-water equipment strikes or isolation/stranding within dewatered cofferdams. The risk from these potential effects would be minimized through application of AMMs.

5.10.4.21 Predator Hot Spot Removal

Predator hot spot removal under the proposed action is primarily focused on providing positive effects to downstream-migrating juvenile salmonids, including CV Steelhead. Although the action would not be limited to existing identified hot spots (e.g., those identified by Grossman et al. 2013), the existing hotspots that may be representative of where removal efforts may be most concentrated are in the primary migratory routes of CV Steelhead. All hotspots are limited in scale relative to overall available habitat, and previous research has not found a consistent positive effect of predator removal on juvenile salmon survival (Cavallo et al. 2012, Michel et al. 2017, Sabal et al. 2017). However, implementation of this action would likely improve conditions for all life stages of CV Steelhead.

5.10.4.22 San Joaquin River Scour Hole Predator Reduction

Steelhead outmigrating from the San Joaquin River are exposed to predation at the junction of the San Joaquin River and Old River. This action would reduce predation at this site, improving juvenile steelhead survival.

Few steelhead are expected to be exposed to in-water construction impacts due to observance of species protective work windows. Impacts of construction to adjust bathymetry would be minimized in accordance with Appendix E, Avoidance and Minimization Measures.

5.10.4.23 Knight’s Landing Outfall Gates Fish Barrier

Reclamation and DWR’s fish barrier at the Knight’s Landing Outfall Gates would prevent possible entrainment of salmonids into the Colusa Basin Drain. This project would reduce entrainment and therefore increase survival of steelhead adults.

Few steelhead are expected to be exposed to in-water construction impacts due to observance of species protective work windows. Impacts of construction would be minimized in accordance with Appendix E, Avoidance and Minimization Measures.

5.10.4.24 Delta Cross Channel Gate Improvements

Completion of DCC gate improvements would benefit CV Steelhead of all life stages within the CVP watershed systems. The peak migration of juvenile CV Steelhead in the Sacramento River past Hood, which is near the DCC, occurs from February through mid-June (Table 5.10-1). No San Joaquin River-origin CV Steelhead are expected to be exposed to the DCC construction. As previously described, juvenile CV Steelhead are largely absent from the Delta between August and November (Table 5.10-1) and, therefore, at most a few late migrants have the potential to be exposed to potential construction from improvements to the DCC under the proposed action.

5.10.4.25 Tracy Fish Facility Improvements

Small proportions of Sacramento River-origin CV Steelhead and moderate proportions of Mokelumne River and San Joaquin River-origin CV Steelhead are expected to be exposed to the Tracy Fish Facility.

However, for fish that arrive at the facility, the proposed improvements resulting in greater salvage efficiency under the proposed action are likely to increase survival of juvenile CV Steelhead.

As previously described, juvenile CV Steelhead are largely absent from the Delta between August and November (Table 5.10-1) and, therefore, none to a few late migrants or early migrants have the potential to be exposed to the effects of construction of the carbon dioxide injection device proposed for the Tracy Fish Facility Improvements. Risks of decrease CV Steelhead juvenile salvage during construction would be minimized through appropriate AMMs.

5.10.4.26 Skinner Fish Facility Improvements

Skinner fish facility improvements under the proposed action to reduce predation on listed fishes following entrainment into CCF could reduce pre-screen loss of juvenile CV Steelhead entrained into CCF; therefore, providing a benefit for all life stages of CV Steelhead.

5.10.4.27 Delta Fishes Conservation Hatchery

Potential effects of the Delta Fishes Conservation Hatchery include inadvertent propagation and release of nuisance species and reduced water quality resulting from hatchery discharge. Mitigation and minimization measures detailed in the EIR/EIS for the facility (Horizon Water and Environment 2017) indicate that potential impacts are less than significant. Potential exposure of juvenile CV Steelhead would be restricted to a small spatial area within the primary migration route.

As with the other proposed construction activities in the Delta under the proposed action, juvenile CV Steelhead are largely absent from the Delta between August and November (Table 5.10-1) which means that none to a few late or early migrants of this life stage could be exposed to Delta Fishes Conservation Hatchery construction. The in-water work constructing the hatchery intake and outfall could result in a small number of individuals experiencing effects such as temporary loss of habitat leading to predation, degraded water quality, noise-related delay in migration, and direct effects from contact with construction equipment or isolation/stranding within enclosed areas. The risk from these potential effects would be minimized through application of AMMs (Appendix E, *Avoidance and Minimization Measures*).

5.10.4.28 Effects of Monitoring

Population estimates for wild steelhead remain outstanding in the Central Valley, therefore it is difficult to quantify the effects of the monitoring on steelhead populations. However, most existing monitoring programs in the Central Valley and Delta/SF Estuary are not designed to capture steelhead, which are much larger than Chinook Salmon upon river and Delta entry. Existing programs likely have poor capture efficiency for collecting and retaining steelhead. Therefore, it is unlikely the monitoring programs have any effects to the population. Reclamation and DWR have proposed one continuing and two new steelhead monitoring programs as part of the proposed action. These include the San Joaquin Basin Steelhead Telemetry Study, which is a continuation of the 6-Year Steelhead telemetry study for the migration and survival of San Joaquin Origin Central Valley Steelhead. In addition, Reclamation and DWR will develop a Steelhead Lifecycle Monitoring Program, which will support a functioning life cycle monitoring program in the Stanislaus River and a Sacramento basin CVP tributary (e.g. Clear Creek, Upper Sacramento, American River) to evaluate how actions related to stream flow enhancement, habitat restoration, and/or water export restrictions affect biological outcomes including population abundance, age structure, growth and smoltification rates, and anadromy and adaptive potential in these two populations. The goal of this monitoring program will be to improve understanding of steelhead demographics and, when combined with other steelhead-focused parts of the Proposed Action (San

Joaquin and Delta steelhead telemetry study), inform actions that will increase steelhead abundance and improve steelhead survival through the Delta. This program would hopefully increase capture efficiency for steelhead, likely leading to some harassment of individuals. Finally, within 1 year, Reclamation will coordinate with CSAMP to sponsor a workshop for developing a plan to monitor steelhead populations within the San Joaquin Basin and/or the San Joaquin River downstream of the confluence of the Stanislaus River, including steelhead and rainbow trout on non-project San Joaquin tributaries. The plan would be delivered to the IEP for prioritization and implementation, where feasible, for actions withing the responsibility of the CVP and SWP and other members of the IEP. If the IEP is not able to implement the plan, the plan may be raised at the Director Level Collaborative Planning Meeting described under the "Governance" section of this PA for resolution.

Table 5.10-3. Monitoring Programs – Steelhead

Species	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Chipps Island Trawl																		
Steelhead	178	133	128	233	132	141	35	82	118	100	37	57	79	81	106	96	143	
Sacramento Trawl																		
Steelhead	37	36	20	9	54	42	56	62	40	40	134	12	287	16	35	44	129	
DJFMP Beach Seine Survey																		
Steelhead	36	27	28	30	42	31	25	17	26	13	13	17	45	7	6	1	20	0
CDFW Mossdale Trawl																		
Steelhead	8	17	12	7	11	41	5	1	4	5	11	26	12	28	3	0	8	
EDSM KDTR Trawls																		
Steelhead	na	na	na	na	na	na	na	na	na na	na	na	na	na	na	0	44	na	
CDFW Bay Study Trawls																		
Steelhead	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	na	
CDFW SKT Study																		
Steelhead	23	38	37	58	54	62	19	13	46	25	36	12	86	49	52	19	40	
Totals																		
Steelhead	282	251	225	425	293	317	140	175	234	183	237	124	509	181	202	160	340	
RBDD Rotary Trap or Juvenile Production Estimate (JPE)																		
Steelhead																		

5.11 Steelhead, Central Valley DPS Critical Habitat

Critical habitat for the California CV steelhead DPS was designated in 2005 and includes all river reaches accessible to steelhead in the Sacramento and San Joaquin rivers and their tributaries, the Delta, and Yolo Bypass (70 FR 52488). The geographical extent of CCV steelhead critical habitat includes the Sacramento, Feather, and Yuba rivers and Deer, Mill, Battle, and Antelope creeks in the Sacramento River; the San Joaquin River, including its tributaries but excluding the mainstem San Joaquin River above the Merced River confluence; and the waterways of the Delta. Critical habitat includes stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line or bankfull elevation (defined as the level at which water begins to leave the channel and move onto the floodplain, and generally corresponds with a discharge that occurs every 1 to 2 years on an annual flood series) (70 FR 52488).

The designated critical habitat includes PBFs that are essential for the conservation of CCV steelhead:

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

5.11.1 Effects of Operation

5.11.1.1 Spawning Habitat

Proposed operations under the proposed action would have largely beneficial effects on the PBFs of spawning habitat for CV steelhead. Based on relationships between flow and spawning WUA for steelhead in the upper Sacramento River (USFWS 2003), lower flows under the proposed action would substantially increase the number of years in which velocities would be within the optimum range during the primary spawning period (January through March). Furthermore, Keswick releases during the spring would be substantially cooler under the proposed action, resulting in suitable water temperatures for eggs and alevins through May.

5.11.1.2 Freshwater Rearing Habitat

Higher flows and lower temperatures under the proposed actoin would have beneficial effects on the PBFs of freshwater rearing habitat for CV steelhead. Although higher summer flows under the proposed action are associated with reductions in WUA, these flows would have positive effects on overall habitat quantity and quality. Potential benefits include increased downstream extent of suitable rearing temperatures, improved access to riparian and off-channel habitat, reduced crowding and competition, and increased prey availability. The flow-related benefits of the proposed action on critical habitat would be further enhanced by Shasta cold water management actions and cooler release temperatures at Keswick Dam to protect winter-run Chinook salmon during the summer spawning and incubation period.

5.11.1.3 Freshwater Migration Corridors

The proposed action would have both positive and negative effects on the PBFs of freshwater migration habitat for adult and juvenile CV steelhead. Lower flows during the winter and early spring (January through April) under the proposed action would have negative effects on migratory habitat for juvenile steelhead. However, higher flows and lower temperatures under the proposed action during the late spring and summer (May through September) would have beneficial effects on migratory habitat of juveniles and adults, especially in dry and critically dry years.

5.11.1.4 Estuarine Areas

The proposed action would have both positive and negative effects on the PBFs of estuarine habitat for CV steelhead. The potential for operation-related impacts on estuarine habitat would be similar to those described for freshwater rearing habitat and migration corridors above.

5.11.1.5 Effects of Maintenance

Implementation of the species avoidance and take minimization steps described in Appendix E – ROC Real-Time Water Operations Charter in section Routine Operations and Maintenance on CVP Activities would be anticipated to minimize potential negative effects to CV Steelhead critical habitats from maintenance activities.

5.11.2 Effects of Conservation Measures

5.11.2.1 Spawning Habitat

Several programmatic actions that are proposed as part of the proposed action include construction components that could affect the critical habitat PBFs of steelhead spawning habitat. These actions include proposed spawning habitat enhancement projects (e.g., gravel augmentation), rearing habitat enhancement projects (e.g., side channel creation), and installation of screens on small unscreened diversions (small screen program). Based on the proposed in-water work windows (see AMM2 *Construction Best Management Practices and Monitoring*), spawning adults, eggs, and alevins could be exposed to construction activities during November through February or mid-May, depending on the river reach. The potential effects of construction activities on steelhead spawning habitat and the proposed AMMs would be similar to those described for spring-run Chinook salmon.

5.11.2.2 Freshwater Rearing Habitat

Construction components of the programmatic actions could also affect the critical habitat PBFs of freshwater rearing habitat for steelhead. Because juvenile steelhead are present year-round in the proposed action area, juveniles would be subject to potential construction activities whenever they occur. Based on the proposed in-water work windows (see AMM2 *Construction Best Management Practices and Monitoring*), rearing juveniles could be exposed to construction activities during October through February or mid-May, depending on the river reach. The potential effects of construction activities on steelhead rearing habitat and proposed AMMs would be similar to those described for spring-run Chinook salmon.

5.11.2.3 Freshwater Migration Corridors

Several programmatic actions that are proposed as part of the proposed action could affect the critical habitat PBFs of freshwater migration corridors for steelhead. These actions include proposed tidal and channel margin restoration, spawning and rearing habitat enhancement projects, and installation of new diversions and screens. Potential exposure of migrating juveniles to construction activities would be avoided or minimized by restricting all instream activities to the proposed in-water construction window (August 31 to October 31 in the legal Delta, and June 1 to October 1 in the Sacramento River between Red Bluff Diversion Dam and the boundary of the legal Delta). However, the potential for exposure of migrating adults to these construction activities is high, especially during the peak migration period (September through October). In addition, although the proposed in-water construction windows would avoid the primary migration periods of juvenile steelhead, timing information for brood years 2004 through 2017 (Appendix F: SacPAS Summary) indicates that juveniles may sometimes occur in the middle Sacramento River and Delta during summer and early fall. However, none of the proposed construction activities would create a migration barrier or cause significant delays in migration of steelhead adults or juveniles. Based on the proposed AMMs, potential effects would be limited to temporary delays in passage resulting from behavioral effects that could occur in response to noise, turbidity, and other physical disturbances at construction sites. Other potential effects of construction activities on steelhead migration habitat would be similar to those described for spring-run Chinook salmon rearing and migration habitat. However, because most steelhead juveniles would be large, actively migrating smolts, their sensitivity to potential construction effects (e.g., injury or mortality from in-water work activities) would be lower than that of juvenile Chinook salmon.

5.11.2.4 Estuarine Areas

The proposed action includes a number of programmatic actions that could affect the PBFs of estuarine habitat for CV steelhead, including tidal and channel margin restoration, facility improvements (Delta Cross Channel Gate improvements), Delta Fish Species Conservation Hatchery, and Small Screen Program). The potential for construction-related impacts of these projects on estuarine habitat would be similar to those described for freshwater rearing habitat and migration corridors above.

5.11.2.5 Effects of Monitoring

Monitoring would have no effect on critical habitat.

5.12 North American Green Sturgeon, Southern DPS

The proposed action has lower flows than the WOA during the spring, in particular March, April, and May, in all the watersheds when adults are migrating upstream to spawn. Releases for water supply in the summer and early fall associated with the proposed action result in higher flows relative to WOA during the period of broadcast spawning. These higher flows increase: (1) spawning habitat; (2) water velocities that flush sediment from green sturgeon redds; (3) the ability to maintain adequate levels of DO in contact with green sturgeon eggs; and (4) water depth suitable for Green Sturgeon

Reclamation has included a variety of conservation measures to increase alevin and juvenile productivity of Green Sturgeon. These include spawning and rearing habitat, cold water pool management, predator hot spot removal, and a small screen program. Volitional passage past the Red Bluff Diversion Dam was achieved in 2013 and allows free movement for adult Green sturgeon throughout their spawning habitat.

5.12.1 Lifestage Timing

General life stage timing and location information for Green Sturgeon is provided in Table 5.12-1.

Table 5.12-1. Temporal Occurrence of (a) Spawning Adult, (b) Larval, (c) Young Juvenile, (d) Juvenile, and (e) Sub-adult/Non-spawning Green Sturgeon (NMFS 2017, Appendix B, p.68)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(a) Adult-sexually mature (≥145 cm TL females, ≥ 120 cm TL males), including pre- and post-spawning individuals.												
Sac River (rkm 332.5-451)	Low / Low	Low / Low	Medium / Medium	High / High	High / High	High / High	High / High	High / High	High / High	High / High	High / Medium	Medium / Medium
Sac River (< rkm 332.5)	Low / Low	Low / Medium	Medium / Medium	Medium / Medium	Low / Low	Low / Low	Low / Low	Low / Low	Low / Low	Low / Low	Low / Low	Low / Low
Sac-SJ-SF Estuary	Low / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Low / Low
(b) Larval												
Sac River (> rkm 332.5)			/ Low	Medium / Medium	High / High	High / High	High / High	Medium / Medium	Medium / Medium	Low / Low		
(c) Juvenile (≤5 months old)												
Sac River (> rkm 332.5)				/ Low	Medium / Medium	Medium / Medium	High / High	High / High	High / High	High / Medium	Medium / Medium	Medium / Medium
(d) Juvenile (≥5 months)												
Sac River (< rkm 391)	Medium / Medium	Medium / Medium	Low / Low	Low / Low	Low / Low	Low / Medium	Medium / Medium	Medium / High	High / High	High / High	High / High	High / Medium
Sac-SJ Delta, Suisun Bay	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium
(e) Sub-Adults and Non-spawning adults												
SAC-SJ-SF Estuary	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	High / High	High / High	High / High	High / High	High / High	High / High	Medium / Medium
Pacific Coast	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium
Coastal Bays & Estuaries[1]	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	High / High	High / High	High / High	High / High	High / High	High / High	Medium / Medium

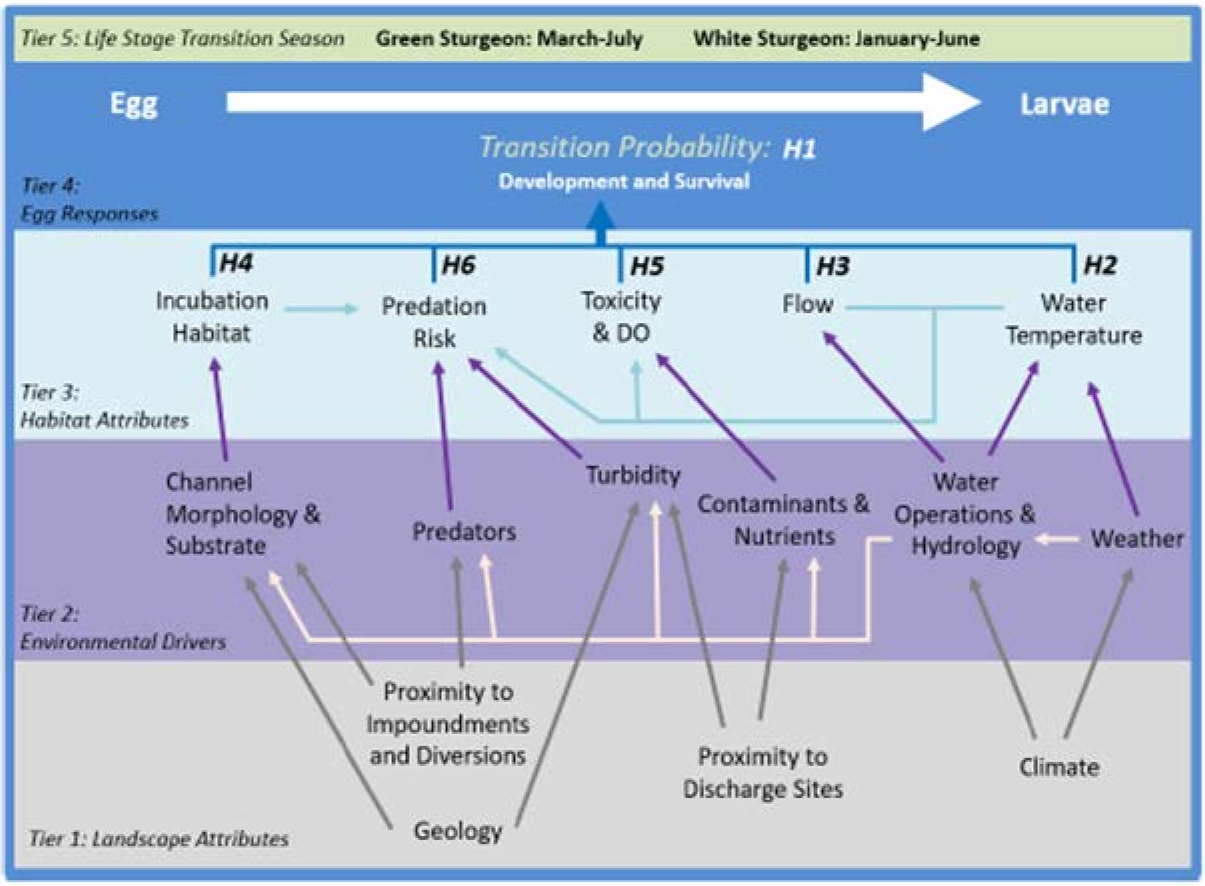
Relative Abundance: = High = Medium = Low

Sources: (a) Heublein et al. 2008; Klimley et al. 2015; Poytress et al. 2015; Mora et al. 2015; (b) Poytress et al. 2015; Heublein et al. in review; (c) Heublein et al. in review, B. Poytress, unpublished; (d) Radtke 1966; CDFG 2002, Heublein et al. in review, B. Poytress, unpublished; (e) Erickson and Hightower 2007; Moser and Lindley 2006; Lindley et al. 2008, Lindley et al. 2011; Huff et al. 2011. Outside of Sac-SJ-SF estuary (e.g. Columbia R., Grays Harbor, Willapa Bay).

5.12.2 Conceptual Model Linkages

The Salmon and Sturgeon Assessment of Indicators by Life Stage (SAIL) conceptual models describe life stage transitions of Green Sturgeon. Life stage transitions are the series of changes in form that an organism undergoes throughout its life cycle. SAIL life stage transitions include egg to larval, larvae to juvenile, juvenile to subadult/adult, adult to spawning, and spawning adult to egg and post-spawn adult period.

The egg to larval period for Green Sturgeon, as described by the SAIL Conceptual model (Heublein et al. 2017), is during March to July for the geographic area from Cow Creek to the Glenn Colusa Irrigation District diversion dam (Sacramento River) and from the Fish Barrier Dam to Shanghai Bend (Feather River). The hypothesized landscape attributes (geographically and temporal characteristics of the Central Valley and Bay-Delta that do not change over the analysis timescale), environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.12-1.



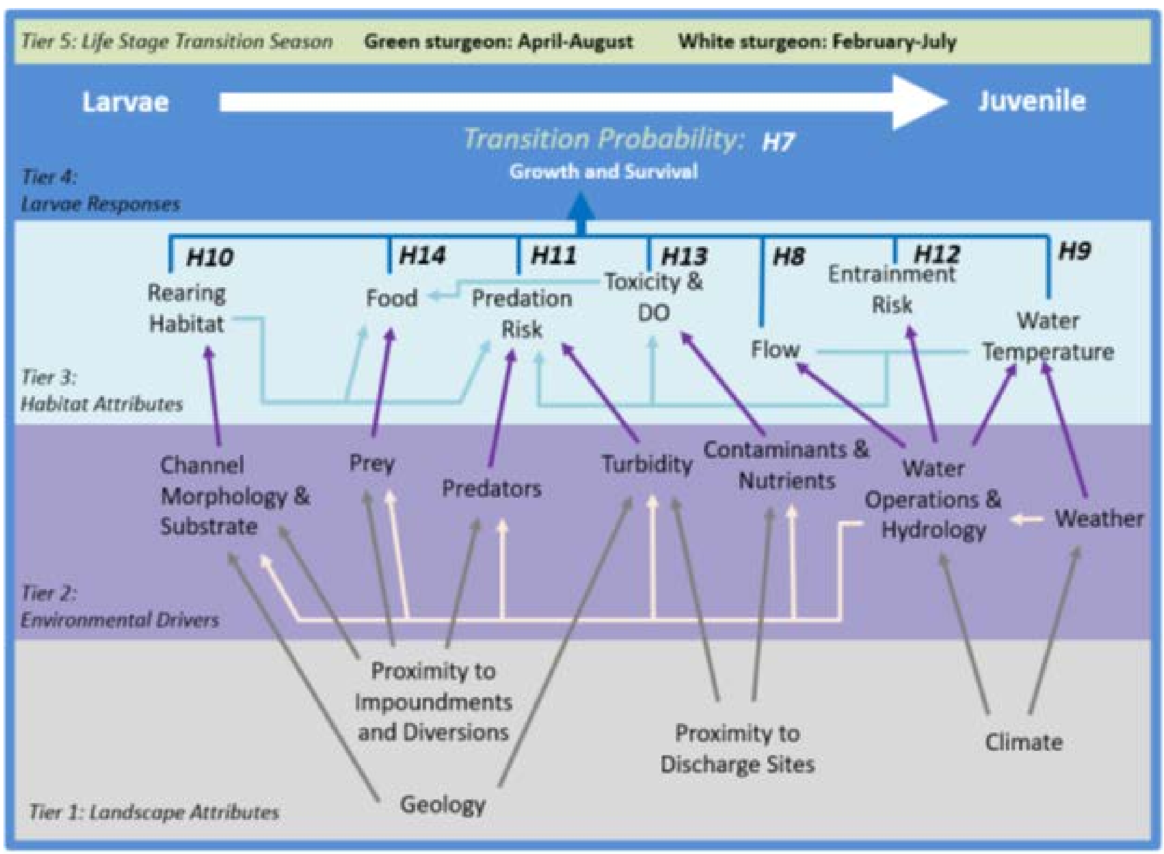
Source: Heublein et al. (2017). Note: Hypotheses are referenced by the H-number for habitat attributes.

Figure 5.12-1. Conceptual Model of Drivers Affecting the Transition of Green Sturgeon from Egg to Larva

Eggs from spawning Green Sturgeon have been found in the middle and upper Sacramento River from the Glen Colusa Irrigation District oxbow (GCID) (River Mile [RM] 207) to Inks Creek (RM 265) and based on adult sightings and presence of suitable habitat, spawning is believed to extend upstream to the confluence with Cow Creek (RM 277) (Heublein et al. 2017b). Green sturgeon spawn in deep pools (averaging about 28 feet deep) (NMFS 2018).

Green Sturgeon spawn primarily from April through July, although they periodically spawn in late summer and fall (as late as October) (Heublein et al. 2009, 2017b, NMFS 2018) (Table 5.12-1). Northern DPS Green Sturgeon eggs incubate at about 60 degrees Fahrenheit from hatch to about a week after fertilization, and incubation time of southern DPS Green Sturgeon eggs is assumed to be similar (Heublein et al. 2017b). Because the incubation time for Green Sturgeon is so short, the effects analysis period for egg to larvae transition is considered to be the same as the spawning period, April through July, occasionally extending to October.

The larvae complete metamorphosis and become juveniles during April through August, as described by the SAIL Conceptual model (Heublein et al. 2017), for the geographic area from Bend Bridge (Sacramento River) and Thermalito Outlet (Feather River) to the Golden Gate Bridge. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.12-2.



Source: Heublein et al. (2017). Note: Hypotheses are referenced by the H-number for habitat attributes.

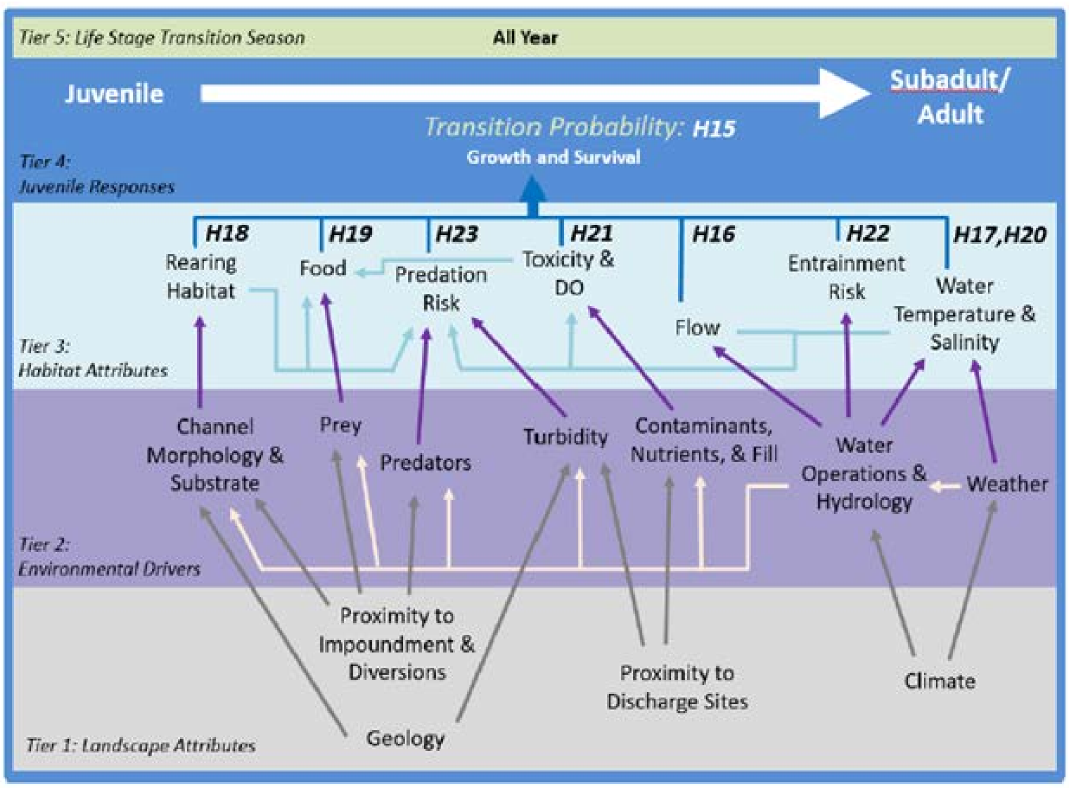
Figure 5.12-2. Conceptual Model of Drivers Affecting the Transition of Green Sturgeon from Larva to Juvenile

According to field observations, Green Sturgeon larvae begin to disperse from hatching areas at 18 days post hatch (dph), and dispersion is complete at about 35 dph (Poytress et al. 2011, cited in Heublein et al. 2017b). They begin exogenous feeding at about 15 dph. The larvae use benthic structure and seek refuge within crevices, but also forage over hard surfaces (Nguyen and Crocker 2007 cited in Heublein et al. 2017b). The juvenile stage begins when metamorphosis of the larvae is complete, typically at about 45 dph (Heublein et al. 2017b).

July is the end of the peak spawning period, so the end of the larva to juvenile period is considered to be September.

The downstream distribution of Green Sturgeon larvae in the Sacramento River is uncertain, but is estimated to extend to the Colusa area, at River Mile 157 (Heublein et al. 2017b). The larvae occur upstream to the Cow Creek confluence, which is the upstream limit of their spawning distribution (Heublein et al. 2017b).

The juvenile life stage transition, as described by the SAIL Conceptual model (Heublein et al. 2017), from complete metamorphosis to ocean migration or 75 cm fork length occurs in the geographic area from Bend Bridge (Sacramento River) and Thermalito Outlet (Feather River) to the Golden Gate Bridge. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.12-3.

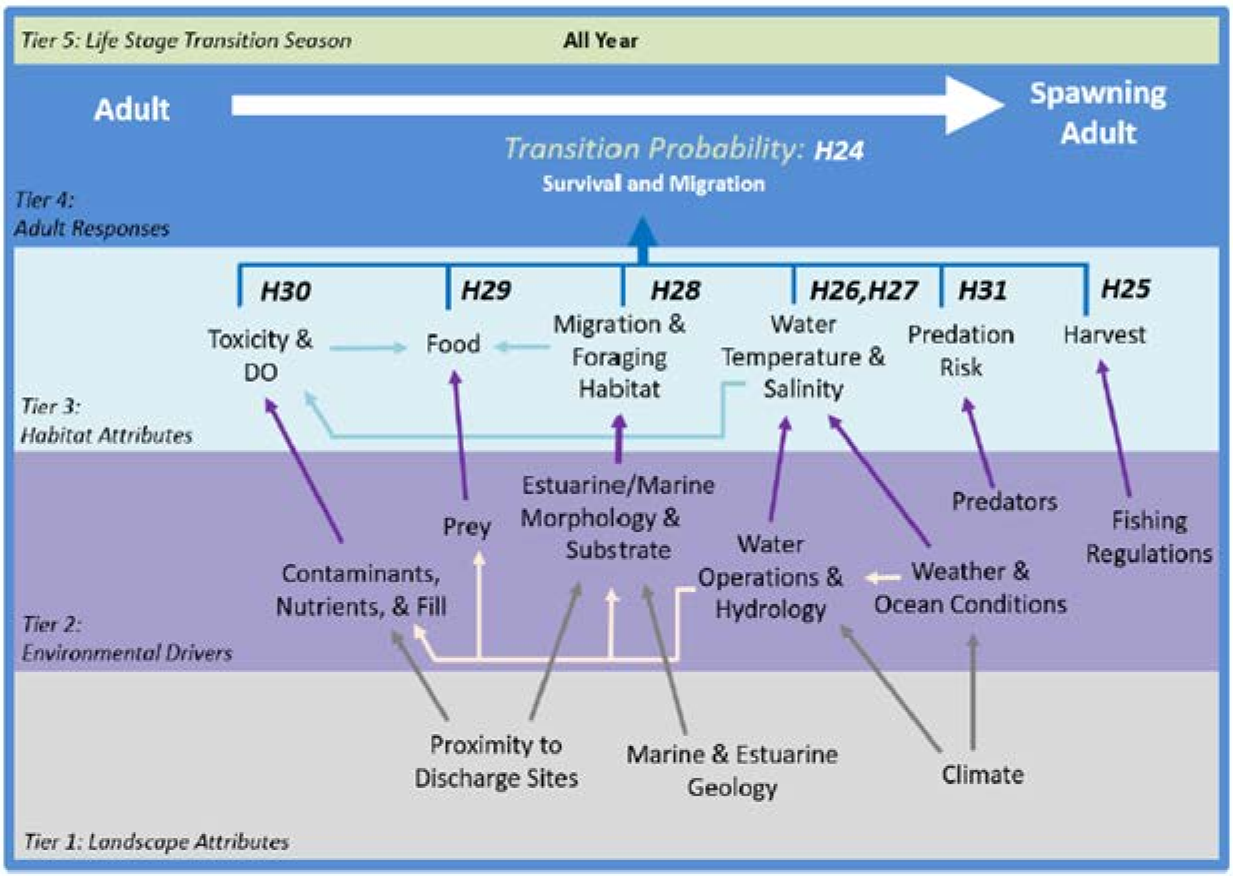


Source: Heublein et al. (2017). Note: Hypotheses are referenced by the H-number for habitat attributes.

Figure 5.12-3. Conceptual Model of Drivers Affecting the Transition of Green Sturgeon from Juvenile to Subadult/Adult

The Green Sturgeon juvenile stage begins when metamorphosis of the larvae is complete, typically at about 45 dph and about 75 mm in length (Heublein et al 2017b). It is likely that juveniles rear near spawning habitat for a few months or more before migrating to the Delta (Heublein et al. 2017b). The period for juveniles less than or equal to 5 months old, considered to be the ages of most juveniles rearing in or migrating through the Sacramento River upstream of the Delta, is given in Table 5.12-1 as May through December. During most of the juvenile Green Sturgeon rearing period, the juveniles are likely to be found anywhere from the upstream spawning habitat near the Cow Creek confluence to the Delta.

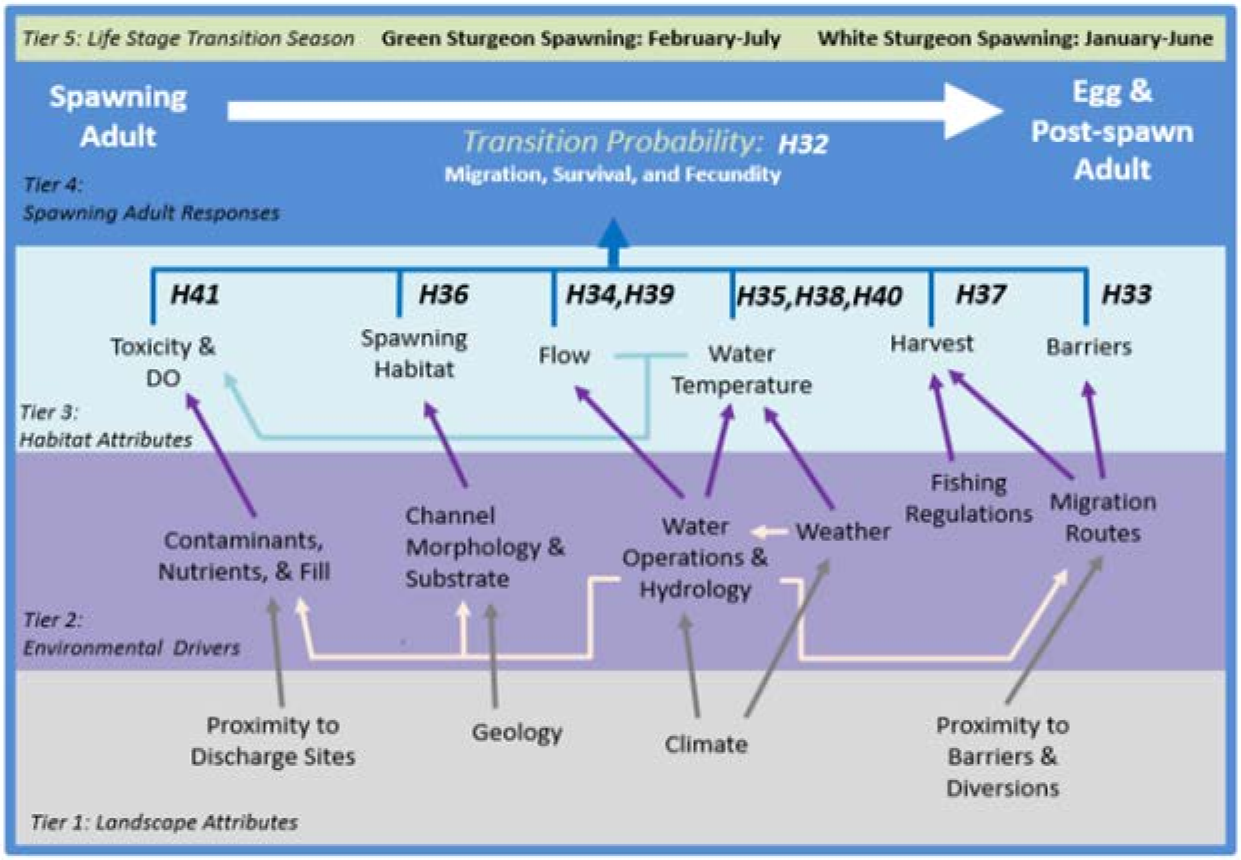
The adult to spawning adult life stage transition, as described by the SAIL Conceptual model (Heublein et al. 2017), is geographically located in California, Oregon, and Washington estuaries during May-October, as well as the nearshore marine environment all year. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.12-4.



Source: Heublein et al. (2017). Note: Hypotheses are referenced by the H-number for habitat attributes.

Figure 5.12-4. Conceptual Model of Drivers Affecting the Transition of Green Sturgeon from Adult to Spawning Adult

The spawning adult life stage transition from spawning adult to egg and post-spawn adult, as described by the SAIL Conceptual model (Heublein et al. 2017), occurs in the geographic area for migration and spawning from the Golden Gate Bridge to Cow Creek (Sacramento River), Fish Barrier Dam (Feather River), and Daguerre Point Dam (Yuba River). The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.12-5.



Source: Heublein et al. (2017). Note: Hypotheses are referenced by the H-number for habitat attributes.

Figure 5.12-5. Conceptual Model of Drivers Affecting the Transition of Green Sturgeon from Spawning Adult to Egg and Post-Spawn Adult.

Continuing their upstream migration from the Delta, Green Sturgeon adults enter the Sacramento River as early as February and ultimately make their way upstream to spawn in deep pools from the Glenn Colusa Irrigation District oxbow (GCID) to the Cow Creek confluence (Heublein et al. 2017b). Elevated flows during the late winter and early spring months may provide an important cue for spawning Green Sturgeon adults to initiate their upstream migrations (Heublein et al. 2009; NMFS 2017b). Green Sturgeon spawn in most years from April through July, but spawn in occasional years as late as October. After spawning, the adults hold in the river for varying amounts of time, but typically emigrate back to the San Francisco Estuary and the ocean from about October through December (Heublein et al. 2017b). Emigration may occur as early as late spring or summer and may be related to elevated flows (Heublein et al. 2009).

As indicated by the SAIL conceptual model (Figures 5.12-1 to 5.12-5), hydrologic conditions and operations of Shasta and Keswick reservoirs affect flows and water temperatures in the upper Sacramento River, which combined with other environmental drivers, affect DO, water quality, predation, and other habitat attributes that influence the timing, condition, growth, and survival of Green Sturgeon in all life stages in the Sacramento River.

Hydrologic conditions and operations of water diversions also affect entrainment risk (Verhille et al. 2014; Heublein et al. 2017a [SAIL model]; Mussen et al. 2014). The proportion of larvae surviving to the juvenile stage, as well as juveniles surviving to emigrate from the Sacramento River depends largely on habitat conditions, including instream flow (Heublein et al. 2017b). Instream flow affects other factors through dilution (e.g., toxicity and contaminants), water temperatures (which also affects DO, food availability, predation, pathogens, and disease), river stage and flow velocity (which affect bioenergetics, food availability, and predation), entrainment, and potentially affects cues that stimulate outmigration (Heublein et al. 2017b, NMFS 2017b). The proportion of eggs to hatch, during the egg to larvae lifestage, is affected by substrate composition, depth, contaminants, sedimentation, predators of the spawning habitat, as well as the other aforementioned factors (Heublein et al. 2017a [SAIL model], 2017b). In addition, instream flow from Keswick Dam releases, relative to flow from the lower Yolo and Sutter bypasses and agricultural drains, may affect navigation cues and increase straying risk of Green Sturgeon adults into these canals and behind these bypass weirs (Figure 5.12-5). Instream flows may affect sedimentation and substrate composition of the spawning habitat and may affect channel morphology (Heublein et al. 2017a [SAIL model] and 2017b). Flow and water temperature also affect the area of river bed suitable for spawning and may influence the timing of spawning (Heublein 2017a [SAIL model] and 2017b). Flows may also disperse larvae to more favorable downstream habitats (NMFS 2018). Larval abundance and distribution may be influenced by spring and summer outflow (Heublein et al. 2017b). Flows may also transport juveniles to more favorable habitats (NMFS 2018). Juvenile abundance and distribution may be influenced by winter outflow (Heublein et al. 2017b).

In addition, water temperatures, combined with other environmental drivers, have the potential to heavily influence condition and survival of Green Sturgeon for all life stages. The egg and larval life stages are the most sensitive to temperature exceedances outside of optimal ranges, and exposure to the effects of elevated water temperatures include elevated mortality and increased occurrence of morphological abnormalities in eggs that do hatch (Van Eenennaam et al. 2005). Thermal tolerance ranges for Green Sturgeon egg and larvae are considered optimal between 53 to 64 ^{0}F, and are suboptimal at 65 to 66 ^{0}F. Temperatures between 67 to 72 ^{0}F result in impaired fitness and temperatures greater than 73 ^{0}F are likely lethal (NMFS 2016).

The life stages of juvenile to subadult/adult Green are not particularly sensitive to temperatures below the lethal level of 73.5 ^{0}F (NMFS 2016). Exposure to the effects of elevated water temperatures can include an increased susceptibility to disease and physiological stress potentially leading to mortality and altered migration timing and speed. Juvenile Green Sturgeon require temperatures of 58 to 66 ^{0}F for optimal survival and growth, 42 to 57 ^{0}F and 67 to 68 ^{0}F are suboptimal, and temperatures greater than 69 ^{0}F may lead to impaired fitness (NMFS 2016).

For the adult to spawning adult life stage, Green Sturgeon require temperatures between 53 °F and 64 °F for optimal survival, with temperatures from 67 °F to 72 °F leading to impaired fitness and temperatures over 73 °F being lethal. Migrating and holding Green Sturgeon require temperatures between 46 °F and 68 °F for optimal survival, with temperatures from 70 °F to 76 °F leading to impaired fitness and temperatures over 77 °F being lethal (NMFS 2016).

5.12.3 Effects of Operation & Maintenance

5.12.3.1 Seasonal Operations

Under the WOA condition, there would be no Shasta and Keswick reservoir operations to control storage or releases and no transfer of water from the Trinity River Basin. Therefore, there would be no control of flow or water temperature in the upper Sacramento River (other than upstream hydropower operations not under Reclamation control), where Green Sturgeon spawn. Reservoir gates and river valves would be kept open, resulting in minimal storage, and assuming stratification developed, the cold water pool would be small and would not be managed. Flows under these conditions, especially in the upper Sacramento River, would approximate uncontrolled flows. The similarity to uncontrolled flows is reflected in the seasonal flows modeled under the CalSim WOA scenario in the Sacramento River at Keswick, with low summer and fall flows and high winter and spring flows (Figure 5.12-6). Other locations in the Sacramento River would show similar seasonal flow patterns as illustrated by flows at the Hamilton City gauge in the middle the Sacramento River (see Appendix D, *Modeling*).

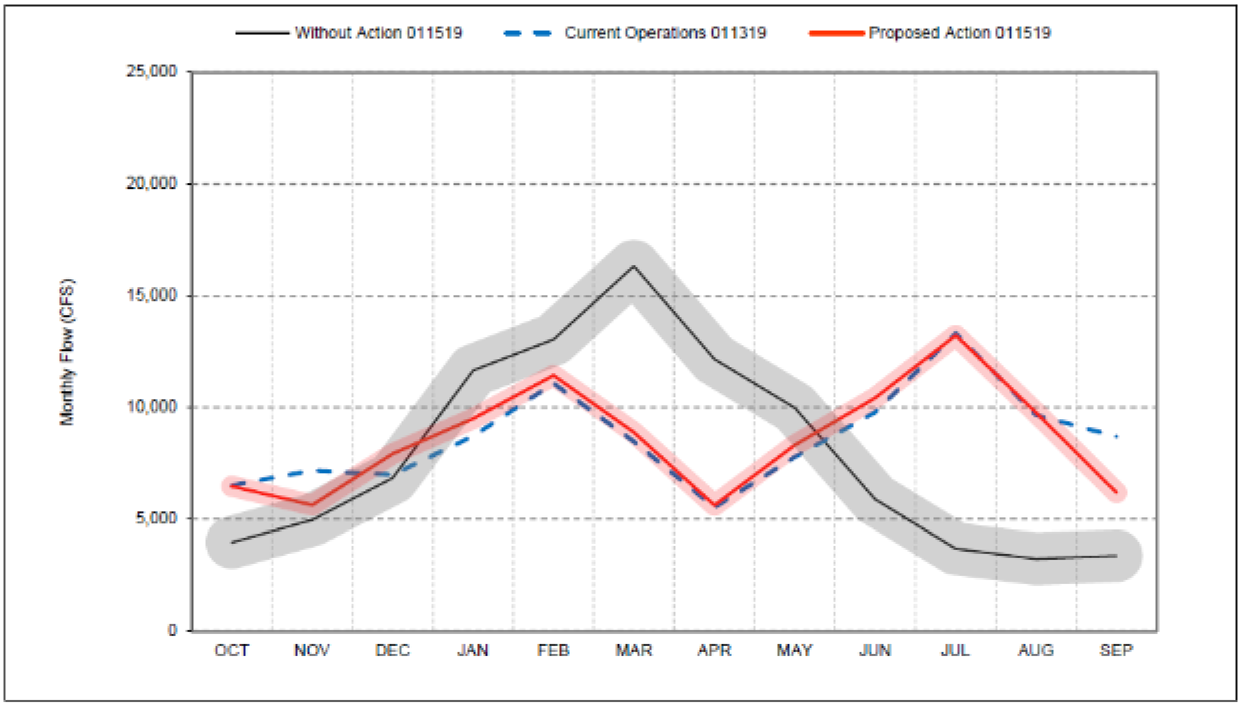


Figure 5.12-6. Flows at Keswick under the Proposed Action (PA), Current Operations (COS), and without Action (WOA)

CalSim modeling indicates that from February through April, when Green Sturgeon adults migrate upstream through the middle Sacramento River to their spawning habitats, the WOA modeling scenario mean monthly flows at Wilkins Slough would range from about 2,500 cfs in April to 24,000 cfs in March (Figures 19-11 and 19-12 in the CalSim flow section of Appendix D), and the flows at Red Bluff Diversion Dam would range from about 3,500 cfs in April to 77,000 cfs in February and March (Figures Figures 17-11 through 17-13 in the CalSim II flow section of Appendix D). From May through July, when adults have begun spawning and some are emigrating downstream, the WOA mean monthly flows at Wilkins Slough would range from 0 cfs in May through July to about 20,000 cfs in May (Figures 19-14 through 19-16 in the CalSim II flow section of Appendix D), and flows at RBDD would range from about 2,950 cfs in June to 36,000 cfs in May (Figures 17-14 through 17-16 in the CalSim II flow section of

Appendix D). Flows below about 3,250 cfs are considered to result in passage difficulties for adult Green Sturgeon in the Sacramento River (NMFS 2017b). From August through December, most of the adults remaining in the river after spawning hold for varying amounts of time and then emigrate downstream to the San Francisco Estuary. As previously noted, in occasional years Green Sturgeon may spawn until October. WOA mean monthly flows at Wilkins Slough during August through December range from a low of about 0 cfs in August to a high of 23,000 cfs in December (Figures 19-7, 19-8, 19-9, 19-17, 19-18, in the CalSim II flow section of Appendix D) and at Red Bluff from about 1,650 cfs in August to about 56,000 cfs in December (Figures 5.12-7 through 5.12-10).

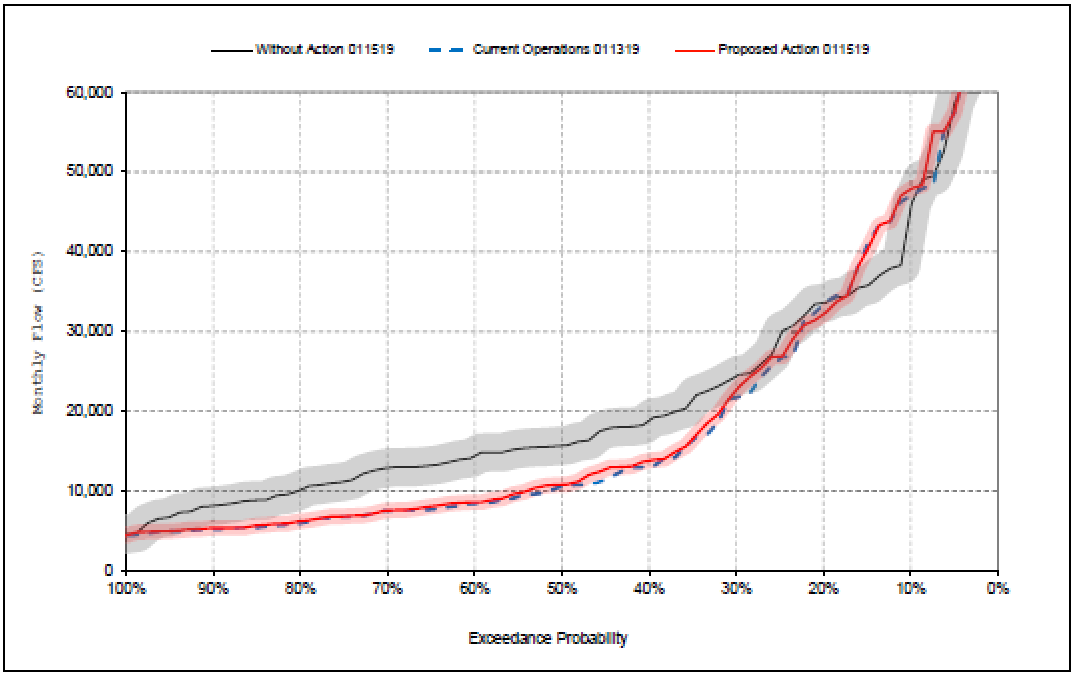


Figure 5.12-7. CalSim II Sacramento River Flows at Red Bluff, February

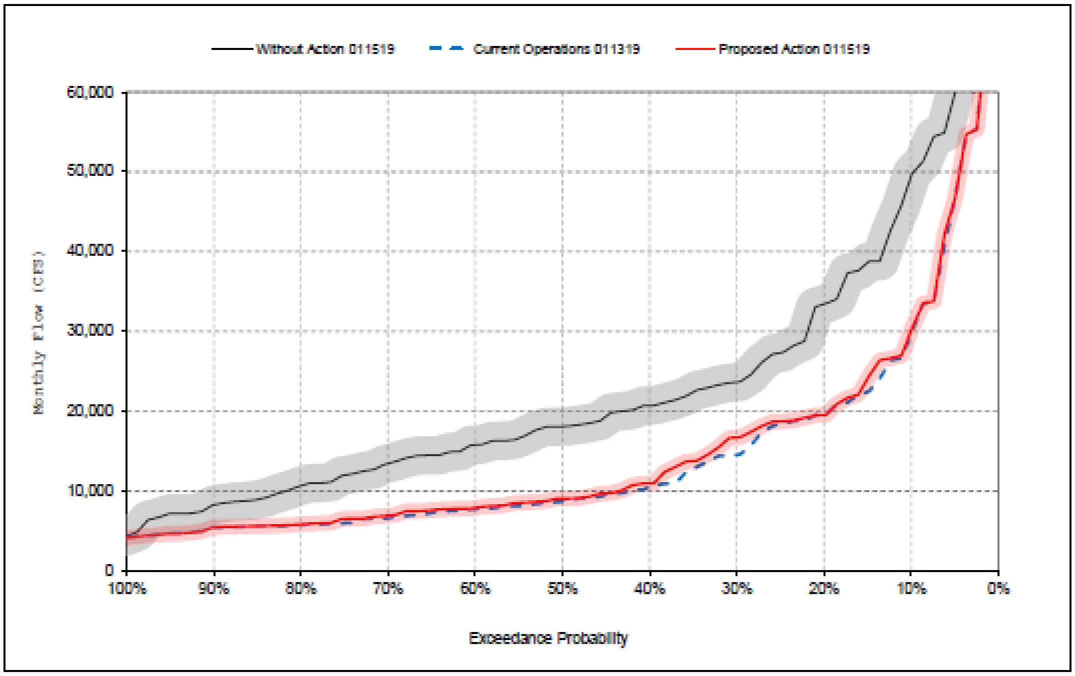


Figure 5.12-8. CalSim II Sacramento River Flows at Red Bluff, March

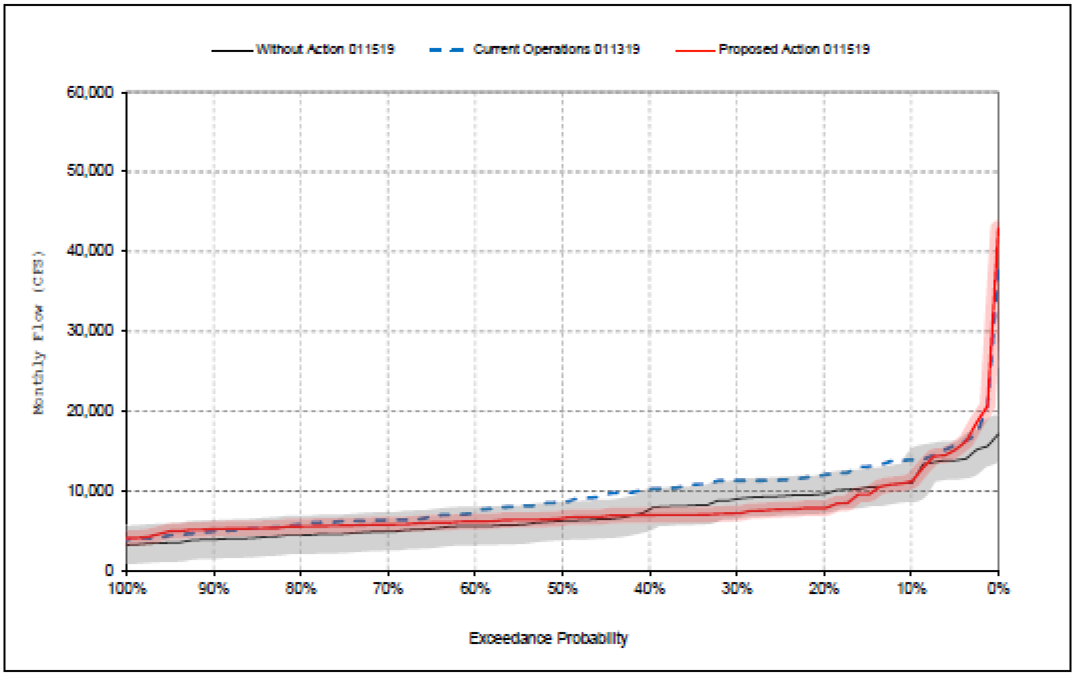


Figure 5.12-9. CalSim II Sacramento River Flows at Red Bluff, November

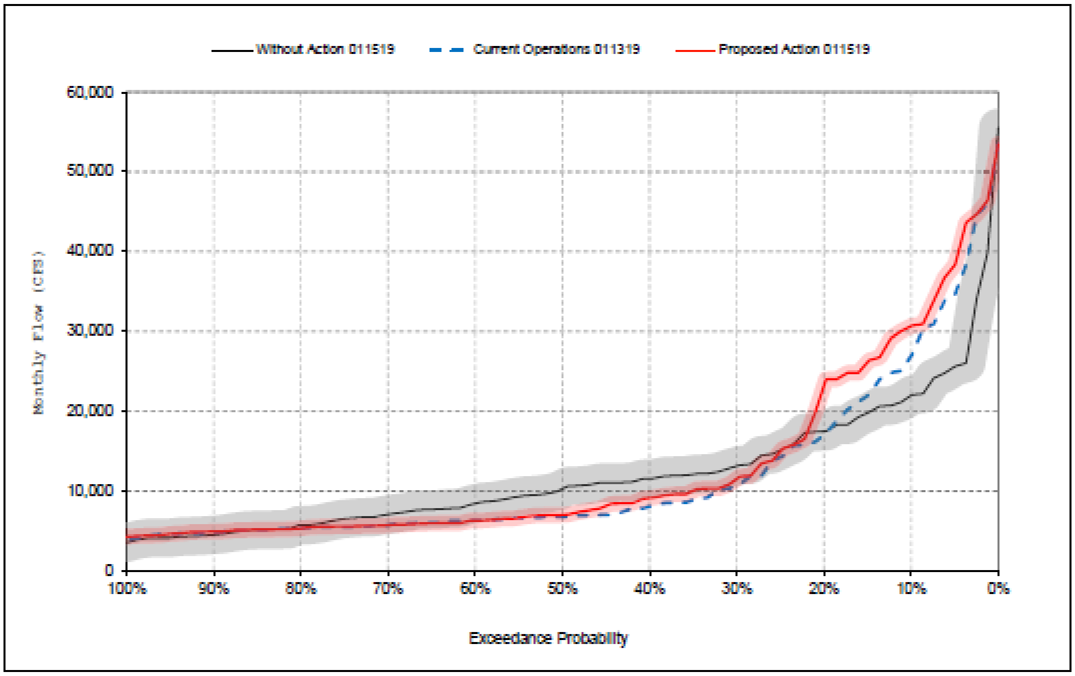


Figure 5.12-10. CalSim II Sacramento River Flows at Red Bluff, December

The very low WOA flows in some years during late spring through the fall would be likely to negatively impact migrating, spawning and holding Green Sturgeon adults. At Wilkins Slough, the mean monthly flow during June through August is less than 100 cfs in 10 to 20 percent of years, and during June through October is less than 3,250 cfs in at least 50 percent of years each month, including over 90 percent of years in July and August. These low flows would potentially cause passage problems for adults emigrating from May through November. They could also affect immigrating adults, but the peak period of immigration is generally complete by early summer. The low flows at RBDD would have potential adverse effects on spawning and holding habitats of Green Sturgeon adults, which include reduced area of river bed suitable for spawning, insufficient depths for spawning and holding habitats, reduced flushing of metabolic wastes from spawning and holding pools, and greater concentration of toxic contaminants and disease organisms.

Sacramento River water temperatures under the WOA conditions vary greatly during the May through December Green Sturgeon juvenile rearing and emigration period (see Appendix D, *Modeling*). During May and October, the mean monthly water temperatures at Woodson Bridge under the WOA modeling scenario lie within the 59 to 66 degrees Fahrenheit optimal temperature range in about 85 percent of years, with a total range of 59 to 70 degrees Fahrenheit for May and 57 and 65 degrees Fahrenheit for October. However, during June through September, the WOA mean monthly water temperatures exceed the 66 degrees Fahrenheit upper limit in every year, and during November and December, they lie below the 59 degrees Fahrenheit threshold in every year. The WOA mean monthly water temperatures would be greater than 78 degrees Fahrenheit during July and August in 25 and 10 percent of years, respectively. Temperatures exceeding 78 degrees Fahrenheit are identified as “likely lethal” (Heublein 2017b et al.). The WOA water temperatures in the upper Sacramento River (upstream of Red Bluff) would be cooler than those at Woodson Bridge, but July and August temperatures at Keswick would exceed the 66 degrees Fahrenheit threshold in every year. The November and December water temperatures at Keswick are consistently below the lower limit of the optimal temperature range for Green Sturgeon larvae (66 degrees Fahrenheit). Under the WOA conditions, Green Sturgeon juveniles are not likely to survive July and August water temperatures at Woodson Bridge and downstream. While they might be able to survive upstream of Red Bluff, they would not be able to migrate downstream until the river had cooled off later in the season.

Sacramento River water temperatures under the WOA conditions vary greatly during the April through September Green Sturgeon larval rearing and emigration period. During April, the WOA mean monthly water temperatures at Woodson Bridge are consistently below the optimal range for Green Sturgeon larvae (63 to 68 degrees Fahrenheit), ranging from 52 to 62 degrees Fahrenheit (Figure 5.12-11). During May, the WOA mean monthly water temperatures are within the optimal range in about 52 percent of years, with a total range of 59 to 70 degrees Fahrenheit (Figure 5.12-12). However, during June, the WOA mean monthly water temperatures exceed the 68 degrees Fahrenheit threshold in 90 percent of years (Figure 5.12-13) and during July through September, they exceed the threshold in every year (Figure 5.12-14 through 5.12-16). The July and August water temperatures under the WOA modeling scenario would be greater than 74 degrees Fahrenheit in all years, which is within a range of temperatures identified as “increasing chance of lethal effects”, and the highest water temperatures in these months (79 to 81 degrees Fahrenheit) are identified as “lethal” (Heublein 2017b et al.). The WOA water temperatures in the upper Sacramento River (upstream of Red Bluff) would be cooler than those at Woodson Bridge, but July and August water temperatures at Keswick would exceed the 68 degrees Fahrenheit threshold in almost every year (Figures 15-16 and 15-17 in the CalSim II flow section of Appendix D). Both April and May water water temperatures at Keswick are consistently below the lower limit of the optimal temperature range for Green Sturgeon larvae (63 degrees Fahrenheit). Under the WOA conditions, Green Sturgeon larvae would likely not be able to survive July and August water temperatures at Woodson Bridge and downstream. While they might be able to survive upstream of Red Bluff, they would not be able to survive dispersion downstream.

Sacramento River water temperatures under the WOA conditions vary greatly during the April through July Green Sturgeon spawning and egg incubation period. During April, at Hamilton City, which is at the lower end of the Green Sturgeon spawning reach in the Sacramento River, the WOA mean monthly water temperatures (HEC-5Q WOA modeling scenario) are consistently low, ranging from 52 to 62 degrees Fahrenheit (Figure 5.12-11). During May, the mean monthly water temperatures range from 59 to 70 degrees Fahrenheit, exceeding the 63 degrees Fahrenheit threshold in 56 percent of years (Figure 5.12-12), and in June and July, the water temperatures exceed the 63 degrees Fahrenheit threshold in all years, and range up to 81 degrees Fahrenheit in July (Figures 5.12-13 and 5.12-14). About 40 percent of years in June and all years in July have mean monthly water temperatures greater than 72 degrees Fahrenheit, which is identified as a likely lethal temperature for Green Sturgeon eggs by Heublein et al. (2017b). During the August through October period, the water temperatures at Woodson Bridge exceed the 63 degrees Fahrenheit threshold in all years in August, about 30 percent of years in September, and about 4 percent of years in October (Figures 5.12-15 through 5.12-17). The WOA water temperatures would be more favorable for Green Sturgeon spawning and egg incubation at more upstream locations, but even at Keswick, water temperatures in July and August would exceed the 63 degrees Fahrenheit threshold in every year and would exceed 68 degrees Fahrenheit, which is identified as “increasing chance of lethal effects” for Green Sturgeon eggs by Heublein et al. (2017b), in July of 90 percent of years (Figures Figures 5.12-13 and 5.12-14). The water temperatures in the Sacramento River under the WOA conditions, especially during July and August, would make survival of incubating eggs unlikely.

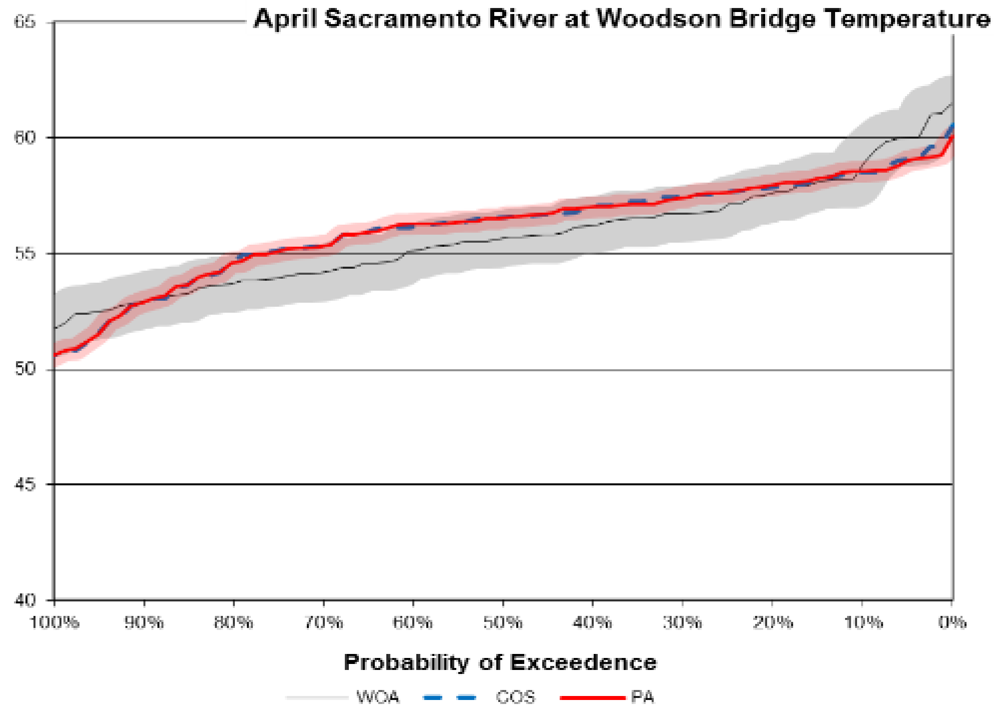


Figure 5.12-11. HEC-5Q Sacramento River Water Temperatures at Woodson Bridge under the WOA, proposed action and COS scenarios, April.

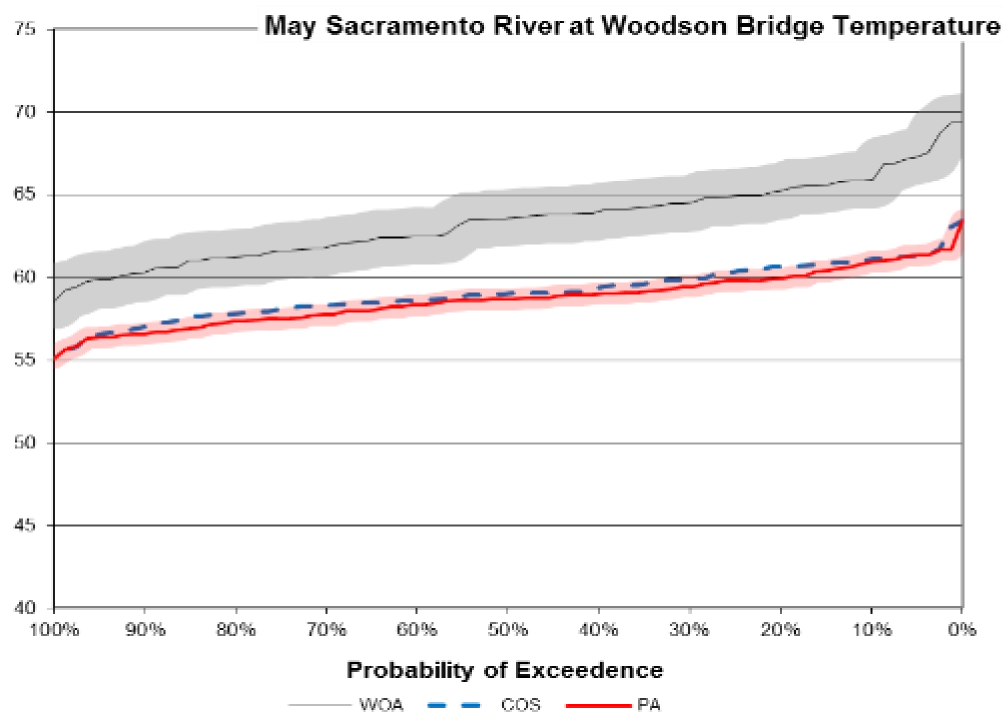


Figure 5.12-12. HEC-5Q Sacramento River Water Temperatures at Woodson Bridge under the WOA, proposed action and COS scenarios, May.

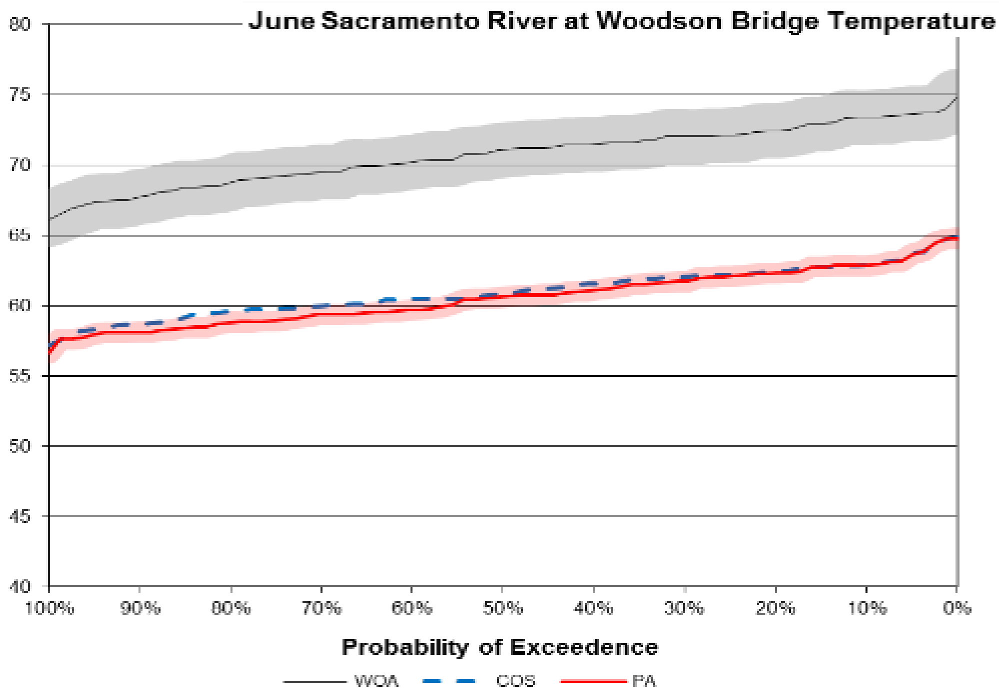


Figure 5.12-13. HEC-5Q Sacramento River Water Temperatures at Woodson Bridge under the WOA, proposed Action and COS Scenarios, June.

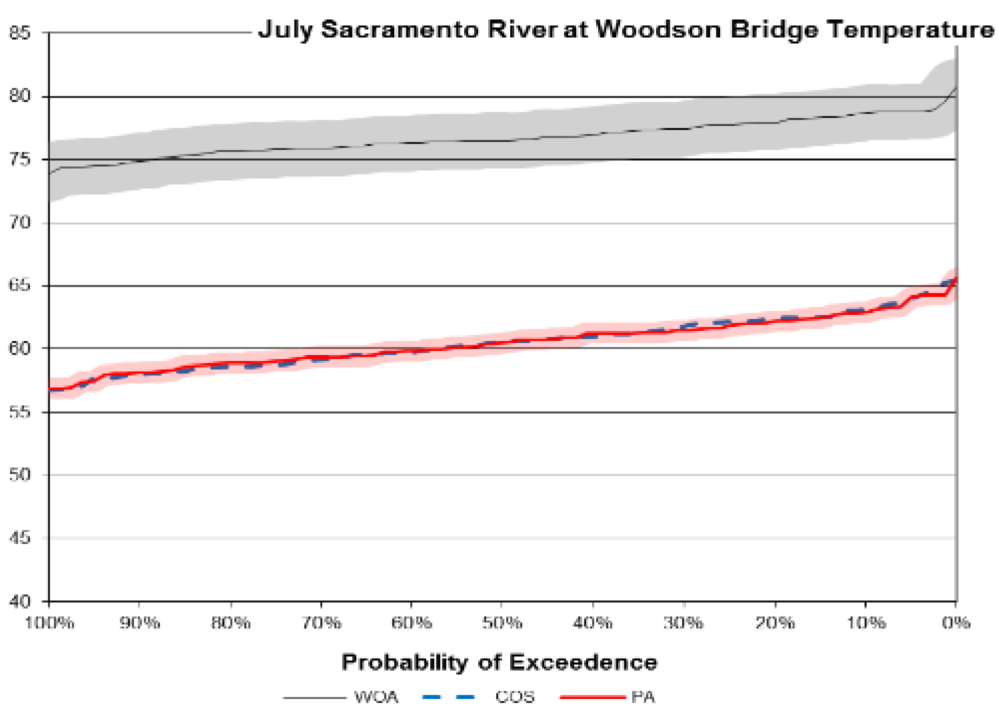


Figure 5.12-14. HEC-5Q Sacramento River Water Temperatures at Woodson Bridge under the WOA, proposed Action and COS Scenarios, July.

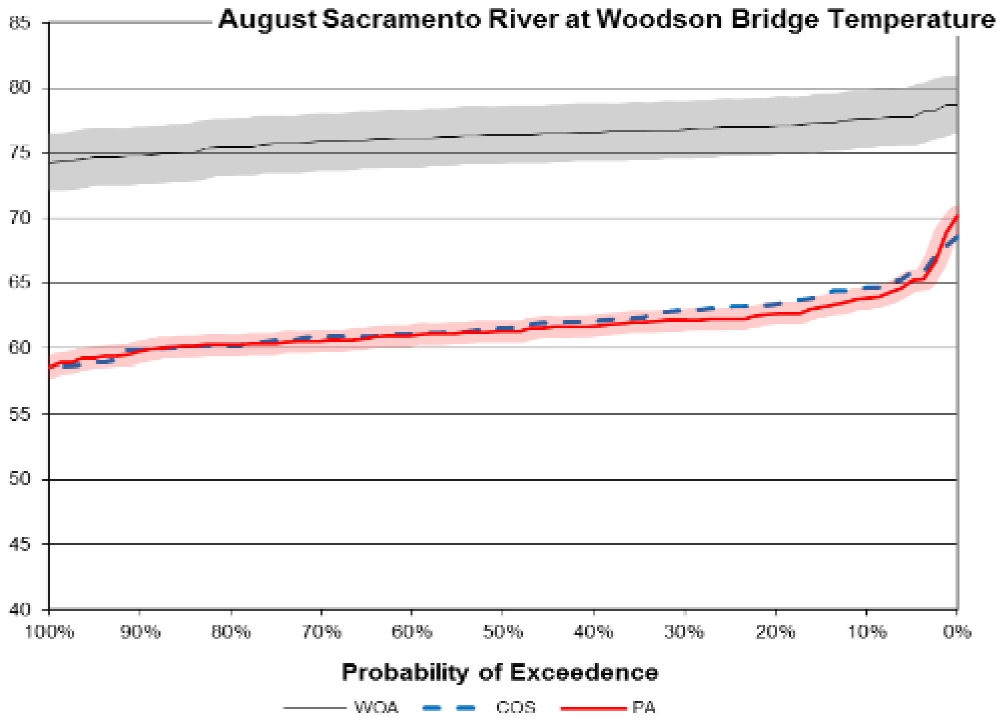


Figure 5.12-15. HEC-5Q Sacramento River Water Temperatures at Woodson Bridge under the WOA, proposed Action and COS Scenarios, August.

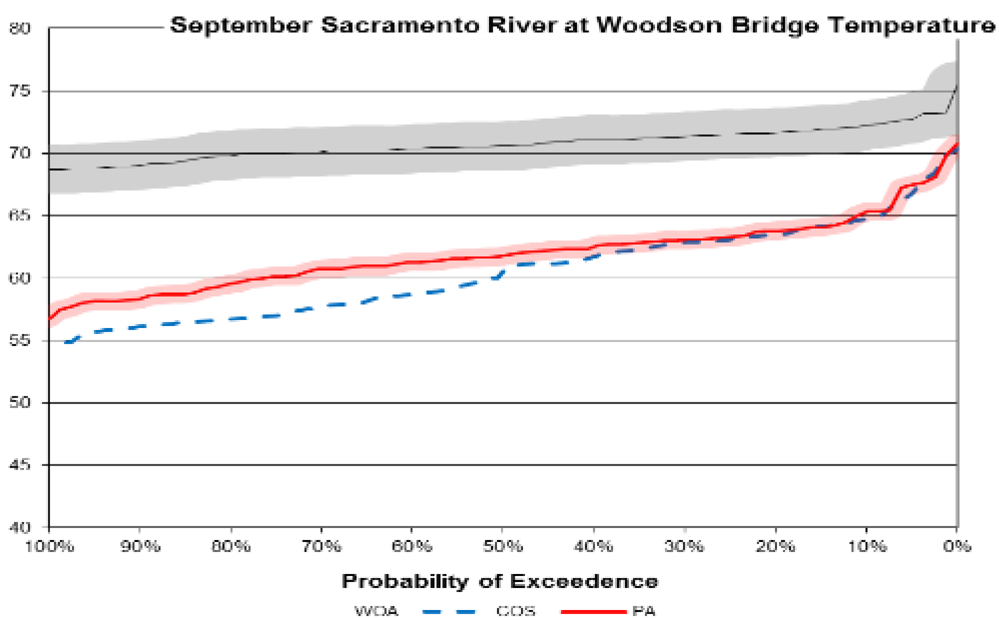


Figure 5.12-16. HEC-5Q Sacramento River Water Temperatures at Woodson Bridge under the WOA, proposed Action and COS Scenarios, September.

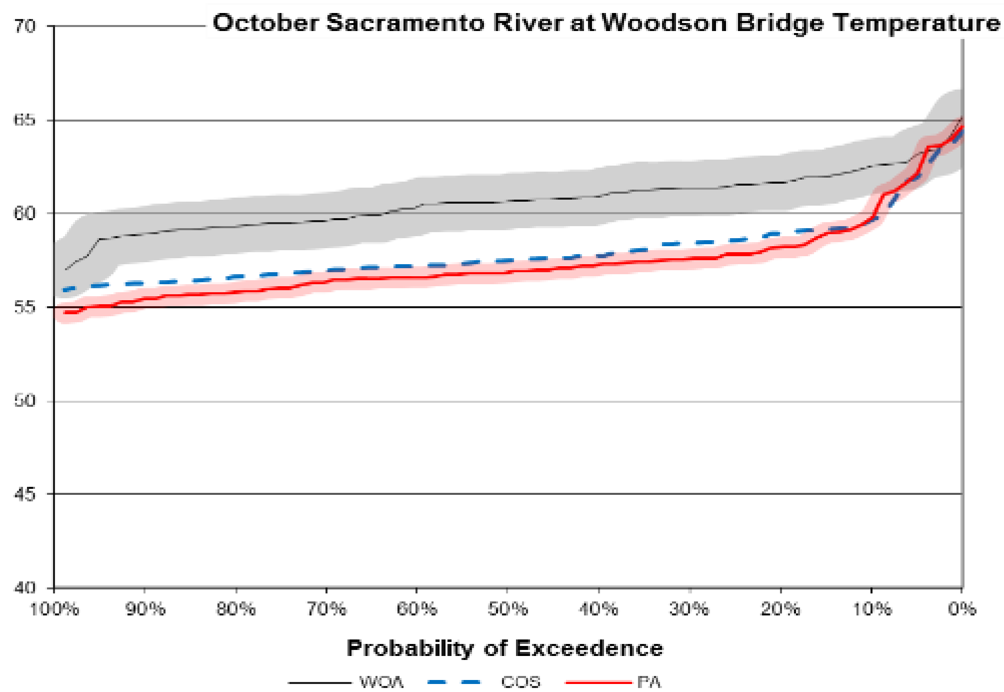


Figure 5.12-17. HEC-5Q Sacramento River Water Temperatures at Woodson Bridge under the WOA, proposed Action and COS Scenarios, October.

The COS is described herein to provide context for the potential positive and negative effects of the proposed action. Under COS, Shasta and Keswick reservoir operations, during most of the juvenile rearing, emigration, and larval period, primarily target flow and water temperature requirements for Winter-run Chinook Salmon and other anadromous fishes, including spring-run and fall/late fall-run Chinook Salmon, steelhead, and Green Sturgeon (NMFS 2011). Fall X2 conditions for Delta smelt are also considered (USFWS 2008). In addition, reservoir operations must balance the current needs of the fish populations with cold water storage needed to satisfy requirements in the following year, while also providing sufficient space for flood control in the winter and spring. During spring, primary operational considerations for the reservoirs in most years are to maximize storage in preparation for summer and fall releases, while during June through September, operations are largely dictated by needs of incubating Winter-run eggs and larvae. Under the proposed action, flow and water temperature management in the upper Sacramento River would be similar to the COS.

5.12.3.2 Sacramento Seasonal Operations including Shasta Cold Water Pool Management

5.12.3.2.1 Spawning Adult to Egg and Post-Spawn Adult

5.12.3.2.1.1 Flows

The CalSim modeling shows large seasonal changes in the differences in middle and upper Sacramento River flow between the proposed action and the WOA scenario. In February, the proposed action flows are generally similar to or lower than the WOA flows for most years at both Wilkins Slough and RBDD (see Appendix D, *Modeling*). In March and April, the proposed action flows are lower than WOA flows at both locations in almost every year (see Appendix D, *Modeling*). In May, the proposed action flows at Wilkins Slough are substantially lower than WOA flows for the 60 percent of highest flow years and are substantially higher for the 25 percent of lowest flow years, while at RBDD, the proposed action flows are higher than the WOA and COS flows for the highest two thirds of flow years and are slightly higher in the other years. For most of the remainder of the Green Sturgeon adult immigration, spawning and holding period (June through November), the proposed action and COS flows are generally higher or much higher than the WOA flows at both locations, but flows of all three modeling scenarios were roughly similar during November and December. The higher flows during May through October in years with dry hydrology at Wilkins Slough and Red Bluff under proposed action relative to the WOA conditions would likely benefit adult Green Sturgeon migrating, spawning and holding in the middle and upper Sacramento River by enhancing water quality and passage, and reducing disease risks (Heublein et al. 2017a[SAIL model]).

Flows during the February through December period of Green Sturgeon immigration, spawning and holding would generally be similar between the proposed action and COS at both Wilkins Slough and Red Bluff (see Appendix D, *Modeling*). Exceptions include higher flows (up to ~2,500 cfs higher) at Wilkins Slough during May and June for the proposed action scenario. The differences in flow occur primarily for flows greater than 5,000 cfs, which are likely high enough to present no passage problems for upstream migrating adults. There are also substantial flow differences between the proposed action and COS scenarios at Red Bluff during June, September and November, with higher proposed action flows in June and higher COS flows in September and November (see Appendix D, *Modeling*). These flow differences occur within a range of river flows (6,000 cfs to 17,000 cfs) not expected to substantially affect migrating Green sturgeon, but the flow reductions under the proposed action in September and November could result in reduced habitat quality in holding pool habitats. See Figures 5.12-18 through 5.12-24.

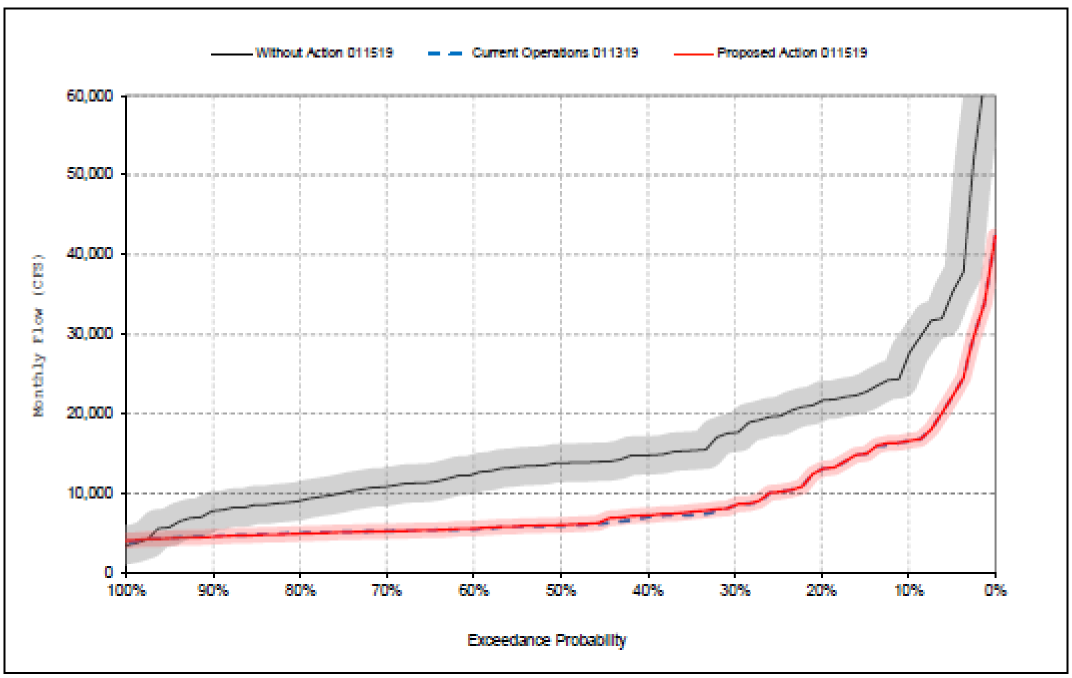


Figure 5.12-18. CalSim II Sacramento River Flows at Red Bluff, April

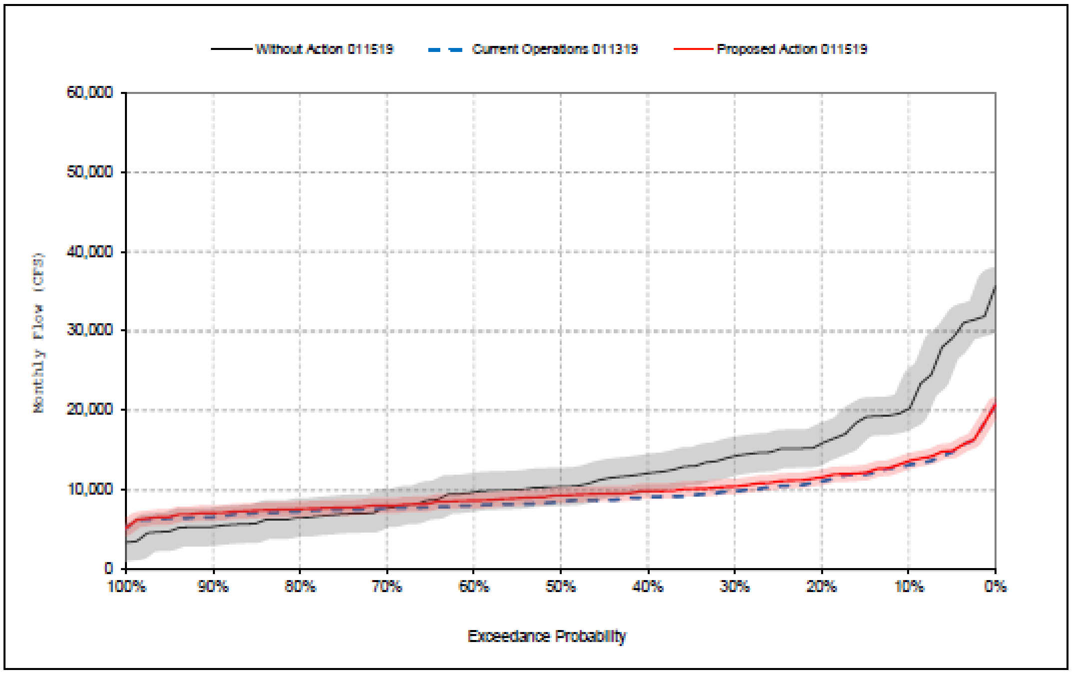


Figure 5.12-19. CalSim II Sacramento River Flows at Red Bluff, May

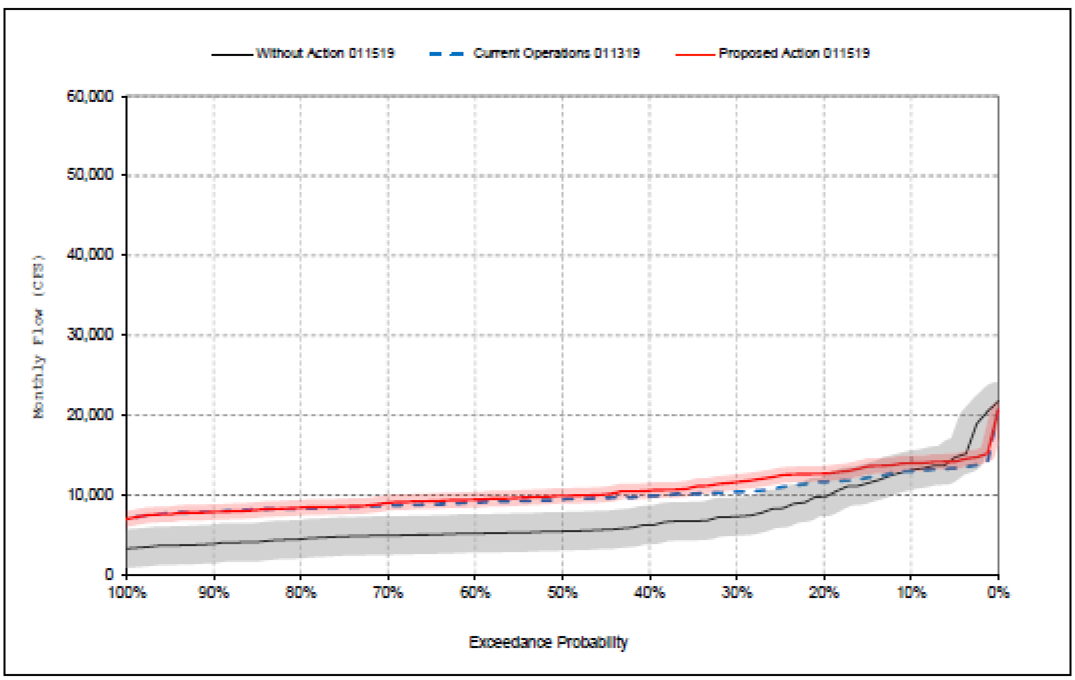


Figure 5.12-20. CalSim II Sacramento River Flows at Red Bluff, June

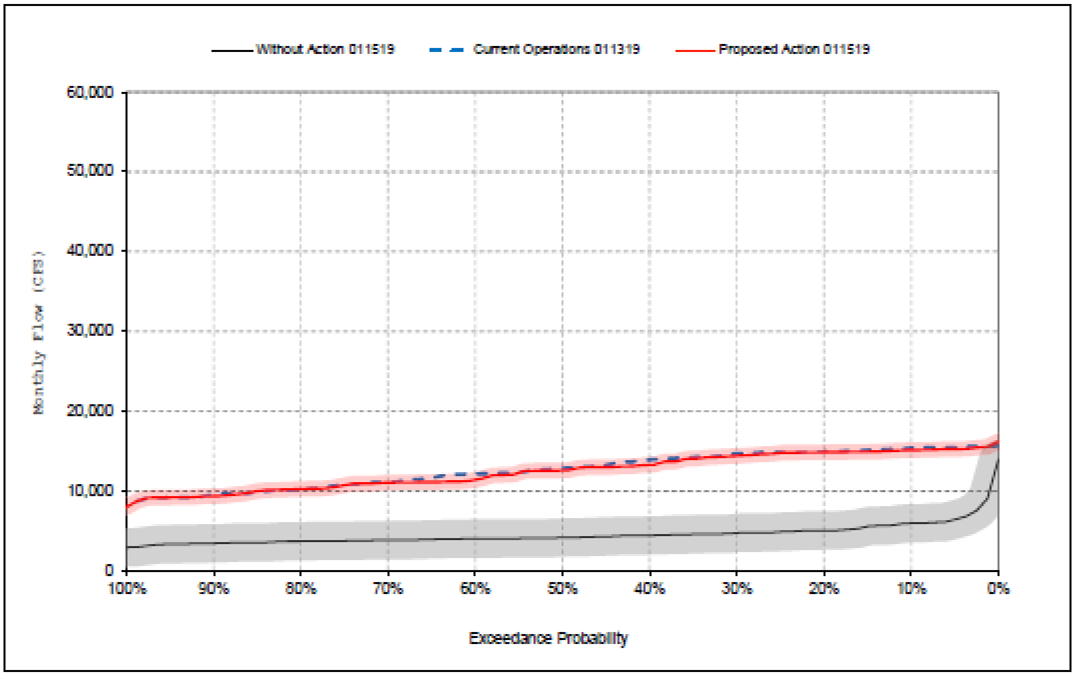


Figure 5.12-21. CalSim II Sacramento River Flows at Red Bluff, July

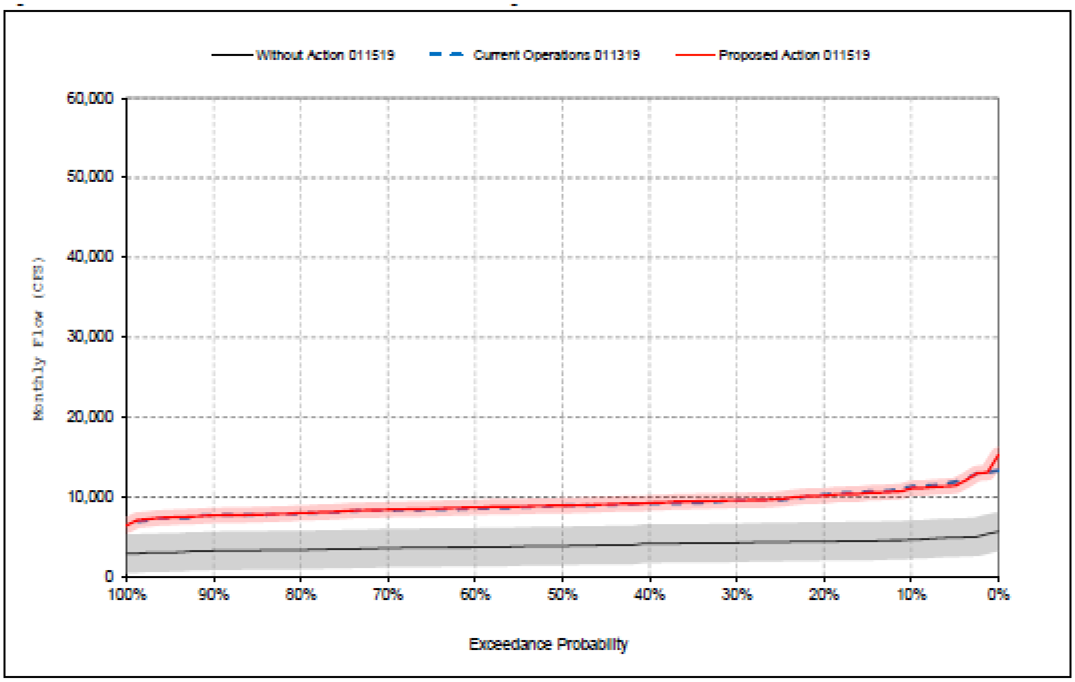


Figure 5.12-22. CalSim II Sacramento River Flows at Red Bluff, August

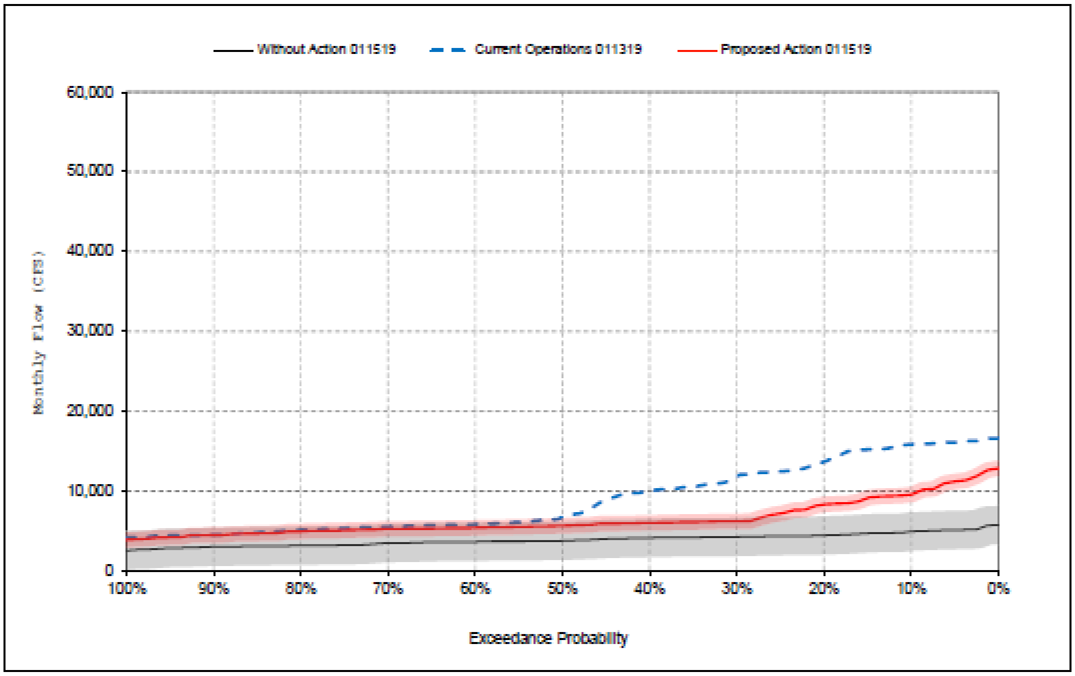


Figure 5.12-23. CalSim II Sacramento River Flows at Red Bluff, September

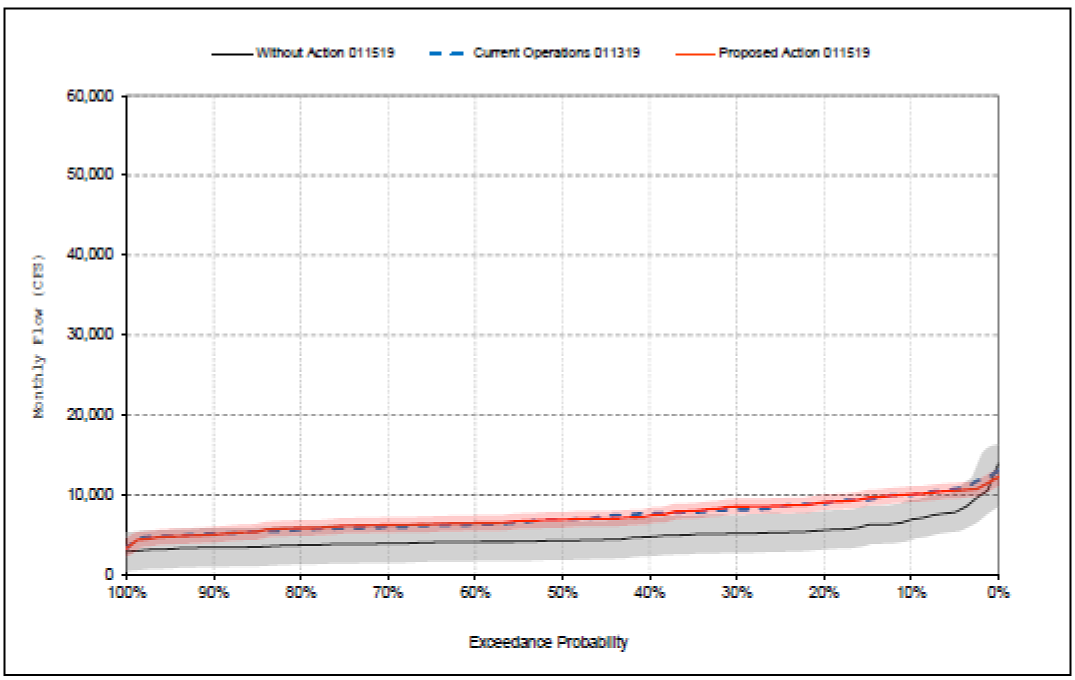


Figure 5.12-24. CalSim II Sacramento River Flows at Red Bluff, October

5.12.3.2.1.2 Water Temperature

The USEPA (2003) gives 61 degrees Fahrenheit as the critical 7DADM water temperature for Green Sturgeon adults holding, although this is based on Pacific Northwest fish and hydrology and does not consider the operational feasibility of operating to 7DADM. The upper limit for mean monthly water temperature of spawning adults is assumed to be similar to that given for incubating eggs, 63 degrees Fahrenheit. In addition, assuming that adults are at least as tolerant to warm temperatures as juveniles, the upper limit for mean monthly water temperatures of migrating adults, whether immigrating or emigrating, is treated as 66 degrees Fahrenheit.

In the middle Sacramento River below the Colusa Basin Drain, which is downstream of any Green Sturgeon spawning areas, the WOA modeling scenario mean monthly water temperatures during February through April and November and December would consistently fall below the 66 degrees Fahrenheit threshold for migrating adults (see Appendix D, *Modeling*). However, the water temperatures would exceed the threshold during May of about 65 percent of years, during June through September in every year, and during October of about 50 percent of the years (see Appendix D, *Modeling* and Figure 5.12-25, for example). Adults migrating downstream from May through October would potentially be negatively impacted by the high water temperatures, but most upstream immigration occurs before late spring (Heublein et al. 2009) when water temperatures are below the 66 degrees Fahrenheit threshold.

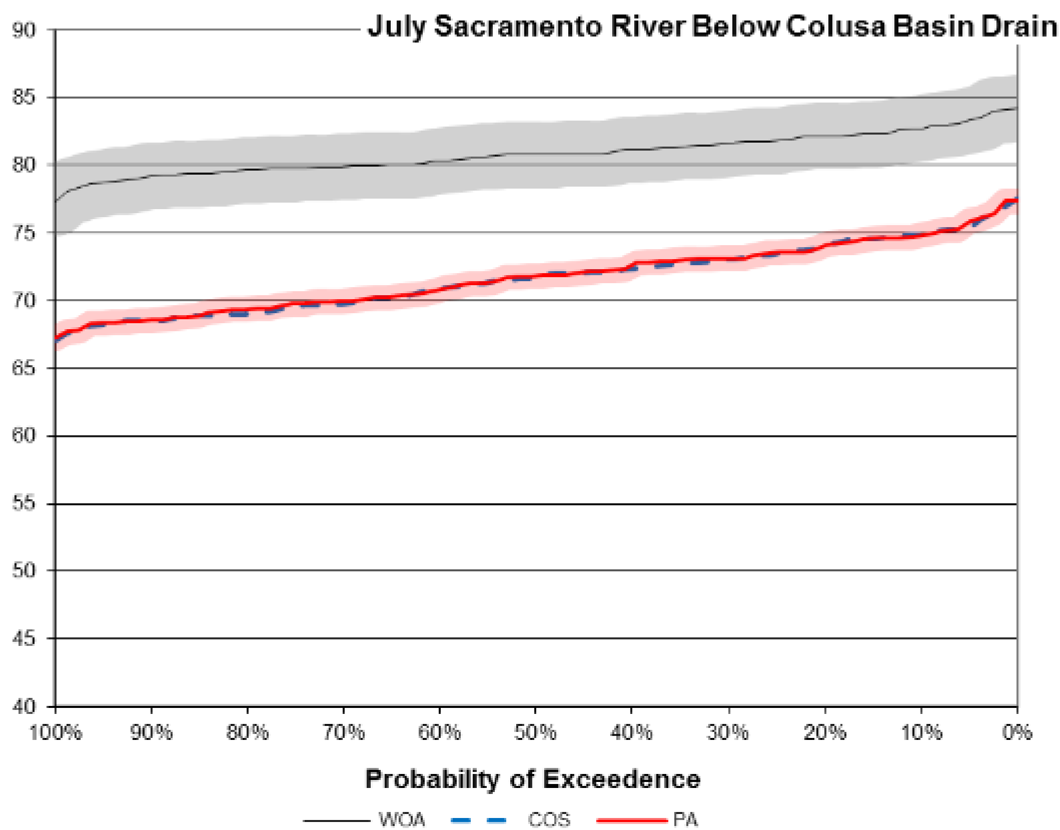


Figure 5.12-25. HEC-5Q Sacramento River Water Temperatures below Colusa Basin Drain under the WOA, Proposed Action and COS Scenarios, July

In the Sacramento River at Woodson Bridge, the WOA mean monthly water temperatures during February through April are below 68 degrees Fahrenheit threshold for migrating adults in every year. This area is located near the GCID oxbow at the most downstream, warmest section of the Green Sturgeon spawning reach. During May through July, which are the peak spawning months, mean monthly water temperatures exceed the 63 degrees Fahrenheit threshold for spawning adults during about 65 percent of the years in May and during every year in June and July (Figures 18-14 through 18-16 in the CalSim II flow section of Appendix D). During August and September, when most Green Sturgeon are holding after spawning or are emigrating downstream, the mean monthly water temperatures at Woodson Bridge under the WOA modeling scenario range from a low of 70 degrees Fahrenheit in September to a high of 81 degrees Fahrenheit in August, thus greatly exceeding the 61 degrees Fahrenheit threshold for holding adults in every year (Figures 18-17 and 18-18 in the CalSim II flow section of Appendix D). During October, the water temperatures exceed the 61 degrees Fahrenheit threshold in about 40 percent of years and during November and December, the water temperatures are well below the threshold in every year (Figures 18-7 through 18-9 in the CalSim II flow section of Appendix D.).

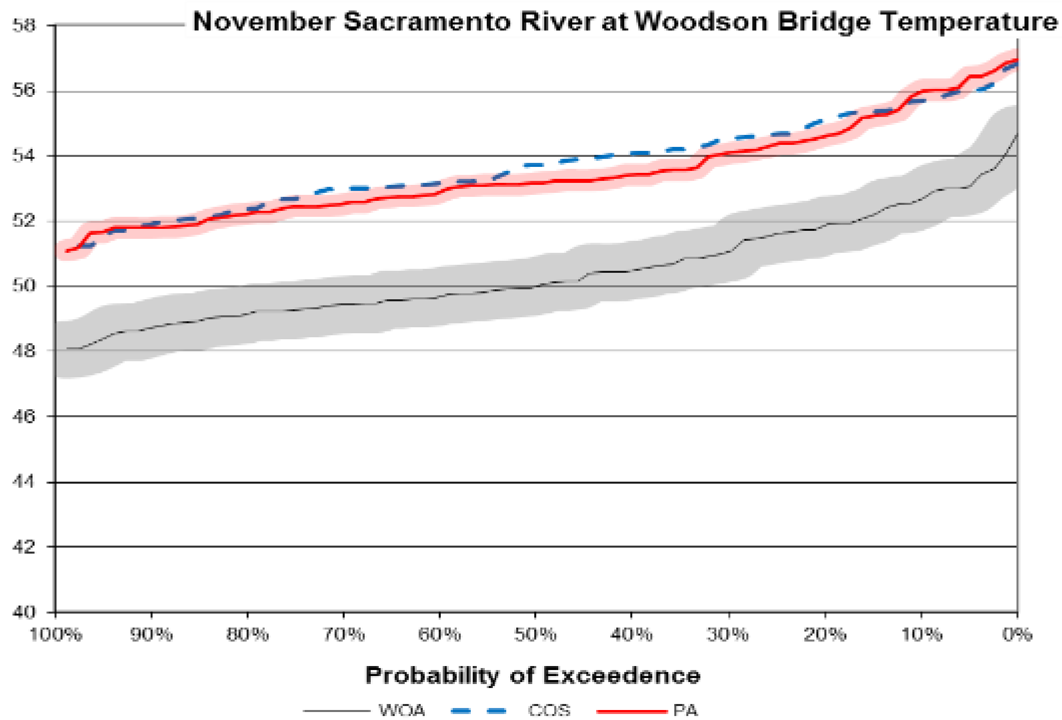


Figure 5.12-26. HEC-5Q Sacramento River Water Temperatures at Woodson Bridge under the WOA, proposed Action and COS Modeling Scenarios, November

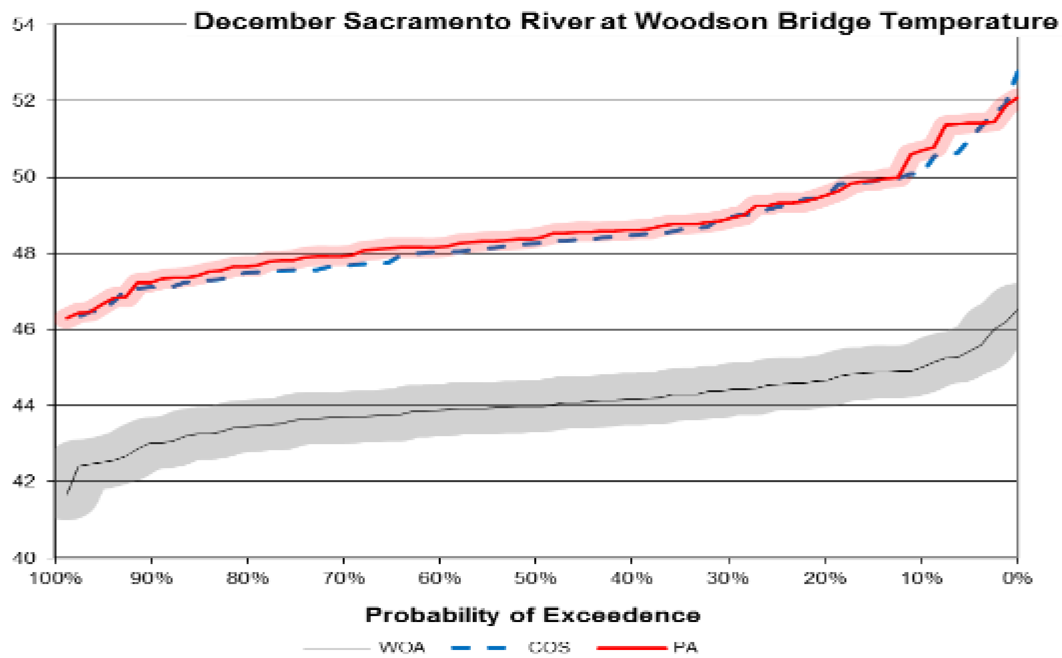


Figure 5.12-27. HEC-5Q Sacramento River Water Temperatures at Woodson Bridge under the WOA, Proposed Action and COS Modeling Scenarios, December

Water temperatures conditions under the WOA modeling scenario in the summer months, June through September, would be highly stressful to adult Green Sturgeon spawning and holding in the Sacramento River. Spawning sturgeon are particularly vulnerable to the effects of elevated water temperature, which may result in egg resorption and reduced fecundity (Heublein et al. 2017a [SAIL model]). Water temperatures in the lower reaches of spawning habitat on the Sacramento River may reach levels that cause egg resorption, affecting fertilization of eggs and survival of embryos (Heublein et al. 2017a [SAIL model]).

There are few major differences in mean monthly water temperatures between the proposed action and COS scenarios in the Sacramento River below the Colusa Basin Drain during the February through April period that most adult Green Sturgeon migrate upstream or during the later months when the sturgeon migrate downstream after spawning (see Appendix D, *Modeling*). The biggest difference occurs in September of cooler years, when water temperatures under the proposed action scenario are higher than those of the COS modeling scenarios, by up to 5 degrees Fahrenheit. The temperatures in September exceed the 66 degrees Fahrenheit threshold for migrating Green Sturgeon adults in 95 percent of years under the proposed action scenario, whereas they exceed the threshold in 65 percent of years under the COS modeling scenario. The temperature difference between the scenarios results from higher flows in wetter years under the COS modeling scenario, which, as previously noted, results from Fall X2 releases.

During the May through December spawning and post-spawn holding period for Green Sturgeon, water temperatures at Woodson Bridge, which is located in the most downstream, warmest section of the Green Sturgeon spawning reach, are generally similar between the proposed action and COS scenario, except for higher temperatures under the proposed action scenario in September, as discussed above for the Colusa Basin Drain location. Adults migrating downstream from May through September would potentially be adversely affected by the high water temperatures. Most upstream immigration occurs before late spring (Heublein et al. 2009), when water temperatures are below the 66 degrees Fahrenheit threshold. Water temperatures during warm years, especially in August and September, would likely be stressful to spawning and holding adult Green Sturgeon.

In the Sacramento River downstream of the Colusa Basin Drain, water temperatures under the proposed action are similar to WOA water temperatures during May, generally higher than the WOA modeling scenario water temperatures from December through April, and below the WOA modeling scenario water temperatures during June through October. In the Sacramento River at Woodson Bridge, water temperatures under the proposed action and COS scenarios are similar to WOA water temperatures during April (Figure 5.12-2), above the WOA modeling scenario water temperatures during February, March, November and December, and below the WOA modeling scenario water temperatures in all years during May through October (see Appendix D, *Modeling*).

Water temperatures in the Sacramento River below the Colusa Basin Drain and at the Woodson Bridge are suitable for adult Green Sturgeon immigrating in the Sacramento River during February through April under all three scenarios, so no negative effects are expected. However, under the WOA modeling scenario during the peak spawning season, May through July, water temperatures at the Woodson Bridge location, near the downstream limit of the Green Sturgeon spawning reach, exceed the 63 degrees Fahrenheit threshold for spawning adults in the majority of years during May and in all years during June and July. Under the proposed action, water temperatures during this period exceed the threshold in at most 50 percent of years (in June and July). During May through December, when most post-spawning Green Sturgeon adults are holding near spawning areas or emigrating back to the estuary, water temperatures under the WOA modeling scenario at Woodson Bridge exceed the 61 degrees Fahrenheit threshold for holding adults during about 85 percent of years in May, in every years during June through September, and in about 40 percent of years in October. The water temperatures at this location under the proposed action exceed the 61 degrees Fahrenheit threshold for holding adults in about 50 percent of years in May, about 95 to 70 percent of years in June through September, and about 10 percent of years in October. Water temperatures below the Colusa Basin Drain during this period, which would affect Green Sturgeon adults emigrating from the Sacramento River, would exceed the 66 degrees Fahrenheit threshold from migrating adults under the WOA modeling scenario in all years during June through September and well over half of years in October. Although the water temperatures below the Colusa Basin Drain exceed the threshold for emigrating adults in all or almost all years during June through September under all three scenarios, the amount by which the threshold is exceeded is consistently much greater under the WOA modeling scenario than under the proposed action.

Summer water temperatures under proposed action are consistently lower than those under the WOA, with far fewer years exceeding the 63 degrees Fahrenheit threshold for spawning adults or the 61 degrees Fahrenheit threshold for holding adults. Summer water temperatures for emigrating adults would also be lower under proposed action for emigrating adults. These results indicate that the proposed action, relative to the WOA, provide a clear benefit to adult Green Sturgeon spawning and holding in the Sacramento River, as well as those emigrating from the river.

5.12.3.2.2 <u>Juvenile to Subadult/Adult</u>

5.12.3.2.2.1 Flows

As noted in the Larvae to Juveniles section, there appears to be a positive relationship between annual outflow and abundance of Green Sturgeon larvae in rotary screw traps at RBDD (Heublein et al. 2017a[SAIL model], 2017b). At federal and state Delta pumping facilities, the highest juvenile Green Sturgeon collection on record occurred in a wet year (2006; Gartz 2007 cited in Heublein et al. 2017b). These findings are consistent with white sturgeon and the relationship between recruitment to age-0 and wet years (Heublein et al. 2017b). These relationships may result from flows transporting larvae and juveniles to areas with greater prey availability and/or enhancing nutrient availability to the Sacramento River and Delta/Estuary.

Green Sturgeon juveniles are believed to be highly susceptible to entrainment in unscreened diversions and impingement on screened diversions (Mussen et al. 2014, NMFS 2018). Risks of entrainment and impingement in the Sacramento River are increased because the period of juvenile presence in the river (May through December), coincides with peak period of irrigation diversions (April to September).

High WOA flows occur frequently during May and December, and these could have both positive and negative effects on rearing and emigrating Green Sturgeon juveniles (Figures 5.12-28 to 5.12-35). The impacts of low flows listed above are generally ameliorated by higher flows, but there can be adverse impacts, including higher contaminant concentrations from stormwater runoff.

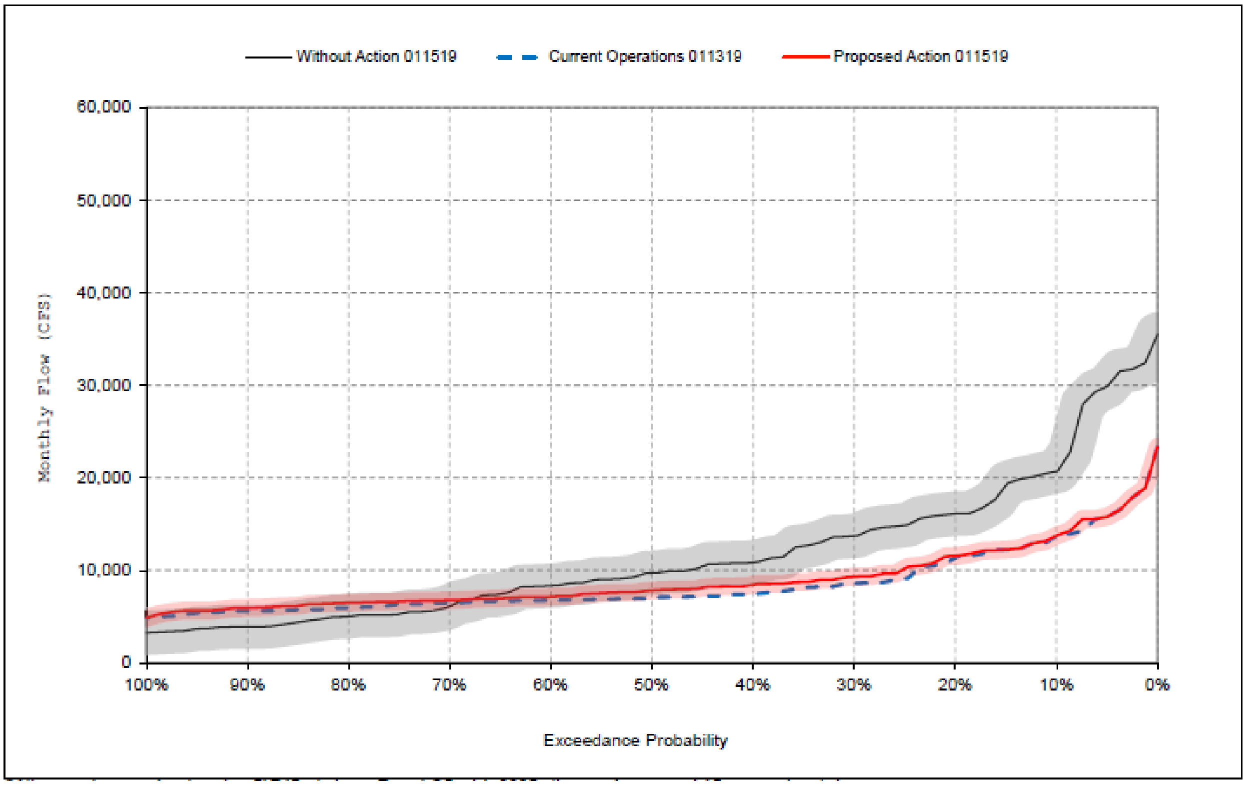


Figure 5.12-28. CalSim II Sacramento River Flows at Hamilton City, May

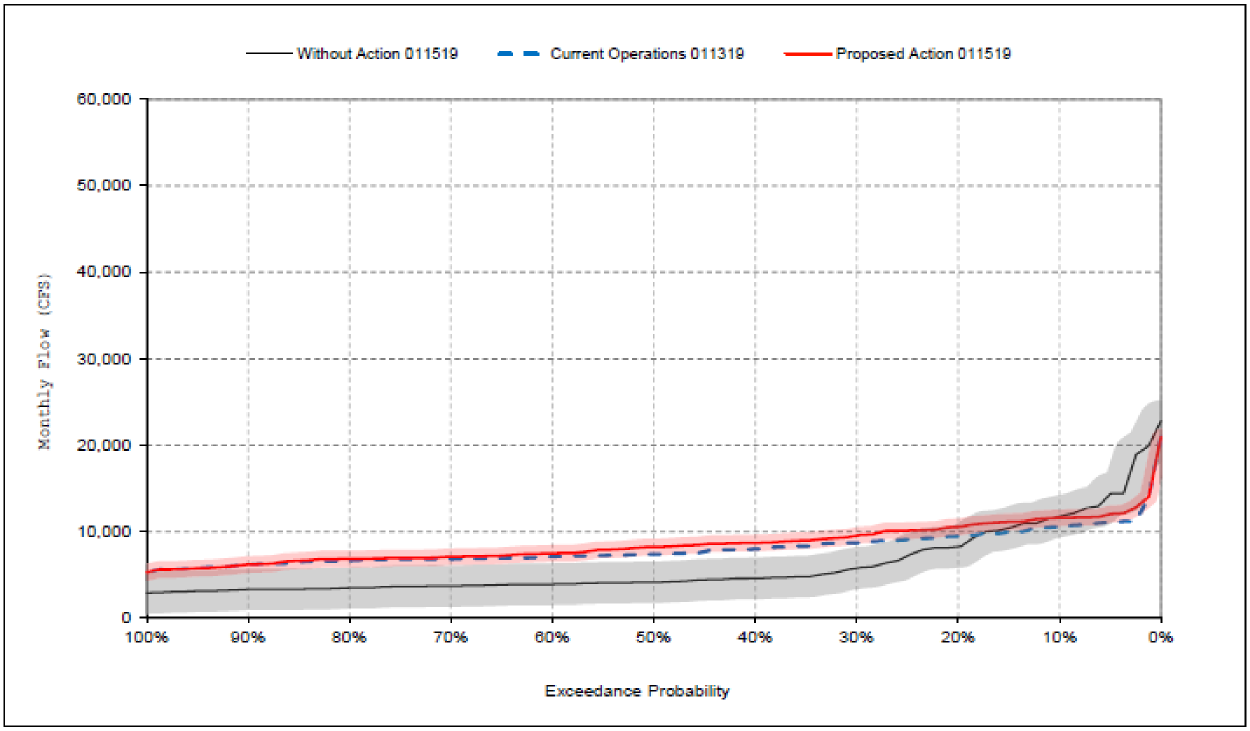


Figure 5.12-29. CalSim II Sacramento River Flows at Hamilton City, June

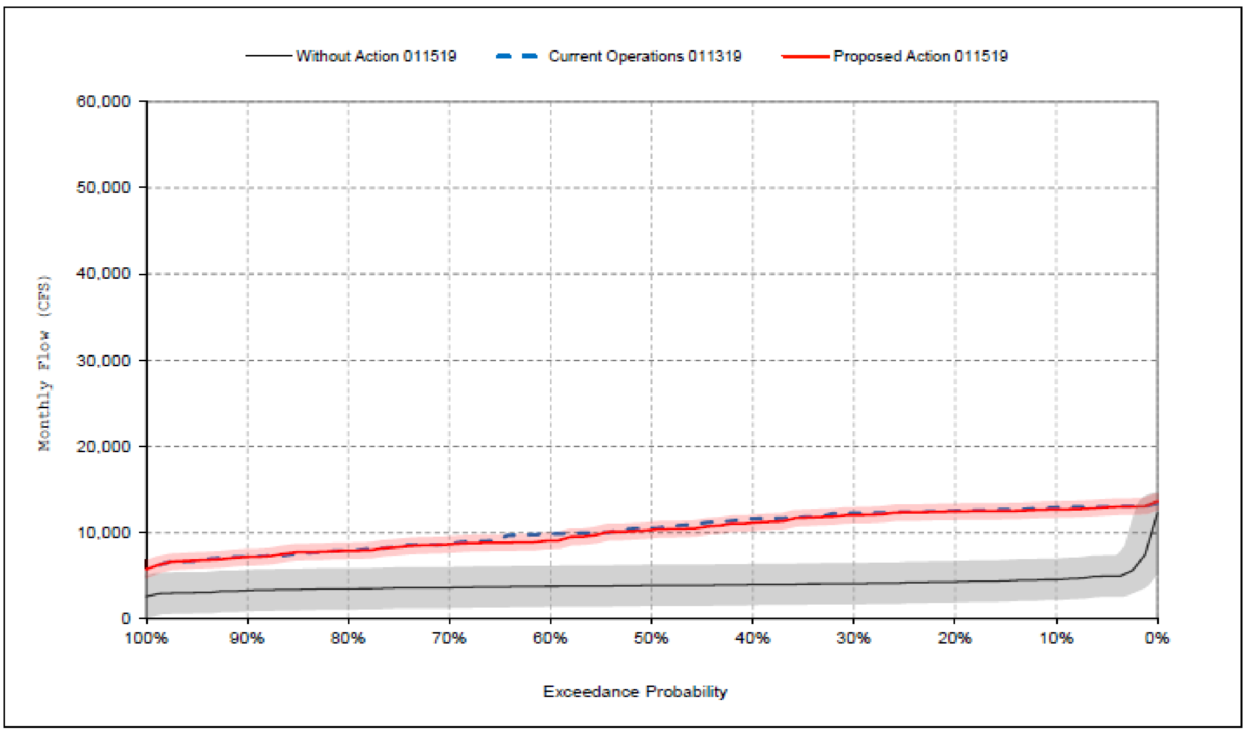


Figure 5.12-30. CalSim II Sacramento River Flows at Hamilton City, July

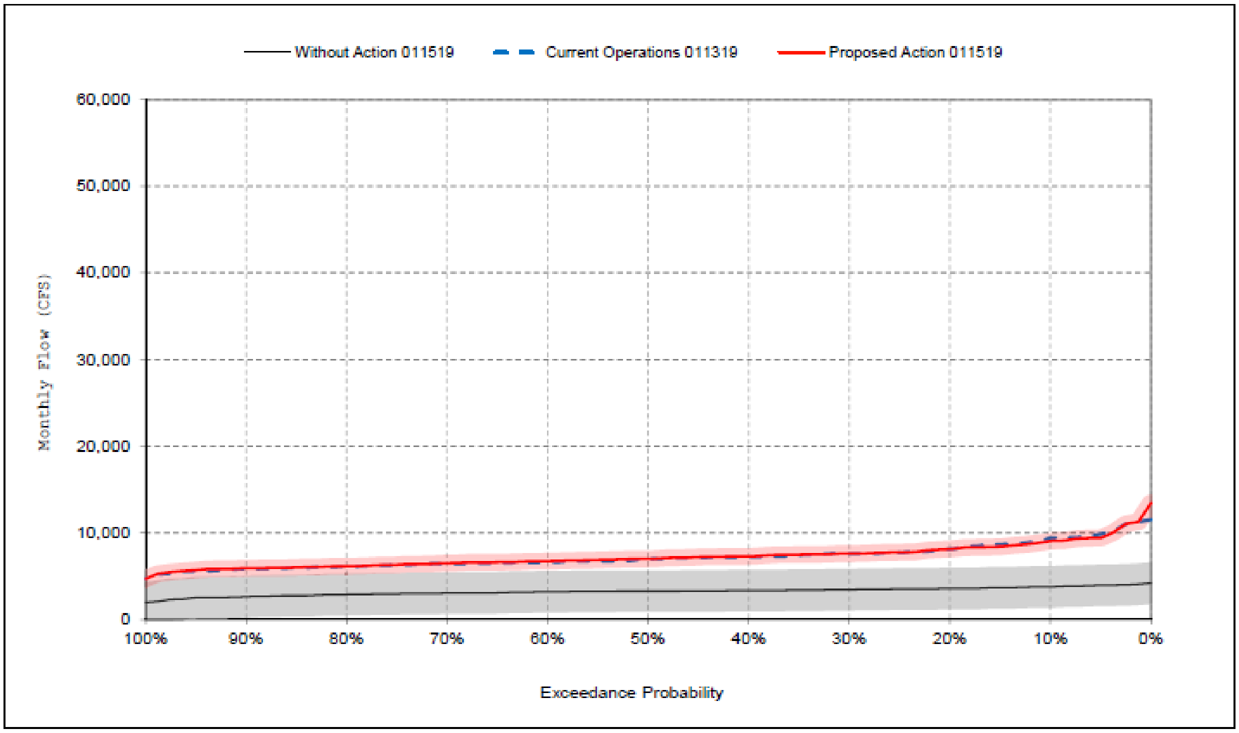


Figure 5.12-31. CalSim II Sacramento River Flows at Hamilton City, August

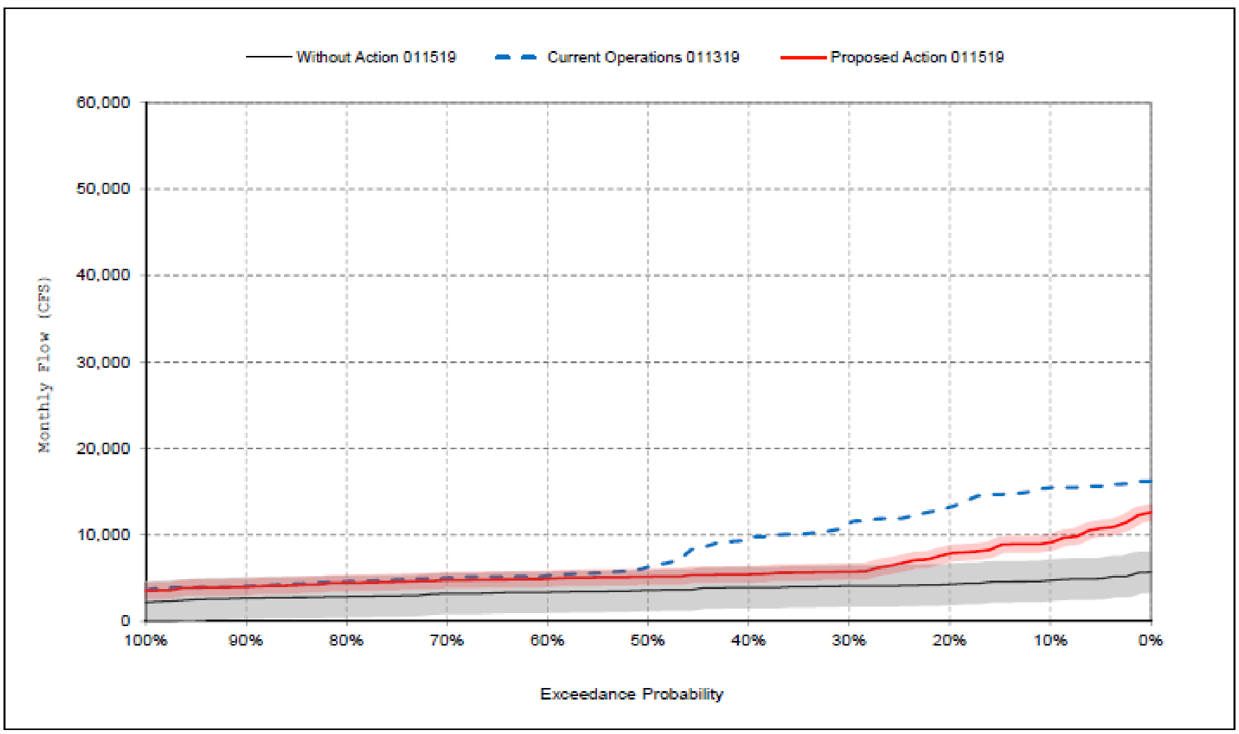


Figure 5.12-32. CalSim II Sacramento River Flows at Hamilton City, September

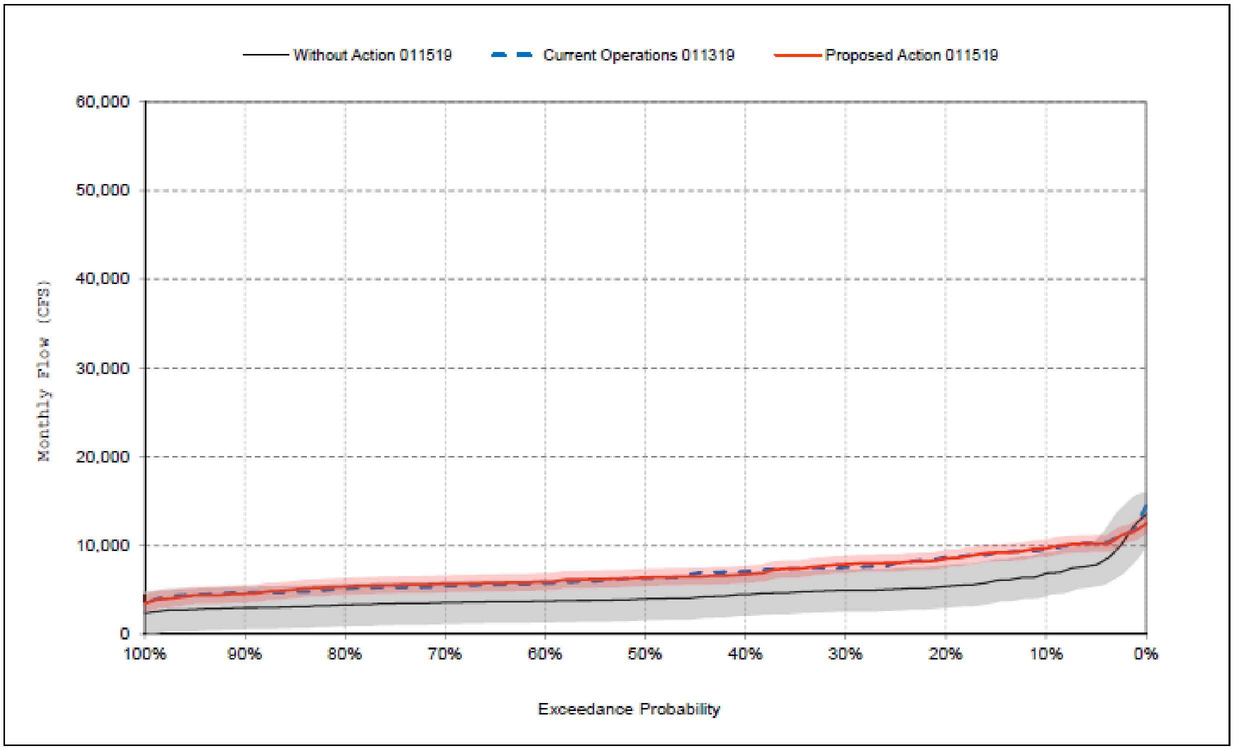


Figure 5.12-33. CalSim II Sacramento River Flows at Hamilton City, October

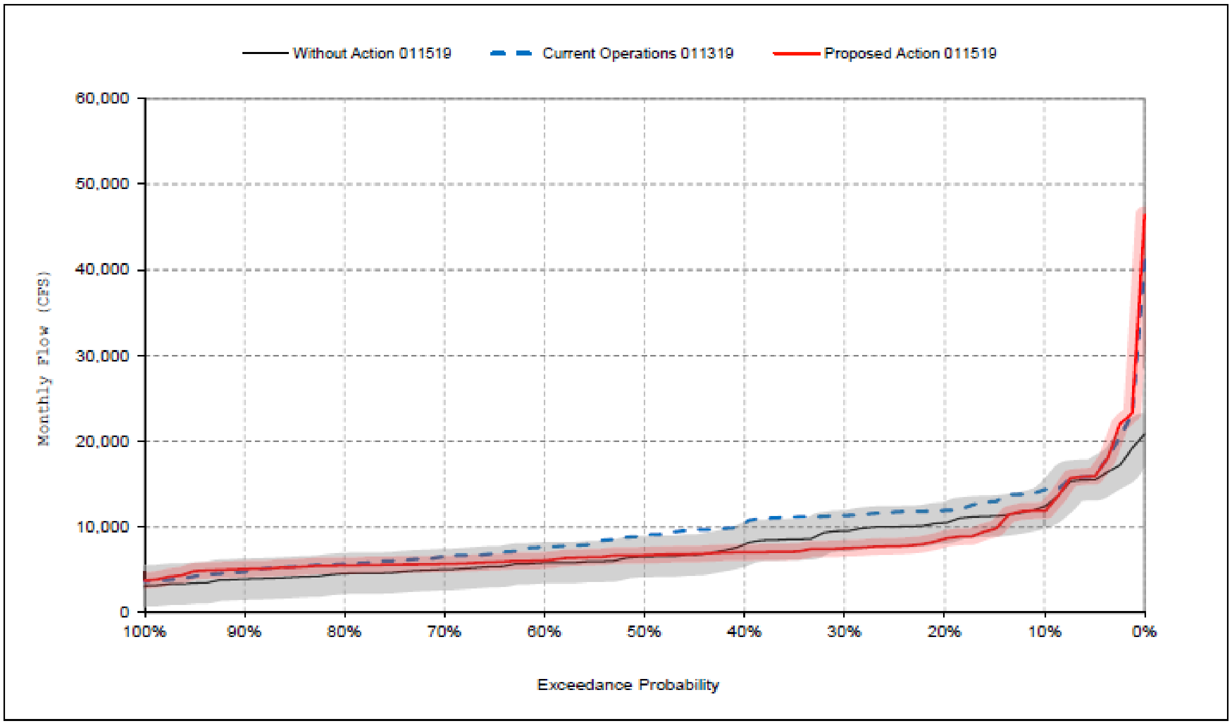


Figure 5.12-34. CalSim II Sacramento River Flows at Hamilton City, November

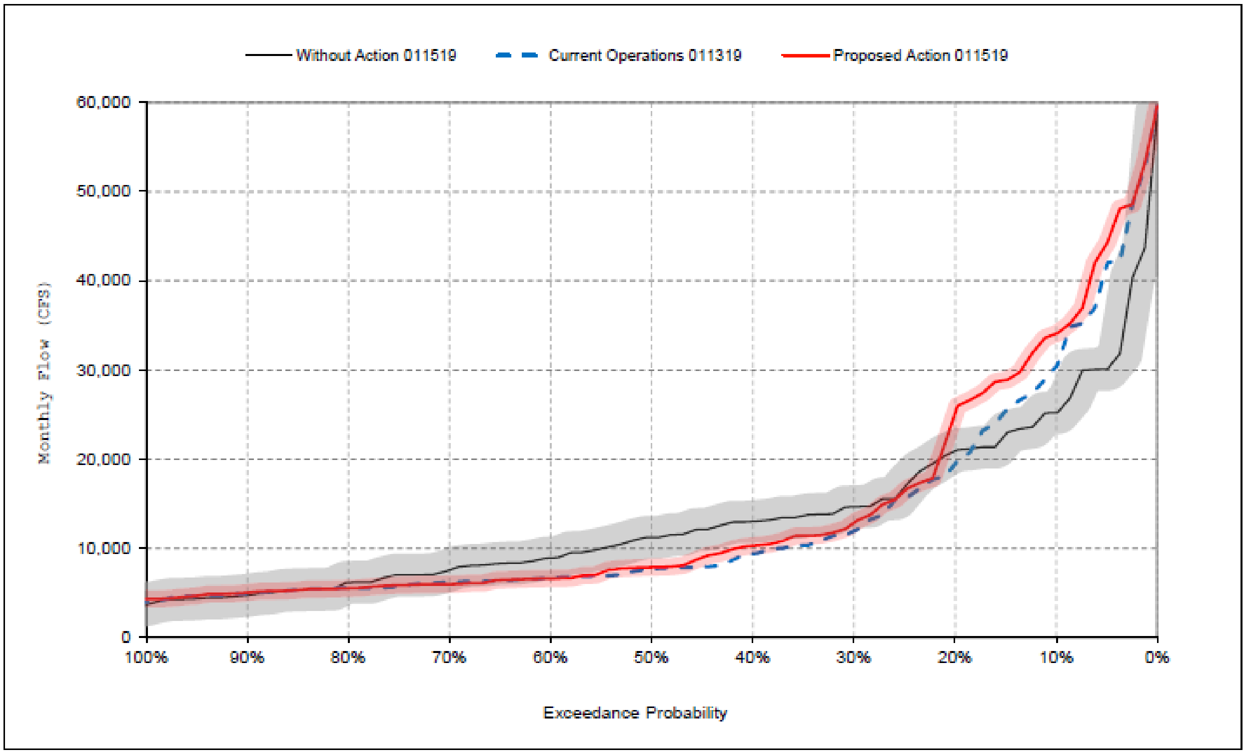


Figure 5.12-35. CalSim II Sacramento River Flows at Hamilton City, December

CalSim modeling for the Sacramento River at Hamilton City indicates that flows during the period of juvenile rearing and emigration are generally similar between proposed action and COS except, as described previously, for much higher flows during September under the COS modeling scenario in the upper range of flows (Figure 5.12-32), which result from Fall X2 releases under COS that are not included in the proposed action. Differences between proposed action and COS flows are also large in June and November (Figures 5.12-29 and 5.12-34), with higher flows for the proposed action in June and for the COS in November, but the differences are much less high than those in September.

The CalSim modeling shows large seasonal changes during the larval period between the WOA modeling scenario and the proposed action. For most years in May, the WOA flows are greater than the proposed action flows (Figure 5.12-28), but for almost all years in June through October, the proposed action flows are higher than the WOA flows (Figures 5.12-29 through 5.12-33). The WOA flows are similar to the proposed action flows in November and December (Figures 5.12-34 and 5.12-35). These seasonal changes result primarily from diversions to Shasta Reservoir storage under the proposed action scenarios during spring, when uncontrolled flows are high, and Shasta Reservoir storage releases under the proposed action scenarios during June through October, when uncontrolled flows are low.

The higher summer and fall flows under the proposed action would potentially result in improved conditions in juvenile rearing habitats, as previously described, and increase transport of the juveniles to favorable rearing habitats.

5.12.3.2.2.2 Water Temperature

Critical water temperatures thresholds have been determined for Northern DPS Green Sturgeon but not for Southern DPS Green Sturgeon, but it is assumed that the temperature tolerances of the two distinct population segments are similar (Heublein et al. 2017b). Based on laboratory studies, Mayfield and Cech

(2004) concluded that 59 to 66 degrees Fahrenheit is the optimal range of water temperatures for growth of juvenile sturgeon. This temperature range overlaps the optimal range temperatures range for Green Sturgeon eggs (below 63 degrees Fahrenheit) and larvae (63 to 68 degrees Fahrenheit)

There is little difference in water temperatures at Woodson Bridge between the proposed action and COS scenarios during the Green Sturgeon juvenile rearing and emigration period in any month except for September. During well over half of the years in September, the proposed action water temperature is greater than the COS water temperature, with a maximum difference of about 4 degrees Fahrenheit (see Figure 12-18 in the HEC 5Q Temperatures section of Appendix D).

Water temperatures under the proposed action at Hamilton City fall within the 59 to 66 degrees Fahrenheit optimal range for Green Sturgeon juveniles during most years in June through September. Temperatures exceed 66 degrees Fahrenheit under the proposed action in 5% of Junes, 8% of Julys, 15% of Augusts, and 20% of Septembers (see Appendix D, *Modeling*). Water temperatures for about 80% of the years in May, most years in June to October, and all years during November and December fall below the 59 degrees Fahrenheit threshold for juvenile Green Sturgeon optimal growth. Water temperatures under the proposed action would be suitable for survival of Green Sturgeon juveniles throughout the rearing and emigration period, although temperature in the colder months would be below the range for optimal growth.

May through October water temperatures under the proposed action are consistently lower than those under the WOA modeling scenario (See Figures 12-7, 12-14, 12-15, 12-16, 12-17 and 12-18 in the HEC5Q temperature section of Appendix D), while November and December temperatures are consistently higher than WOA temperatures (See Figures 12-8 and 12-9 in the HEC5Q temperature section of Appendix D). During June through September, the WOA water temperatures always exceed the optimal range, and during the same months, the proposed action water temperatures lie within the optimal range in most years and exceed the upper threshold (66 degrees Fahrenheit) in only a few percent of years in August and September. Only in May under the WOA modeling scenario, do the majority of years lie within the optimal temperature range. These results indicate that the proposed action provides more favorable water temperature conditions for Green Sturgeon juveniles than the WOA modeling scenario, although it also provides temperatures too cold of optimal growth in some months. As previously noted, the juveniles would be unlikely to survive water temperature conditions in the middle Sacramento River expected under the WOA scenario in July and August.

5.12.3.2.3 Larvae to Juvenile (April – August)

5.12.3.2.3.1 Flow

The effects of flow on Green Sturgeon larvae are poorly understood. There appears to be a positive relationship between annual outflow and abundance of Green Sturgeon larvae and juveniles in rotary screw traps at RBDD (Heublein et al. 2017a [SAIL model], 2017a). Also, there is a positive correlation between mean daily freshwater outflow (April to July) and white sturgeon year class strength (CDFG 1992 and USFWS 1995, cited in NMFS 2018). These relationships may result from flows transporting larvae to areas with greater food availability, dispersing larvae over a wider area, and/or enhancing nutrient availability to the Sacramento River and Delta/Estuary.

Green Sturgeon larvae may be particularly susceptible to entrainment at water diversions. The larvae are present in areas where substantial water volumes are diverted, such as the Red Bluff Diversion Dam and Glen-Colusa Irrigation District (GCID) facilities and, due to their small size and relatively poor swimming performance, it is highly likely that entrainment effects larval survival (Heublein et al.

2017a[SAIL model]; Verhille et al. 2014). Modern fish screens are designed to reduce entrainment of juvenile salmonids, but the effectiveness of screens and facility operations in reducing larval Green Sturgeon entrainment is poorly understood. Furthermore, many small-scale unscreened diversions are present near larval habitat throughout the mainstem Sacramento River. Periods of extended low flow may reduce the effectiveness of fish protection devices and operational measures intended to reduce entrainment (Heublein et al. 2017a[SAIL model]).

Flows under the WOA modeling scenario would generally be low in summer and fall, potentially affecting the Green Sturgeon larvae. High WOA flows occur during April and May in many years, and these could have both positive and negative effects on rearing Green Sturgeon larvae. The impacts of low flows listed above are generally ameliorated by higher flows, but there can be adverse effects including higher stranding risk because of greater flow fluctuations and higher contaminants concentrations from stormwater runoff.

The CalSim modeling shows large seasonal changes during the larval period between the WOA modeling scenario and the proposed action. For all years in April and most years in May, the WOA flows are greater than the proposed action flows, but in June through September, the proposed action flows are almost always higher than the WOA flows. These seasonal changes result primarily from diversions to Shasta Reservoir storage under the proposed action during spring, when uncontrolled flows are high, and Shasta Reservoir storage releases under the proposed action during June through September, when uncontrolled flows are low.

The lower summer and fall flows under the WOA modeling scenario would potentially result in reduced conditions in larval rearing habitats, as previously described, and reduce dispersion of the larvae to favorable rearing habitats.

5.12.3.2.3.2 Water Temperature

Critical water temperatures thresholds have been determined for Northern DPS Green Sturgeon but not for Southern DPS Green Sturgeon, but it is assumed that the temperature tolerances of the two distinct population segments are similar (Heublein 2017b). Based on laboratory studies, Van Eenennaam et al. (2005) concluded that 63 degrees Fahrenheit is the minimum water temperature for optimal growth and survival of larvae and 68 degrees Fahrenheit is the maximum. This water temperature range exceeds the upper limit of optimal temperatures for Green Sturgeon eggs (63 degrees Fahrenheit)

Water temperatures under the proposed action fall below the 63 to 68 degrees Fahrenheit optimal range for Green Sturgeon larvae in most years throughout the entire April to October period of potential larval presence in the Sacramento River. During April, May and October, the mean monthly water temperatures at Hamilton City are above 63 degrees Fahrenheit in no more than about 10 percent of years, while during June through September, the water temperatures fall within the optimal range for a minimum of 50 percent of years to a maximum of 70 percent of years. The water temperatures exceed the 68 degrees Fahrenheit upper temperature threshold in at most 8 percent of years in any month.

Late spring, summer, and early fall water temperatures under the proposed action are consistently lower than those under the WOA modeling scenario, except during April, when water temperatures for all three scenarios are similar. During July through September, the WOA water temperatures always exceed the optimal range, and under the proposed action water temperatures are within the optimal range approximately half of the time at Hamilton City. Only in May under the WOA modeling scenario do the majority of years lie within the optimal temperature range. These results indicate that neither the WOA, proposed action, nor COS provide optimal water temperature conditions for Green Sturgeon larvae.

However, cooler water temperatures under the proposed action would have beneficial impacts on Green Sturgeon larvae (especially July and August) because WOA temperatures frequently approach lethal levels.

5.12.3.2.4 Egg to Larvae (March – July)

5.12.3.2.4.1 Flows

In the section of the Sacramento River where Green Sturgeon spawn, the WOA flows during the April through July period, when most Green Sturgeon spawning and egg incubation occurs, vary greatly, ranging from about 3,000 cfs for about two percent of years during July to well over 50,000 cfs for three percent of years in April. During years with dry hydrology (left-hand portion of the flow probability of exceedance plots), the July flows in about five percent of years would drop below the proposed action minimum flow of 3,250 cfs. During June in about 40 percent of years and July in about 80 percent of years, flows would be below 5,000 cfs, which is the proposed action minimum flow for the Sacramento River at Wilkins Slough.

Higher flows may also adversely impact spawning and egg incubation. If flows are sufficiently high, incubating eggs are at risk of being scoured from the river bed. Dewatering of Green Sturgeon eggs is less of a risk than it is for most fish species because eggs are generally spawned in deep water.

During the April through July Green Sturgeon spawning period, mean monthly flows at Red Bluff under the proposed action range from about 3,000 cfs for a few years in July to about 40,000 cfs in April. Flows in the majority of years during this period are moderate (~10,000 cfs to 15,000 cfs), with the percentage of years with flows under 10,000 cfs decreasing progressively from 75 percent in April to only 15 percent in July. The reductions in low flows over the course of this period reflects the increased flow releases needed for water temperature management in the river and instream demands and Delta requirements. The proposed action flow levels in most years throughout the April through July period are suitable for Green Sturgeon spawning and egg incubation, and no impacts are expected to result. During the August through October period, when Green Sturgeon spawning occurs in occasional years, the proposed action flows tend to be lower than those in April through July, but flows would drop below 5,000 cfs for only about 15 percent of years in September and no years and 5 percent of years in August and October, respectively. The late summer and fall spawning by Green Sturgeon has occurred sporadically and primarily in wetter years (NMFS 2018), so the occasional moderately low September flows (less than 5,000 cfs) under the proposed action scenarios are not expected to have any meaningful biological effect on spawning and egg incubation of the Sacramento River Green Sturgeon population.

Differences in flows between the proposed action are small in most months, but flows are moderately higher for the proposed action in June (Figures 5.12-20). The flow differences are expected for years with relatively wet hydrology (~10,000 cfs to 15,000 cfs) and, therefore, are not expected to have a meaningful effect on development or survival of incubating Green Sturgeon eggs.

During April, WOA flows are consistently well above proposed action flows (Figure 5.12-18) and likely provide more favorable conditions for Green Sturgeon spawning and egg incubation, except in the wettest years, when the WOA flows may be high enough to scour the incubating eggs. During June and July, the proposed action flows are almost always higher than the WOA flows (Figures 5.12-20 and 5.12-21) and during May, flows under the proposed action are lower than flows under the WOA modeling scenario in wetter years, but are higher than WOA flows in drier years (Figures 5.12-19). During May through July, therefore, the potential adverse impacts of low flows on Green Sturgeon spawning and egg incubation listed above are expected to occur less frequently and with less severity under the proposed action than under the WOA conditions.

5.12.3.2.4.2 Water Temperature

Critical water temperatures thresholds have been determined for Northern DPS Green Sturgeon but not for Southern DPS Green Sturgeon. It is assumed that the temperature tolerances of the two distinct population segments are similar (Heublein et al. 2017b). Based on laboratory studies, Van Eenennaam et al. (2005) concluded that 63 degrees Fahrenheit is the maximum water temperature for normal embryo development.

The presence of a large cold water pool and the flexibility afforded by the TCD under the proposed action make possible the provision of cold water in the upper Sacramento River during the summer and fall, which would benefit Green Sturgeon spawning and egg incubation. Under the proposed action, monthly mean water temperatures at Hamilton City range from about 51 to 69 degrees Fahrenheit during April through July (Figures 5.12-36 through 5.12-42). About 50 percent of years in June and July have mean monthly water temperatures exceeding the 63 degrees Fahrenheit threshold. During August and September, about 70 percent of years have mean monthly water temperatures that exceed 63 degrees Fahrenheit, but during October the frequency of exceedance is less than 5 percent (Figures 5.12-36 through 5.12-42).

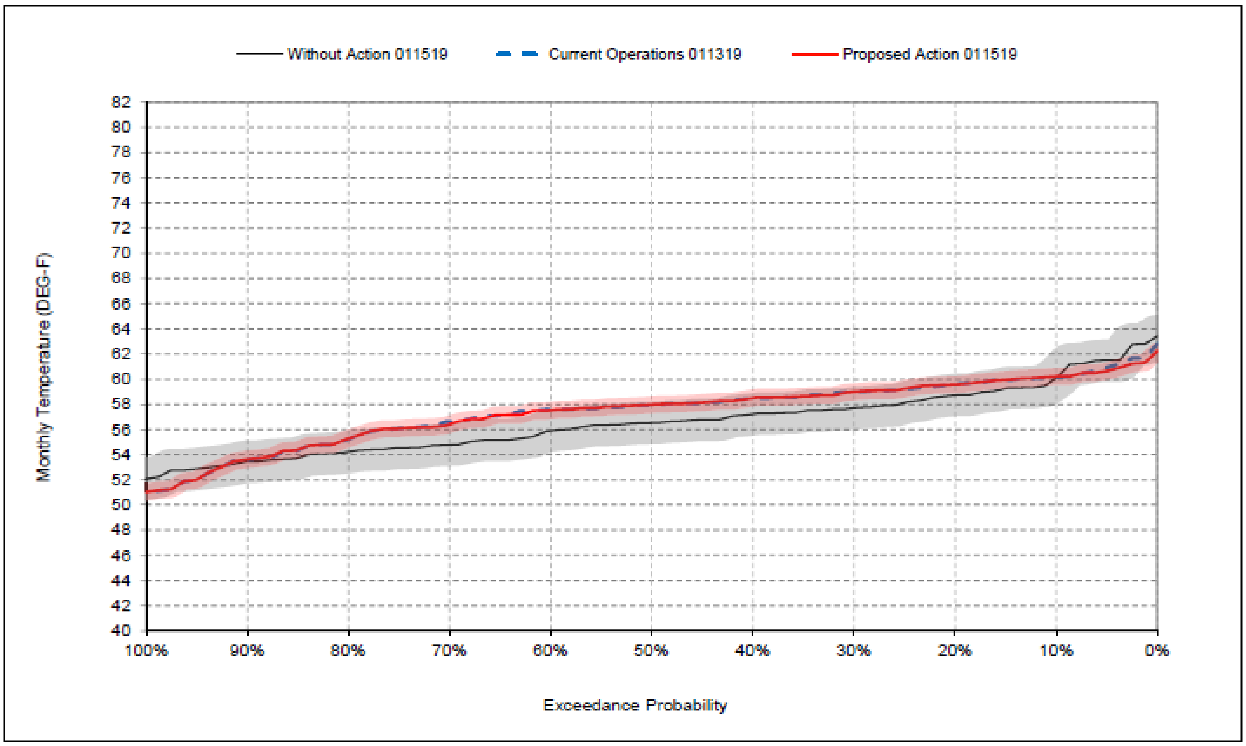


Figure 5.12-36. HEC-5Q Sacramento River Water Temperatures at Hamilton City under the WOA, proposed Action and COS Scenarios, April

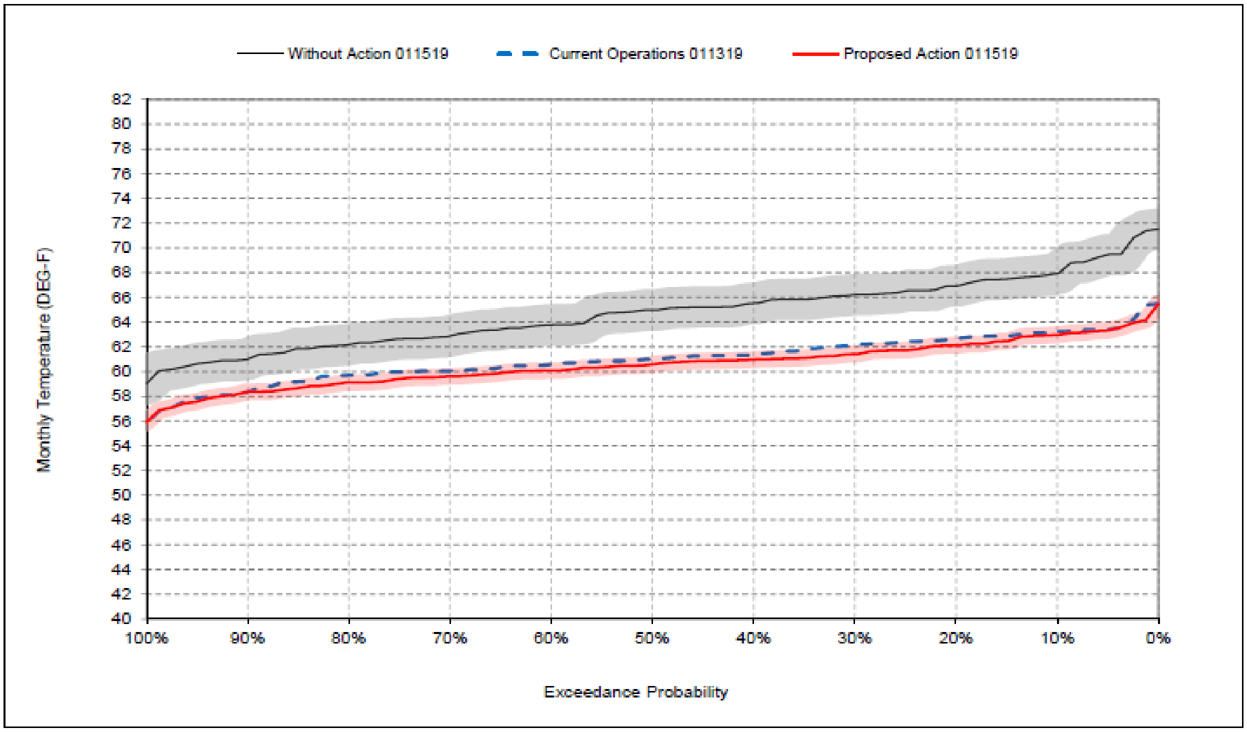


Figure 5.12-37. HEC-5Q Sacramento River Water Temperatures at Hamilton City under the WOA, proposed Action and COS Scenarios, May

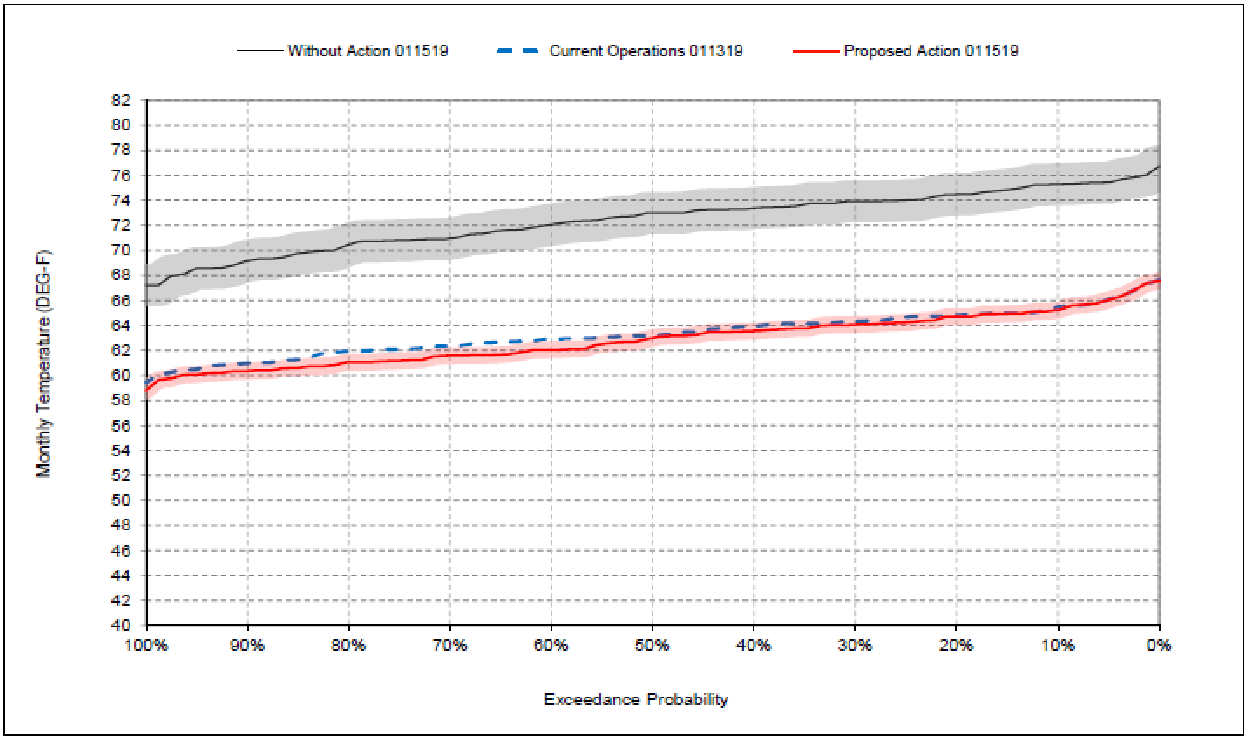


Figure 5.12-38. HEC-5Q Sacramento River Water Temperatures at Hamilton City under the WOA, proposed Action and COS Scenarios, June

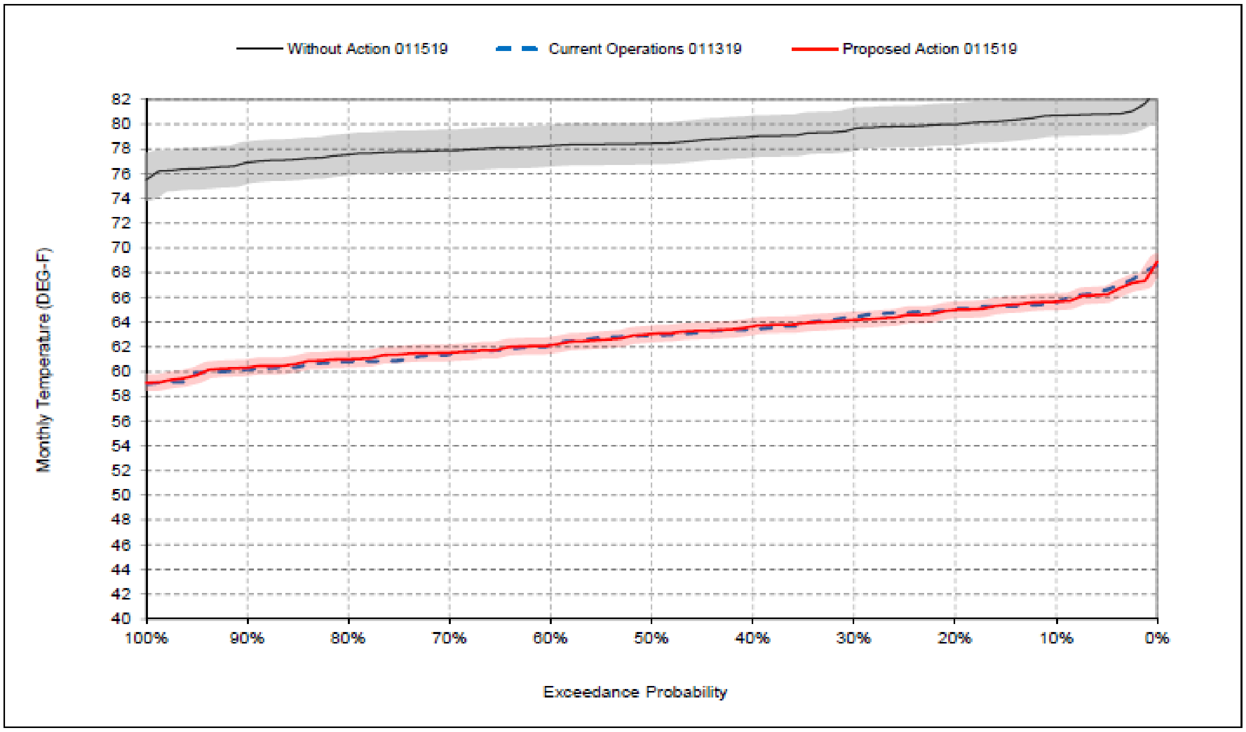


Figure 5.12-39. HEC-5Q Sacramento River Water Temperatures at Hamilton City under the WOA, proposed Action and COS Scenarios, July

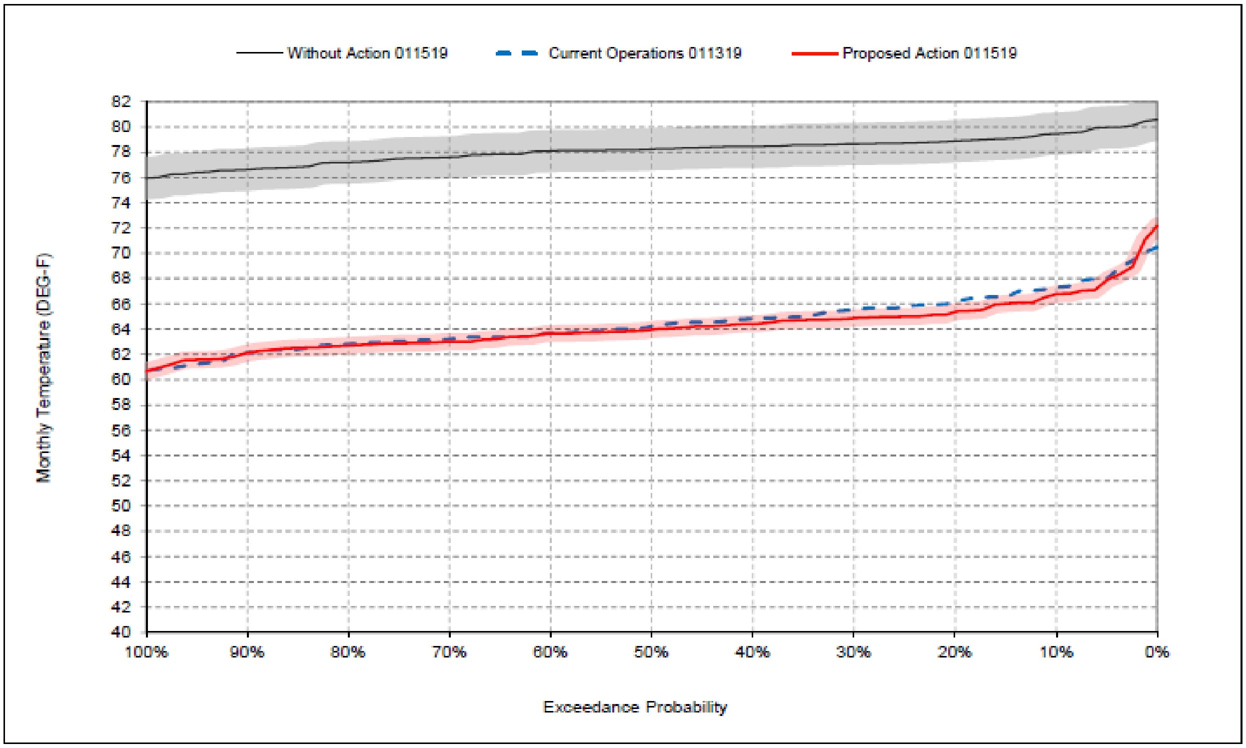


Figure 5.12-40. HEC-5Q Sacramento River Water Temperatures at Hamilton City under the WOA, Proposed Action and COS Scenarios, August

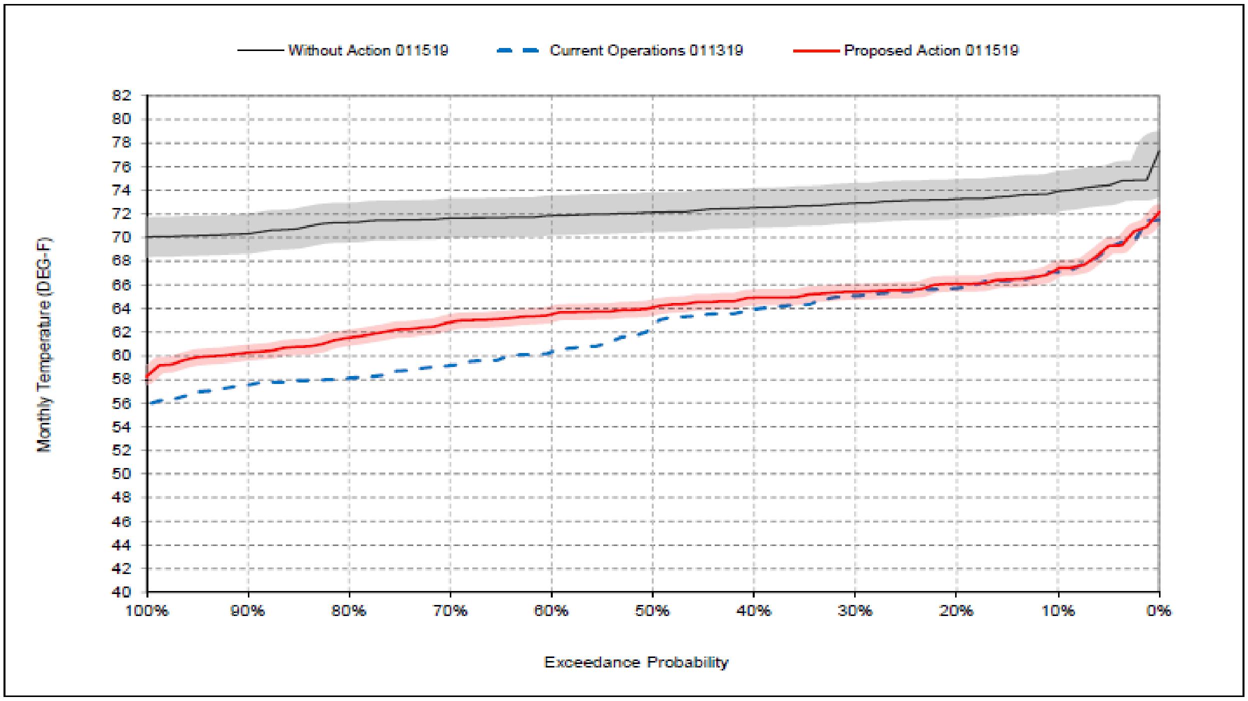


Figure 5.12-41. HEC-5Q Sacramento River Water Temperatures at Hamilton City under the WOA, Proposed Action and COS Scenarios, September

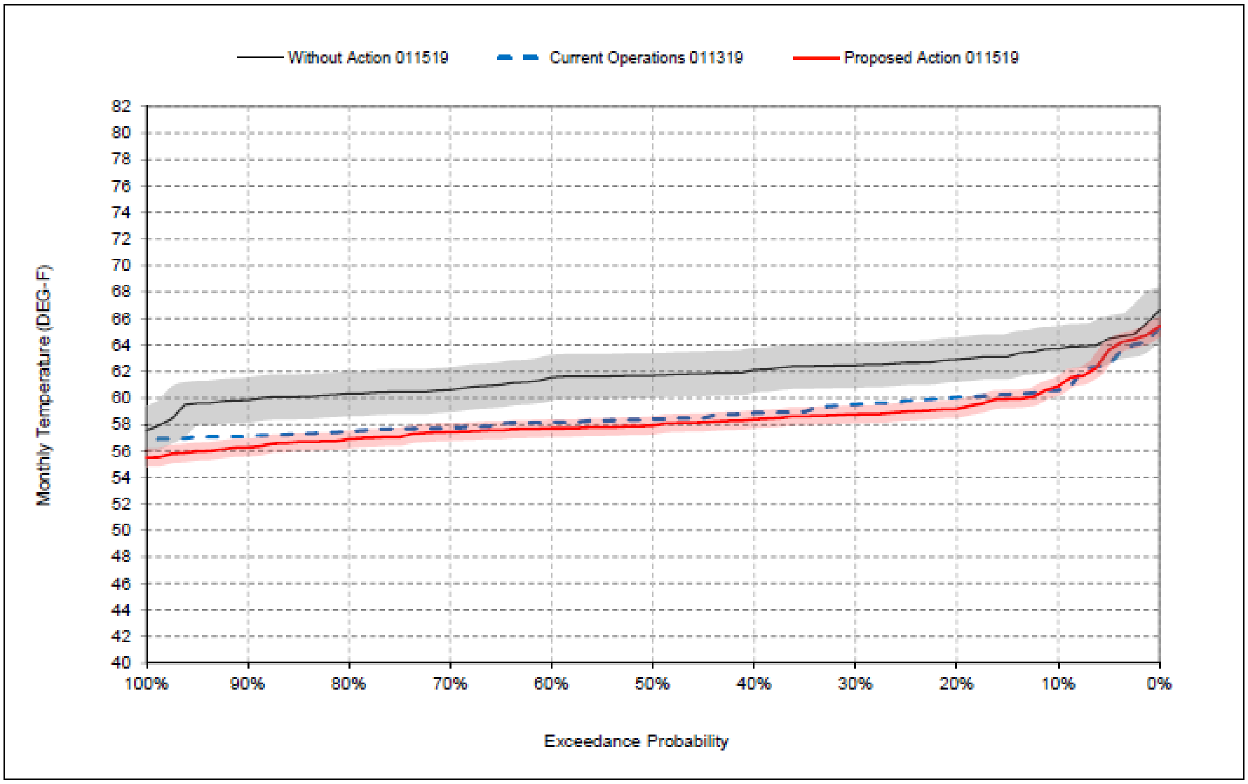


Figure 5.12-42. HEC-5Q Sacramento River Water Temperatures at Hamilton City under the WOA, Proposed Action and COS Scenarios, October

Summer water temperatures under the proposed action are consistently lower than those under the WOA modeling scenario (Figures 5.12-38 to 5.12-41), with far fewer years exceeding the 63 degrees Fahrenheit threshold. These results indicate that the proposed action, relative to the WOA modeling scenario, provide a clear benefit to Green Sturgeon spawning and egg incubation in the Sacramento River. The temperature management operations under the proposed action are likely to benefit Green Sturgeon egg survival relative to the WOA modeling scenario.

5.12.3.3 Spring Pulse Flows

Under WOA, spring pulse flows would occur naturally and more often. Under the Proposed Action, Reclamation would release spring pulse flows for juvenile salmonid outmigration when storage levels allow. These flow increases could reduce temperatures during the early portion of larval stage of Green Sturgeon, which could help keep temperatures below the 63 degree Fahrenheit threshold for Green Sturgeon egg development.

5.12.3.4 Fall and Winter Refill and Redd Maintenance

Under WOA, fall flows would be low. Under the Proposed Action, Reclamation would adjust fall flows based on Shasta storage levels to avoid redd dewatering of fall-run and winter-run Chinook salmon redds and avoid cold water pool impacts. Higher flows in the fall could negatively affect the juvenile lifestage of Green Sturgeon, but reducing temperatures further below the 63 to 68 degree optimal range for Green Sturgeon juvenile development.

5.12.3.5 Feather River

5.12.3.5.1 Egg to Larvae (March – July)

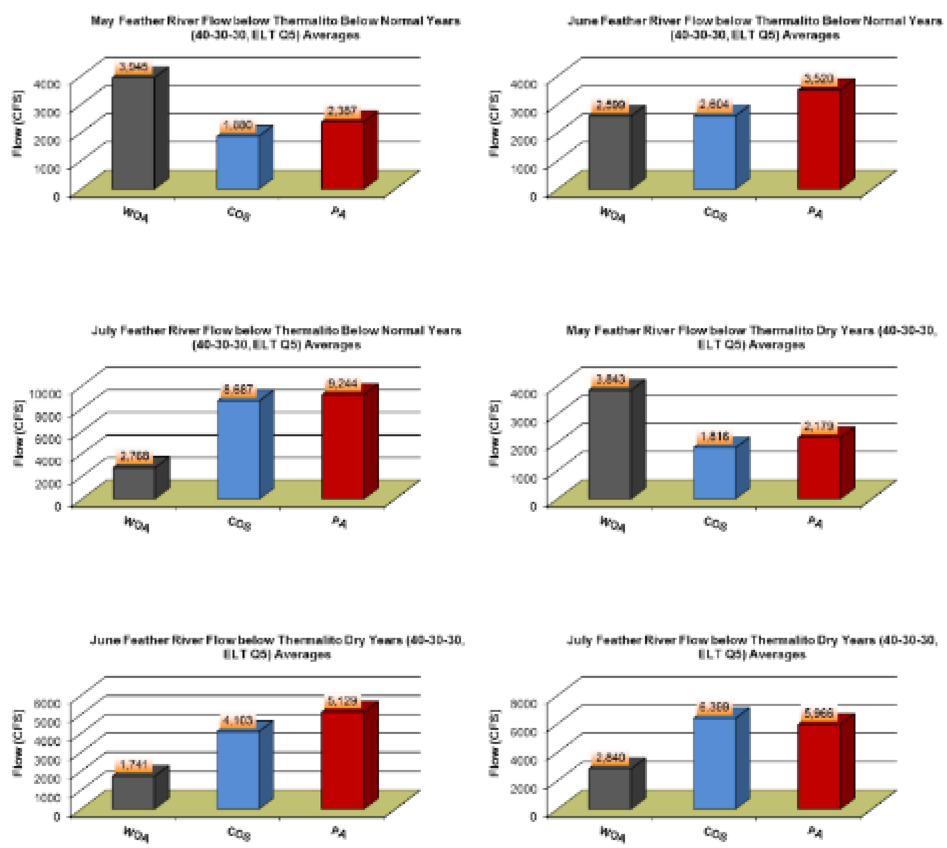
Eggs and larvae of southern DPS Green Sturgeon would be exposed to the effects of Oroville Dam releases and resulting flows in the high flow channel (HFC) of the Feather River downstream of the Oroville Complex FERC boundary proposed in the proposed action, based on the seasonal occurrence of this life stage in the Feather River (May to July; NMFS 2016), minimum instream flow requirements in the high flow channel of the Feather River (year-round requirements; Table 5.12-2), and compliance with Water Rights Decision 1641 (D-1641).

Table 5.12-2. Feather River High Flow Channel minimum instream flow requirements

Preceding April – July Unimpaired runoff (Percent of Normal)	Oct-Feb (cfs)	March (cfs)	April-Sept (cfs)
55% or greater	1,700	1,700	1,000
Less than 55%	1,200	1,000	1,000

Under the WOA, Lake Oroville would not be operated to control storage or flow releases and no conveyance of water to San Luis Reservoir via the Banks Pumping Plant would be made. Reservoir gates and diversion tunnels would be kept open, resulting in annual storage volumes less than 1,000 TAF (see figure from Spring-run section). As a result, there would be limited control of flow or water temperature in the Feather River HFC, which provides habitat for this life stage. Feather River flows under the proposed action would be generally higher in the summer and fall and lower in the winter and spring compared to the WOA (see figures in Spring-run section).

Flows in the Feather River HFC under the proposed action during the May to July egg incubation, larval development, and early larval rearing period are lower in May during all water year types, and similar or higher in June and July in below normal, dry, and critically dry water years; flows in July are higher under the proposed action during all water year types (Figure 5.12-43). Importantly, CalSim II model output indicates June and July flows projected under the proposed action will increase the likelihood of minimum instream flow compliance in June and July of many drier water year types, minimizing potential exposure to low flows (Figure 5.12-43). As a result, potential adverse impacts of low flows on this life stage are anticipated to be less severe under the proposed action. Therefore, flow-related actions in the proposed action are anticipated to produce benefits for this life stage.



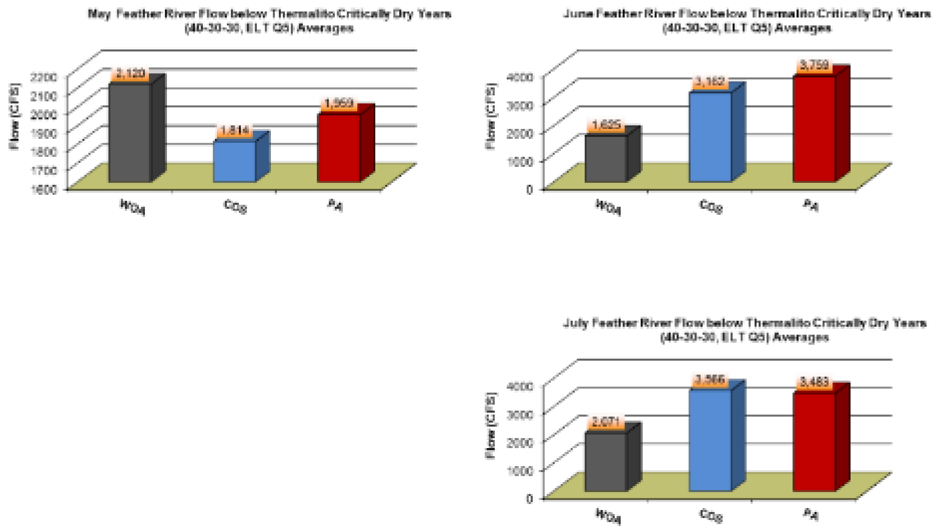


Figure 5.12-43. CalSim II estimates of Feather River Flow below the Thermalito Afterbay in May–July under the WOA, Proposed Action, and COS Scenarios.

5.12.3.5.1.1.1 Temperature Effects

Eggs and emerging fry of southern DPS Green Sturgeon would be exposed to the effects of water temperature objectives for the Feather River HFC, based on the seasonal occurrence of this life stage in the Feather River (May-July; NMFS 2016), and the timing of the temperature objectives (year-round objectives; Table 5.12-3). Water temperature objectives would be expected to be met in years when the Oroville Temperature Management Index (OTMI) is greater than 1.35 MAF and would be achieved through a combination of flow releases from Lake Oroville, and operations modifications stipulated in Article A108.1(b) [(*i*) curtailment of pump-back operation, (*ii*) shutter removal on Hyatt Intake, (*iii*) increase flow releases in the Low Flow Channel up to a maximum of 1,500 cfs]. If OTMI is equal to or less than 1.35 MAF a Conference Year is designated, triggering consultation between DWR and NMFS, USFWS, CDFW, and the SWRCB to prepare a strategic plan to manage the coldwater pool to minimize temperature exceedances at the lower FERC project boundary, while maintaining water supply and other legal obligations.

Table 5.12-3. Maximum Daily Mean Water Temperature for the HFC.

Period	**Temperature**
January 1 – March 31	56
April 1 – 30	61
May 1 – 15	64
May 16 – 31	64
June 1 – August 31	64

Period	Temperature
September 1 – 8	61
September 9 – 30	61
October 1 – 31	60
November 1 – December 31	56

Water temperatures in the Feather River during summer and fall are heavily influenced by flow releases from Lake Oroville which are determined by operations and storage releases. Under the WOA, Lake Oroville would not be operated to control storage or flow releases and no conveyance of water to San Luis Reservoir via the Banks Pumping Plant would be made. Therefore, there would be limited control of flow or water temperature in the Feather River HFC from the Thermalito After Bay Outlet Pool downstream to the vicinity of the Gridley Bridge, where spawning occurs (NMFS 2016). Resulting water temperatures under the WOA in the Feather River HFC at Gridley Bridge as modeled by the RecTemp temperature model are generally lower during the winter months, and higher during the summer and fall with peak annual water temperatures of approximately 78 °F occurring in July and August (see figures in Spring-run section).

Under almost all conditions, the WOA scenario would increase the likelihood of temperature related stress and mortality during the months of June and July. In addition, modeled water temperatures at Gridley Bridge under the proposed action indicate the proposed action would increase the likelihood of temperature compliance at the compliance point (lower FERC project boundary). Temperature objectives at the compliance point in April to July (maximum daily mean water temperatures of 61 ^{0}F in April, 64 ^{0}F May to July) fall within the optimal range of Green Sturgeon egg and larval temperature tolerances (NMFS 2016).

Water temperatures exceeding the objectives would have a number of adverse impacts on this life stage, including acute to chronic physiological stress, eventually leading to egg and larval mortality. Water temperatures in the Feather River HFC under the proposed action during the egg and larval development period are similar to or lower than WOA water temperatures. Importantly, RecTemp model output indicates water temperatures projected under the proposed action will increase the likelihood that May to July water temperatures will be less likely to reach lethal levels (> 73 ^{0}F) (see figures in spring-run section). As a result, potential adverse impacts of water temperature objectives on this life stage are anticipated to be less severe under the proposed action. Therefore, water temperature-related actions in these scenarios are anticipated to produce benefits for this life stage.

5.12.3.5.2 Larvae to Juvenile (April – August)

Larval rearing to juvenile southern DPS Green Sturgeon would be exposed to the effects of Oroville Dam releases and resulting flows in the HFC of the Feather River downstream of the Oroville Complex FERC boundary proposed in the proposed action, based on the seasonal occurrence of this life stage in the Feather River (May–October; Table 5.12-1), minimum instream flow requirements in the high flow channel of the Feather River (year-round requirements; Table 5.12-2), and compliance with Water Rights Decision 1641 (D-1641).

Feather River flows below Thermalito Afterbay under the WOA are generally greater than the proposed action during the months of May and June and are less then the proposed action during the months of July through October during the larval to juvenile period of southern DPS Green Sturgeon (see figures in Spring-run section). Proposed action flows exceed WOA flows during the months of June through September, a period of peak abundance for this life stage. In addition, the likelihood of projected flows under all scenarios declining below the required minimum flow for April–September (1,000 cfs depending on preceding April—July) is very low (Figure 5.12-44).

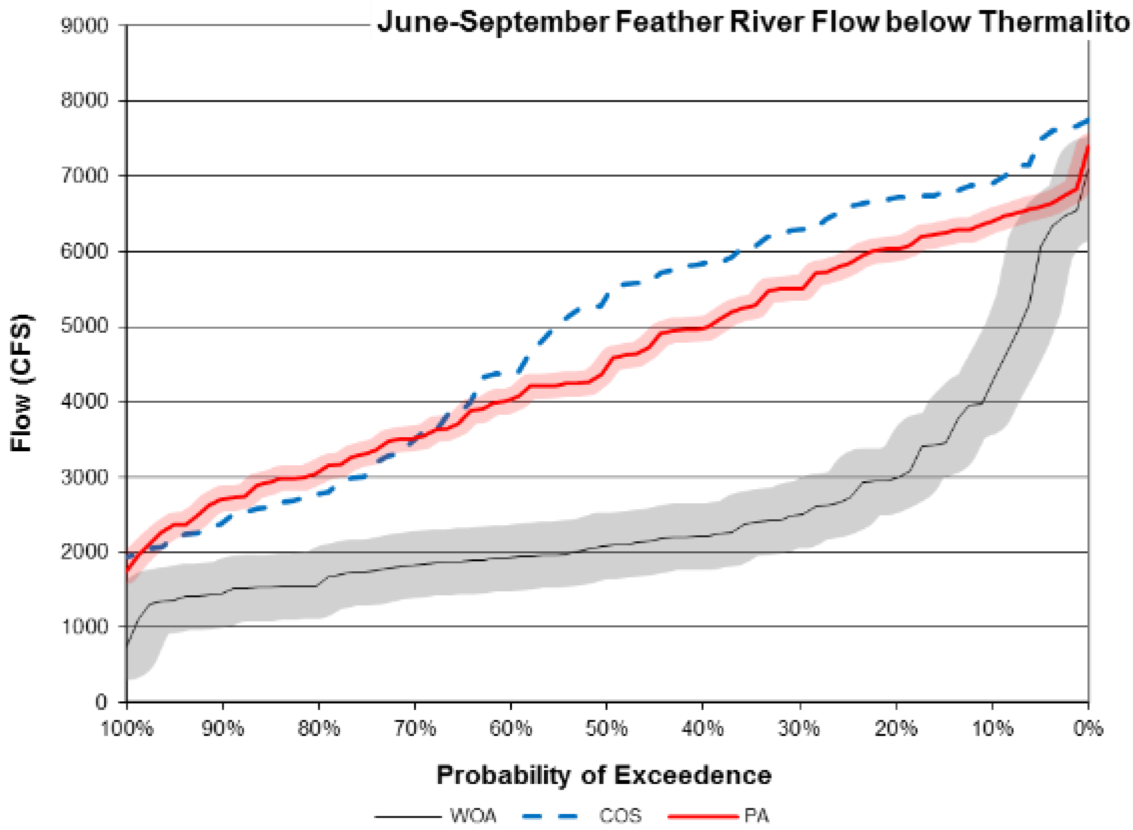


Figure 5.12-44. CalSim II Estimates of Feather River Flow below the Thermalito Afterbay in June–September under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action) Scenarios.

5.12.3.5.2.1.1 Temperature Effects

Larval and juvenile life stages of Green Sturgeon would be exposed to the effects of water temperature objectives for the Feather River HFC, based on the seasonal occurrence of this life stage in the Feather River (May to October; NMFS 2016), and the timing of the temperature objectives (year-round objectives; Table 5.12-2).

Water temperatures on the Feather River at Gridley Bridge under the proposed action during the months of May to October are lower than the impaired fitness temperature tolerance limit (72 ^{0}F) for larvae in all water year types but dry and critically dry years when July and August temperatures exceed this threshold. However, the proposed action provide substantial temperature reductions compared to the WOA under these conditions (see Figures 3-1 through 3-6 in the RecTemp Temperature Results section of Appendix D, *Modeling*).

In addition, modeled water temperatures at Gridley Bridge indicate the proposed action would increase the likelihood of temperature compliance at the compliance point (lower FERC project boundary). As a result, potential adverse impacts of water temperature objectives on this life stage are anticipated to be less severe under the proposed action. Therefore, water temperature related actions in these scenarios are anticipated to produce benefits for this life stage compared to the COS.

5.12.3.5.3 Juvenile to Subadult/adult in Bay-Delta

Juvenile to subadult/adult southern DPS Green Sturgeon would be exposed to the effects of Oroville Dam releases and resulting flows in the HFC of the Feather River downstream of the Oroville Complex FERC boundary proposed in the proposed action, based on the occurrence of this life stage in the Feather River (year round; NMFS 2016), minimum instream flow requirements in the high flow channel of the Feather River (year-round requirements; Table 5.12-2), and compliance with Water Rights Decision 1641 (D-1641).

The differences in flows between the WOA scenario and the proposed action scenarios may affect the development, survival and downstream migration of juvenile Green Sturgeon to the subadult/adult phase. Lower proposed action flows compared to WOA flows from January to June could reduce migration cues and conditions resulting in harmful impacts on juvenile Green Sturgeon foraging conditions, water temperatures and DO, toxicity, and habitat area. Higher flows under the proposed action from July to September could similarly benefit juvenile to subadult Green Sturgeon during these months. The comparative magnitude of positive and negative impacts under the proposed action are difficult to quantify, however impacts of lower flows under the proposed action from January to June are anticipated to be minimal since projected proposed action flows during this period remain well in excess of all applicable minimum instream flows for the Feather River HFC.

Therefore, the proposed action will have no negative impacts on juvenile to subadult Green Sturgeon.

5.12.3.5.3.1 Temperature Effects

Juvenile and subadult/adult southern DPS green sturgeon would be exposed to the impacts of water temperature objectives for the Feather River HFC, based on the year-round occurrence of this life stage in the Feather River (NMFS 2016), and the timing of the temperature objectives (year-round objectives; Table 55.12-3). Water temperature objectives would be expected to be met in years when the Oroville Temperature Management Index (OTMI) is greater than 1.35 MAF and would be achieved through a combination of flow releases from Lake Oroville, and operations modifications stipulated in Article A108.1(b) [(*i*) curtailment of pump-back operation, (*ii*) shutter removal on Hyatt Intake, (*iii*) increase flow releases in the Low Flow Channel up to a maximum of 1,500 cfs]. If OTMI is equal to or less than 1.35 MAF a Conference Year is designated, triggering consultation between DWR and NMFS, USFWS, CDFW, and the SWRCB to prepare a strategic plan to manage the coldwater pool to minimize temperature exceedances at the lower FERC project boundary, while maintaining water supply and other legal obligations.

Water temperatures in the Feather River from March to June are relatively less influenced by flow releases from Lake Oroville than in late summer and fall, given the larger flow volumes, and cooler air temperatures during these months. Under the WOA, Lake Oroville would not be operated to control storage or flow releases and no conveyance of water to San Luis Reservoir via the Banks Pumping Plant would be made. Therefore, there would be limited control of flow or water temperature in the Feather River HFC where this life stage occurs. However, resulting water temperatures under the WOA in the Feather River HFC at Gridley Bridge as modeled by the RecTemp temperature model are similar to proposed action water temperatures from March to May, with small differences projected in June. Water temperatures under the WOA in the Feather River HFC at Gridley bridge as modeled by the RecTemp temperature model are significantly higher in July to September and are above the lethal limits of temperature tolerance of this life stage (Figure 5.12-44). There are no temperature-related stress and mortality impacts under the proposed action. These impacts produce a substantial reduction in projected water temperatures compared to the WOA

5.12.3.5.4 Adult to Egg and Post-Spawn Adult

5.12.3.5.4.1 Flow Effects

Spawning adult to egg and post-spawn adult Green sturgeon would be exposed to the effects of Oroville Dam releases and resulting flows in the High Flow Channel (HFC) of the Feather River downstream of the Oroville Complex FERC boundary, based on the seasonal occurrences of these life stages in the Feather River (March-August with peak seasonal occurrence March-May; NMFS 2016), minimum instream flow requirements in the high flow channel of the Feather River (year-round requirements; Table 5.12-2), and compliance with Water Rights Decision 1641 (D-1641).

Instream flow from Lake Oroville releases may influence upstream and downstream passage of physical barriers on the Feather River.

Proposed action flows during this period are lower than WOA flows, however flows are not anticipated to decline below minimum instream flow standards or to a level that results in any increased passage or barrier issues in the Feather River HFC. A potential passage barrier exits at the Sunset Pumps Rock Weir (RM 28.5), which require flows of 2,500–3,000 cfs for passage. Flows below the Thermalito Afterbay and at the Feather River mouth are well above this threshold during the peak seasonal timing of this life stage (Figures 21-1 and 22-1 in the CalSim II Flows section of Appendix D, *Modeling*). Post-spawning downstream migration is triggered by increased flows (6,150–14,725 cfs) in the late summer (NMFS 2016) and long-term average flows below Thermalito Afterbay and at the Feather River mouth are slightly below this during the months of July and August. However, flows are significantly higher under the proposed action than under the WOA (Figures 21-1 and 22-1 in the CalSim II Flows section of Appendix D, *Modeling*).

Differences in flow between the WOA, proposed action, and COS are likely to impact migrating adults and their habitat. Higher WOA flows from March to May could result in positive impacts on migrating, spawning, and post-spawning adults in the Feather River, including increased migration success and an increase in spawning habitat. However, flows at the Thermalito Afterbay and at the Feather River mouth during this period are not expected to be sufficiently low to create substantial negative impacts. Increased flows under the proposed action during July to August are expected to have beneficial impacts on post-spawn adults. As a result of these offsetting impacts, there are not expected to be any negative impacts on spawning adult to egg and post-spawn adult Green Sturgeon.

5.12.3.5.4.2 Temperature Effects

Spawning adult to egg and post-spawn adult Green sturgeon would be exposed to the impacts of water temperature objectives for the Feather River HFC, based on the seasonal occurrence of this life stage in the Feather River (March to August with peak seasonal occurrence March to May; NMFS 2016), and the timing of the temperature objectives (year-round objectives; Table 5.12-3).

Temperatures at Gridley Bridge under the proposed action are similar to temperatures under the WOA from March to May, which coincides with the peak seasonal timing of Green Sturgeon upstream migration and spawning. The risk of temperature-related stress and mortality during this period is low as temperatures are projected to be equal to or lower than the optimal ranges for migrating, spawning, and holding Green Sturgeon (Figure 3-1 in the RecTemp Temperature Results section of Appendix D). Reduced water temperatures under the proposed action from July to August are expected to produce temperature benefits for post-spawn adults. Therefore, water temperature-related actions in the proposed action are anticipated to produce benefits for this life stage.

5.12.3.6 American River Seasonal Operations, 2017 FMS and "Planning Minimum"

North American Green Sturgeon are not known to occur in the American River and their historical distribution in the American River is not known (Beamesderfer et al. 2004). However, there is the potential for juvenile rearing in the lower reaches of the American River near the confluence with the Sacramento River (NMFS 2009). If the North American Green Sturgeon do occur in the American River, the proposed action would likely provide beneficial effects to North American Green Sturgeon relative to WOA through increased fall flows increasing inundated habitat.

5.12.3.7 Delta Seasonal Operations and OMR Management

Hydrodynamic changes associated with river inflows and South Delta exports have been suggested to negatively impact southern DPS Green Sturgeon in two distinct ways: 1) "near-field" mortality associated with entrainment to the export facilities, 2) "far-field" mortality resulting from altered hydrodynamics. The SST completed a thorough review of this subject and defined a driver- linkage-outcome (DLO) framework for specifying how water project operations (the "driver") can influence juvenile salmonid behavior (the "linkage") and potentially cause changes in survival or routing (the "outcome"). A similar analysis is not available for southern DPS Green Sturgeon.

5.12.3.7.1 <u>Entrainment</u>

As described by NMFS (2009: 386), impacts to the migratory corridor function of juvenile and sub-adult Green Sturgeon critical habitat from south Delta exports are less clear than for juvenile salmonids because Green Sturgeon spend one to three years rearing in the Delta environment before transitioning to their marine life history stage. During this Delta rearing phase, Green Sturgeon are free to migrate throughout the Delta. In the conceptual model, it is hypothesized that higher rates of exports may result in higher rates of entrainment. However, estimating entrainment risk from raw salvage data is not possible due to a lack of information on the number of juvenile Green Sturgeon potentially exposed to salvage.

Juvenile southern DPS Green Sturgeon (> 5 mo) are present in the Delta all year and sub-adults are most abundant from June through November. As there are no exports under WOA, there is no Green Sturgeon entrainment risk under WOA. In the June through September period under the proposed action Reclamation proposes an average total export rate slightly higher than COS (41 cfs; Figure H-27 – Appendix H, *Bay-Delta Aquatics Effects Figures*) and will, therefore, have a similar entrainment risk. Total exports proposed for proposed action in September-November (121 cfs higher than COS; Figure H-28 – Appendix H, *Bay-Delta Aquatics Effects Figures*) are unlikely to measurably increase entrainment risk relative to COS. Relative to WOA, the proposed action significantly increases entrainment risk.

Juvenile white and green sturgeon are infrequent at the TFCF, but may occur in the facility salvage year-round. Salvage is expected to be similar and slightly higher than COS under the proposed action.

5.12.3.7.2 Routing

Juvenile Green Sturgeon (>5 mo) are present in the Delta all year and sub-adults are most abundant from June to November (Table 5.12-1). Juvenile Green Sturgeon swim and behave quite differently and have distinct body morphologies and habitat associations in the Delta compared to outmigrating salmonids, so it is hypothesized that juvenile Green Sturgeon have different routing-hydrology survival relationships. Per NMFS (2009: 338), Green Sturgeon are likely to be found in the main channels of the Delta and the larger interconnecting sloughs and waterways, with western Delta waterways having a higher likelihood of presence than eastern Delta waterways. It is highly uncertain how Green Sturgeon routing would change with the proposed action.

5.12.3.7.3 Through Delta Survival

Little is known about the relationship between survival of juvenile Green Sturgeon and Delta hydrology. Green Sturgeon reside in the Delta for one to three years suggesting they encounter a variety of daily, seasonal, and annual hydrological conditions. The majority of Green Sturgeon in the Delta are likely not surviving through the Delta per se, but using these habitats for rearing and foraging. Per NMFS (2009: 338), Green Sturgeon are likely to be found in the main channels of the Delta and the larger interconnecting sloughs and waterways, with western Delta waterways having a higher likelihood of presence than eastern Delta waterways. For juvenile outmigrating Green Sturgeon present in these regions, increasing negative velocities under the proposed action may result in lower survival. However, as described above, there is a lower probability of juvenile Green Sturgeon residing in this area.

5.12.3.8 Delta Cross Channel Operations

Delta Cross Channel operations under the proposed action are changed to allow Reclamation to predict water quality exceedances and open the DCC if D-1641 criteria are predicted to be exceeded. This results in greater opening times of the DCC.

Little is known about the migratory behavior of juvenile Green Sturgeon in the Sacramento River basin. It is likely that juvenile Green Sturgeon (larger than the 75 mm) will not enter the Delta prior to their first winter and thus would not be exposed to the open DCC gates. If juvenile Green Sturgeon are exposed to the open DCC gates, they could be entrained into the central/south Delta and exposed to biological and physical conditions in this area, including potentially greater predation. It is likely that these fish will enter the Delta sometime in the winter or spring following their hatching upriver and encounter both types of gate configurations as they enter the Delta.

5.12.3.9 Agricultural Barriers

Agricultural Barriers (Temporary Barrier Project, TBP) are included in the proposed action and consists of three rock barriers across south Delta channels to improve water levels for agricultural diversions. The temporary rock barriers are installed and removed at Middle River near Victoria Canal, Old River near Tracy, and Grant Line Canal near Tracy Boulevard Bridge. The TBP is operated based on San Joaquin River flow conditions. The agricultural barriers at Middle River and Old River near Tracy can begin operating as early as April 15 but the tide gates are tied open from May 16 to May 31. After May 31, the barriers in Middle River, Old River near Tracy, and Grant Line Canal are permitted to be operational until they are completely removed by November 30.

Juvenile Green Sturgeon are present in the Delta in all months of the year. However, little is known about their spatial distribution. When the south Delta agricultural barriers are operating with tidal flap gates down, a significant decline in passage and reach survival of acoustically tagged juvenile Chinook Salmon migrating past the barrier has been observed compared to when the barrier is not present (DWR 2018). When flap gates are tied up (May 16 to May 31), outmigrating Chinook Salmon passage past the agricultural barrier was improved (DWR 2018). It could be inferred that passage of outmigrating juvenile Green Sturgeon may also be improved when flap gates are tied up. Therefore, the potential negative effects of the agricultural barriers under the proposed action depends on when they are installed and whether the flap gates are down or tied up.

5.12.3.10 Contra Costa Water District Operations

As discussed in Chapter 4, CCWD's operations in the proposed action are consistent with the operational criteria specified in separate biological opinions and permits that govern operations at CCWD's intakes and Los Vaqueros Reservoir (NMFS 1993; NMFS 2007; NMFS 2010; NMFS 2017; USFWS 1993a; USFWS 1993b; USFWS 2000; USFWS 2007; USFWS 2010; USFWS 2017; CDFG 1994; CDFG 2009). The operation of the Rock Slough Intake for the Proposed Action remains unchanged.

The Contra Costa Canal Rock Slough Intake is located on a dead-end slough, far from the main migratory routes for southern DPS Green Sturgeon (NMFS 2017), approximately 18 miles from the Sacramento River and 10 miles from the San Joaquin River via the shortest routes. Water temperatures in Rock Slough range from lows of about 40 degrees F in winter (December and January) to over 70 degrees F beginning in May and continuing through October (NMFS 2017).

A review of the 24 years of fish monitoring data (1994-2018) near the Rock Slough Intake both pre- and post-construction of the Rock Slough Fish Screen (RSFS) showed that southern DPS Green Sturgeon have never been observed in Rock Slough (CDFG 2002; Reclamation 2016; NMFS 2017; Tenera 2018b, ICF 2018).

5.12.3.10.1 Juvenile to Subadult/Adult

It is unlikely that juvenile and sub-adult Green Sturgeon would be present in Rock Slough due to the shallow depth, warm water temperatures, and low DO which make the area unsuitable habitat during most of the year. Currently, there is not a reliable measure of juvenile southern DPS Green Sturgeon population abundance in the Delta, nor is there a reliable estimate of the relative fraction of the population utilizing the area near the Rock Slough Intake (NMFS 2017). The Rock Slough intake maximum capacity is 350 cfs for the maximum annual diversion of 195 TAF.

5.12.3.10.2 Adult to Spawning Adult

Adult Green Sturgeon are unlikely to be present near the Rock Slough Intake since they typically prefer to migrate upstream through the mainstem Sacramento River and adult Green Sturgeon have not been observed spawning in the San Joaquin River (Jackson and Van Eenennaam 2013). It is unlikely that Green Sturgeon will be entrained into the Rock Slough Intake, and unlikely to be impacted by operations.

5.12.3.10.3 Spawning Adult to Egg and Post-Spawn Adult

Since it is unlikely that adult Green Sturgeon will be present near the Rock Slough Intake, it is also unlikely that eggs or post-spawn adults will be present in the area.

5.12.3.11 North Bay Aqueduct

Overall, the modeled exports in the proposed action represent a significant increase in export levels and, thus, a greater risk to Green Sturgeon in the waters adjacent to the pumping facility compared to their historical vulnerability (NOAA 2009). However, Green Sturgeon are expected to be fully screened out of the facilities by the positive barrier fish screen in place at the pumping facility.

5.12.3.12 Water Transfers

As discussed under the Spring-run Chinook Salmon water transfer section, while there is no pumping from the Delta for the CVP or SWP under WOA, under the proposed action Reclamation proposes to expand the transfer window to November. This extended transfer window could result in approximately 50 TAF of additional pumping per year in most years, with associated entrainment, routing, and through-Delta survival impacts. Please see the OMR management section for a discussion of the effects of pumping.

Juveniles older than 5 months, sub-adults, and adult Green Sturgeon could be exposed to the effects of increased pumping due to water transfers. Although southern DPS Green Sturgeon are present in the Delta in all months of the year, Green Sturgeon are likely to be found in the main channels of the Delta and the larger interconnecting sloughs and waterways, with western Delta waterways having a higher likelihood of presence than eastern Delta waterways (NMFS 2009:338). Therefore, there are no negative impacts of increased pumping at Jones and Banks Pumping Plants due to water transfers under the proposed action.

Juvenile southern DPS Green Sturgeon are present in the Delta in every month of the year (Table 5.12-1). Thus, some portion of the population would be exposed to this action. Increases in Delta inflow during water transfers may have benefits for juvenile Green Sturgeon. However, there is no information on relationships between flow and juvenile Green Sturgeon ecology.

5.12.3.13 Clifton Court Forebay Aquatic Weed Control Program

Few southern DPS juvenile Green Sturgeon Salmon would be expected to be exposed to the Clifton Court Forebay Aquatic Weed Control Program as part of the proposed action. Although southern DPS juvenile Green Sturgeon are present in the Delta in all months of the year, Green Sturgeon are likely to be found in the main channels of the Delta and the larger interconnecting sloughs and waterways, with western Delta waterways having a higher likelihood of presence than eastern Delta waterways (NMFS 2009:338). The application of aquatic herbicide to the waters of Clifton Court Forebay will occur during the summer months of July and August. Thus, the likelihood of exposing juvenile Green Sturgeon to the herbicide is very low. Mechanical harvesting would occur on an as-needed basis and, therefore, juvenile Green Sturgeon could be exposed to this action, if entrained into the Forebay.

5.12.3.14 Suisun Marsh Facilities

Under WOA, the Suisun Marsh facilities would be left open, resulting in a more saline and variable Suisun Marsh.

5.12.3.14.1 Suisun Marsh Salinity Control Gates

Operation of the SMSCG from June through October under the proposed action coincides with a portion of the downstream migration of juvenile southern DPS Green Sturgeon, as well as adult southern DPS Green Sturgeon. Montezuma Slough provides an alternative route to their primary migration corridor through Suisun Bay. During full gate operation, the flashboards are installed and the radial gates open and close twice each tidal day. Green Sturgeon are thought to successfully pass through either the boat lock or through the gates during periods when the gates are open. NMFS (2009) determined that operation of the SWSCG is unlikely to produce conditions that support unusually high numbers of predators, change habitat suitability or availability for rearing or migration of juvenile and adult Green Sturgeon. Green Sturgeon are strong swimmers and therefore the operation of the Suisun Marsh Salinity Control Gate will have no impact on adults or juvenile Green Sturgeon.

5.12.3.14.2 Roaring River Distribution System

The low screen velocity at the intake culverts combined with a small screen mesh size are expected to successfully prevent Green Sturgeon from being entrained into the RRDS under the proposed action. (NOAA 2009).

5.12.3.14.3 Morrow Island Distribution System

The MIDS intakes under the proposed action do not currently have fish screens, and juvenile Green Sturgeon are more prone to entrainment than other species such as white sturgeon (Poletto et al. 2014). However, fisheries monitoring performed in 2004-05 and 2005-06 identified entrainment of 20 fish species, none of which were Green Sturgeon (NOAA 2009). Presence of Green Sturgeon in the area of the MIDS intake is not well studied or documented, but it if Green Sturgeon are present they may potentially avoid entrainment as they do not typically swim along the surface where the diversion is located.

5.12.3.14.4 Goodyear Slough Outfall

Due to its location and design, Green Sturgeon are not likely to encounter this structure or be negatively affected by its operation. Improved water circulation by the operation of the Goodyear Slough Outfall under the proposed action likely benefits juvenile Green Sturgeon in Suisun Marsh by improving water quality and increasing foraging opportunities (NOAA 2009).

5.12.3.15 Maintenance Activities

Under WOA, no maintenance would occur as the CVP and SWP are not operating. Implementation of the species avoidance and take minimization steps described in Appendix C, *ROC Real Time Water Operations Charter* in section *Routine Operations and Maintenance on CVP Activities* would be anticipated to minimize potential negative effects to Green Sturgeon adults from maintenance activities.

5.12.3.16 Operation of a Shasta Dam Raise

Reclamation would operate a raised Shasta Dam consistent with the rest of the proposed action. Therefore, effects described elsewhere in the document would also apply to the operation of a raised Shasta Dam, and there would be no operational changes.

5.12.4 Effects of Conservation Measures

The following are proposed conservation measures that are intended to offset the effects of operations and maintenance. These conservation measures would only occur due to the implementation of the Proposed Action and are beneficial in nature. The following analysis examines the construction related effects of the measures but also the benefits to the population once completed. Conservation measures would not occur under WOA.

5.12.4.1 Lowering Intakes in Wilkins Slough

5.12.4.1.1 Egg to Larvae (March – July)

The installation of fish screens near Wilkins Slough under the proposed action would be beneficial to Green sturgeon. The fish screens would prevent fish entrainment at diversions, thus, increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning. Additionally, the installation of new diversions and screens that would operate at lower flows, would directly benefit fish of all life stages. Specifically, operation of diversions with fish screens near Wilkins Slough would decrease entrainment risk.

Green sturgeon egg and fry, as well as the population, would benefit from this action.

In the southern DPS, adult Green Sturgeon begin their upstream spawning migrations into the San Francisco Bay in March and reach Knights Landing on the Sacramento River during April (Heublein et al. 2006 *as cited in* OCAP BA 2008). Based on the distribution of sturgeon eggs, larvae, and juveniles in the Sacramento River, DFG (2002 *as cited in* OCAP BA 2008) indicated that Green Sturgeon spawn in late spring and early summer in the upper Sacramento River. Peak spawning is believed to occur between April and June (OCAP BA 2008). Construction activities under the proposed action would occur during an in-water work window (June 1 through October 1); therefore, effects on Green Sturgeon eggs and fry are not anticipated.

Additionally, preferred spawning habitats are thought to be deep, cool pools with turbulent water and large cobble (DFG 2002; Moyle 2002; Adams et al. 2002 *as cited in* OCAP BA 2008). Wilkins Slough does not contain suitable spawning habitat; therefore, the potential for egg or fry to be present is low.

5.12.4.1.2 Larvae to Juvenile (April – August)

The installation of fish screens near Wilkins Slough would be beneficial to Green Sturgeon. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning.

Larval Green Sturgeon are present within the Sacramento River between May and August, with a peak from June through July, both at RBDD and GCID (OCAP BA 2008). Larval Green Sturgeon have the potential to be exposed to construction activities as the larvae migrate downstream from the upper Sacramento River; however, implementation of AMM’s identified in Appendix E, *Avoidance and Minimization Measures* would minimize those effects.

Juvenile Green Sturgeon (greater than 10 months old, younger than 3 years old) are located in the Bay-Delta (OCAP BA 2008). Wilkins Slough is not located in the legal Delta. Wilkins Slough is not tidally influenced; therefore, no effects to juvenile Green Sturgeon are expected due to construction activities associated with construction of diversions and screens.

5.12.4.1.3 Juvenile to Subadult/Adult

The installation of fish screens near Wilkins Slough would be beneficial to Green Sturgeon. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults.

Juvenile to subadult/adult Green Sturgeon are located in the Bay-Delta; and therefore are located outside of the action area.

5.12.4.1.4 Adult to Spawning Adult (May – October)

The installation of fish screens near Wilkins Slough would be beneficial to Green Sturgeon. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning.

Adults migrate upstream primarily through the western edge of the Delta into the lower Sacramento River between March and June (Adams et al. 2002). Adult Green Sturgeon do not spawn every year, and are believed to spawn every three to five years. Green sturgeon spawn in late spring and early summer above Hamilton City, possibly up to Keswick Dam (Brown 2007). Peak spawning is believed to occur between April and June. Wilkins Slough is outside of known spawning habitat; therefore, construction activities would not affect spawning adults. Additionally, implemented of an in-water work window and other AMM's identified in Appendix E, *Avoidance and Minimization Measures* would further reduce effects to adults and spawning adults.

5.12.4.1.5 Spawning Adult to Egg and Post-Spawn Adult

The installation of fish screens near Wilkins Slough would be beneficial to Green Sturgeon. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning.

5.12.4.2 *Shasta TCD Improvements*

5.12.4.2.1 Egg to Larvae (March – July)

The implementation of the proposed Shasta TCD improvements under the proposed action would improve Reclamation's ability to manage flows, and water quality (e.g., water temperatures and DO) in the Sacramento River that would be suitable for Green Sturgeon, improving conditions for their eggs and larvae.

5.12.4.2.2 Larvae to Juvenile (April – August)

The implementation of the proposed Shasta TCD improvements under the proposed action would improve Reclamation's ability to manage flows, and water quality (e.g., water temperatures and DO). However, under the proposed action, summer flows are kept cold for Winter-run Chinook salmon, which results in temperatures that are too cold for Green sturgeon juvenile rearing.

5.12.4.2.3 Juvenile to Subadult/Adult

The implementation of the proposed Shasta TCD improvements under the proposed action would improve Reclamation's ability to manage flows, and water quality (e.g., water temperatures and DO).

Juvenile to subadult/adult Green Sturgeon are located in the Bay-Delta; and therefore are located outside of the action area for the improvements.

5.12.4.2.4 Adult to Spawning Adult (May – October)

The Shasta TCD improvements under the proposed action would not be expected to have an effect on adult Green Sturgeon.

5.12.4.2.5 Spawning Adult to Egg and Post-Spawn Adult

The implementation of the proposed Shasta TCD improvements under the proposed action would improve Reclamation's ability to manage flows, and water quality (e.g., water temperatures and DO) in the Sacramento River that would be suitable for Green Sturgeon, improving conditions for spawning and post-spawning adults.

5.12.4.3 Spawning and Rearing Habitat (Sacramento River)

Reclamation proposes to create additional spawning habitat by injecting 40-55 tons of gravel into the Sacramento River by 2030, using the following sites: Salt Creek Gravel Injection Site, Keswick Dam Gravel Injection Site, South Shea Levee, Shea Levee, and Tobiasson Island Side Channel. As green sturgeon are broadcast spawners in deep pools, adding spawning gravel would not benefit Green Sturgeon. Addition of rearing habitat could provide benefits to green sturgeon juveniles.

Construction of spawning and rearing habitat could affect Green Sturgeon larvae in the river. Based on the proposed in-water work windows for the upper Sacramento River (see AMM2 *Construction Best Management Practices and Monitoring* in Appendix E, *Avoidance and Minimization Measures*), Green Sturgeon would be subject to potential adverse effects from proposed spawning (e.g, gravel augmentation) and rearing habitat (e.g., side channel) restoration projects in the upper Sacramento River associated with the proposed action. Construction activities could result in mortality of larvae or juveniles by crushing if heavy equipment enters the stream channel or otherwise disturbs larvae or juveniles during in-water activities. Larvae and juveniles could also be negatively impacted by increases in suspended sediment, turbidity, and contaminant exposure risk, leading to indirect impacts on individuals from reductions in habitat quality (e.g., reduced flow and dissolved oxygen from increases in sediment deposition) or direct impacts from sublethal and lethal exposures to contaminants. Although these potential effects may be unavoidable, exposure of the Green Sturgeon population to construction effects would be low based on the limited extent of proposed restoration projects relative to the overall distribution of spawning adults, and the implementation of other AMMs described in Appendix E, *Avoidance and Minimization Measures*. These measures include AMM1, which requires worker awareness training, AMM2, which specifies monitoring oversight by a qualified biologist, and AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention and containment.

5.12.4.4 Small Screen Program

Under WOA, small diversions would not be screened. Under the proposed action, Reclamation would work with partners to screen small diversions on the Sacramento River and Delta.

5.12.4.4.1 Egg to Larvae (March – July)

No egg to larvae North American Green Sturgeon would be benefited by fish screens under the proposed action since they remain in the stream substrate and would not be exposed to fish screens. Therefore, there would be no effects from fish screen construction for this life stage.

Few if any North American Green Sturgeon in the egg-to-larvae life stage are expected to be exposed to the effects of construction of screens on water diversion intakes based on the seasonal occurrence of this life stage in the Sacramento River. This period follows spawning, which generally occurs between March and July, with peak spawning believed to occur between April and June (Adams et al. 2002). The embryos incubate for a period seven to nine days before hatching as larvae (Van Eenennaam et al. 2001; Poytress et al. 2012).

5.12.4.4.2 Larvae to Juvenile (April – August)

The operation of fish screens on water diversions would have a beneficial effect on larvae to juvenile North American Green Sturgeon in the Sacramento River by reducing the entrainment of rearing and migrating fish into unscreened or poorly screened diversions. There is the potential for adverse impacts to this life stage, including injury or mortality from exposure to screens that are not functioning properly due to lack of maintenance, occlusion, debris accumulation or other factors. However, the risk of this exposure will be minimized since the screens would be designed to meet NMFS and CDFW fish screen criteria and protect this life stage. Therefore, it is concluded that the operation of fish screens under the proposed action would result in beneficial effects for this life stage, due to the reduced risk of entrainment and injury.

North American Green Sturgeon in the larvae to juvenile life stage may be exposed to the effects of construction of screens since they are present in the Sacramento River throughout the year (Table 5.12-1). After hatching, larvae and juveniles migrate downstream toward the Sacramento-San Joaquin Delta and estuary, where they may encounter work area of these projects; however, these work areas are localized and the number of fish is expected to be low. Potential short-term adverse impacts may include temporary effects to water quality as result from in-water work, resulting in increased turbidity and suspended sediments and sediment deposition in the direct vicinity of the work area, and the temporary displacement of individual fish in the work area. If fish are present in the work area, flowing water will be isolated and fish captured and relocated to an appropriate location in an effort to minimize possible mortality. Juveniles would likely experience increased levels of stress and injury during handling, which could be exacerbated by poor water quality (increased temperatures, low dissolved oxygen saturation), and prolonged periods of holding between capture and release. There may be a minor effect to a small number of individuals, although the risk from these potential effects would be would be minimized through the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures*. In addition, the appropriate conservation measures and handling techniques will be employed to ensure that the stress resulting from handling and transport is short-lived and minor.

5.12.4.4.3 Juvenile to Subadult/Adult

Southern DPS Green Sturgeon are expected to be present in the Delta during the main irrigation period for small diversions (late spring-fall). Diversion screening under the proposed action could reduce entrainment of individual Green Sturgeon. However, there is currently no information on the proportion of juvenile Green Sturgeon that are entrained into small unscreened diversions. North American Green Sturgeon in the juvenile to subadult/adult life stage may be exposed to the effects of construction of screens since they are present in the Sacramento River year-round (Table 5.12-1). Effects are the same as described above for juveniles. AMMs would minimize risk.

5.12.4.4.4 Adult to Spawning Adult (May – October)

Few, if any Adult North American Green Sturgeon are expected to be exposed to the effects of operation of screens on diversion intakes under the proposed action. Spawning Green Sturgeon inhabit deep pools in large, turbulent, freshwater river mainstems (Moyle et al. 1992), and thus, they are not likely to encounter the small screen diversions. Few, if any Adult North American Green Sturgeon are expected to be exposed to the effects of construction of screens. The timing of the adult upstream migration for spawning (February–July; Figure 5.12-4) largely avoids the July 15 – October 15 in-water construction work window as described avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures*. AMMs would minimize risks.

5.12.4.4.5 Spawning Adult to Egg and Post-Spawn Adult

Effects are the same as for Adult to Spawning Adult, above.

5.12.4.5 Adult Rescue

The operation of adult rescue is targeted towards adult salmonids and sturgeon, including adult Green Sturgeon, that become trapped in the Yolo and Sutter bypasses, with the goal of increasing the number of adults returning to spawning areas; therefore, this effort could increase the number of Green Sturgeon of all life stages in the Sacramento River.

Exposure of this life stage to adult rescue effects would be restricted only to those adult Green Sturgeon that become stranded in the Yolo and Sutter Bypasses and subsequently rescued and released to the Sacramento River. Adults that migrate in-river or that do not become stranded in the Yolo and Sutter bypasses would be unaffected by adult rescue activities. The number of adult Green Sturgeon that would be expected to be exposed to the effects of adult rescue activities would be based on the abundance of adults that stray into the bypasses and the timing and frequency of stranding events in the bypasses. Individual adult Green Sturgeon exposed to adult rescue activities would be at risk of increased stress, injury, and/or mortality, which could vary in intensity depending on the techniques used to capture individuals. Injury and increased stress associated with capture, handling and transport may affect survival of individuals after release. The risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*).

Juvenile Green Sturgeon larvae could be incidentally captured by gear used to rescue adult salmonids and sturgeon during implementation of adult rescue activities. The number of juvenile Green Sturgeon that would be expected to be exposed to the effects of adult rescue activities would be based on the timing of proposed adult rescue activities, gear type used to rescue adults, and the typical seasonal occurrence of this life stage in the Yolo and Sutter bypasses. Individual juvenile Green Sturgeon exposed to adult rescue activities would be at risk of increased stress, injury, and/or mortality during efforts to capture stranded adults, handling, and transport. Injury and increased stress associated with capture, handling, and transport may reduce disease resistance or swimming ability in juveniles, thereby adversely impacting survival of affected individuals after release. Furthermore, the risk of these effects to this life stage may be dependent on fish size (fish collected at a smaller [younger] size may be more susceptible to injury and stress) and timing of collection (fish collected later in the season when water quality conditions [e.g., water temperature] generally are more stressful for fish may make juveniles more susceptible to injury and stress-related effects). The risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*), and any potential adverse effects on individual juvenile Green Sturgeon would be expected to be offset by benefits associated with increased numbers of adult Green Sturgeon returning to spawning grounds.

5.12.4.6 Juvenile Trap and Haul

Green Sturgeon larvae metamorphose into juveniles at lengths of 62 to 94 mm (Deng et al. 2002). Therefore, larger Green Sturgeon larvae in the vicinity of temporary juvenile collection weirs could be incidentally captured by gear used to trap juvenile salmonids during implementation of juvenile trap and haul activities. The number of Green Sturgeon larvae that would be expected to be exposed to the effects of juvenile trap and haul activities would be based on the timing of proposed juvenile trap and haul activities (December 1 to May 31), trap location and efficiency at collecting Green Sturgeon larvae, and the typical seasonal occurrence of this life stage in the Sacramento River (Table 5.12-1). Because gear type and location would be focused on trapping juvenile salmonids, and not Green Sturgeon, few Green Sturgeon individuals would be expected to be collected in the traps. Individual Green Sturgeon larvae exposed to juvenile trapping activities would be at risk of increased stress, injury, and/or mortality during capture and subsequent handling. The risk of these effects to this life stage could be greater for smaller (younger) larvae which may be more susceptible to injury and stress than larger (older) larvae. In addition, larvae collected later in the season when water quality conditions [e.g., water temperature] may be more stressful for larvae and may make larvae more susceptible to injury and stress-related effects associated with capture and handling than larvae captured and handled earlier in the season when water quality conditions generally are more suitable. However, the risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*). Because Green Sturgeon larvae and juveniles spend an extended period rearing in the river before migrating to the Delta, it is assumed that any larval Green Sturgeon trapped during juvenile trap and haul activities would be returned to the Sacramento River rather than be transported to the Delta and released.

Juvenile Green Sturgeon larvae in the vicinity of temporary juvenile collection weirs could be incidentally captured by gear used to trap juvenile salmonids during implementation of juvenile trap and haul activities. The number of juvenile Green Sturgeon that would be expected to be exposed to the effects of juvenile trap and haul activities would be based on the timing of proposed juvenile trap and haul activities (December 1 to May 31), trap location and efficiency at collecting juvenile Green Sturgeon, and the typical seasonal occurrence of this life stage in the Sacramento River (Table 5.12-1). Because gear type and location would be focused on trapping juvenile salmonids, and not Green Sturgeon, few juvenile Green Sturgeon individuals would be expected to be collected in the traps. Individual Green Sturgeon juveniles exposed to juvenile trapping activities would be at risk of increased stress, injury, and/or mortality during capture and subsequent handling. The risk of these effects to this life stage could be greater for smaller (younger) juveniles which may be more susceptible to injury and stress than larger (older) juveniles. In addition, juveniles collected later in the season when water quality conditions [e.g., water temperature] may be more stressful for juveniles and may make juveniles more susceptible to injury and stress-related effects associated with capture and handling than juveniles captured and handled earlier in the season when water quality conditions generally are more suitable. However, the risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*). Because juvenile Green Sturgeon rear in-river for an extended period before migrating to the Delta, it is assumed that any juvenile Green Sturgeon trapped during juvenile trap and haul activities would be returned to the Sacramento River rather than be transported to the Delta and released.

Because of their large size and benthic behavior, adult Green Sturgeon are not expected to be vulnerable to capture during implementation of juvenile trap and haul activities.

5.12.4.7 American River Spawning and Rearing Habitat

Pursuant to CVPIA 3406(b)(13), Reclamation proposes to implement the Cordova Creek Phase II and Carmichael Creek Restoration projects, and increase woody material in the American River. Reclamation also proposes to conduct gravel augmentation and floodplain work at: Paradise Beach, Howe Ave, Howe Avenue to Watt Avenue, William Pond Outlet, Upper River Bend, Ancil Hoffman, Sacramento Bar - North, El Manto, Sacramento Bar - South, Lower Sunrise, Sunrise, Upper Sunrise, Lower Sailor Bar, Nimbus main channel and side channel, Discovery Park, and Sunrise Stranding Reduction. As green sturgeon are broadcast spawners in deep pools, adding spawning gravel would not benefit Green Sturgeon. Addition of rearing habitat could provide benefits to green sturgeon juveniles.

Construction of spawning and rearing habitat could affect Green Sturgeon larvae in the river. Based on the proposed in-water work windows for the American River (see AMM2 *Construction Best Management Practices and Monitoring* in Appendix E, *Avoidance and Minimization Measures*), Green Sturgeon would be subject to potential adverse effects from proposed spawning (e.g, gravel augmentation) and rearing habitat (e.g., side channel) restoration projects in the American River associated with the proposed action. Construction activities could result in mortality of larvae or juveniles by crushing if heavy equipment enters the stream channel or otherwise disturbs larvae or juveniles during in-water activities. Larvae and juveniles could also be negatively impacted by increases in suspended sediment, turbidity, and contaminant exposure risk, leading to indirect impacts on individuals from reductions in habitat quality (e.g., reduced flow and dissolved oxygen from increases in sediment deposition) or direct impacts from sublethal and lethal exposures to contaminants. Exposure of the Green Sturgeon population to construction effects would be low based on the limited extent of proposed restoration projects relative to the overall distribution of spawning adults, and the implementation of other AMMs described in Appendix E, *Avoidance and Minimization Measures*. These measures include AMM1, which requires worker awareness training, AMM2, which specifies monitoring oversight by a qualified biologist, and AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention and containment.

5.12.4.8 Tracy Fish Collection Facility

Upgrades to the TFCF under the proposed action will aim to minimize the effects of the salvage process on listed fishes, in particular juvenile salmonids and Green Sturgeon. Salvage improvements will improve survival of salvaged fish, and potentially allow reduction of the expansion factors used to extrapolate take estimates from observed salvage.

5.12.4.9 Suisun Marsh Salinity Control Gates Operation

Under the proposed action, Reclamation would operate the Suisun Marsh Salinity Control Gate more frequently to provide freshwater to Suisun Marsh for Delta Smelt. This action could increase food in Suisun Marsh, which could have food web effects that benefit Green Sturgeon juveniles. Operation of the SMSCG from June through October under the proposed action coincides with a portion of the downstream migration of juvenile southern DPS Green Sturgeon, as well as adult southern DPS Green Sturgeon. Montezuma Slough provides an alternative route to their primary migration corridor through Suisun Bay. NMFS (2009) determined that operation of the SWSCG is unlikely to impede migration of juvenile salmonids or produce conditions that support unusually high numbers of predators. Adult Green Sturgeon are strong swimmers and therefore the operation of the Suisun Marsh Salinity Control Gate is unlikely to affect adult or juvenile Green Sturgeon.

5.12.4.10 Clifton Court Predator Management

Predator control efforts under the proposed action can reduce predation on listed fish species, following their entrainment into Clifton Court Forebay. This could also reduce pre-screen loss of juvenile southern DPS Green Sturgeon. It is unknown what proportion of juvenile Green Sturgeon are entrained into CCF but individuals are salvaged infrequently.

5.12.4.11 Sacramento Deepwater Ship Channel Study

5.12.4.11.1 <u>Larvae to Juvenile (April – August)</u>

This study would hydrologically connect the Sacramento River with the SDWSC via the Stone Lock facility from mid-spring to late fall (Wood Rodgers 2018). Juvenile southern DPS Green Sturgeon are present in the Delta in every month of the year with a similar frequency (Table 5.12-1). Juvenile Green Sturgeon passing the Stone Lock facility when there is a hydrologic connection between the waterways could potentially be entrained into the SDWSC. Estimates of Green Sturgeon survival in the SDWSC are not available to compare with rates in the Sacramento River route. However, fish entering the SDWSC would not be exposed to entrainment into the interior Delta through the DCC or Georgiana Slough. This would provide a benefit if survival rates are similar between the SDWSC and the Sacramento main stem.

5.12.4.11.2 Juvenile to Subadult/Adult

As described above, juvenile Green Sturgeon may potentially be entrained into the DWSC. Fish entering the SDWSC would not, however, be exposed to entrainment into the interior Delta through the DCC or Georgiana Slough which would provide a benefit if survival rates are similar between the SDWSC and the Sacramento main stem

5.12.4.12 Suisun and Colusa Basin Food Subsidies

Provision of north Delta or Suisun Marsh food subsidies by routing drain water would occur in summer/fall and therefore could provide food benefits to Green Sturgeon juveniles, who are in the Delta in the fall.

5.12.4.13 Tidal Habitat Restoration

5.12.4.13.1 Juveniles

A large proportion of juvenile southern DPS Green Sturgeon are expected to be exposed to continuing to implement the 8,000 acres of tidal habitat restoration in the Delta under the proposed action. Tidal habitat restoration is expected to benefit juvenile Green Sturgeon in several aspects represented by the Green Sturgeon juvenile conceptual model (Figure 5.12-3) including, increased food availability and quality and refuge habitat from predators. These benefits can manifest in higher growth rates and increased survival through the Delta.

5.12.4.13.2 Adults

The timing of the adult Green Sturgeon upstream migration for spawning (February-–July; Figure 5.12-5) avoids the August–October in-water construction work window for tidal and channel margin restoration under the proposed action. Benefits would be the same as described for juvenile Green Sturgeon.

5.12.4.14 Predator Hot Spot Removal

Predator hot spot removal under the proposed action is primarily focused on providing positive effects to downstream-migrating juvenile salmonids. It is currently unknown if predation on juvenile Green Sturgeon in the Delta is limiting their productivity. Although the action would not be limited to existing identified hot spots (e.g., those identified by Grossman et al. 2013), the existing hotspots that may be representative of where removal efforts may be most concentrated are in the rearing and migratory corridors of juvenile Green Sturgeon.

5.12.4.15 San Joaquin River Scour Hole Predation Reduction

It is currently unknown if predation on juvenile Green Sturgeon in the Delta is limiting their productivity. If so, reduction in predation at this specific hot spot could increase survival.

Juvenile or sub-adult green sturgeon could potentially be exposed to construction effects of this action. Construction effects would be minimized with worker awareness training and other measures in Appendix E, Avoidance and Minimization Measures.

5.12.4.16 Knight's Landing Outfall Gates Fish Barrier

Reclamation and DWR's fish barrier at the Knight's Landing Outfall Gates would prevent possible entrainment of green sturgeon into the Colusa Basin Drain. While entrainment of green sturgeon unto the Colusa Basin Drain is already unlikely, this project would further reduce possible entrainment.

Few green sturgeon are expected to be exposed to in-water construction impacts due to observance of species protective work windows. The timing of the adult Green Sturgeon upstream migration for spawning (February-–July; Figure 5.12-5) avoids the August–October in-water construction work window. Impacts of construction would be minimized in accordance with Appendix E, Avoidance and Minimization Measures.

5.12.4.17 Delta Cross Channel Gate Improvements

Little is known about the migratory behavior of juvenile Green Sturgeon in the Sacramento River basin. It is likely that juvenile Green Sturgeon (larger than the 75 mm) will not enter the Delta prior to their first winter and thus would not be exposed to the open DCC gates. It is likely that these fish will enter the Delta sometime in the winter or spring following their hatching upriver and encounter both types of gate configurations as they enter the Delta. More information is required to accurately assess the migratory movements of juvenile Green Sturgeon in the river system, as well as their movements within the Delta during their rearing phase in estuarine/Delta waters. Greater operational flexibility and increased gate reliability resulting from improvements would reduce the risk of gate failure that could result in higher rates of entrainment.

5.12.4.18 Tracy Fish Facility Operations and Improvements

5.12.4.18.1 Larvae to Juvenile (April – August)

Upgrades to the TFCF will aim to minimize the effects of the salvage process on listed fishes, in particular juvenile salmonids and Green Sturgeon. Salvage improvements will improve survival of salvaged fish and potentially allow reduction of the expansion factors used to extrapolate take estimates from observed salvage.

As previously described, juvenile Green Sturgeon can occur in the Delta year-round (Table 5.12-1; Figure 5.12-3) and, therefore, have the potential to be exposed to the effects of construction of the CO_2 injection device proposed for the Tracy Fish Facility Improvements. If construction affects the efficiency of Green Sturgeon salvage (which is an element of entrainment risk; Figure 5.12-3), there could be a minor effect to a small number of individuals, although risk would be minimized through appropriate AMMs (Appendix E, *Avoidance and Minimization Measures*).

5.12.4.18.2 Adult to Spawning Adult (May – October)

As with other proposed construction in the Delta under the proposed action, the timing of adult Green Sturgeon occurrence in the Delta could overlap with CO_2 injection device construction as part of Tracy Fish Facility Improvements. Application of AMMs and the small scale of the in-water construction would minimize the potential for any effects to individual adult Green Sturgeon. As adult sturgeon are not salvaged, no benefits of this action are expected for this lifestage.

5.12.4.18.3 Spawning Adult to Egg and Post-Spawn Adult

As previously described for tidal habitat restoration, the timing of the adult Green Sturgeon upstream migration for spawning (February–July; Figure 5.12-5) avoids the in-water work window (August to October) for CO2 injection device construction for the Tracy Fish Facility Improvements under the proposed action.

5.12.4.19 Skinner Fish Facility Improvements

Skinner Fish Facility improvements under the proposed action, which involve predator control efforts, can reduce predation on listed fish species, following their entrainment into Clifton Court Forebay. This could also reduce pre-screen loss of juvenile southern DPS Green Sturgeon. It is unknown what proportion of juvenile Green Sturgeon are entrained into CCF but individuals are salvaged infrequently. Thus, the proposed action is not likely to negatively impact juvenile Green Sturgeon.

5.12.4.20 Delta Fish Species Conservation Hatchery

None of the Green Sturgeon life stages would benefit from the Delta Fish Species Conservation Hatchery under the proposed action. As with the other proposed construction activities in the Delta, the year-round occurrence of juvenile Green Sturgeon in the Delta (Table 5.12-1; Figure 5.12-3) means that this life stage, as well as the timing of the adult Green Sturgeon occurring in the Delta during May to October, could be exposed to Delta Fish Species Conservation Hatchery construction under the proposed action. The in-water work constructing the hatchery intake and outfall could result in a small number of individuals experiencing effects such as temporary loss of habitat leading to predation, degraded water quality, noise-related delay in migration, and direct effects from contact with construction equipment or isolation/stranding within enclosed areas. The risks from these potential effects would be minimized with through the application of AMMs (Appendix E, *Avoidance and Minimization Measures*).

5.12.4.21 Effects of Monitoring

Population estimates for Green Sturgeon also remain outstanding in the Central Valley. Similar to steelhead, the existing monitoring programs very rarely catch green sturgeon because most monitoring programs are not designed to capture them. Similar to steelhead, it is unlikely the monitoring programs have an effect to the population.

Table 5.12-4. Monitoring Programs – Green Sturgeon

Survey	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Chipps Island Trawl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sacramento Trawl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DJFMP Beach Seine Survey	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CDFW Mossdale Trawl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EDSM KDTR Trawls	na	na	na	na	na	na	na	na	na	na	na	na	na	na	0	0	na
CDFW Bay Study Trawls	0	0	3	1	2	0	1	2	2	0	0	3	4	1	0	1	na
CDFW SKT Study	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Green Sturgeon	0	0	3	1	2	0	1	2	2	0	0	3	4	1	0	1	na
RBDD Rotary Trap or Juvenile Production Estimate (JPE)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

5.13 North American Green Sturgeon, Southern DPS Critical Habitat

Critical habitat for the southern DPS of North American Green Sturgeon, was designated in 2008 and includes the Sacramento River, lower Feather River, and lower Yuba River in California; the Sacramento-San Joaquin Delta and Suisun, San Pablo, and San Francisco bays. Critical habitat includes stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line or bankfull elevation (defined as the level at which water begins to leave the channel and move onto the floodplain, and generally corresponds with a discharge that occurs every 1 to 2 years on an annual flood series). For bays and estuarine areas, critical habitat includes the lateral extent of the mean higher high water (MHHW) line. (73 FR 52084).

The designated critical habitat includes PBFs that are essential for the conservation of Green Sturgeon, southern DPS. The critical habitat designation includes separate list of PBFs for riverine and estuarine habitat.

The specific PBFs essential for the conservation of the Southern DPS freshwater riverine systems include:

1. *Food resources.* Abundant prey items for larval, juvenile, subadult, and adult life stages. Food resources are important for juvenile foraging, growth, and development during their downstream migration to the Delta and bays. In addition, subadult and adult Green Sturgeon may forage during their downstream post-spawning migration, while holding within deep pools, or on non-spawning migrations within freshwater rivers. Subadult and adult Green Sturgeon in freshwater rivers most likely feed on benthic prey species similar to those fed on in bays and estuaries, including shrimp, clams, and benthic fishes.
2. *Substrate type or size (i.e., structural features of substrates).* Substrates suitable for egg deposition and development (e.g., bedrock sills and shelves, cobble and gravel, or hard clean sand, with interstices or irregular surfaces to “collect” eggs and provide protection from predators, and free of excessive silt and debris that could smother eggs during incubation), larval development (e.g., substrates with interstices or voids providing refuge from predators and from high flow conditions), and subadults and adults (e.g., substrates for holding and spawning).
3. *Water flow.* A flow regime (i.e., the magnitude, frequency, duration, seasonality, and rate-of-change of fresh water discharge over time) necessary for normal behavior, growth, and survival of all life stages. Such a flow regime should include stable and sufficient water flow rates in spawning and rearing reaches to maintain water temperatures within the optimal range for egg, larval, and juvenile survival and development. Sufficient flow is needed to reduce the incidence of fungal infestations of the eggs. In addition, sufficient flow is needed to flush silt and debris from cobble, gravel, and other substrate surfaces to prevent crevices from being filled in (and potentially suffocating the eggs and to maintain surfaces for feeding. Successful migration of adult Green Sturgeon to and from spawning grounds is also dependent on sufficient water flow. Spawning success is associated with water flow and water temperature. Post-spawning downstream migrations are triggered by increased flows.
4. *Water quality.* Water quality, including temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages. Suitable water temperatures would include stable water temperatures within spawning reaches. Suitable salinity levels range from fresh water for larvae and early juveniles to brackish water for juveniles prior to their transition to salt water. Adequate levels of dissolved oxygen are needed to support oxygen consumption by fish in their early life stages. Suitable water quality would also include

water containing acceptably low levels of contaminants that may disrupt normal development of embryonic, larval, and juvenile stages of Green Sturgeon. Water with acceptably low levels of such contaminants would protect Green Sturgeon from adverse impacts on growth, reproductive development, and reproductive success.

5. *Migratory corridor.* A migratory pathway necessary for the safe and timely passage of southern DPS fish within riverine habitats and between riverine and estuarine habitats (e.g., an unobstructed river or dammed river that still allows for safe and timely passage). Safe and timely passage requires that no human-induced impediments, either physical, chemical or biological, alter the migratory behavior of the fish such that its survival or the overall viability of the species is compromised (e.g., an impediment that compromises the ability of fish to reach their spawning habitat in time to encounter con-specifics and reproduce). Unimpeded migratory corridors are necessary for adult Green Sturgeon to migrate to and from spawning habitats, and for larval and juvenile Green Sturgeon to migrate downstream from spawning/rearing habitats within freshwater rivers to rearing habitats within the estuaries.
6. *Water depth.* Deep (≥ 5 m) holding pools for both upstream and downstream holding of adult or subadult fish, with adequate water quality and flow to maintain the physiological needs of the holding adult or subadult fish.
7. *Sediment quality.* Sediment quality (i.e., chemical characteristics) necessary for normal behavior, growth, and viability of all life stages. This includes sediments free of elevated levels of contaminants (e.g., selenium, polyaromatic hydrocarbons (PAHs), and organochlorine pesticides) that may adversely impact Green Sturgeon.

The specific PBFs essential for the conservation of the southern DPS Green Sturgeon in estuarine areas include:

1. *Food resources.* Abundant prey items within estuarine habitats and substrates for juvenile, subadult, and adult life stages. Prey species for these life stages within bays and estuaries primarily consist of benthic invertebrates and fishes, including crangonid shrimp, burrowing thalassinidean shrimp (particularly the burrowing ghost shrimp), amphipods, isopods, clams, annelid worms, crabs, sand lances, and anchovies. These prey species are critical for the rearing, foraging, growth, and development of juvenile, subadult, and adult Green Sturgeon within the bays and estuaries.
2. *Water flow.* Within bays and estuaries adjacent to the Sacramento River (*i.e.*, the Sacramento-San Joaquin Delta and the Suisun, San Pablo, and San Francisco bays), sufficient flow into the bay and estuary to allow adults to successfully orient to the incoming flow and migrate upstream to spawning grounds. Sufficient flows are needed to attract adult Green Sturgeon to the Sacramento River to initiate the upstream spawning migration.
3. *Water quality.* Water quality, including temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages. Suitable water quality includes water with acceptably low levels of contaminants (*e.g.*, pesticides, organochlorines, elevated levels of heavy metals) that may disrupt the normal development of juvenile life stages, or the growth, survival, or reproduction of subadult or adult stages.
4. *Migratory corridor.* A migratory pathway necessary for the safe and timely passage of southern DPS fish within estuarine habitats and between estuarine and riverine or marine habitats. Within the bays and estuaries adjacent to the Sacramento River, unimpeded passage is needed for juvenile Green Sturgeon to migrate from the river to the bays and estuaries and eventually out into the ocean. Passage within the bays and the Delta is also critical for adults and subadults for

feeding and summer holding, as well as to access the Sacramento River for their upstream spawning migrations and to make their outmigration back into the ocean.

5. *Water depth.* A diversity of depths necessary for shelter, foraging, and migration of juvenile, subadult, and adult life stages. Subadult and adult Green Sturgeon occupy a diversity of depths within bays and estuaries for feeding and migration. Juveniles occur primarily in shallow waters for rearing and foraging. Thus, a diversity of depths is important to support different life stages and habitat uses for Green Sturgeon within estuarine areas.
6. *Sediment quality.* Sediment quality (*i.e.*, chemical characteristics) necessary for normal behavior, growth, and viability of all life stages. This includes sediments free of elevated levels of contaminants (*e.g.*, selenium, PAHs, and organochlorine pesticides) that can cause adverse impacts on all life stages of Green Sturgeon.

5.13.1 Freshwater Riverine Systems

5.13.1.1 Food Resources

Availability of food resources for Green Sturgeon in the Sacramento River would potentially be affected by changes in flow and water temperature, although the nature of the effects is difficult to predict. Higher flow generally produces greater habitat complexity, potentially resulting in greater diversity and density of prey, although higher flow can also reduce foodweb productivity. Increased water temperature potentially stimulates foodweb productivity, leading to higher densities of prey species, but large temperature increases may physiologically stress prey species, ultimately leading to reduction in food resources. Larval and juvenile Green Sturgeon are more vulnerable to reductions in food resources than adults. Sturgeon larvae and juveniles typically feed on insect larvae, amphipods, mysids and other benthic invertebrates (Muir et al. 2000). Differences in flow and water temperatures between the proposed action and COS would be too small to cause any important differences in food resources for Green Sturgeon. In contrast, the differences in flow and water temperatures between the proposed action and the WOA would be sufficiently large to produce substantial changes in food resources. However, the nature of these changes and how they would impact the different life stages of Green Sturgeon feeding in the Sacramento River is highly uncertain. Probably the most significant environmental change resulting from the WOA scenario, would be the much higher late spring, summer and early fall water temperatures, as described throughout Section 5.15, *North American Green Sturgeon, southern DPS.* The period of high water temperatures overlaps with the period of maximum occurrence of Green Sturgeon larvae and juveniles in the river (Figure 5.12-1). The predicted increases in temperature are potentially large enough to result in major changes in the prey species that would dominate the benthic invertebrates on which the Green Sturgeon feed. However, while these changes would potentially reduce growth and survival of the Green Sturgeon larvae and juveniles, this conclusion is uncertain. Overall, the impacts of the proposed action relative to COS and the WOA scenario on food resources in Green Sturgeon critical habitat are expected to have no impact, but this conclusion is uncertain.

5.13.1.2 Substrate Type or Size

The proposed action includes projects to improve spawning habitat for Chinook Salmon in the upper Sacramento River, and these projects would likely benefit substrate type or size in Green Sturgeon spawning habitat. River substrate type and size can also be affected by changes in flow. Very high flows scour bottom sediments, potentially creating the types of deep holes that Green Sturgeon favor for spawning, although such flows could also remove suitable spawning gravels from spawning habitat. High, but less extreme flows flush sediments from gravels, which may improve Green Sturgeon spawning and egg incubation habitat. Overall, high flows are expected to improve river substrates for Green

Sturgeon. Differences in flow between the proposed action and COS would generally be minor, as described throughout Section 5.15, *North American Green Sturgeon, Southern DPS,* and would not be large enough to effect meaningful changes in substrate type or size. The differences in flow between the proposed action and the WOA would often be large, but only the wet-year winter and spring flows would be high enough to scour sediments. WOA flows during such years are generally higher than proposed action flows and would therefore be more likely to result in improved Green Sturgeon spawning habitats. However, proposed action flow during the late spring and summer months, when Green Sturgeon spawn, is much higher than WOA flow, and likely high enough to flush sediments from the gravel substrates, thereby improving conditions for incubating embryos. These results indicate that, relative to the WOA, the proposed action would adversely impact Green Sturgeon substrate type and size in Green Sturgeon spawning habitat during winter and early spring, but benefit the suitability of the substrate for incubating embryos during summer. However, this conclusion is uncertain.

5.13.1.3 Water Flow

As described throughout Section 5.15, *North American Green Sturgeon, Southern DPS*, differences in Sacramento River flow between the proposed action and COS would generally be minor, but differences in flow between the proposed action and the WOA would be large enough to potentially affect all life stages of Green Sturgeon. Proposed action flow is generally higher than WOA flow during late spring, summer and early fall, when Green Sturgeon spawn, the eggs incubate, and the larvae and juveniles rear, disperse and migrate downstream. Post-spawn adults also emigrate during this period. Proposed action flow is generally similar or lower than WOA flow during late fall, winter, and early spring. Juveniles and adults continue emigrating through December, and by February adults enter the river and begin migrating upstream to holding and spawning habitat. The higher proposed action flows during late spring, summer and early fall would potentially benefit spawning, eggs, larvae, and juveniles in a number of ways, including increased water depth for holding and spawning habitat, reduced fine sediment deposition on incubating eggs, greater dispersion of larvae and juveniles, reduced crowding and competition, improved migration habitat and migration cues, reduced entrainment risk, and lower contaminant concentrations in the river. There is evidence that abundance of Green Sturgeon larvae and juveniles is positively related to annual outflow (Heublein et al. 2017a [*SAIL model*]). WOA flow in the middle Sacramento River is predicted to be low enough in many years during summer to adversely impact emigrating juveniles and adults. Reduced flows under the proposed action during winter and early spring would potentially have adverse impacts on immigrating adults, but the flows would consistently be high to prevent passage problems. Overall, the proposed action is not expected to adversely impact flow conditions in Green Sturgeon critical habitat.

5.13.1.4 Water Quality

In the critical habitat designation final rule for Green Sturgeon (October 9, 2009, 74 FR 52300), the Water Quality PBF includes “temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages”. These factors could potentially be affected by changes in flows and increases in water temperatures in the Sacramento River. As described throughout Section 5.15, *North American Green Sturgeon, Southern DPS,* differences in Sacramento River flow and water temperature would generally be minor between the proposed action and COS, but would be large enough between the proposed action and WOA to potentially impact all life stages of Green Sturgeon. Differences in flow are described above in Section 5.16.2.1.3, *Water Flow* and differences in water temperature are described in Section 5.16.2.1.3, *Water Temperature*. Higher spring, summer and fall flows under the proposed action would dilute contaminants present in the Green Sturgeon critical habitat, reducing their adverse impacts. Water temperatures under the proposed action would be much lower than WOA temperatures during spring, summer and early fall, when the presence of

Green Sturgeon eggs, larvae, and young juveniles peaks in the river. High water temperatures result in reduced DO. The young life stages of Green Sturgeon are especially vulnerable to high water temperatures and low DO. During June and July, predicted water temperatures in many years reach levels that are likely lethal to Green Sturgeon embryos. Overall, the proposed action is expected to have no impact on water quality of the Green Sturgeon critical habitat relative to the COS, and to substantially benefit water quality relative to the WOA.

5.13.1.5 Migratory Corridor

The middle Sacramento River is the main migratory corridor for Green Sturgeon critical habitat upstream of the Delta. Principal potential impacts of the proposed action on this corridor are instream flow and water temperature. Flow may affect upstream and downstream passage of migratory adults, dispersal and emigration rates of juveniles, and concentration of contaminants. Water temperature potentially affects growth and survival of adult and juvenile sturgeon in the migratory corridor. As described above in Section 5.16.2.1.3, *Water Flow*, flow in the middle Sacramento River under the proposed action is generally similar to COS flow, but is reduced relative to WOA flow during many years in winter and spring, when adult Green Sturgeon migrate upstream to holding and spawning areas in the middle and upper river. The flow under both scenarios are high enough to eliminate passage problems. Flow in the middle river is much higher under the proposed action than under WOA conditions during summer through fall, when larvae are dispersed downstream in the migratory corridor and juveniles and post-spawned adults migrate downstream. Adequate flow is essential to quickly move larvae and juveniles to critical rearing habitats before they starve (Muir et al. 2000). Flow in the middle river under the WOA scenario is often low enough to interfere with downstream passage of emigrating adults. The low flow may also concentrate contaminants in the river, which are likely to be highest in the late spring through early fall because this is the primary season for treating croplands with fertilizer and pesticides.

Predicted water temperatures in the middle Sacramento River migratory corridor of Green Sturgeon differ little between the proposed action and the COS scenarios, but proposed action temperatures are much lower than WOA temperatures during the late spring through early fall, and are much higher during late fall through early spring. The potential impact of water temperature is much greater during late spring to early fall than in the late fall to early spring because temperatures in the latter period under both scenarios are below levels that are stressful to Green Sturgeon. Temperatures in late spring to early fall regularly exceed critical thresholds for Green Sturgeon under the WOA scenario but rarely do so under the proposed action.

Overall, the proposed action would have no negative impact relative to COS on migratory corridor habitat in Green Sturgeon's Sacramento River critical habitat, and would have largely beneficial effects relative to the WOA scenario.

5.13.1.6 Depth

The proposed action would potentially have two different types of effects on depths for Green Sturgeon critical habitat in the Sacramento River: 1) the proposed action would potentially reduce the number and depth of pools suitable for Green Sturgeon holding and spawning by reducing unregulated high discharge scouring flows and 2) the proposed action could increase the depth of water in these pools by increasing the level of more moderate flows in the river. The proposed action is not expected to have either of these effects relative to the COS scenario. However, relative to the WOA scenario, the proposed action would potentially reduce the number and/or depth of pools suitable for Green Sturgeon holding and spawning and would increase the depth of water in the pools. The main difference between the WOA scenario and the proposed action, is that Sacramento River flow is not regulated under the WOA scenario and the river would therefore experience a more natural flow regime, including a higher frequency of pulse flows strong enough to scour deep holes in portions of the river bottom. In contrast, the river is regulated under the proposed action scenario, including high flow releases from Shasta Reservoir during summer and early fall when most Green Sturgeon hold and spawn, which results in deeper water levels in the spawning pools. The higher flows would potentially improve water quality in the pools as well, by more effectively flushing out fine sediments, metabolic wastes and other contaminants. Therefore, the proposed action would potentially adversely impact the availability of deep pools for Green Sturgeon holding and spawning, but would benefit the quality of the pool habitats available.

5.13.1.7 Sediment Quality

High levels of fine sediments in the Sacramento River upstream of the Delta can adversely impact Green Sturgeon by smothering spawning substrates, which may increase mortality of embryos (Kock et al. 2006. Effects of Sediment Cover on Survival and Development of White Sturgeon Embryos. *Nor. Am. J. Fish. Manag*. 26: 134-141). However, more moderate levels provide essential habitat for small burrowing invertebrate organisms, such as chironomid larvae and other benthic invertebrates that may be important prey of Green Sturgeon larvae and young juveniles (Muir et al. 2000). Sacramento River flow is predicted to be much higher under the proposed action than the WOA scenario during the late spring and summer when most Green Sturgeon spawning occurs, which would likely improve spawning habitat. The availability of habitat with fine sediment deposits for burrowing benthic invertebrate prey is presumably related to the overall sediment supply, which depends mostly on stormwater runoff and imports from unregulated tributaries during major flows. The proposed action would have little effect on imports from tributaries, but it potentially would reduce inundation flows and subsequent stormwater runoff because unregulated pulse flows from upstream of Shasta Dam would potentially be larger and more frequent under the WOA scenario. Also, it is possible that imports of fine sediments from upstream of Shasta Dam would be higher under the WOA scenario because more of the fine sediment that currently deposits in Shasta Lake might be carried through the reduced reservoir and the fully open Shasta Dam. Overall, the proposed action is expected to improve conditions regarding fine sediment in Green Sturgeon spawning habitat, but may adversely impact fine sediment habitat for prey organisms of larval and juvenile Green Sturgeon. Both of these conclusions are uncertain.

5.13.2 Estuarine Habitats

Young-of-the-year Green Sturgeon juveniles emigrate from the Sacramento River into the Bay/Delta several months after hatching. They disperse to all parts of the Bay/Delta and rear there for a year or more before entering the ocean as subadults (Heublein et al. 2017b). Adults and subadults visit the Bay/Delta sporadically, and are most commonly found in summer and fall. Spawning Green Sturgeon enter the Bay/Delta from the ocean from late winter to spring and ascend the Sacramento River with minimal staging and feeding in the estuary (Heublein et al. 2009).

The principal potential effects of the proposed action on southern DPS Green Sturgeon in the Bay/Delta are changes related to flow, flow routing, and entrainment.

5.13.2.1 Food Resources

Juvenile southern DPS Green Sturgeon are present in the Delta all year and sub-adults are most abundant from June through November. When juvenile Green Sturgeon enter the estuary from the Sacramento River, their diet shifts to larger benthic food items, though they remain generalists and opportunists. Mysid shrimp and amphipods (Corophium) were observed to be the primary food items in juvenile (Israel et al. 2008). Adult and subadult Green Sturgeon in the Columbia River estuary, Willapa Bay, and Grays

Harbor feed on crangonid shrimp, burrowing thalassinidean shrimp, amphipods, clams, juvenile Dungeness crab (*Cancer magister*), anchovies, sand lances (*Ammodytes hexapterus*), lingcod (*Ophiodon elongatus*), and other fishes. It expected that the diet of adult and subadult Green Sturgeon in the Bay/Delta would be similar.

Changes in Delta inflow resulting from the proposed action potentially impact prey of Green Sturgeon in the Bay/Delta Green Sturgeon critical habitat. Sacramento River flow at Freeport and Rio Vista, which are important rearing and migratory habitat areas for Green Sturgeon juveniles, subadults and adults, would be higher under the proposed action than under the WOA during many months, but particularly during July and August of all but the wettest years (e.g., Figures 5.13-1 and 5.13-2). The increased flow would result in greater depths and would likely lead to greater diversity in habitats, both factors that would potentially increase the diversity and productivity of Green Sturgeon food resources.

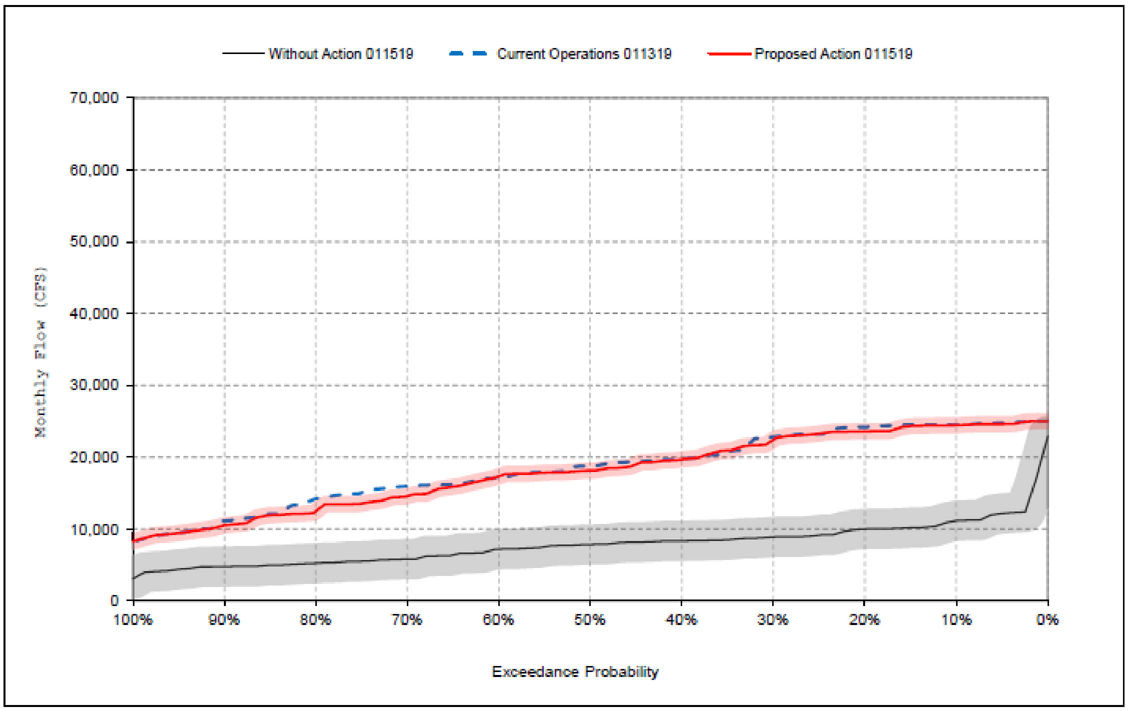


Figure 5.13-1. CalSim II Sacramento River Flows at Freeport, July

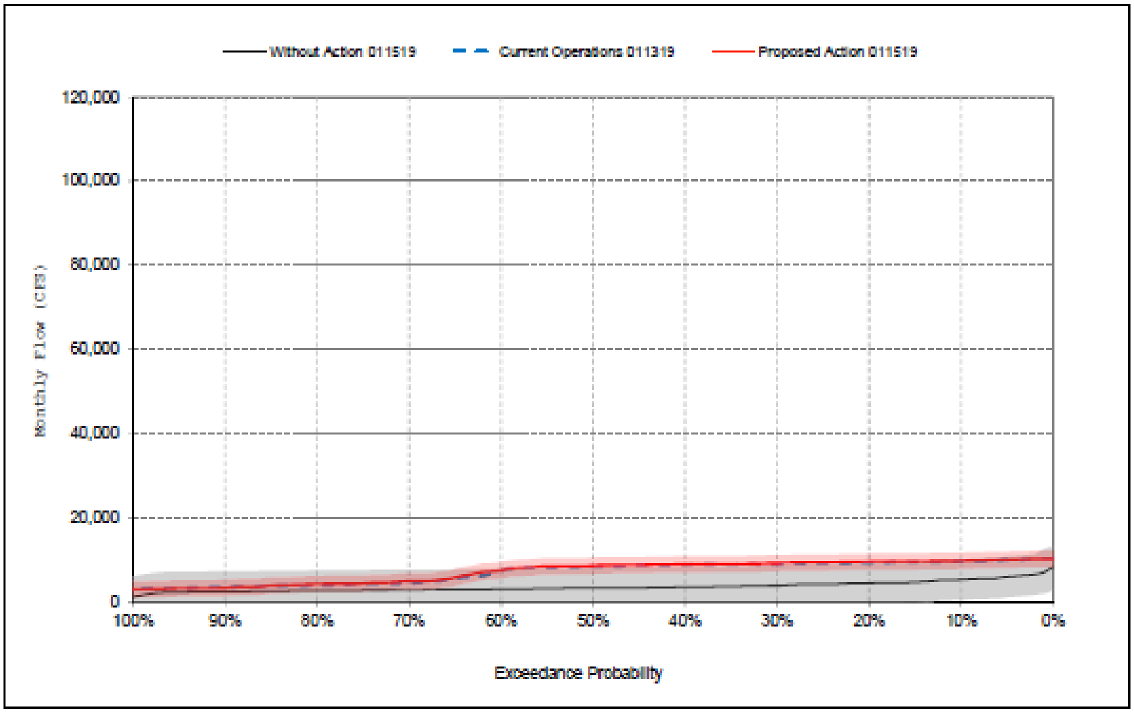


Figure 5.13-2. CalSim II Sacramento River Flows at Rio Vista, August

However, operation of the proposed action's proposed SMSCG operations during June to October of wet, above normal and below normal water years (reducing salinity to improve habitat conditions in the relatively food-rich Suisun Marsh, the proposed action's proposed tidal restoration, and various programmatic actions would potentially enhance foodweb productivity in the Bay/Delta and result in greater food resources for Green Sturgeon.

5.13.2.2 Water Flow

Little is known about the relationship between survival of juvenile Green Sturgeon and Delta hydrology. Green sturgeon juveniles are thought to reside in the Delta for 1-3 years, so they encounter a variety of hydrological conditions. The juveniles are present in the Delta all year and sub-adults are most abundant from June-November (Table 5.12-1).

The effects of the proposed action on flow in Green Sturgeon estuarine critical habitat were evaluated by analyzing the effects of flow changes on Delta hydrodynamics, with potential effects on how fish are routed through Delta channels. The results indicate that routing into the interior Delta, where Green Sturgeon would be at higher risk from entrainment and reduced water quality (NMFS 2009), would be higher under the proposed action and the COS relative to the WOA, but the difference was likely not high enough to substantially mpact Green Sturgeon. The proposed action on through Delta survival of juvenile Green Sturgeon has no impact, so the proposed action is not expected to adversely impact water flow for Green Sturgeon in the Delta.

Sacramento River flow at Freeport and Rio Vista, which are important rearing and migratory habitat areas for Green Sturgeon juveniles, subadults and adults, would be higher under the proposed action than under the WOA during many months, but particularly during July and August of all but the wettest years (e.g., Figures 5.13-1 and 5.13-2). As noted above, the higher flows would potentially improve Green Sturgeon food resources. They would also potentially improve water quality and depth conditions in the Green Sturgeon critical habitat (see below).

Potential negative impacts on river flow could occur as a result of tidal restoration effects on channel hydrodynamics, although modeling and design of restoration would be done so as to minimize such impacts.

5.13.2.3 Water Quality

In the critical habitat designation final rule for Green Sturgeon (October 9, 2009, 74 FR 52300), the Water Quality PBF includes “temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages”. The proposed action is expected to have no impact on water temperature and DO in the estuarine critical habitat for Green Sturgeon. As described throughout the analysis of the effects to the species, these water quality parameters are major discriminators for comparing potential impacts of the proposed action and the WOA on Green Sturgeon in the Sacramento River upstream of the Delta. In the Bay/Delta, however, flow and water temperature of reservoir releases are generally considered to have little effect on water temperatures (Wagner et al. 2011, USFWS 2017b). This assessment, however, has been based on experience with smaller flow and water temperature differences than those expected between the proposed action and WOA (USFWS 2017b), so the conclusion that the proposed action would have no impacts on water temperature in the Bay/Delta is uncertain. Other than downstream of major effluents, DO in the Bay/Delta is primarily determined by water temperature. Juvenile Green Sturgeon have developed a tolerance for a wide range of salinities by the time they move into the Bay/Delta, so this water quality parameter is not expected to impact estuarine critical habitat for Green Sturgeon (Heublein et al. 2017b).

The proposed action has the potential to positively and negatively affect other water quality factors in the Green Sturgeon estuarine critical habitat relative to the WOA conditions. Higher summer flows under the proposed action at Freeport and Rio Vista (e.g., Figures 5.13-1 and 5.13-2) would dilute contaminants present in the mainstem Sacramento River, reducing their adverse impacts. Impacts of flows on contaminants in other parts of the Delta are uncertain. The increase in high unregulated Sacramento River flows, including pulse flows, expected during winter and spring under the WOA, would potentially increase loading of contaminants related to runoff from inundated croplands. However, the increase in high flows under the WOA would also flush contaminated sediments downstream from the Bay/Delta, potentially increasing water quality and sediment quality in the critical habitat. Thus, the proposed action has both positive and negative potential impacts with respect to water quality in Green Sturgeon estuarine critical habitat and the overall impact is uncertain.

Relative to the WOA, reduced winter-spring inflow to the Delta under the proposed action (e.g., Figures 29-9 through 29-14 in the CalSim II Flows summary in Appendix D, *Modeling*) has the potential to reduce sediment supply and therefore turbidity during winter to spring, as well as during summer and fall when resuspension of sediment supplied in the winter and spring produces turbidity. Impacts of turbidity on Green Sturgeon, if any, are unknown.

The year-round occurrence of juvenile Green Sturgeon in the Delta means that this life stage could be exposed to Delta Fishes Conservation Hatchery operations. Any water discharged from the facilities into the Sacramento River would be treated and subject to regular monitoring of water quality within the FTC for fish health, so there are not likely to be impacts on water quality associated with discharges from the FTC.

The Delta Fishes Conservation Hatchery including marinas would house a number of boats. Boat motors introduce metals, hydrocarbons, and other pollutants into the Sacramento River. These compounds can have a negative effect on the water quality for Green Sturgeon in the system, including affecting pH and DO. These increased pollutants have been associated with the impaired development and survival of juveniles (Soule et al. 1991; Von Westerhagen et al. 1987). In some instances, motorboat traffic can increase turbidity and nutrients in the water column, decreasing water quality. Increased boat traffic may negatively impact the designated Green Sturgeon critical habitat by disturbing sediment and decreasing water quality and food resources, and possibly limiting space and access for rearing or resident fish. Safe passage through critical habitat might also be compromised for migrating Green Sturgeon. The potential sites currently have very high boating and shipping traffic and the relatively small output from the ERS marina would not dramatically increase the amount of pollutants, turbidity, and nutrients to which Green Sturgeon would be exposed. Furthermore, the proposed action would not change the overall number of boats in the region, only their harbor location. Therefore there would be no negative impacts on juvenile Green Sturgeon critical habitat.

During summer/fall, there is the potential for impacts to flow, flow velocity, and water clarity under the proposed action to negatively impact water quality in the critical habitat relative to the WOA by increasing the potential for harmful algal blooms, although this is uncertain. Reclamation and DWR's proposal includes programmatic elements that could limit potential negative impacts from harmful algal blooms.

5.13.2.4 Migratory Corridor

The effects of combined exports present an entrainment issue that could delay migration or decrease survival or population viability through entrainment into the South Delta facilities.

As discussed in Section the analysis of entrainment, impacts to the migratory corridor function of juvenile and sub-adult Green Sturgeon critical habitat from south Delta exports are less clear than for juvenile salmonids because Green Sturgeon spend one to three years rearing in the Delta environment before transitioning to their marine subadult life stage. During this Delta rearing phase, Green Sturgeon are free to migrate throughout the Delta. Estimating entrainment risk from raw salvage data is hamstrung by a lack of information on the number of juvenile Green Sturgeon potentially exposed to salvage. However, it can be inferred that higher rates of exports will result in higher rates of entrainment.

Juvenile southern DPS Green Sturgeon are present in the Delta all year and sub-adults are most abundant from June through November. Average total exports for months when Green Sturgeon juveniles are present in the Delta indicate zero entrainment risk for the WOA scenario. In the June through September period, the proposed action has an average total export rate slightly higher than COS (Figure H-27 – Appendix H, *Bay-Delta Aquatics Effects Figures*) and will therefore have a similar entrainment risk. Total exports proposed for the proposed action in September through November (Figure H-28 – Appendix H, *Bay-Delta Aquatics Effects Figures*) will only slightly increase entrainment risk relative to COS. Therefore, the proposed action would potentially adversely impact entrainment of Green Sturgeon in the Delta relative to the WOA, but would have a minor impact relative to the COS.

5.13.2.5 Depth

Juvenile southern DPS Green Sturgeon are present in the Delta all year and sub-adults are most abundant from June through November. One of the PBFs for Green Sturgeon estuarine critical habitat is a diversity of depths for shelter, foraging, and migration of juvenile, subadult, and adult life stages. Sacramento River flow at Freeport and Rio Vista, which are important rearing and migratory habitat areas for Green

Sturgeon juveniles, subadults and adults, would be much higher under the proposed action than under the WOA during most months, but particularly during July and August of all but the wettest years (e.g., Figures 29-16 and 32-17 in the CalSim II flow section of Appendix D). These differences would likely afford the three Green Sturgeon life stages a greater diversity of depth. Therefore, the proposed action is expected to benefit Green Sturgeon critical habitat in the Bay/Delta relative to the WOA with respect to depth.

5.13.2.6 Sediment Quality

Fine sediments provide essential habitat for burrowing invertebrate organisms such as shrimp, clams, amphipods, worms, and insect larvae that are important prey of Green Sturgeon juveniles, subadults and adults. The availability of habitat with fine sediment deposits is presumably related to the overall sediment supply, which depends mostly on stormwater runoff and imports from unregulated tributaries during major flows. The proposed action would have little impact on imports from tributaries, but it potentially would reduce inundation flows and subsequent stormwater runoff because unregulated pulse flows from upstream of Shasta Dam would potentially be larger and more frequent under the WOA scenario. Also, it is possible that imports of fine sediments from upstream of Shasta Dam would be higher under the WOA scenario because more of the fine sediment that currently deposits in Shasta Lake might be carried through the reduced reservoir and the fully open Shasta Dam. Therefore, the proposed action may adversely impact fine sediment habitat for prey organisms of Green Sturgeon in their estuarine critical habitat. These conclusions are uncertain. Implementation of tidal and channel margin restoration would provide additional sand substrate for Delta Smelt spawning habitat (USFWS 2017, p.111), which would contribute to offsetting the potential negative impact of the proposed action on sediments for Green Sturgeon prey habitat.

5.14 Killer Whale, Southern Resident DPS

Ford et al. (2016) confirmed the importance of Chinook Salmon to Southern Residents in the summer months using DNA sequencing from whale feces. The researchers found that more than 90 percent of the whale's inferred diet consisted of salmonids; almost 80 percent was Chinook Salmon. Bellinger et al. (2015) estimated that Central Valley Chinook SSalmon made up about 22 percent of the Chinook Salmon sampled off the Oregon coast and about 50 percent of those sampled off the California coast (south to Big Sur). While this apex predator certainly eats a variety of other species as well, Central Valley Chinook Salmon (all runs) can be estimated to make up approximately 40% of the killer whale diet when killer whales are off the California coast, and 18% of the killer whale diet when the killer whales are off the Oregon coast.

As discussed by NMFS (2017, p.831), individual-level effects to killer whale from changes in Chinook Salmon prey could include changes in areas searched for prey and consequent changes in energy expended for such searches, resulting in changes in energy intake and the risk of nutritional stress. Changes in energy consumption and nutritional stress could lead to changes in body size, condition, and growth; and changes in reproductive and survival rates for adults (NMFS 2017, p.831).

The southern distinct population segment of killer whales is thought to move with the seasonal abundance of salmonids returning to natal rivers to spawn from early summer through fall. There are correlations between the occurrence of southern residents and commercial and sport Salmon fishery catches in US waters off southeastern Vancouver Island and in Puget Sound (Heimlich-Boran, 1986). This population of killer whales is commonly found off southeastern Vancouver Island and in Puget Sound, Washington, from late spring to late fall (Ford, 2006, Osborne 1999). The winter distribution of Southern Resident

Killer Whales is poorly known. K and L pods have been observed off the mouth of the Columbia River and in Monterey Bay, California, associated with local production of Chinook Salmon (Wiles 2004; Balcomb 2006).

The reduced flows in the spring of the proposed action, as compared to the WOA, are likely to affect rearing and migrating Fall-run Chinook Salmon, which could possibly reduce juvenile production. Effects include a decrease in floodplain and side-channel habitat, reduced foraging conditions, increased competition and predation, and reduced emigration flows. To reduce these effects, Reclamation has included a variety of conservation measures including fall and winter refill and redd maintenance, spawning and rearing habitat restoration on the Sacramento, American, Stanislaus, and lower San Joaquin rivers, tidal habitat restoration, and predator hot spot removal. The proposed action also includes conservation measures such as improvements at fish collection facilities to improve facility survival and reduce impacts of the proposed action on Killer Whale prey as compared to WOA. In addition, as discussed above, Chinook Salmon from the Central Valley are a relatively small portion of the killer whale diet, between 18 – 40%.

5.14.1 Effects of Operation

The proposed action relative to WOA has potential beneficial and negative effects on Chinook Salmon stocks which form part of the diet of SRKW. Potential beneficial effects of the proposed action to killer whale prey relative to the WOA would occur because reservoir storage under the proposed action allows summer/fall releases to maintain favorable water temperature conditions for early life stages, as exemplified for Winter-run Chinook salmon in the Sacramento River below Keswick Dam. Potential negative effects to killer whale prey generally could occur during winter and spring, particularly the latter, which coincides with the main period of juvenile downstream migration and is when flow is often appreciably lower under the proposed action compared to the WOA, which could increase the duration of juvenile travel time and decrease survival.

Conservation measures under the proposed action generally would be expected to have overall beneficial effects on Chinook Salmon stocks from the Central Valley relative to WOA, although some temporary negative effects are also possible, as discussed in Chinook Salmon effects sections.

Studies have suggested that most Chinook salmon in the coastal ocean off California appear to be of hatchery origin (Barnett-Johnson et al. 2007; Johnson et al. 2016). The potential effects of the proposed action on Central Valley Chinook Salmon stocks would be expected to be zero to minimal on hatchery-origin juvenile Chinook Salmon released downstream of the Delta. The percentage of hatchery-origin fish released downstream of the Delta has been variable over time. For example, from the mid-1980s to 2012, the proportion of hatchery Fall-run Chinook Salmon juveniles released downstream of the Delta by state and federal hatcheries varied from around 20% to 60% (Huber and Carlson 2015). Similarly, from 2013 to 2017, the percentage of juvenile Fall-run and Spring-run Chinook Salmon released by state Central Valley hatcheries downstream of the Delta varied between 24% (2016) and 60% (2013) (California Department of Fish and Wildlife 2018).

While the proposed action is likely to negatively impact individual Central Valley Chinook salmon from operation of the export facilities, this reduction is not expected to result in decreased overall ocean abundance or availability of prey for killer whale, when weighed against hatchery production. The proposed action is expected to be beneficial to Central Valley Chinook salmon due to flow and temperature management as compared to without the operation of the CVP and SWP.

Due to the generally medium priority (18-41% of the diet, only when off the coast of California and Oregon) of the Central Valley stocks that could be affected by proposed action among many stocks contributing to the SRKW diet, and the contribution of hatchery-origin Chinook Salmon released downstream of the potential influence of proposed action, population-level effects of the proposed action to SRKW prey species are not expected.

5.14.2 Effects of Maintenance

Implementation of the species avoidance and take minimization steps under the proposed action described in Appendix C, *ROC Real Time Water Operations Charter* in section *Routine Operations and Maintenance on CVP Activities* would be anticipated to minimize potential negative effects to Chinook Salmon stocks from maintenance activities.

5.14.3 Effects of Conservation Measures

Construction components of the proposed action have the potential to affect Chinook Salmon stocks, which form part of the diet of SRKW. The various proposed construction activities would generally benefit Chinook salmon stocks in the long-run, through increased operational flexibility and habitat restoration. The conservation measures potentially could also result in negative effects to individual fish such as: temporary loss of aquatic and riparian habitat leading to increased predation and reduced food availability; degraded water quality from contaminant discharge by heavy equipment and soils, and increased discharges of suspended solids and turbidity, leading to direct toxicological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), loss of aquatic vegetation providing physical shelter, and reduced foraging ability caused by decreased visibility; impediments and delay in migration caused by elevated noise levels from machinery; and direct injury or mortality from in-water equipment strikes or isolation/stranding within dewatered cofferdams. These potential effects would be minimized through restriction of in-water work to windows limiting exposure by reducing potential for spatiotemporal overlap, and implementation of other AMMs to minimize the potential for effects when species do overlap with in-water work.

5.14.4 Effects of Monitoring Activities

Monitoring activities described in Appendix C, *ROC Real Time Water Operations Charter* in section *Monitoring Program for Core CVP and SWP Operation* would result in capture of individual juvenile Chinook salmon that otherwise could have reached the ocean and become prey for SRKW. However, the extent of this capture is limited relative to the overall abundance of juvenile Chinook salmon. In addition, the priority of the Chinook salmon stocks is low to moderate relative to other stocks for the SRKW diet.

5.14.5 Chinook Salmon, Central Valley Fall-run/Late Fall-run ESU

The reduced spring flows of the proposed action, compared to the WOA, are likely to affect rearing and migrating Fall-run Chinook Salmon, which could possibly reduce juvenile production and affect Killer Whale prey. Effects include a decrease in floodplain and side-channel habitat, reduced foraging conditions, increased competition and predation, and reduced emigration flows.

Reclamation has included fall and winter refill and redd maintenance as well as smoothing rice decomposition, to consider keeping flows higher in the fall for avoiding Fall-run redd dewatering when Shasta Reservoir storage allows.

In addition to the fall and winter redd maintenance and smoothing of rice decomposition, several conservation measures for Winter-run Chinook salmon, Spring-run Chinook salmon, or steelhead would incidentally minimize impacts on Fall-run Chinook Salmon. These include spawning and rearing habitat restoration on the Sacramento, American, Stanislaus, and lower San Joaquin rivers, tidal habitat restoration, and predator hot spot removal. OMR management establishes protective criteria to minimize and avoid entrainment based on historical salvage. Additional protective measures occur when environmental criteria indicate that entrainment is more likely and allow for more flexible operations when entrainment is less likely. The proposed action also includes conservation measures such as improvements at fish collection facilities to improve facility survival and reduce impacts of the proposed action on Killer Whale prey as compared to WOA.

5.14.5.1 Life stage Timing and Location

General life stage timing and location information for Fall-run and Late Fall-run Chinook Salmon is provided in Tables 5.14-1 and 5.14-2. Additional detail regarding juvenile life stage timing at various monitoring locations is provided in Appendix F, *Juvenile Salmonid Monitoring, Sampling, and Salvage Timing Summary from SacPAS.*

Table 5.14-1. The Temporal Occurrence of Adult and Juvenile Fall-run Chinook Salmon at Locations in the Central Valley (DWR and Reclamation 2016, p.11A-103).

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult												
Delta[1]						Medium	High	High	High	High	High	Medium
Sacramento River Basin[2]							Low	Low	Low	High	High	High
San Joaquin River[2]								Low	Low	High	High	Medium
Juvenile												
Sacramento River at Red Bluff[3]	High	High	High	High	Medium	Medium	Medium	Low	Low	Low	Low	Medium
Delta (beach seine)[4]	High	High	High	High	Medium	Medium	Low	Low	Low		Low	Medium
Mossdale (trawl)[4]	Medium	High	High	High	High	Medium						
West Sacramento River (trawl)[4]	Medium	High	High	High	High	Low	Low	Low	Low		Low	Low
Chipps Island (trawl)[4]	Medium	Medium	Medium	High	High	High	Low	Low	Low	Low	Low	Low
Knights Landing (trap)[5]	High	High	High	High	High	Low	Low	Low	Low	Low	Low	Medium

Relative Abundance: High | Medium | Low

Note: Darker shades indicate months of greatest relative abundance.

Sources:

1 State Water Project and Federal Water Project fish salvage data 1981–1988.

2 Yoshiyama et al. 1998; Moyle 2002; Vogel and Marine 1991.

3 Martin et al. 2001.

4 U.S. Fish and Wildlife Service 2001b.

5 Snider and Titus 2000.

Table 5.14-2. The Temporal Occurrence of Adult and Juvenile Late Fall-run Chinook Salmon at Locations in the Central Valley (DWR and Reclamation 2016, p.11A-104).

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult												
Delta[1]	High	High	High	Medium	Medium					Medium	Medium	Medium
Sacramento River Basin[2]	High	High	High	Medium						Medium	Medium	Medium
Juvenile												
Sacramento River at Red Bluff[3]	High	High	High	High	Medium	Low	Low	High	High	High	High	Medium
West Sacramento River (trawl)[4]	Medium	Low		Low		Low	Low	Low	Low	Low	High	High
Delta (beach seine)[4]	High	Medium		High	High	Medium	Low				Low	High
Chipps Island (trawl)[4]	Medium	Low			Low	Low	Low	Low	Low	Low	Medium	High
Knights Landing (trap)[5]	Medium	Low		Medium	Medium	Low				Low	Medium	High

Relative Abundance: ■ = High ■ = Medium ■ = Low

Note: Darker shades indicate months of greatest relative abundance.

Sources:

[1] Moyle 2002.

[2] Yoshiyama et al. 1998; Moyle 2002; Vogel and Marine 1991.

[3] Martin et al. 2001.

[4] U.S. Fish and Wildlife Service 2001b.

[5] Snider and Titus 2000.

5.14.5.2 Conceptual Model Linkages

Central Valley Fall-run/Late Fall-run Chinook Salmon populations occur in several Central Valley streams. The SAIL conceptual model (Figure 5.6-1) was prepared specially for Sacramento River Winter-run Chinook Salmon, but the cause and effects relationships it diagrams apply equally well to the Fall-run and Late Fall-run races in Sacramento River. The primary differences in the habitat requirements between the Fall-run/Late Fall-run Chinook Salmon and Winter-run Chinook Salmon are the duration and the time of year that the different life stages use their habitats, as well as spawning locations within the Sacramento River (see Chapter 2, Species Accounts). Releases from Keswick Dam and the resulting flows in the upper Sacramento River, combined with other environmental drivers, affect water temperature, dissolved oxygen level (DO), and other habitat attributes that influence the timing, condition and survival of eggs and alevins in the spawning redds. The proportion of eggs surviving to emerge as fry depends largely on the quality of conditions in the redd (Windell et al. 2017). Redd quality is affected by substrate size and composition, flow velocity, temperature, DO, contaminants, sedimentation, and pathogens and diseases. Flow affects sedimentation and gravel composition of the redds and may cause redd scour, stranding or dewatering (Windell et al. 2017). Flow also affects the surface area of river bed available for redd construction.

Fall-run adults spawn in the Sacramento River and eggs and alevins are in the gravel primarily between September and December with a peak during October through December (Table 5.14-1). Spawning occurs between Keswick Dam to Red Bluff Diversion Dam primarily, although spawning occurs as far down as Princeton (Reclamation 2017).

Late Fall-run Chinook Salmon spawn in the Sacramento River and eggs and alevins are in the gravel primarily between December and June with a peak during January through March (Table 5.14-1). Spawning occurs between Keswick Dam and Red Bluff Diversion Dam, with the majority of spawning between Keswick Dam and Red Bluff (Reclamation 2017).

Fry emergence occurs up to 3.5 months after eggs are spawned (Moyle 2002), so effects of flow in the upper Sacramento River on incubating fall-run eggs and alevins potentially occur from September through April and on incubating Late Fall-run Chinook Salmon eggs and alevins potentially occur from December through August.

As indicated by the SAIL conceptual model (Figure 5.6-2), releases from Keswick Dam and the resulting flows in the upper Sacramento River, combined with other environmental drivers, affect water temperature, DO, stranding, outmigration cues and other habitat attributes that influence the timing, condition and survival of rearing juvenile Fall-run/Late Fall-run Chinook Salmon. The proportion of juveniles surviving to emigrate from the upper Sacramento River depends largely on habitat conditions, including instream flow (Windell et al. 2017). Instream flow affects other factors through dilution (e.g., toxicity and contaminants), water temperatures (which also affects DO, food availability, predation, pathogens, and disease), river stage and flow velocity (which affect habitat connectivity, bioenergetics, food availability, and predation), entrainment and stranding risk, and potentially affects cues that stimulate outmigration (Windell et al. 2017, Moyle 2002).

Fall-run/Late Fall-run Chinook Salmon juveniles rear in and emigrate from the upper Sacramento (Keswick to Red Bluff) year-round, with a peak rearing period during January through April and, for Late Fall-run Chinook Salmon only, a secondary peak in August through November (Table 5.14-1; Table 5.14-2). Flows during summer, fall and winter of dry and critically dry years generally have the greatest potential to negatively impact the juvenile life stage in the upper Sacramento River because reservoir storage and cold water pool in these seasons and water year types may be insufficient to provide suitable flow and water temperature conditions in the rearing habitats.

Many of the factors that affect rearing and emigrating Fall-run/Late Fall-run Chinook Salmon juveniles in the middle Sacramento River are similar to those described above for the upper Sacramento River. As indicated by the SAIL conceptual model (Figure 5.6-3), flows from the upper Sacramento River and tributaries of the middle Sacramento, combined with other environmental drivers such as floodplain connectivity, food production and retention, and water diversions, affect water temperature, DO, food availability, stranding, outmigration cues and other habitat attributes that influence the timing, condition and survival of rearing juvenile Fall-run/Late Fall-run Chinook Salmon. The proportion of juveniles surviving to emigrate from the middle Sacramento River depends largely on growth and predation, which are greatly affected by habitat conditions, including instream flow (Windell et al. 2017).

Juvenile Fall-run/Late Fall-run Chinook Salmon spend varying amounts of time rearing in the upper Sacramento River following emergence before migrating to the middle River. They use the middle Sacramento River as rearing habitat and a migratory corridor to the Delta. Fall-run/Late Fall-run Chinook Salmon-sized juveniles occur in the middle Sacramento River at Knights Landing primarily from November through May (Table 5.14-1), with two separate peak occurrences for Late Fall-run Chinook Salmon: November through February and April and May (Table 5.14-2). The two peaks may reflect differences in the timing of emigration from different Sacramento River tributaries.

Inundated floodplains of the middle Sacramento River, such as the Yolo and Sutter Bypasses, have proven successful habitats for juvenile salmon growth (Katz, 2017). This success has been attributed to optimum water temperature, lower water velocity, and higher food quality and food density relative to the main channel. Reduced predator and competitor density also likely contribute to high growth rates observed for juvenile salmon rearing in floodplains (Windell et al. 2017).

Continuing their upstream migration from the Delta, Fall-run Chinook Salmon adults migrate through the middle and upper Sacramento River between July and December and Late Fall-run enter the middle Sacramento River between October and April. The adults typically spawn soon after reaching their spawning habitats, but some hold for a month or two in the upper river before spawning (Satterthwaite et al. 2017; California Natural Resources Agency 2016. Appendix 5E Essential Fish Habitat Assessment). The holding period for Fall-run Chinook Salmon in the Sacramento River is August to October (California Natural Resources Agency 2016. Appendix 5E Essential Fish Habitat Assessment). No information has been found regarding the period that Late Fall-run Chinook Salmon hold, but it is assumed that they hold during October and November (Satterthwaite et al. 2017).

As indicated by the SAIL conceptual model (Figure 5.6-6), flows from Keswick Dam releases affect water temperature, DO, and other habitat attributes that influence the timing, condition, distribution and survival of adult Fall-run/Late Fall-run Chinook Salmon during their upstream migration, holding and spawning in the upper Sacramento River.

5.14.5.3 Effects of Operation

5.14.5.3.1 <u>Seasonal Operations</u>

Under the WOA conditions, there would be no Shasta and Keswick reservoir operations to control storage or releases and no transfer of water from the Trinity River Basin. Therefore, there would be no control of flow or water temperature in the upper Sacramento River (other than upstream hydropower operations not under Reclamation control), where Fall-run spawn. Reservoir gates and river valves would be kept open, resulting in minimal storage (Figure 5.6-7). The seasonal flows modeled under the WOA scenario in the Sacramento River at Keswick Dam, show low summer and fall flows and high winter and spring flows (Figures 5-15 through 5-18 in the HEC5Q Temperatures section of Appendix D, *Modeling*). Other locations in the Sacramento River would show similar seasonal flow patterns (See figures in the HEC-5Q Temperatures section of Appendix D, and Figures 5.14-1 and 5.14-2).

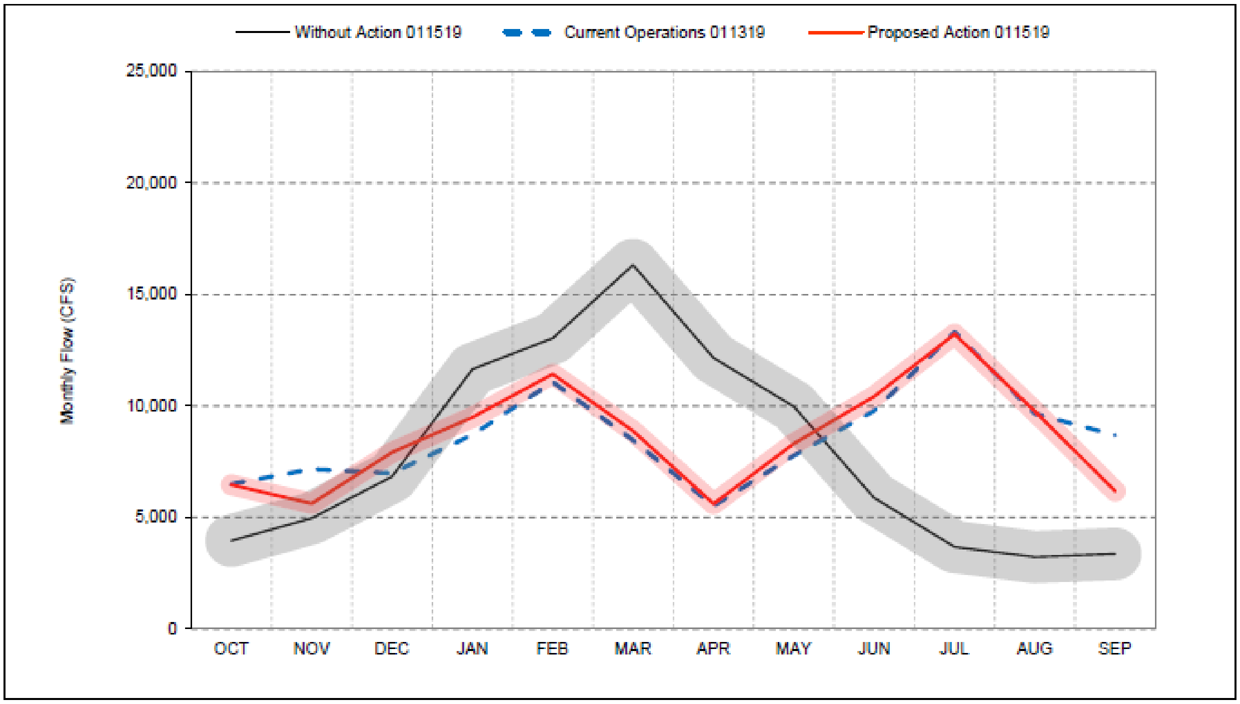


Figure 5.14-1. Mean Modeled Flows in the Sacramento River Below Keswick Dam

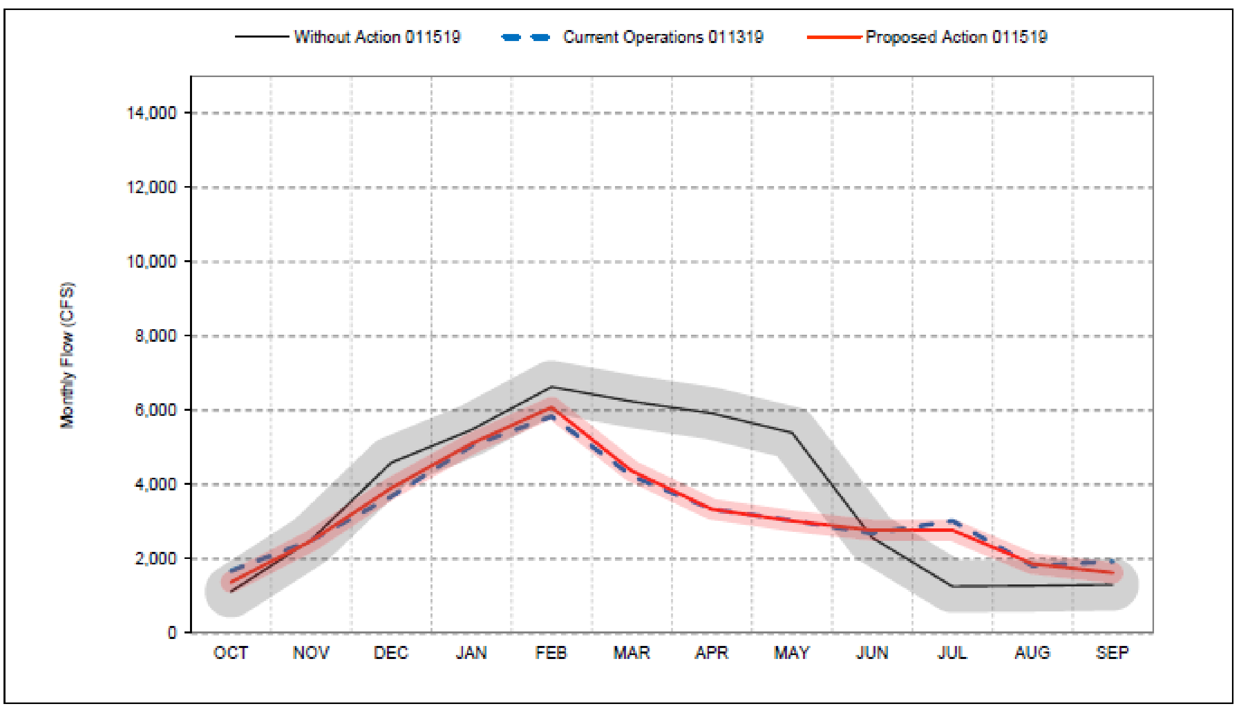


Figure 5.14-2. Mean Modeled Flows in the American River Below Nimbus Dam

Higher flows may negatively impact spawning and egg/alevin incubation. If flows are sufficiently high, they result in excessive depths and flow velocities for constructing redds, and redds that were previously built are at risk of being scoured from the bed (NMFS 2017 – CWF BO). In addition, under high flows, adults may build redds in areas that are later dewatered or isolated from the main river channel when the flows decline. High flow events with rapid flow fluctuations are likely to occur more frequently in rivers with uncontrolled flows, like the Sacramento River under the WOA conditions.

In the spawning reaches of Fall-run/Late Fall-run Chinook Salmon in the upper Sacramento River, flows under WOA during the October through April (Fall-run) and December through July (Late Fall-run) spawning, egg incubation, and alevin periods are highly variable. Flows under WOA are modeled as approximately 4,000 cfs from July through October in most water year types. The low flows would have a number of negative effects on spawning, egg incubation, and alevins of both Fall-run and Late Fall-run Chinook Salmon. As described by Windell et al. 2017, potential adverse effects of the low flows on eggs and alevins include:

- An insufficient area of river bed with suitable attributes to accommodate redds for all spawning-ready Fall-run/Late Fall-run adults.
- Inadequate flow velocities to flush sediments from the redds.
- Insufficient flow to maintain adequate levels of DO in contact with eggs and alevins in the redds and to flush metabolic wastes from the redd.
- Insufficient water depths for redds, such that minor reductions in flow result in redd stranding and dewatering.

5.14.5.3.2 Sacramento River Cold Water Pool Management

5.14.5.3.2.1 Eggs to Fry Emergence

5.14.5.3.2.1.1 Flow

Under the WOA, flows are approximately 4,000 cfs from July through October in the Sacramento River in most water year types, as inflow to Shasta Reservoir is minimal after snowmelt runoff in the late spring and summer and flows are maintained by constant spring fed sources of around 3,000 cfs upstream of Shasta in the Pit and McCloud rivers. Lower flows could limit spawning habitat, result in higher water temperatures, and dissolved oxygen for Fall-run Chinook Salmon eggs and alevin. Under COS flows during the October through February egg incubation period are usually above 6,000 cfs. The proposed action flows are similar to the COS flows at the lower end of the flow range where spawning habitat generally is most plentiful.

Differences in flows between COS and the proposed action are small in most months, but flows are moderately higher for the proposed action in June and substantially higher for the COS scenario in September and November (15-14 and 15-in the CalSim II Flows section of Appendix D). In these three months, the flow differences are expected for years with relatively wet hydrologies and, therefore, are not expected to have a meaningful effect on most Fall-run/Late Fall-run growth and survival factors. However, the Weighted Usable Area (WUA) of fall-run spawning habitat declines substantially over this range of flows (~6,000 cfs to 12,000 cfs [proposed action] or 17,000 [COS]) (Figure 15.4-3; USFWS 2003).

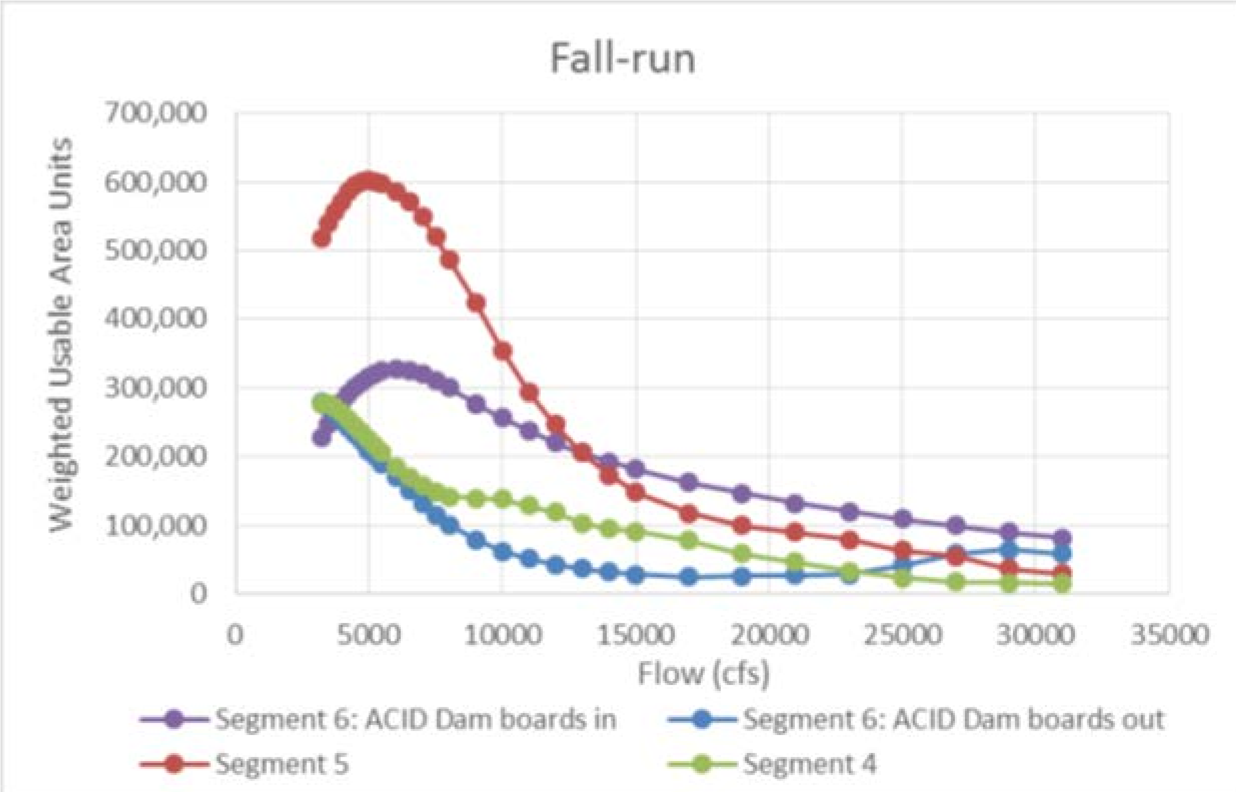


Figure 5.14-3. Spawning Habitat WUA Curves for Fall-run Chinook Salmon in the Sacramento River, Segments 4 to 6. ACID = Anderson-Cottonwood Irrigation District.

Flows under the proposed action and COS scenarios are consistently well above the WOA flows in June through October, but not during November through April (Figures 15-3through 15-18 in the CalSim II Flows section of Appendix D). In November, there is little difference in flow between the WOA and proposed action scenarios, except in the highest flow years, when the proposed action flows tend to be higher, but the COS flows are well above the WOA flows under most of the flow range. In December and February, proposed action and COS flows are generally below WOA flows for years with dry hydrologies, and are generally higher in wet years, except for the wettest Decembers. In January, proposed action and COS flows are moderately lower than the WOA flows in almost all years and during March and April, they are consistently well below the WOA flows. In May, proposed action and COS flows are below WOA flows during the wettest 50 percent of years, and similar to or slightly higher than the WOA flows in the driest 50 percent of years (Figure 15-14 in the CalSim II Flows section of Appendix D). Therefore, during the first two months of the fall-run spawning and incubation period (September through October), all the potential negative effects of low flows on Fall-run/Late Fall-run spawning and incubation listed above are expected to be less under the proposed action scenarios than under the WOA scenario. But during January through April, the potential negative effects of low flows are expected to be greater under the proposed action.

5.14.5.3.2.1.2 Water Temperature

Critical water temperatures thresholds for Fall-run/Late Fall-run Chinook Salmon vary by life stage, with eggs and alevins the most sensitive to elevated temperatures. Under the proposed action, Reclamation would operate to new water temperature management measures that include a water temperature maximum of 53.5 degrees Fahrenheit in the Sacramento River above the Clear Creek confluence.

In the upper Sacramento River, where most Fall-run/Late Fall-run spawning occurs, the WOA monthly mean water temperatures (HEC-5Q WOA scenario) during the September through April (Fall-run) and December through July (Late Fall-run) spawning and egg/alevin incubation periods would be variable. Between November and March, water temperatures would be consistently under the 53.5 and 56 degree Fahrenheit thresholds (see Appendix D, *Modeling*). Approximately 20 percent of Aprils would be above 53.5 degrees Fahrenheit but all would be below 56 degrees Fahrenheit (Figure 5.6-30). Between May and October, aside from the coldest ~5 percent of Mays and ~35 percent of Octobers, water temperatures under the WOA scenario would always be higher than 53.5 degrees Fahrenheit and 56 degrees Fahrenheit, reaching as high as 73 degrees Fahrenheit in the warmest years (Figures 5-14 through 5-18 in the HEC-5Q Temperatures section of Appendix D). Such warm summer conditions would adversely affect survival of early incubating Fall-run and later incubating Late Fall-run eggs and alevins under the WOA scenario in the upper Sacramento River during those months.

The presence of a large cold water pool and the flexibility afforded by the TCD make possible the provision of much colder water under the proposed action in the upper Sacramento River during May through October than would be possible under the WOA conditions. Under the proposed action, monthly mean water temperature outputs from HEC 5Q at Keswick range from about 46 to 66 degrees Fahrenheit during May through October (Figures 5-14 through 5-19 in the HEC-5Q Temperatures section of Appendix D). During November through April, water temperatures range from about 43 to 58 degrees Fahrenheit (Figures 5-8 through 5-13 in the HEC5Q Temperatures section of Appendix D)(). While the HEC-5Q model provides 6-hour data, the results presented here are monthly averages, which should reasonably estimate daily average water temperatures near the dam because operations at Shasta and Keswick dams create relatively stable summer flow and water temperature conditions. Variable weather conditions and travel time of water result in greater fluctuations around the mean further downstream of the dam.

There is little difference in water temperatures at Keswick Dam between the proposed action and COS scenarios during the Fall-run/Late Fall-run spawning and egg/alevin incubation period, except for in October, when the proposed action is two degrees Fahrenheit colder than the COS in the middle of the exceedance plot range (90% to 20% exceedance; Figures 5-10 through 5-12, 5-13, and 5-14 through 5-18 in the HEC-5Q Temperature section of Appendix D). It is expected that the Proposed Action would be more protective of Fall-run/Late Fall-run than Current Operations.

With the proposed improvements in water temperature management, adverse impacts on Fall-run/Late Fall-run individuals are expected to lessen under the proposed action. Therefore, benefits of the CVP include fall temperature management for Fall-run and Late Fall-run Chinook Salmon.

5.14.5.3.2.2 Rearing to Outmigrating Juveniles

5.14.5.3.2.2.1 Flows

The low fall flows under the WOA conditions would likely result in degraded conditions in juvenile rearing habitats in the upper Sacramento River for any juvenile Late Fall-run that remain in the river in the fall, as Shasta Dam is still a passage barrier under WOA. The low flows under WOA conditions during June through October would have adverse impacts on rearing habitat of Late Fall-run juveniles. These degraded habitat conditions would lead to reduced growth rate and higher mortality of the individual juveniles and a potentially reduced population abundance.

CalSim modeling indicates that upper Sacramento River flows during the year-round Fall-run/Late Fall-run juvenile rearing and emigration period in the upper Sacramento River are generally similar between the proposed action and COS (Figures 15-7 through 15-18 in the CalSim II Flows section of Appendix D) except, as described previously, for higher flows under the proposed action during December and January and higher flows during September and November under the COS scenario. These differences in flow between proposed action and COS scenarios could potentially affect juvenile habitat attributes of Fall-run and Late Fall-run juveniles both positively and negatively depending on the underlying habitat attribute (Figure 5.6-2).

From January through April, WOA flows would often be nearly twice as high as the proposed action and COS flows during years with dry hydrologies. The proposed action and COS flows in such years would generally be at the required minimum of 3,250 cfs per WRO 90-5. The WUA for rearing habitat of both Fall-run and Late Fall-run Chinook Salmon juveniles is at or near its maximum at 3,250 cfs (e.g., Figure 5.14-4) (USFWS 2005). This flow was the lowest flow included in the USFWS study. Depending on the reach sampled in the study, flow of approximately 6,000 cfs, which is the most frequent flow level for dry hydrologies under the WOA scenario, was estimated to have similar to much lower juvenile rearing habitat WUA than the 3,250 cfs flow (USFWS 2005). Although the WUA analyses indicate potentially greater juvenile rearing habitat WUA in dry years under the proposed action and COS scenarios than under the WOA scenario, the reductions in flow predicted for these scenarios would potentially affect other rearing habitat attributes of Fall-run/Late Fall-run juveniles than those measured for the WUA analyses.

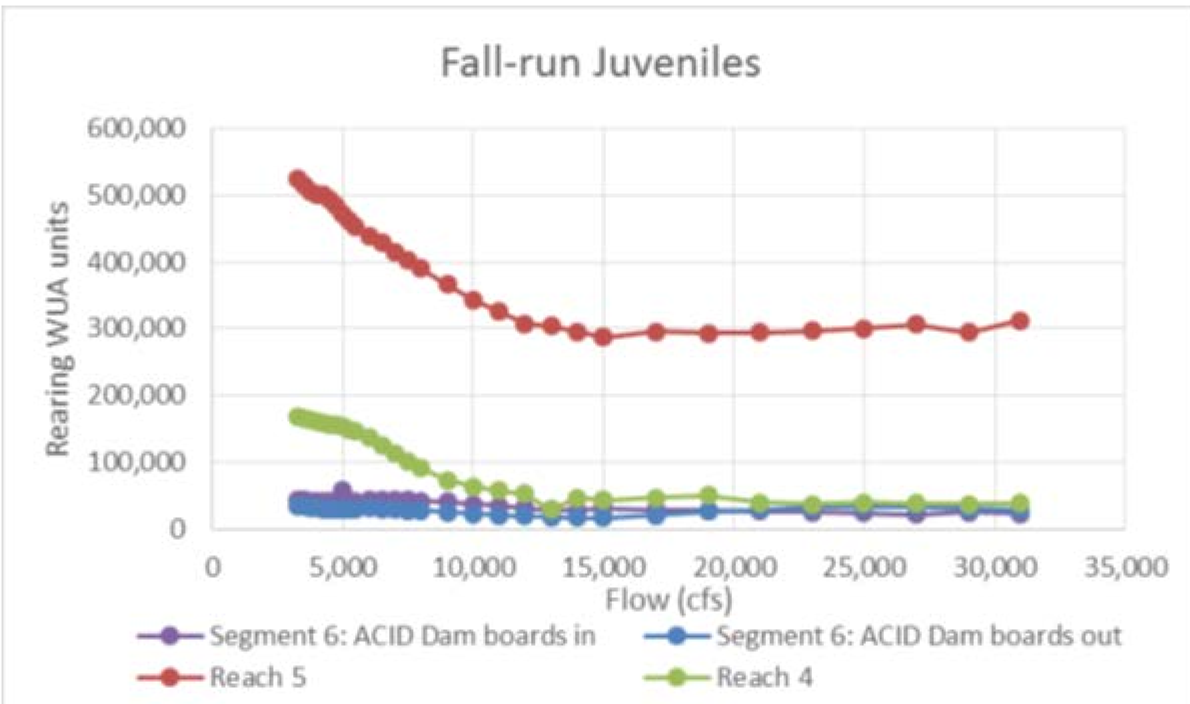


Figure 5.14-4. Rearing Habitat WUA Curves for Fall-run Chinook Salmon in the Sacramento River, Segments 4 to 6. ACID = Anderson-Cottonwood Irrigation District.

Lower winter and spring flows under the proposed action and COS relative to WOA could have both negative and positive effects on rearing juvenile Fall-run/Late-Fall run Chinook Salmon. Potential impacts include less inundation of floodplain and side-channel habitat, degraded feeding conditions, increased competition and predation, higher water temperatures and lower DO, and reduced emigration flows, while benefits include lower stranding risk because of decreased use of flood plains and lower flow fluctuations. On balance, given the USFWS (2005) results, the effect of lower winter and spring flows during most years under the proposed action relative to the WOA scenario on Fall-run/Late Fall-run Chinook Salmon juveniles and their rearing habitat is uncertain.

5.14.5.3.2.2.2 Water Temperature

In the upper Sacramento River, the WOA scenario monthly meanwater temperatures at Keswick Dam during October through April would be below the 61 degree Fahrenheit rearing juvenile threshold (USEPA, 2003) in 99-100 percent of years (Figures 5-7 to 5-9, 5-10-5-12, and 5-13 in the HEC-5Q Temperatures section of Appendix D), but would frequently be above 61 degrees Fahrenheit from May to September. The frequent exceedances of the 61 degrees Fahrenheit threshold that would occur during May through September in the upper Sacramento River would impact rearing Fall-run/Late Fall-run Chinook Salmon juveniles with greater effect to Late Fall-run.

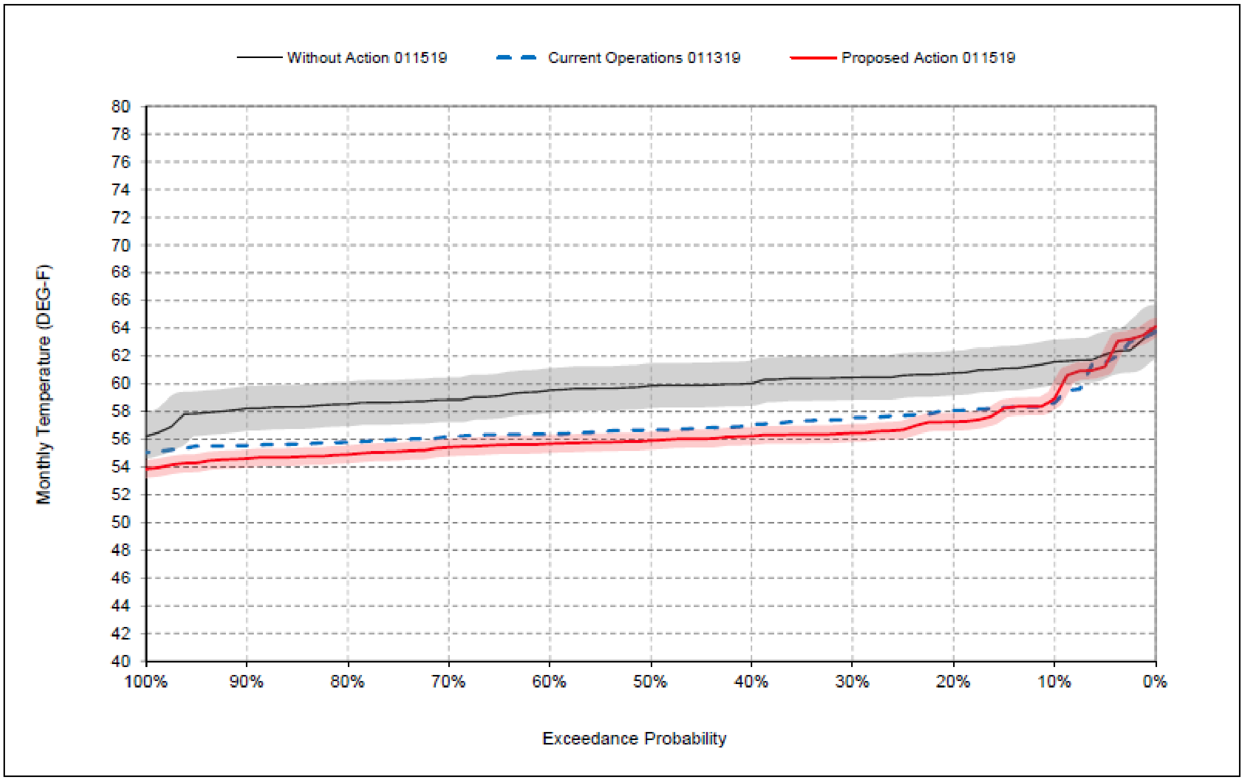


Figure 5.14-5. HEC-5Q Sacramento River Water Temperatures at Red Bluff under the WOA, proposed action and COS scenarios, October

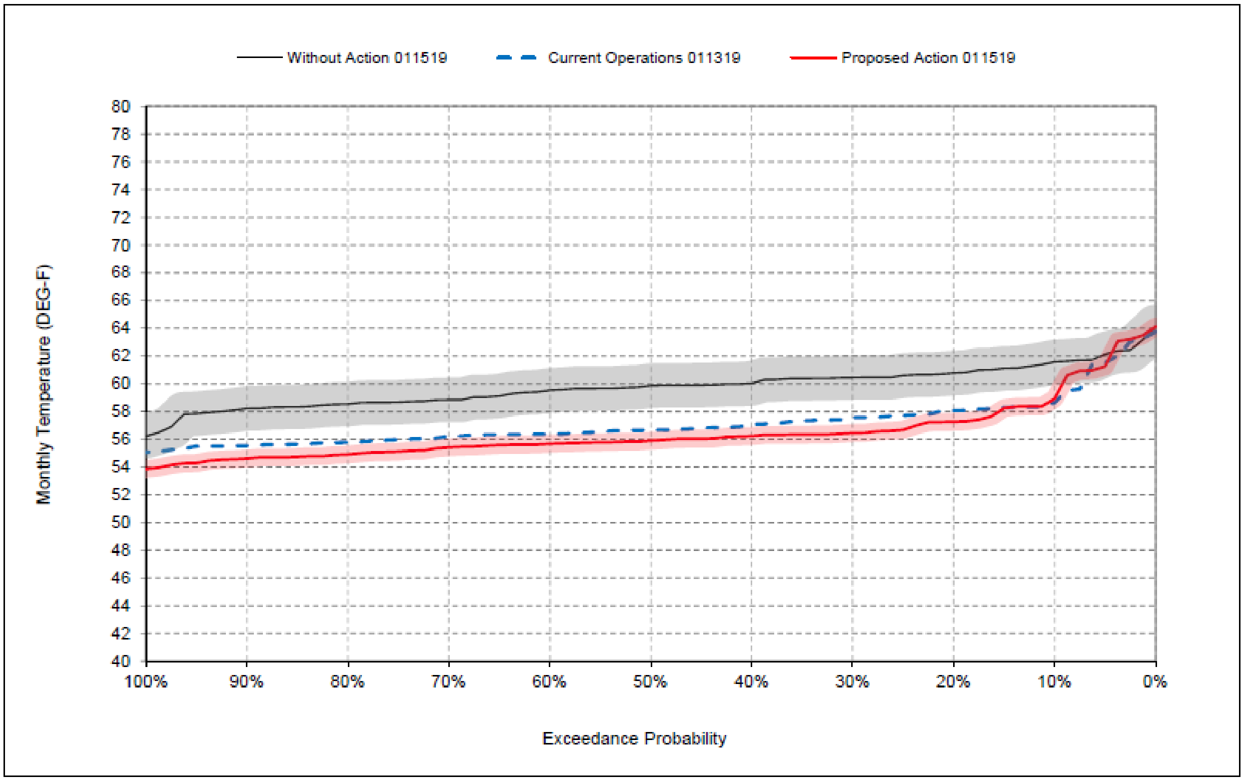


Figure 5.14-6. HEC-5Q Sacramento River Water Temperatures at Red Bluff under the WOA, proposed action and COS scenarios, May

Water temperatures at Keswick under the proposed action and COS scenarios are higher than those under the WOA scenario during November through February, are similar in March, and are lower than those under the WOA scenario in April through September (Figures 5-12 to 5-12, 5-13, and 5-14 through 5-18 in the HEC-5Q Temperatures section of Appendix D). In October, temperatures under proposed action and COS are lower than those under the WOA except in the warmest 10 percent of years (see Figure 5-7 in the HEC-5Q Temperatures section of Appendix D). A similar pattern is observed for Red Bluff, although March water temperatures under proposed action and COS would be higher than those under the WOA and April water temperatures t would be similar among the three scenarios (e.g., Figure 5.14-6, Figure 10-16, and Figure 10-6 in the HEC-5Q Temperatures section of Appendix D). All water temperatures under proposed action and COS scenarios during the Fall-run/Late Fall-run juvenile rearing period are consistently below the 61 degrees Fahrenheit threshold, except for June through October. However, during June through October, water temperatures under the WOA in almost every year would be substantially higher (~10 to 20 degrees Fahrenheit) than those under the proposed action and COS. Therefore, water temperature conditions under proposed action would provide benefits relative to the WOA conditions to juvenile Fall-run/Late Fall-run Chinook Salmon rearing in the upper Sacramento River.

5.14.5.3.2.3 Rearing to Outmigrating Juveniles in the Middle Sacramento River

5.14.5.3.2.3.1 Flow

CalSim modeling indicates that middle Sacramento River flows during November through May are generally similar between the proposed action and COS, except during November of above normal and wet years, for which the mean flows under the COS scenario are higher (Tables 17-3 in the CalSim II Flows section of Appendix D). The November reductions in flow under the proposed action scenario are predicted for the middle ranges of the exceedance curves (roughly 6,000 cfs to 13,000 cfs) (Figure WRF_LS3_Wsnov): flows in this range would provide generally comparable rearing habitat Weighted Usable Area (WUA) for Fall-run and Late Fall-run Chinook Salmon juveniles (USFWS 2005), although this study is not applicable to the middle and lower river.

As was true for the upper Sacramento River, the CalSim modeling shows large seasonal changes in the differences in middle Sacramento River flow between the WOA scenario and the proposed action and COS scenarios. In November, there are small to moderate differences in flow between the WOA and proposed action scenarios, with higher flows under the WOA scenario in the middle-high range of flow years, and lower flows under the WOA scenario in the lower flow years, but the COS flows are consistently above the WOA flows in all but the highest flow years (Figure 19-8; Tables 17-1, 18-1, and 19-1 in the Flows section of Appendix D). In December through February, the WOA flows are generally similar to or slightly higher than the proposed action and COS flows for most years (Figures 19-9 through 19-11; Tables 17-1, 18-1, and 19-1 in the Flows section of Appendix D), and in March and April, the WOA flows are consistently higher than the proposed action and COS flows (Figures 19-12 and 19-13 in the Flows section of Appendix D). In May, the WOA flows are substantially higher than the proposed action and COS flows for the 60 percent of highest flow years and are substantially lower for the 25 percent of lowest flow years (Figure 19-14 in the Flows section of Appendix D).

The higher November and May flows under the COS relative to WOA during years with drier hydrologies would likely result in enhanced conditions in juvenile rearing habitats, including more habitat complexity, side channel habitat structure and refuge habitat, and reduced disease potential. The lower proposed action flows in December through April could have both negative and positive effects on rearing juvenile Fall-run/Late Fall-run Chinook Salmon. Potential impacts include less floodplain and side-channel habitat, worse feeding conditions, increased competition and predation, higher water temperatures and lower DO, and degraded emigration flows, while potential benefits include lower stranding risk because of decreased use of flood plains and lower flow fluctuations, and lower contaminants loading from stormwater runoff. The potential impacts of lower winter and early spring flows under the proposed action are presumed provide an overall impact to the population through lesser juvenile productivityThe proposed action addresses the impact to juvenile productivity of the change in flows and water temperatures through conservation measures.

5.14.5.3.2.3.2 Water Temperature

The USEPA (2003) gives 64 degrees Fahrenheit as the critical 7 day average daily maximum (7DADM) water temperature for Chinook Salmon juveniles rearing, although this is based on Pacific Northwest fish and hydrology and does not consider the operational feasibility of 7DADM. In the middle Sacramento River below the Colusa Basin Drain, which is close to Knights Landing. The WOA scenario monthly mean water temperatures remain below the 64 degrees Fahrenheit threshold from November through March (14-8, 14-9, 14-10 through 14-13in the HEC 5Q Temperatures section of Appendix D), but exceed the threshold during the warmest 5 percent of years in April and the warmest 85 percent of years in May, with a maximum water temperature of 75 degrees Fahrenheit (Figures 14-13 and 14-14 in the HEC 5Q Temperatures section of Appendix D).

Water temperatures under the proposed action and COS scenarios are substantially or moderately above the WOA scenario water temperatures during most years in November through April (Figures 14-8, 14-914-12, 14-13 in the HEC 5Q Temperatures section of Appendix D), and are moderately below the WOA scenario water temperatures during most years in May (Figure 14-14 in the HEC 5Q Temperatures section of Appendix D). Water temperatures during most years in the November through April period are suitable for juvenile Fall-run/Late Fall-run Chinook Salmon that rear in and emigrate from the middle Sacramento River under the WOA and the proposed action and COS scenarios, therefore, adverse impacts on the Fall-run/Late Fall-run Chinook Salmon juveniles are not expected for these months. Under all three scenarios during May, however, the 64 degrees Fahrenheit threshold would be exceeded in most years, with the WOA scenario having greater exceedances than the proposed action and COS scenarios, especially in warmer years (Figure 14-14 in the HEC 5Q Temperatures section of Appendix D). These results indicate that water temperature conditions would too warm for juvenile Fall-run/Late Fall-run rearing and emigrating in the middle Sacramento River during May under WOA conditions, the proposed action and COS and that conditions would be worse under the WOA conditions. It should be noted that May is the last month during spring or summer that Fall-run/Late Fall-run juveniles are abundant in the middle river (Table 5.14-1), and it is likely that when water temperatures are too high they emigrate to the ocean before May. Water temperatures in the middle and lower river cannot be efficiently managed with Shasta Reservoir releases so are predominantly dependent on ambient conditions.

5.14.5.3.2.4 Adult Migration from Ocean to Rivers

5.14.5.3.2.4.1 Flow

Under WOA, CalSim modeling indicates that during the July through December fall-run Chinook salmon immigration period, the lowest flows at Keswick Dam during July through October are low enough to create potential passage problems for immigrating fall-run Chinook salmon adults, and this is even more true at Wilkins Slough, where flows reach 0 cfs in some years. The low flows under WOA would have major adverse impacts on adults migrating upstream in the middle Sacramento River and for adults holding in the upper river.

During the July through December Fall-run Chinook salmon immigration period and the October through April Late Fall-run immigration period, flows are similar between the proposed action and COS scenarios at Wilkins Slough and at Keswick, except for much higher flows during September under the COS scenario (up to ~7,000 cfs higher) at Wilkins Slough and Keswick for flows in the range from about 8,000 cfs to 16,000 cfs (Figures 19-18 and 15-18 in in the Flows section of Appendix D) and higher flows during November under the COS scenario (~3,500 cfs higher at Keswick and ~4,000 cfs higher at Wilkins Slough) for flows from about 6,000 cfs to 13,000 cfs (Figure 19-8 and 15-8 in the Flows section of Appendix D). These flow differences occur primarily for flows greater than 5,000 cfs, which are likely high enough to present no passage problems for upstream migrating adults.

The CalSim modeling shows large seasonal changes in the differences in middle and upper Sacramento River flow between the WOA scenario and the proposed action and COS scenarios. In November through February, the WOA flows are generally similar to or slightly higher than the proposed action and COS flows for most years at both Wilkins Slough and Keswick Dam. The main exception is November, when there is little difference in flow between the WOA and proposed action scenarios, except for higher proposed action flows in the highest flow years at Keswick, but the COS flows are well above the WOA flows under most of the flow range (Figures 19-8 and 15-8 in the Flows section of Appendix D). In

March and April, the WOA flows are generally higher than the proposed action and COS flows at both locations (Figures 19-12 and 19-13 and 15-12 and 15-13 in the Flows section of Appendix D). For the remainder of the months included in the Fall-run and Late Fall-run Chinook Salmon adult immigration periods (July through October), the proposed action and COS flows are generally higher or much higher than the WOA flows at both locations (Figures 19-16 through 19-18 and 19-7; 15-16 through 15-18 and 15-7 in the Flows section of Appendix D. The higher flows during July through October in years with dry hydrologies at Wilkins Slough and Keswick under the proposed action relative to the WOA scenario would likely benefit Fall-run/Late Fall-run adults migrating in the middle and upper Sacramento River by enhancing water quality and upstream passage, and reducing stranding, straying, poaching, and disease risks (Windell et al. 2017).

5.14.5.3.2.4.2 Water Temperature

Under WOA conditions there would be no control of flow or water temperature in the Sacramento River, Shasta storage levels would be very low (see Shasta Lake Storage figures in the CalSim Storage section of Appendix D) and, assuming stratification developed, the cold water pool would be small and would not be managed.

The USEPA (2003) gives 68 degrees Fahrenheit as the critical 7DADM water temperature for Chinook Salmon adults migrating and 61 degrees Fahrenheit as the critical 7DADM for holding adults, although this is based on Pacific Northwest fish and hydrology and does not consider the operational feasibility of 7DADM. In the middle Sacramento River below the Colusa Basin Drain, WOA water temperatures exceed the water temperature threshold for migrating adults in summer, but not in the winter. During almost all years in July and August, the WOA water temperatures exceed the threshold by at least 10 degrees Fahrenheit. Therefore, water temperatures would be highly stressful to Fall-run Chinook Salmon adults migrating upstream during the first months of their July through December immigration period, whereas they would be moderately stressful in some years to Late Fall-run migrating upstream during October.

In the upper Sacramento River at Keswick, the WOA scenario monthly average water temperatures are consistently below the 61 degrees Fahrenheit threshold for holding Fall-run/Late Fall-run adults from October through December, when the Late Fall-run adults are expected to hold, but exceed the threshold by over 15 degrees Fahrenheit in every year during the July and August holding period of fall-run adults (Figures 5-16 and 5-17 in the HEC 5Q Temperatures section of Appendix D). Therefore, water temperatures under the WOA conditions would be suitable for holding Late Fall-run adults, but would negatively impact holding Fall-run Chinook Salmon females and their unspawned eggs.

Under the proposed action and COS scenarios, the monthly mean water temperatures in the middle Sacramento River below the Colusa Basin Drain would be below the 68 degrees Fahrenheit threshold for immigrating adults from November through April and in almost all years during October (Figures 14-7, 14-8, 14-9 through 14-14, 14-13 in the HEC 5Q Temperatures section of Appendix D), but would exceed the threshold during July and August in all or almost all years (Figures 14-16 and 14-17 in the HEC 5Q Temperatures section of Appendix D). The much higher percentage of years exceeding the threshold under the proposed action than the COS scenario, indicates that conditions in the middle Sacramento River would be more stressful for the upstream migrating fall-run Chinook salmon adults under the proposed action than under COS. The reason for this difference in water temperatures under the two scenarios is that river flow is much higher under the COS scenario (see Figure 5-18 in the HEC 5Q Temperatures section of Appendix D) because of Fall X2 releases for Delta smelt protection. Upstream migrating fall-run Chinook salmon adults would also be exposed to water temperatures exceeding the 68 degrees Fahrenheit threshold during July and August, but Late Fall-run Chinook salmon would not be exposed to water temperatures exceeding the threshold in any month during their October through April migration period, except for a few years (less than 5 percent) in October.

In the upper Sacramento River at Keswick, under the proposed action and COS scenarios, the average water temperatures would stay below the 61 degrees Fahrenheit threshold for holding adults during November through July of all years (Figures 5-8, 5-9, 5-19 through 5-12, 5-13, 5-14 through 5-16 in the HEC 5Q Temperatures section of Appendix D) and from August through October in, at most, 4 percent of years (Figures 5-17 and 5-7 in the HEC 5Q Temperatures section of Appendix D).

In the middle Sacramento River downstream of the Colusa Basin Drain, water temperatures under the proposed action and COS scenarios are generally similar to the WOA scenario water temperatures during November and December (Figures 14-8 and 14-9 in the HEC 5Q Temperatures section of Appendix D), above the WOA scenario water temperatures from January through April (Figure 14-10 through 14-12, 14-13 in the HEC 5Q Temperatures section of Appendix D), below the WOA scenario water temperatures during July through October (Figures 14-16 through 14-18, and Figure 14-7 in the HEC 5Q Temperatures section of Appendix D). In the upper Sacramento River at Keswick, water temperatures under the proposed action and COS scenarios are similar to WOA water temperatures during March (Figure 5-12 in the HEC 5Q Temperatures section of Appendix D), well above the WOA scenario water temperatures during November through February (Figures 5-8 through 5-11 in the HEC 5Q Temperatures section of Appendix D), and well below the WOA scenario water temperatures in all years during April through September, and all but 7 percent of years in October (Figures 5-13, 5-14 through 5-7 in the HEC 5Q Temperatures section of Appendix D).

Water temperatures are suitable for Late Fall-run Chinook salmon immigration during their October through April migration period under all three scenarios in the middle Sacramento River as well as for holding in the upper rive. However, water temperatures during July through September, the first three months of the fall-run Chinook salmon immigration and holding period, exceed the 68 degrees Fahrenheit threshold below the Colusa Basin Drain during every year under the WOA scenario and in most years under the proposed action and COS scenarios, but the exceedances are typically much greater under the WOA scenario (Figures 14-16 through 14-18 in the HEC 5Q Temperatures section of Appendix D). In October, the threshold is exceeded in much lower percentages of years, but the water temperatures are consistently higher for the WOA scenario (Figure 14-7 in the HEC 5Q Temperatures section of Appendix D).

At Keswick, the 61 degrees Fahrenheit threshold for holding adults is not exceeded in any years during November through April under any of the scenarios (Figures 5-8, 5-9, 5-10 through 5-12, 5-13 in the HEC 5Q Temperatures section of Appendix D). In July through September, the threshold is exceeded in every year under the WOA scenario, but in only a few years under the proposed action and COS scenarios (5-16 through 5-18 in the HEC 5Q Temperatures section of Appendix D). In October, the threshold is exceeded in no years under the WOA scenario and in 4 percent of years under the proposed action and COS scenarios, although water temperatures under the proposed action and COS scenarios are lower than those under the WOA scenario, except in the warmest 7 percent of years (Figure 5-7 in the HEC 5Q Temperatures section of Appendix D). Water temperatures would be suitable for Late Fall-run Chinook salmon holding adults, except under the proposed action and COS scenarios in the warmest five percent of Octobers. During the summer months (July through September), when water temperatures are generally stressful for adult salmon in the Sacramento River, the water temperatures under the WOA conditions in both the middle and upper Sacramento River are almost always much higher than those under The proposed action or COS. It is unlikely that migrating adult fall-run Chinook salmon could survive the elevated water temperatures in the middle Sacramento River predicted for the summer months under tWOA or that eggs of the adult fall-run Chinook salmon holding in the upper Sacramento River could survive the predicted high summer water temperatures. Water temperature conditions under the proposed action and COS are also unfavorable for fall-run adults migrating during July through September, but the temperatures are less than 5 degrees Fahrenheit above the 68 degree Fahrenheit threshold in at least 50 percent of years, while water temperatures under the WOA scenario are more than 10 degrees Fahrenheit above the threshold in almost every year during July and August, and are more than 5 degrees Fahrenheit above the threshold in most years during September. Water temperature conditions under the proposed action would be favorable for fall-run Chinook salmon adults holding in the upper Sacramento River in almost every year.

5.14.5.3.2.5 Adult Holding in Rivers

5.14.5.3.2.5.1 Flows

WOA's low flows in July and August would potentially increase exposure of holding fall-run Chinook salmon adults to poor water quality, pathogens and anglers. WOA flows are roughly similar to proposed action and COS flows during November and December, except for the higher COS flows during November noted above (Figures 15-8 and 15-9 in the Flows section of Appendix D), and are much lower than proposed action and COS flows during July, August and most years in October (Figures 15-16 and 15-17, and 15-7 in the Flows section of Appendix D 15-Kaug, and WSF_LS1_KWKoct). In general, higher flows are likely to benefit holding Fall-run/Late Fall-run adults by affording better water quality (including cooler water temperatures and higher DO), reduced exposure to pathogens, and lower risk from anglers (Windell et al. 2017). The proposed action and COS scenarios would have much higher flows than the WOA scenario during summer, when flow is often low Therefore, the proposed action is expected to be more protective of Fall-run/Late Fall-run Chinook Salmon than the Without Action conditions.

5.14.5.3.2.5.2 Water Temperatures

In the upper Sacramento River at Keswick, water temperatures under the proposed action and COS scenarios are higher than WOA water temperatures during November and December (Figures 5-8 and 5-9 in the HEC 5Q Temperatures section of Appendix D), and well below the WOA scenario water temperatures in July, August and October, except for the warmest Octobers (Figures 5-16, 5-17 and 5-7 in the HEC 5Q Temperatures section of Appendix D). Water temperatures under the WOA scenario are predicted to exceed the 61 degrees Fahrenheit holding threshold in all years during July and August, and are predicted to exceed the 61 degrees Fahrenheit holding threshold under the proposed action and COS scenarios less than 5% percent of years in August and October. These results indicate that proposed action, relative to WOA, provide a clear benefit to adult Fall-run/Late Fall-run Chinook Salmon holding in the upper Sacramento River.

5.14.5.3.3 Spring Pulse Flows

5.14.5.3.3.1 Eggs to Fry Emergence

As described in the proposed action, Reclamation will release pulse flows in the spring if projected storage on May 1 in Shasta Reservoir is above 4 MAF. If Shasta Reservoir total storage on May 1 is projected to be greater than 4 MAF, Reclamation would make a Spring pulse release as long as the release would not cause Reclamation to drop into a lower Tier of the Shasta summer temperature management or interfere with the ability to meet other anticipated demands on the reservoir.

Spring pulse releases are not at the time of year of egg incubation, and rather would be timed to attract juvenile Fall-run Chinook salmon to move downstream. Spring pulses could benefit late redds by increasing dissolved oxygen in the water for eggs. Late eggs emerging from the gravel could be exposed to redd dewatering on the ramp-down side of a spring pulse.

5.14.5.3.3.2 Rearing to Outmigrating Juveniles

Spring pulse flows would benefit juvenile salmonids by triggering their outmigration (Kjelson et al.,1981), and possibly by increasing survival and reducing predation. Please see the Spring-run Chinook salmon effects analysis for more detail on mechanisms and benefits.

5.14.5.3.4 Fall/Winter Refill and Redd Maintenance

Under WOA, fall flows are low. Under the proposed action, Reclamation proposes to adjust fall flows based on Shasta Reservoir storage to avoid dewatering Winter-run and Fall-run Chinook salmon redds and cold water pool impacts. Higher flows than the WOA during this September – November period could benefit fall-run Chinook salmon redds. Currently, Reclamation lowers flows in the early fall period in order to conserve water for spring cold water pool. This can result in dewatering Fall-run Chinook salmon redds that were laid at higher flows when Reclamation was keeping flows high to avoid dewatering Winter-run Chinook salmon redds. Therefore, this action could potentially benefit Fall-run Chinook salmon in years where Reclamation ends the year with high storage in the reservoir.

5.14.5.3.5 Clear Creek Flows

5.14.5.3.5.1 Eggs to Fry Emergence

Fall-run/Late Fall-run Chinook salmon eggs and emerging fry would be exposed to the effects of Clear Creek geomorphic flows, and potentially spring attraction flows based on the proposed timing of these releases (after January 1 for geomorphic flows; April-June for spring attraction flows [Clear Creek Technical Team 2018]), and the seasonal occurrence of this life stage in Clear Creek (October – February; Table 5.14-1). Potential effects of these flows include increased gravel scour which could displace incubating eggs from redds, resulting in exposure to increased predation, mechanical shock and abrasion, and increased water temperature if transported out of suitable incubation habitat. Geomorphic flows could also temporarily increase suspended solids and turbidity, causing sediment deposition in redds that can reduce hydraulic conductivity through the redd and result in reduced oxygen delivery to eggs, reduced flushing of metabolic waste, and entombment of alevins via a sediment "cap" that prevents or impedes emergence (Everest et al. 1987, Lisle et al. 1989).

Studies on Clear Creek have shown that the sediment transport threshold generally occurs between 3000–3500 cfs (McBain and Trush 2001, Pittman and Matthews 2004). Events of this magnitude occurred in 50% (26 of 52) of years since Whiskeytown Dam was constructed, while daily average flows > 3000 cfs occur on 0.2% of days since WY 1965 (37 days total). Proposed geomorphic and attraction flows up to the safe release capacity (approximately 900 cfs) under the proposed action represent approximately 30% of the flow needed to transport sediment in the absence of flows from downstream tributaries. As a result, adverse impacts associated with these releases are expected to be of low magnitude, compared to conditions created by existing storm peak discharges, and occur with low frequency.. If geomorphic flows under the proposed action were to achieve their intended effect (gravel mobilization), the total area and overall quality of egg incubation habitat would be increased.

Fall-run/Late Fall-run Chinook Salmon eggs and emerging fry would not be exposed to the effects of Whiskeytown water temperature controls in Clear Creek, based on the timing of these controls (60°F at IGO gage June 1-September 15; 56°F at IGO gage September 15-October 31), and the seasonal occurrence of this life stage in Clear Creek (December-April; Table 5.14-1). Therefore, temperature controls are anticipated to have no effect on this life stage.

5.14.5.3.5.2 Rearing to Outmigrating Juveniles

Rearing and outmigrating juvenile Fall-run/Late Fall-run Chinook samon would be exposed to the effects of geomorphic and spring attraction flows under the proposed action relative to WOA given the likely timing of spring attraction flows (May-June [Clear Creek Technical Team 2018]), geomorphic flows (contemporaneous with peak storm flows after January 1), and the peak timing of this life stage in Clear Creek (year-round; Table 5.14-1).

These flow releases have the potential to degrade water quality via increased suspended solids and turbidity, leading to direct physiological impacts on rearing and outmigrating juvenile health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), loss of aquatic vegetation providing physical shelter, and reduced foraging ability caused by decreased visibility. The effects of this exposure could also include displacement of rearing fish from suitable habitat, leading to increased predation and exposure to increased water temperatures.

Studies on Clear Creek have shown that the sediment transport threshold generally occurs between 3000–3500 cfs (McBain and Trush 2001, Pittman and Matthews 2004). Events of this magnitude occurred in 50% (26 of 52) of years since Whiskeytown Dam was constructed, while daily average flows > 3000 cfs occur on 0.2% of days since WY 1965 (37 days total). Proposed geomorphic and spring attraction flows up to the safe release capacity (approximately 900 cfs) under the proposed action represent approximately 30% of the flow needed to transport sediment in the absence of flows from downstream tributaries. As a result, adverse effects associated with geomorphic flow releases are expected to be of low magnitude, compared to conditions created by existing storm peak discharges, and occur with low frequency. Therefore, the potential for geomorphic and spring attraction flow releases to result in negative population-level effects on rearing and outmigrating Fall-run/Late Fall-run Chinook is anticipated to be low.

Some rearing and outmigrating Fall-run/Late Fall-run Chinook salmon juveniles would be exposed to the effects of Whiskeytown water temperature controls in Clear Creek given the timing of these controls (June 1-September 15 & September 15-October 31), and the peak timing of this life stage in Clear Creek (year-round; Table 5.14-1). However, this life stage of Fall-run/Late Fall-run Chinook typically utilizes rearing habitat during cooler winter and spring months, so a low number of individuals would be affected by water temperature controls from June-October. The oversummering Fall-run/Late Fall-run juveniles would benefit from the temperature management.

5.14.5.3.5.3 Adult Migration from Ocean to Rivers

Few, if any, migrating adults would be exposed to the effects of geomorphic and spring attraction flows under the proposed action given the likely timing of these flows (geomorphic flows contemporaneous with peak storm flows after January 1; spring attraction flows May-June [Clear Creek Technical Team 2018]) and the peak timing of this life stage in Clear Creek (October-December; Table 5.14-1). Therefore, this action is anticipated to have no effect on this life stage.

Under the proposed action relative to WOA, low numbers of migrating adults could be exposed to Whiskeytown Dam water temperature controls in Clear Creek, based on the timing of these controls (June 1-September 15 & September 15-October 31) and the seasonal timing of this life stage in Clear Creek

(October-December; Table 5.14-1). Water temperature objectives during this period (56°F-60°F) are well within the acceptable range (38°F -56°F; Bell 1991) for this life stage of Fall-run/Late Fall-run Chinook and well below the levels that cause acute to chronic stress (≥ 70°F; Lindley et al. 2004). In addition, effects of exposure to Whiskeytown Dam temperature controls in Clear Creek would result in a reduction in water temperatures in Clear Creek compared to the WOA, both at IGO and the creek mouth, by 5-13°F in the months of September and October at 50% exceedance probability.

5.14.5.3.5.4 Adult Holding in Rivers

Few, if any, holding adults would be exposed under the proposed action to the effects of geomorphic and spring attraction flows given the likely timing of these flows (geomorphic flows contemporaneous with peak storm flows after January 1; spring attraction flows May-June [Clear Creek Technical Team 2018]) and the peak timing of this life stage in Clear Creek (July-December; Table 5.14-1). Therefore, this action is anticipated to have no effect on this life stage.

Holding adults would be exposed to Whiskeytown Dam temperature controls in Clear Creek, based on the timing of these controls (June 1-September 15 & September 15-October 31) and the seasonal timing of this life stage in Clear Creek (July-December; Table 5.14-1). Water temperature objectives during this period (56°F-60°F) are well within the acceptable range (38°F -56°F; Bell 1991) for this life stage of Fall-run/Late Fall-run Chinook and well below the levels that cause acute to chronic stress (≥ 70°F; Lindley et al. 2004). In addition, effects of exposure to Whiskeytown Dam temperature controls in Clear Creek would be a reduction in water temperatures in Clear Creek compared to the WOA, both at IGO and the creek mouth, by 5-13°F (HEC 5Q Temperature Results) in the months of September and October at 50% exceedance probability.

5.14.5.3.6 <u>Feather River</u>

5.14.5.3.6.1 Eggs to Fry Emergence

5.14.5.3.6.1.1 Flow Effects

Eggs and emerging fry of Fall-run/Late Fall-run Chinook salmon would be exposed to the effects of Oroville Dam releases and resulting flows in the High Flow Channel (HFC) of the Feather River downstream of the Oroville Complex FERC Project boundary, based on the seasonal occurrence of this life stage in the Feather River (January–April; Table 5.14-1 and Table 5.14-2, NMFS 2016), minimum instream flow requirements in the HFC (Table 5.14-3), and compliance with Water Rights Decision 1641 (D-1641).

As indicated by the Salmon and Sturgeon Assessment of Indicators by Life-stage (SAIL) Upper River conceptual model (CM1), these flows, combined with other environmental drivers, affect water temperature, DO levels, sedimentation, substrate composition, and other habitat attributes that influence redd quality, which in turn determines egg-to-fry survival (Johnson et. Al., 2016, Windell et. Al., 2017). Insufficient flow during this life stage may result in higher water temperatures, lower DO in redds, and redd dewatering, each of which may lead to elevated egg mortality. Insufficient flow may also limit the habitat area available for redd construction, thereby limiting available habitat for this life stage. Excessive flow during this life stage may scour redds, and higher flows upstream of the HFC may attract spawning adults further upstream into the Low Flow Channel (LFC), where spawning habitat is less abundant, and the effects of superimposition are greater (Sommer et. Al., 2001).

Table 5.14-3. Feather River High Flow Channel minimum instream flow requirements included in the NMFS BO and USFWS BO

	High Flow Channel Minimum Instream Flow (cfs)		
Preceding April – July runoff (Percent of Normal)	**Oct-Feb**	**March**	**April-Sept**
55% or greater	1,700	1,700	1,000
Less than 55%	1,200	1,000	1,000

Under WOA, Lake Oroville would not be operated to control storage or flow releases and no conveyance of water to San Luis Reservoir via the Banks Pumping Plant would be made. Reservoir gates and diversion tunnels would be kept open, resulting in annual storage volumes less than 1,000 TAF (Figure 5.14-7). As a result, there would be limited control of flow or water temperature in the Feather River HFC, which provides habitat for this life stage. Oroville Dam under the WOA releases lower summer and fall flows and higher winter and spring flows compared to the proposed action and current operations (Figures 5.14-8 and 5.14-9).

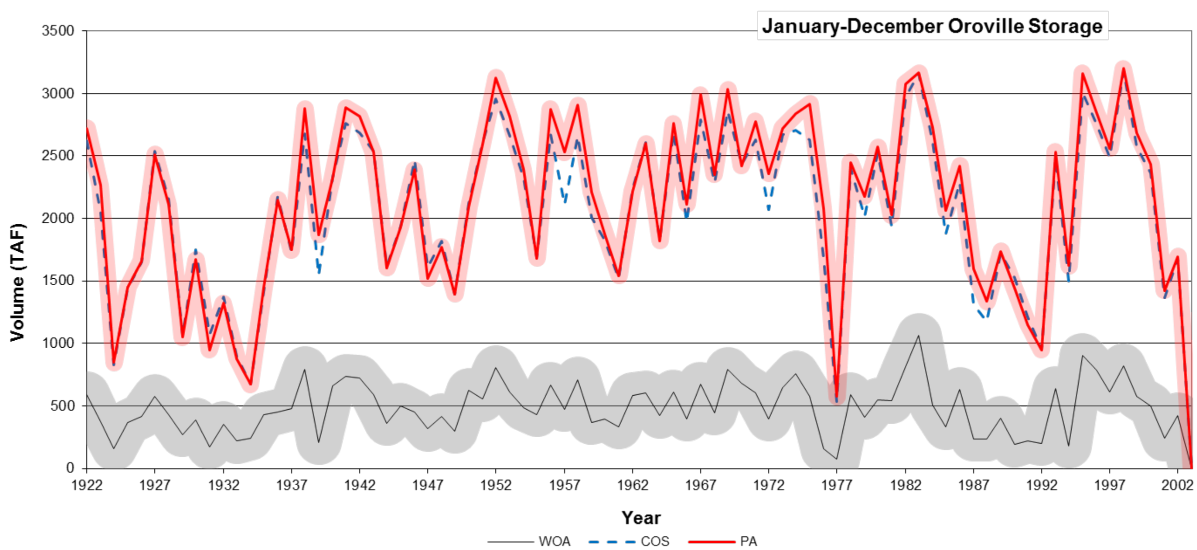


Figure 5.14-7. CalSim II estimates of mean Oroville storage (Thousand Acre-Feet [TAF]) for the period 1923–2002 under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action).

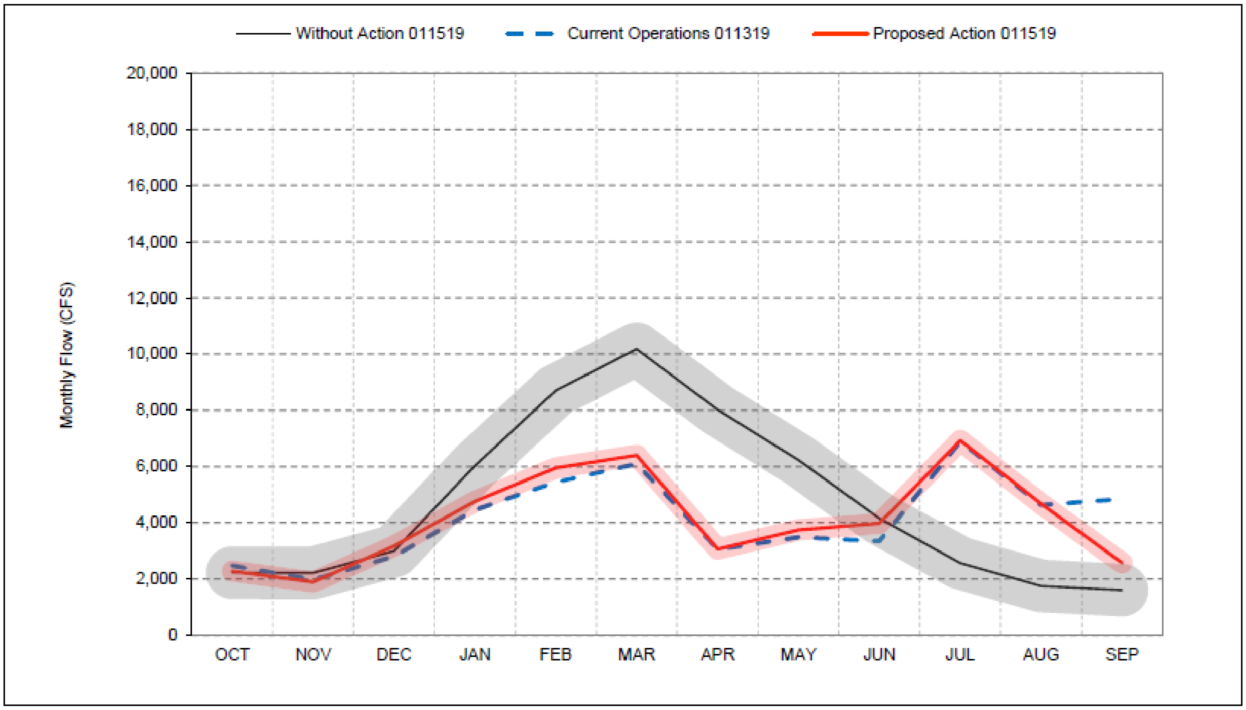


Figure 5.14-8. CalSim II estimates of Feather River long-term average streamflow below Thermalito Afterbay under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action).

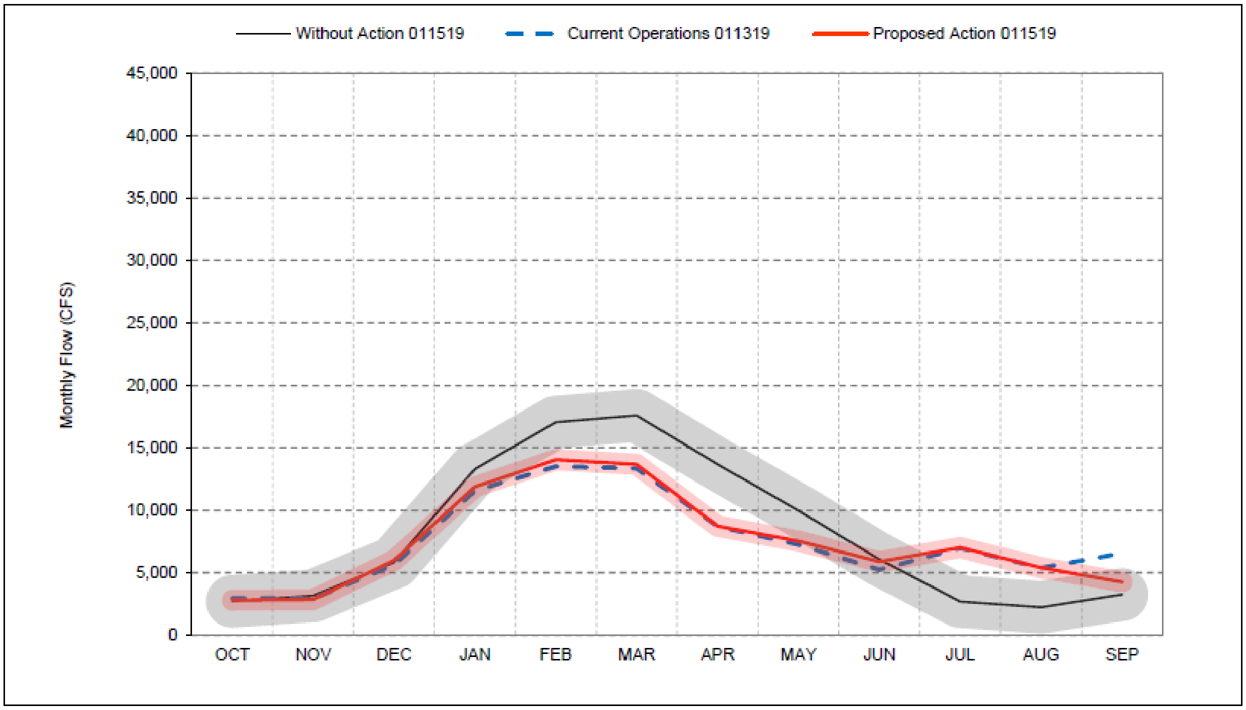
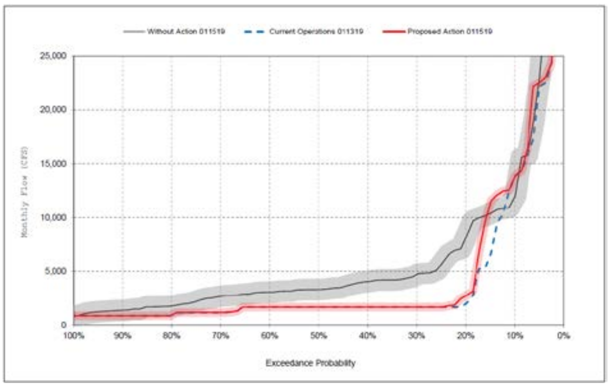


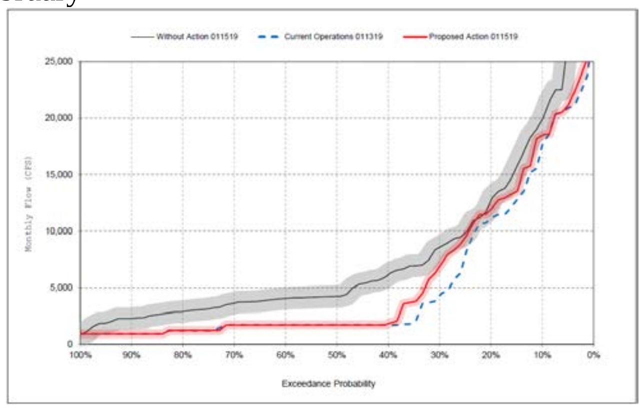
Figure 5.14-9. CalSim II estimates of Feather River mouth long-term average flow under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action).

Feather River flows below Thermalito Afterbay under the WOA would be similar to or higher than flows under the proposed action and COS during the peak seasonal timing of Fall-run/Late Fall-run Chinook salmon egg incubation and fry emergence (January–April) (Figure 5..14-10). Although flows under the proposed action and COS are lower, there is little to no risk falling below the required minimum flow for January and February (1,200–1,700 cfs, depending on preceding April–July runoff) and March and April (1,000–1,700 cfs, depending on preceding April–July runoff).

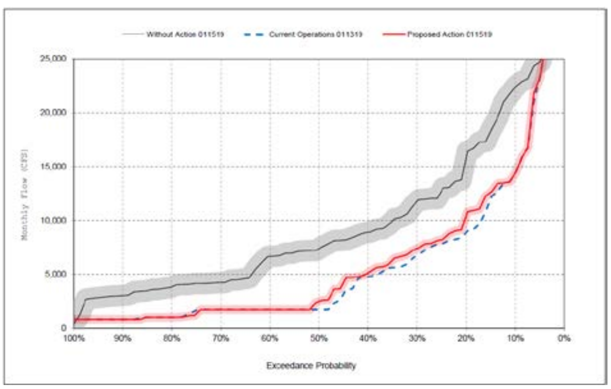
January



February



March



April

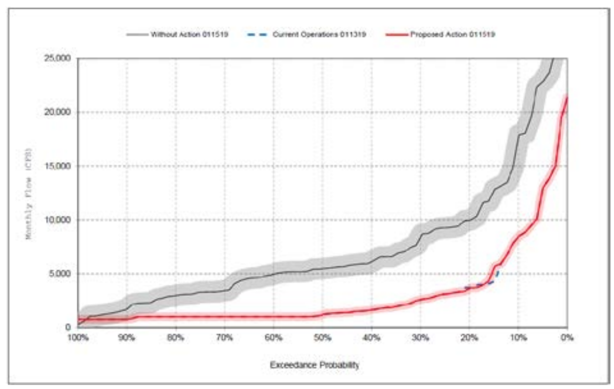


Figure 5.14-10. CalSim II estimates of Feather River flow below the Thermalito Afterbay in January–April under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action).

Flows in the Feather River HFC during the egg incubation to fry emergence period under the proposed action and COS would be lower than under WOA in below normal, dry, and critically dry year types (Figure 5.14-11). Importantly, CalSim II model output indicates projected flows under the proposed action and COS would increase the likelihood that flows in January–March would not meet the minimum instream flow criteria of 1,700 cfs for preceding April–July runoff of 55% or greater; an exception is February and March in below normal years. In years where the preceding April–July runoff is less than 55%, the minimum instream flow criteria would not be met in January of critically dry years (Figure 5.14-11).

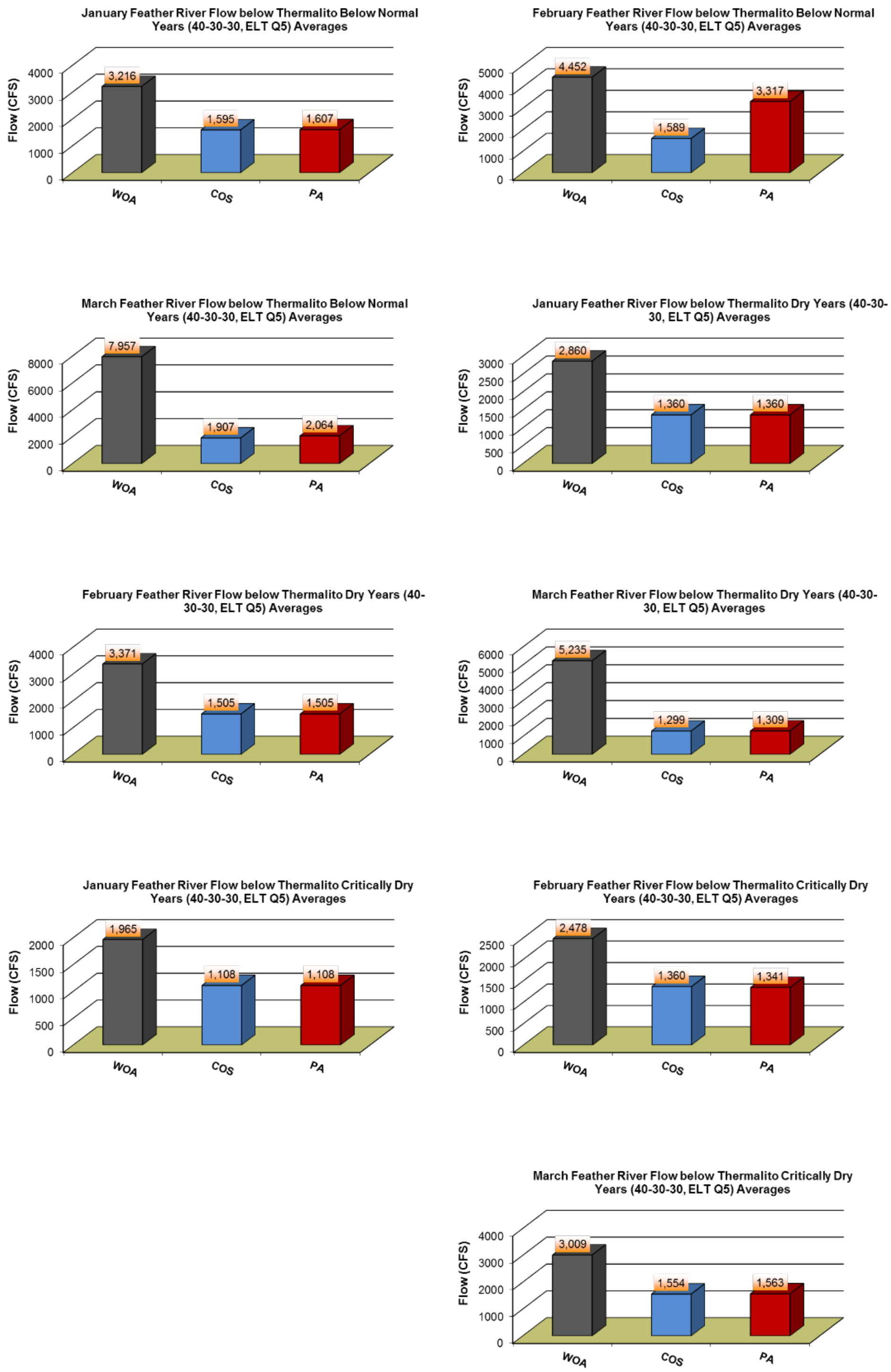


Figure 5.14-11. CalSim II estimates of Feather River flow below Thermalito Afterbay, January through February, for below normal, dry, and critically dry water years under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action) scenarios.

5.14.5.3.6.1.2 Water Temperature Effects

Water temperatures, combined with other environmental drivers, have the potential to heavily influence condition and survival of Fall-run/Late Fall-run Chinook salmon eggs. Exposure to the effects of elevated water temperatures include an inability to satisfy metabolic demand, and acute to chronic physiological stress, eventually leading to egg mortality (Stillwater Sciences 2006, Anderson 2017, Martin et al. 2017). The highest survival rates for Fall-run/Late Fall-run Chinook eggs occur at < 54 °F; water temperatures are stressful to eggs above 56 °F, are lethal above 60 °F, and the upper lethal limit is 62 °F (Stillwater Sciences 2006).

Eggs and emerging fry of Fall-run/Late Fall-run Chinook salmon would be exposed to the effects of water temperature objectives for the Feather River HFC, based on the seasonal occurrence of this life stage in the Feather River (January–April; NMFS 2016), and the timing of the water temperature objectives (year-round objectives; Table 5.14-4). Under WOA, Lake Oroville would not be operated to control storage or flow releases and no conveyance of water to San Luis Reservoir via the Banks Pumping Plant would be made. Therefore, there would be no control of flow or water temperature in the Feather River HFC where Fall-run/Late Fall-run Chinook salmon egg incubation could occur. Resulting water temperatures under the WOA in the Feather River HFC at Gridley Bridge as modeled by the RecTemp temperature model are generally lower during the winter months, and higher during the summer and fall with peak annual water temperatures of approximately 78°F occurring in July and August (Figure 5.14-12).

Table 5.14-4. Maximum Daily Mean Water Temperature for the HFC.

Period	Temperature
January 1 – March 31	56
April 1 – 30	61
May 1 – 15	64
May 16 – 31	64
June 1 – August 31	64
September 1 – 8	61
September 9 – 30	61
October 1 – 31	60
November 1 – December 31	56

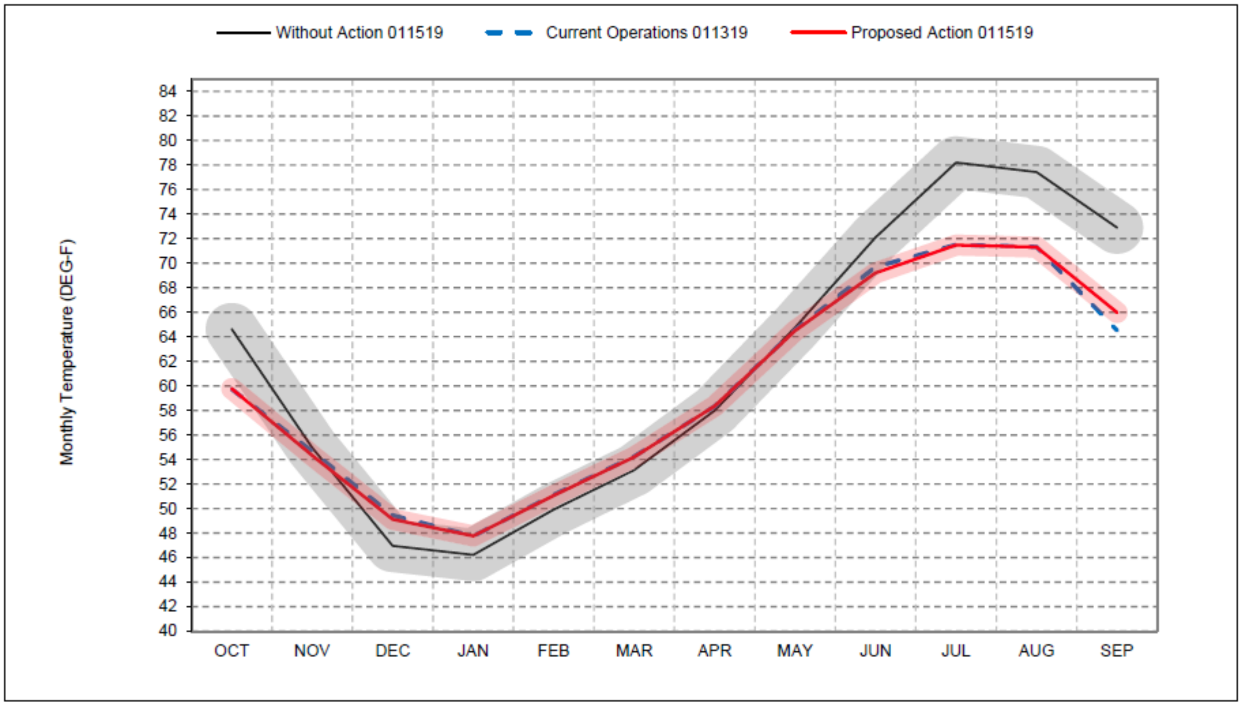


Figure 5.14-12. Long-term average RecTemp estimates of Feather River water temperature at Gridley Bridge under the WOA, COS, and proposed action.

Under the proposed action and COS operations and flow releases would be managed to achieve Feather River HFC water temperature objectives, resulting in water temperatures that are generally lower than those modeled under the WOA from June to October, and water temperatures that are roughly equivalent from November to May. Temperatures at Gridley Bridge under the WOA are slightly lower than water temperatures under the proposed action and COS during January through March, and are roughly equivalent during the month of April (Figure 5.14-13).

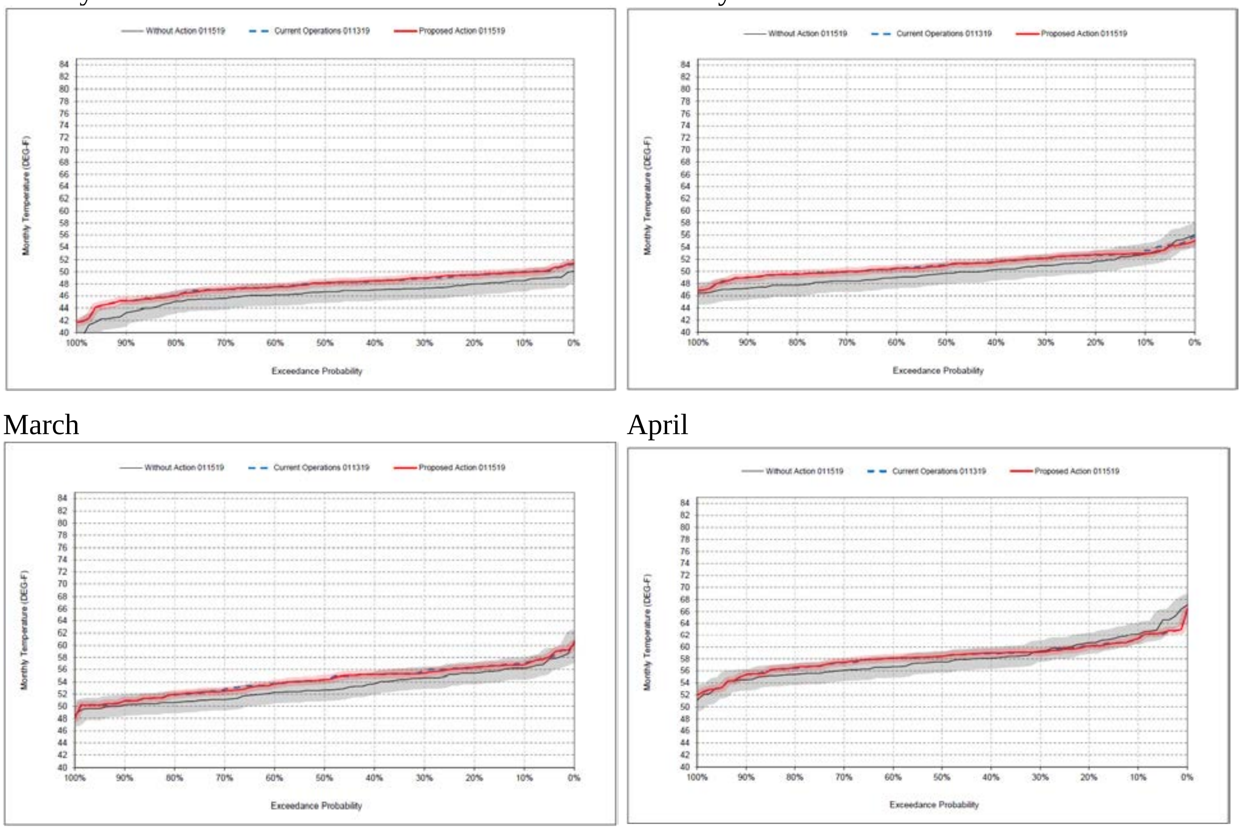


Figure 5.14-13. RecTemp estimates of Feather River water temperature at Gridley Bridge under the WOA, COS, and proposed action for January to April.

Water temperatures at Gridley Bridge under the WOA, COS, and proposed action could fall below 56 °F during the months of January–March, which is within the range of optimal egg development and survival. Water temperatures in April under all three scenarios would range from 56 °F to 60 °F, which is within the chronic to acute stress range. Water temperatures exceeding the objectives and the biological thresholds for this life stage of Fall-run/Late Fall-run Chinook would have adverse impacts on individuals, including acute to chronic physiological stress and increased likelihood of egg mortality. However, RecTemp model output indicates water temperatures projected under the proposed action and COS will increase the likelihood that the April water temperatures would remain below the lethal limit (62 °F) at low exceedance probabilities and that April water temperature objectives are met. As a result, potential adverse effects of water temperature objectives on this life stage are anticipated to be minimized under the proposed action.

5.14.5.3.6.2 Rearing to Outmigrating Juveniles

5.14.5.3.6.2.1 Flow Effects

Rearing to outmigrating juvenile Fall-run/Late Fall-run Chinook salmon would be affected by Oroville Dam releases and resulting flows in the HFC of the Feather River downstream of the Oroville Complex FERC boundary, based on the seasonal occurrence of this life stage in the Feather River (year-round possible with peak abundance January–April and August–November; Table 5.14-1 and Table 5.14-2, NMFS 2016), minimum instream flow requirements in the High Flow Channel of the Feather River (year-round requirements; Table 5.14 -1), and compliance with Water Rights Decision 1641 (D-1641).

Feather River flows below Thermalito Afterbay under – WOA generally approximate or are significantly higher than flows under the proposed action and COS during the peak seasonal timing of Fall-run/Late Fall-run Chinook juvenile rearing (January–April, Figure 5.14-10; August–November, Figure 5.14-11). In particular, flows are reliably higher under the WOA from January to May and in November (Figures 5.14-10 and 5.14-11), lower in August–October, a trend especially pronounced in wetter water year types. The likelihood of flows occurring that are less than the minimum instream flow requirements during these months is very low under all scenarios. Differences in flows between the proposed action and COS are less pronounced than differences between the proposed action and WOA during the January to April and August to November periods.

Lower proposed action flows could have both negative and positive effects on rearing juvenile Fall-run/Late Fall-run Chinook Salmon. Flows can modulate water temperature and DO concentration leading to changes in contaminant toxicity, pathogen virulence, food availability, bioenergetics and disease susceptibility. In addition, river stage and flow velocity may affect habitat connectivity, and availability which in turn may influence food availability, predation, crowding, entrainment and stranding risk, and can potentially affect cues that stimulate outmigration (Windell et al. 2017, Moyle 2002). There can be positive effects of lower flows including lower stranding risk resulting from decreased use of floodplain habitat and lower flow fluctuations, and lower contaminant loading from stormwater runoff. The comparative magnitude of positive and negative effects of lower flows under the proposed action and COS compared to the WOA are difficult to quantify, however, potential adverse effects of the proposed action lower flows from January–April are anticipated to be minimal since projected flows during this period remain well in excess of all applicable minimum instream flows for the Feather River HFC.

5.14.5.3.6.2.2 Water Temperature Effects

Rearing Fall-run/Late Fall-run Chinook salmon would be exposed to the effects of water temperature objectives for the Feather River HFC, based on the seasonal occurrence of this life stage in the Feather River (year-round possible with peak abundance January–April and August–November; Table 5.14-1 and Table 5.14-2, NMFS 2016), and the timing of the water temperature objectives (year-round objectives; Table 5.14-8)..

Water temperatures under WOA in the Feather River HFC at Gridley Bridge are similar to the proposed action and COS water temperatures during the January–April period and significantly higher during the August–November period (Figure 5..14-12). Under the proposed action and COS, operations and flow releases would be managed to achieve Feather River HFC water temperature objectives, resulting in water temperatures that are generally lower than those modeled under the WOA from June to October, and water temperatures that are roughly equivalent from November to May (Figure 5.14-12). Water temperatures at Gridley Bridge under the WOA are the same or lower than water temperatures under the proposed action and COS from January to April, and higher than the proposed action and COS from August to November, which coincides with the peak seasonal timing of rearing Fall-run/Late Fall-run Chinook. The risk of water temperature-related stress and mortality are not present during the January–April period as water temperatures remain well within the optimal range (< 61°F) for this life stage and under the Feather River HFC temperature objectives for these months. The risk of water temperature-related stress under the proposed action and COS are present during the month of August, however water temperatures are significantly lower than under the WOA, which approach lethal levels in August. As a result, potential adverse effects of water temperature objectives on this life stage are anticipated to be less severe under the proposed action, especially during below normal, dry, and critically dry water year types (Figure 5.14-13).

5.14.5.3.6.3 Migrating Adults

5.14.5.3.6.3.1 Flow Effects

Feather River flows below Thermalito Afterbay under the WOA are generally somewhat lower than the proposed action and COS during October and are approximate or are significantly higher than flows under the proposed action and COS during November–March, the peak seasonal timing of Fall-run/Late Fall-run Chinook adult migration (Figure 5.14-10). The likelihood of flows occurring that are less than the minimum instream flow requirements during these months is very low under all scenarios, although some risk exists under the three scenarios in October, November, and January of critically dry years, when flows are less than or are approaching the minimum instream flow requirements (Figure 5.14-11).

Proposed action and COS flows during this period are lower than WOA flows, however, flows are not anticipated to decline below minimum instream flow standards or to a level that results in any increased passage or barrier issues in the Feather River HFC. These adverse impacts of lower flows are generally mitigated by flow increases, but there can be adverse effects of high flows including higher stranding risk resulting from increased use of flood plain habitat and greater flow fluctuations, and higher contaminant loading from stormwater runoff.

Significantly lower proposed action flows in February and March could result in both negative and positive effects on migrating adult Fall-run/Late Fall-run Chinook. Negative effects include a decrease in floodplain and side-channel habitat, degraded foraging conditions, increased competition and predation, higher water temperatures and lower DO, and reduced immigration flows. Positive effects are anticipated to be a lower stranding risk resulting from decrease use of flood plain habitat and less flow fluctuations, and contaminant loading from storm water runoff. The comparative magnitude of positive and negative effects of lower flows under the proposed action and COS to the WOA are difficult to quantify, however, potential adverse effects of lower flows are anticipated to be minimal since projected flows during this period remain well in excess of all applicable minimum instream flows for the Feather River HFC.

5.14.5.3.6.3.2 Water Temperature Effects

Water temperatures, combined with other environmental drivers, have the potential to heavily influence condition and survival of migrating adults. Exposure to the effects of elevated water temperatures can include an increased susceptibility to disease, and physiological stress potentially leading to mortality and altered migration timing and speed. Migrating adult Fall-run/Late Fall-run Chinook require temperatures < 57°F for optimal survival (Marine 1992 as cited in Stillwater Sciences 2006).

Migrating adult Fall-run/Late Fall-run Chinook salmon would be exposed to the effects of water temperature objectives for the Feather River HFC, based on the seasonal occurrence of this life stage in the Feather River (July–April, peak abundance October–March; Table 5.14-1, Table 5.14-2, and NMFS 2016), and the timing of the water temperature objectives (year-round objectives; Table 5.14-3 -2).

Water temperatures in the Feather River from October to March are relatively less influenced by flow releases from Lake Oroville than in summer, given the larger flow volumes, and colder air temperatures during these months. Under the WOA water temperatures in the Feather River HFC at Gridley Bridge l are approximately similar to the proposed action and COS water temperatures from February and March, with small differences projected in November to January and slightly larger differences projected in October (Figure 5.14-12).

Under the proposed action and COS operations and flow releases would be managed to achieve Feather River HFC water temperature objectives, resulting in water temperatures that are generally lower than those modeled under the WOA from June to October, and water temperatures that are roughly equivalent from November to May. Water Temperatures at Gridley Bridge under the proposed action and COS are the same or slightly higher than water temperatures under the WOA from November to March and lower than the WOA in October, which coincides with the peak seasonal timing of migrating adult Fall-run/Late Fall-run Chinook salmon. The risk of water temperature-related stress and mortality are low during this period as water temperatures are projected to be within the optimal range (<57 °F) for this life stage from November to March; water temperatures under the proposed action and COS are slightly above the optimal range in October, however, are significantly less than under the WOA (Figure 5.14-12). As a result, potential adverse effects of water temperature objectives on this life stage are anticipated to be less severe under the proposed action relative to WOA, especially during below normal, dry, and critically dry water year types (Figure 5.14-13).

5.14.5.3.7 American River Seasonal Operations (includes 2017 FMS and "planning minimum")

5.14.5.3.7.1 Egg to Fry Emergence

For lower American River flows (below Nimbus Dam), Reclamation proposes to adopt the minimum flow schedule and approach proposed by the Water Forum in the 2017 Flow Management Standard (FMS) as part of the proposed action. The 2017 FMS includes a Minimum Release Requirement (MRR) with flows that range from 500 to 2000 cfs based on time of year and annual hydrology. The objective of the planned minimum is to preserve storage to protect against future drought conditions and to facilitate the development of the cold water pool when possible and improve habitat conditions for steelhead and fall-run Chinook Salmon in the lower American River. In addition, redd dewatering protective adjustments were included in the 2017 FMS to limit potential redd dewatering due to reductions in the MRR during the January through May period coincident with the embryo incubation period for Fall-run/Late Fall-run Chinook Salmon.

The embryo incubation and alevin development period for Fall-run/Late Fall-run Chinook Salmon follows the October through March spawning period (peaking in Nov through September) (Table 5.14-1 and Table 5.14-2), with fry emerging from the gravel from late December to March. This period coincides with the timing of this proposed action, and would likely directly benefit this life stage. The implementation of the proposed 2017 FMS measures under the proposed action would provide suitable habitat conditions in the lower American River tailored for Chinook Salmon and Steelhead, particularly during drought conditions and improve conditions for this life stage relative to WOA.

5.14.5.3.7.2 Rearing to Outmigrating Juveniles

The 2017 FMS under the proposed action also includes the provision for spring pulse flows, with the purpose to provide a juvenile salmonid (fall-run Chinook Salmon and steelhead) emigration cue before relatively low flow conditions and associated unsuitable thermal conditions later in the spring in the river, and downstream in the lower Sacramento River. The 2017 FMS should provide a pulse flow event at some time during the period extending from March 15 to April 15 by supplementing normal operational releases from Folsom Dam under certain conditions when no such flow event has occurred between the preceding February 1 and March 1 time frame. Fall-run/Late Fall-run Chinook Salmon exhibit a stream-type life history where excessively high water temperatures have been identified as one of the factors threatening Fall-run/Late Fall-run Chinook Salmon in the Central Valley and a factor for listing of the species (NMFS 2014). The 2017 FMS under the proposed action also includes water temperature objectives that would provide suitable temperatures for juveniles by maintaining water temperatures below 65°F from mid-May to mid-October. The implementation of the proposed 2017 FMS measures would provide suitable habitat conditions in the lower American River and for Fall-run/Late Fall-run Chinook Salmon, particularly during drought conditions and improve conditions for this life stage.

5.14.5.3.7.3 Adult Migration from Ocean to Rivers

Adult Fall-run/Late Fall-run Chinook Salmon enter freshwater beginning in July, peak in October through December, and are present until about February 1 (Table 5.14-1 and 5.14-2). Adults hold primarily in deep cold pools in proximity to spawning areas or below the dam or weir until they are sexually mature and ready to spawn (CDFG 1998; NMFS 2009). Excessively high water temperatures has been identified as one the factors threatening Fall-run/Late Fall-run Chinook Salmon and a factor for considering listing of the species, particularly in the adult immigration and holding life stage (NMFS 2014). In addition to the MRR flows, the 2017 FMS under the proposed action also includes the following water temperature objectives to provide suitable temperatures for salmonids:

- 60°F or less by October 1 to provide suitable conditions for fall-run Chinook holding and early spawning,

Although the Folsom coldwater pool is generally insufficient to meet water temperature objectives, the implementation of the 2017 FMS under the proposed action would provide more suitable habitat conditions in the lower American River for Fall-run/Late Fall-run Chinook Salmon relative to WOA, particularly during drought conditions.

5.14.5.3.7.4 Adult Holding in Rivers

Fall-run Chinook Salmon experience egg retention or pre-spawning mortality in the American River in most years when water temperatures in the fall holding period are sub-optimal. During 1993 to 2017 the proportion of unspawned adults ranged from 3% to 67% and averaged 20% and the proportion that retained some eggs (greater than 30% egg retention) ranged from 6% to 80% with and average of 33% (Figure 5.14-14). The American River has the highest level of pre-spawning mortality for Fall-run/Late Fall-run Chinook Salmon measured for any river in the Central Valley. Effects for adult holding would be the same as for migrating adults, discussed above. The proposed action strives to provide conditions more conducive to successful spawning and would benefit adults holding in the American River.

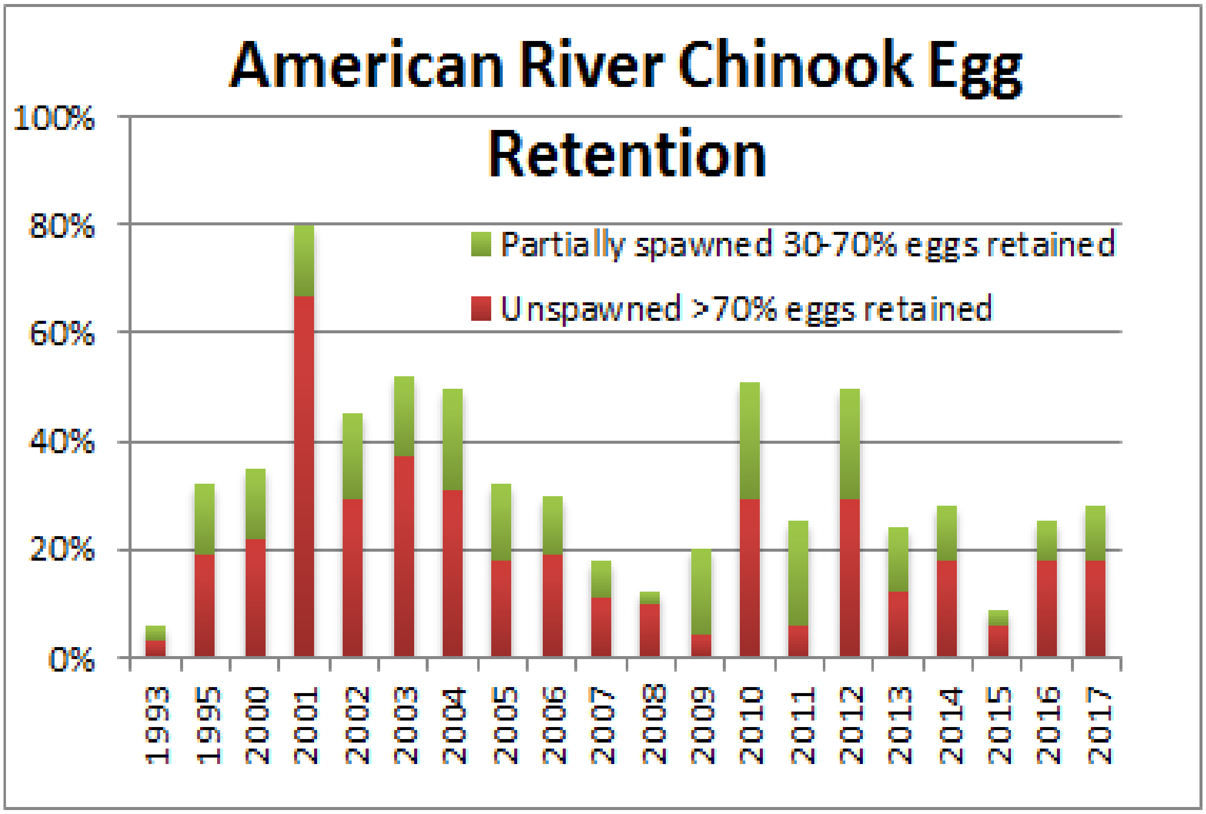


Figure 5.14-14. American River Chinook Salmon egg retention. Egg retention refers to eggs left unspawned in female carcasses.

5.14.5.3.8 Stanislaus River Stepped Release Plan

5.14.5.3.8.1 Eggs to Fry Emergence

Fall-run Chinook Salmon eggs, alevin and/or fry are found throughout most of the Stanislaus River from Goodwin Dam downstream to Oakdale. Under WOA conditions, the lower level river outlets of New Melones would be closed to preserve the integrity of the gate structure and the Flood Control and Industrial gate would be set fully open and assumed to pass a flow of approximately 8,000 cfs. Inflow exceeding this capacity would be stored in New Melones until the releases capacity could physically evacuate the water. If necessary, the spillway would be used to prevent overtopping of the New Melones Dam and protecting the structural integrity of the New Melones Dam and related facilities. This spillway is not gated and would naturally flow should the reservoir reach that height. This would result in Fall-run/Late Fall-run Chinook Salmon distribution being similar to current conditions as Goodwin Dam would still represent a total barrier to further upstream migration. Water temperatures under the WOA scenario within the Stanislaus River would represent those of uncontrolled flows coming off the western Sierra Nevada that travel through the CVP storage and conveyance facilities on the Stanislaus River that would be operated only to the extent necessary to fulfill non-discretionary duty to ensure their continued existence. Operations of non-CVP facilities would still occur as they are occurring today. Modeled flows associated with this scenario below Goodwin Dam are depicted below.

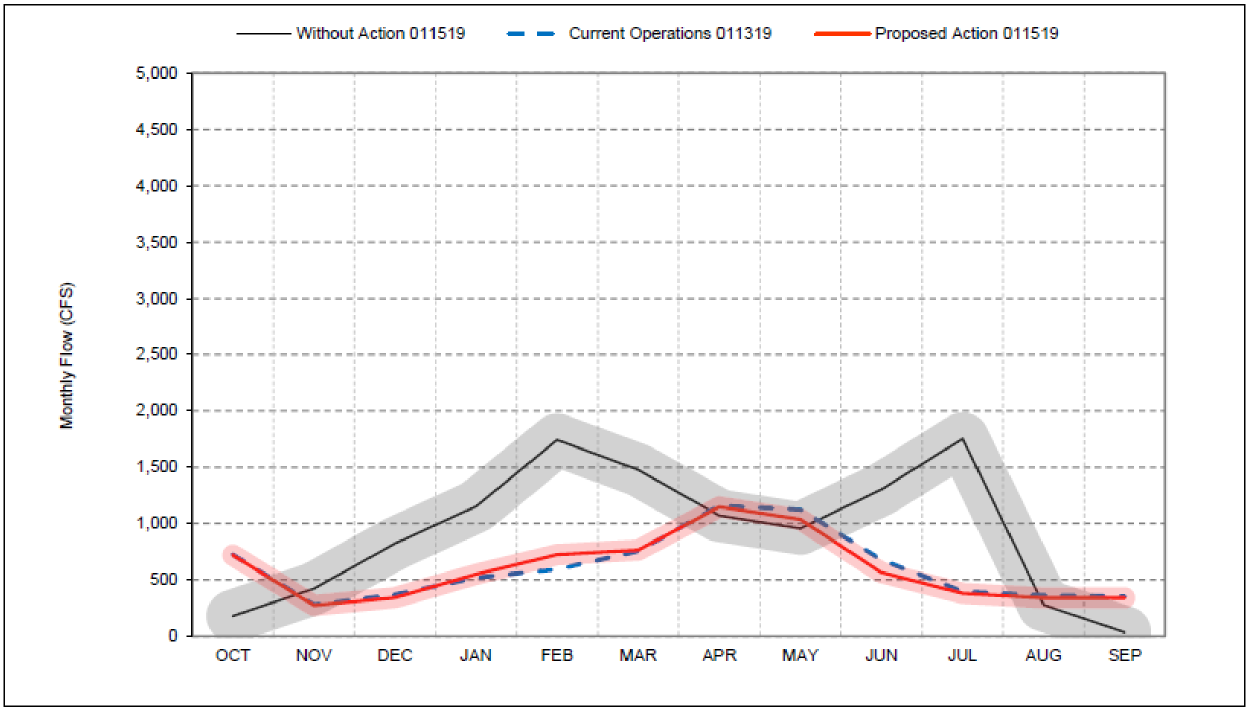


Figure 5.14-15. Stanislaus Modeled Flows. Long-Term-Average Modeled flows under WOA, COS and proposed action Scenario in the Stanislaus River Below Goodwin Dam

Current operations within the Stanislaus River are managed according to the 2008 USFWS BO, the 2009 NMFS BO, COA, and the New Melones Interim Plan of Operations (IPO).

Current operations of New Melones Dam under the IPO, which has been in effect since 1997, were developed prior to completion of current tools to understand hydrology in the Stanislaus River Basin, and the water delivered from New Melones was overallocated in many years and was not able to consistently meet requirements for fish flows, water temperature, water quality, dissolved oxygen, and water deliveries.

Under the proposed action, Reclamation proposes to implement the New Melones Stepped Release Plan to create a sustainable operation on the Stanislaus River that strives to meet requirements for fish flows, temperature, water quality, dissolved oxygen, and water deliveries. The Draft Stepped Release Plan incorporates up-to-date information about hydrology in the basin and is based on recent versions of CalSim modeling.

An attraction flow in October would be provided each year and assist in upstream migration of Fall-run Chinook Salmon. Attraction flows would be maintained at 200 cfs through the November-December spawning period. This is slightly less than the optimal 300 cfs spawning flow but would maintain Fall-run Chinook Salmon populations. Egg incubation during November to February would occur under suitable water temperature and flow conditions at most times. During dryer years water temperature in October and November would be above suitable at times but proposed action water temperatures would be cooler than WOA and COS so the proposed action would generally improve incubation success.

5.14.5.3.8.2 Rearing to Outmigrating Juveniles

The NMFS' *Recovery Plan for Central Valley Chinook Salmon and Steelhead* (NMFS 2014) identifies recovery actions on the Stanislaus River. These actions include managing flow releases to provide suitable water temperatures and flows for all steelhead life stages, and the Stepped Release Plan would improve the ability to manage water temperatures in droughts. The plan also identifies the need to evaluate whether pulse flows are beneficial to adult steelhead immigration and juvenile steelhead emigration.

The stepped operation plan under the proposed action includes spring flows during April and May intended to improve juvenile rearing and outmigration survival. These flows occur earlier than the natural flows under WOA. The earlier flows are beneficial in providing a way for juveniles to get out through the lower San Joaquin River and Delta before water temperatures become unsuitable later in the spring to summer.

5.14.5.3.8.3 Adult Migration from Ocean to Rivers

The attraction flows under the stepped release plan are timed to assist with Fall-run/Late Fall-run Chinook immigration. Flows of about 750 cfs or higher attract high numbers of Fall-run Chinook Salmon into the Stanislaus River, including many strays from other rivers. A partial barrier to Fall-run Chinook Salmon exists in Goodwin Canyon where early migrating Chinook hold over the summer. When the fall attraction flows occur Chinook are able to pass this area more quickly and reach habitats near Goodwin Dam. The area near Goodwin Dam provides cooler water earlier in the fall, conducive to successful spawning.

5.14.5.3.8.4 Adult Holding

Fall-run Chinook Salmon Adults hold in the Stanislaus River from summer for early running Chinook up until spawning in October. Generally water temperatures would be suitable most years in the upper portions of the river at Knights Ferry and above for the proposed action scenarios and the COS and unsuitable under WOA. A key holding location is in the Goodwin Canyon area for the early running Fall-run Chinook salmon and as noted above the fall pulse flow provides a cue and ability for the fish to distribute to suitable spawning areas. The proposed action is generally cooler than COS which as a benefit to adult survival during holding prior to spawning.

5.14.5.3.9 <u>Alteration of Stanislaus River Dissolved Oxygen Requirement</u>

5.14.5.3.9.1 Eggs to Fry Emergence

Fall-run Chinook Salmon eggs, alevin and/or fry are found throughout most of the Stanislaus River from Goodwin Dam downstream to Oakdale. Under WOA, flow would be uncontrolled through the CVP project facilities and fish distribution would be similar to current operations as Goodwin Dam would represent a significant barrier to further upstream migration but the warm fall water temperatures would not be conducive to high survival. Current operations are required to meet a year-round dissolved oxygen minimum of 7 mg/L, which was introduced in an effort to protect salmon, steelhead, and trout in the river (CDFW 2018). However, maintaining dissolved oxygen concentrations above 7 mg/L in the Stanislaus River at Ripon is challenging during drought conditions, and, based on studies of juvenile distribution and abundance, does not appear to be warranted to protect salmonids in the Stanislaus River (Kennedy and Cannon 2005, Kennedy 2008).

Reclamation currently operates to a 7.0 mg/L dissolved oxygen requirement at Ripon from June 1 to September 30. Reclamation proposes to move the compliance location to Orange Blossom Bridge, where the species (steelhead) are primarily located at that time of year. Based on multi-year observations of salmonid abundance in the River Kennedy and Cannon (2005) and Kennedy (2008) found that over-summering juvenile salmonids are primarily found upstream of Orange Blossom Bridge, which is approximately 31 miles upstream from Ripon. Dissolved oxygen monitoring at the Stanislaus River Weir (approximately 15 miles upstream from Ripon) indicates that dissolved oxygen concentrations can be 0.5-1 mg/L higher at this location than those measured at Ripon (Cramer Fish Sciences 2006a-d). Because the fish are located primarily at least twice this distance upstream from Ripon, the dissolved oxygen concentration is likely to be at this level or higher where the majority of these fish occur. The majority of Fall-run Chinook Salmon eggs, alevin and/or fry are found in locations where summer dissolved oxygen levels would be expected to be maintained at or near 7 mg/L, although no eggs, alevin, or fry are present in the river in the summer.

5.14.5.3.9.2 Rearing to Outmigrating Juveniles

As discussed above, as the majority of juvenile Fall-run Chinook Salmon are found in locations where summer dissolved oxygen levels would be expected to be maintained at or above 7 mg/L.

Additionally, as juvenile fall run Chinook are outmigrating from January through the end of June (Zerg et al, 2014), there would be no individual- or population-level effects from this element on this life stage.

5.14.5.3.9.3 Adult Migration from Ocean to Rivers

Based on the typical seasonal occurrence of this life stage in the River (July to October), adult migrating Chinook Salmon would be expected to be exposed to the effects of the relaxation of dissolved oxygen requirements at Ripon. During low flow periods in the Stanislaus River there could be delay of adults migrating up the Stanislaus River if dissolved oxygen is too low.

5.14.5.3.10 Delta Seasonal Operations including OMR Management

Hydrodynamic changes associated with river inflows and South Delta exports under the proposed action have been suggested to adversely affect juvenile Chinook Salmon in two distinct ways: 1) “near-field” mortality associated with entrainment to the export facilities, 2) “far-field” mortality resulting from altered hydrodynamics.

5.14.5.3.10.1 Entrainment

Zeug and Cavallo (2014) analyzed > 1000 release groups representing, more than 28 million coded wire tagged juvenile fish including winter, Fall-run/Late Fall-run Chinook Salmon. The average proportion Sacramento River-origin Fall-run Chinook salvaged over a 15-year period was 0.0001 and the proportion of mortality accounted for by entrainment averaged 0.0003 (Zeug and Cavallo 2014). Salvage increased with increasing exports but loss never exceeded 1% regardless of export rate. Late Fall-run Chinook Salmon juveniles were salvaged at a higher rate than any other race (0.02% of each release group) and entrainment related mortality accounted for almost 1% of total mortality on average (Zeug and Cavallo 2014). Proportional loss of Late-Fall Chinook salmon remained low until exports exceeded ~9,000 cfs when proportional loss could approach 8% (Zeug and Cavallo 2014). Average total exports for months when Fall-run/Late-Fall run Chinook Salmon juveniles are present in the Delta indicate zero entrainment risk for WOA. In the December through February period when Late-Fall run are most abundant, the proposed action proposes an average total export rate slightly higher than COS (366 cfs; Figure H-1 – Appendix H, *Bay-Delta Aquatics Effects Figures*) and will therefore have a similar entrainment risk. Total exports proposed for the proposed action in March-June (1,699 cfs higher than COS; Figure H-2 –

Appendix H, *Bay-Delta Aquatics Effects Figures*) when juvenile Fall-run/Late Fall-run Chinook Salmon are most abundant in the Delta, will increase entrainment risk relative to COS, but entrainment losses for Fall-run/Late Fall-run Chinook Salmon will be low relative to total population. Entrainment risk will also increase for Late-Fall run and losses will likely be higher relative to Fall-run Chinook salmon.

Zeug and Cavallo (2014) analyzed salvage of 313 releases totaling more than 7,000,000 San Joaquin River-origin juvenile Fall-run juvenile Chinook Salmon. Salvage of Fall-run Chinook originating from the San Joaquin River averaged 1.4% and increased with export rate at the CVP and SWP (Zeug and Cavallo 2014). However, there were few observations at export rates greater than 3,000 cfs. Average mortality at the facilities represents < 5% total juvenile mortality for San Joaquin River-origin populations but can range as high as 17.5% (Zeug and Cavallo 2014). Average total exports for months when Fall-run Chinook Salmon juveniles are present in the Delta indicate zero entrainment risk for WOA. In the December through February period the proposed action proposes an average total export rate slightly higher than COS (366 cfs; Figure H-1 – Appendix H, *Bay-Delta Aquatics Effects Figures*) and will, therefore, have a similar to slightly higher entrainment risk. Total exports proposed for the proposed action in March-June (1,699 cfs higher than COS; Figure H-2 – Appendix H, *Bay-Delta Aquatics Effects* Figures) when juvenile Fall-run Chinook Salmon are most abundant in the Delta, will increase entrainment risk relative to COS. Recent acoustic studies of juvenile Fall-run Chinook Salmon in the San Joaquin River revealed that when the HORB is out, >60% of fish detected at Chipps Island came through CVP, indicating that salvage is a higher survival route than volitional migration.

As shown by the following figures, CVP and SWP Fish Facilities salvage between 0 and 140,000 Fall-run Chinook salmon annually, and between 0 and 450 Late Fall-run Chinook salmon annually. As indicated above, under the proposed action exports are expected to increase compared to both WOA and COS, and so salvage and entrainment would also be expected to increase. However, salvage may be a higher survival route than through the San Joaquin River.

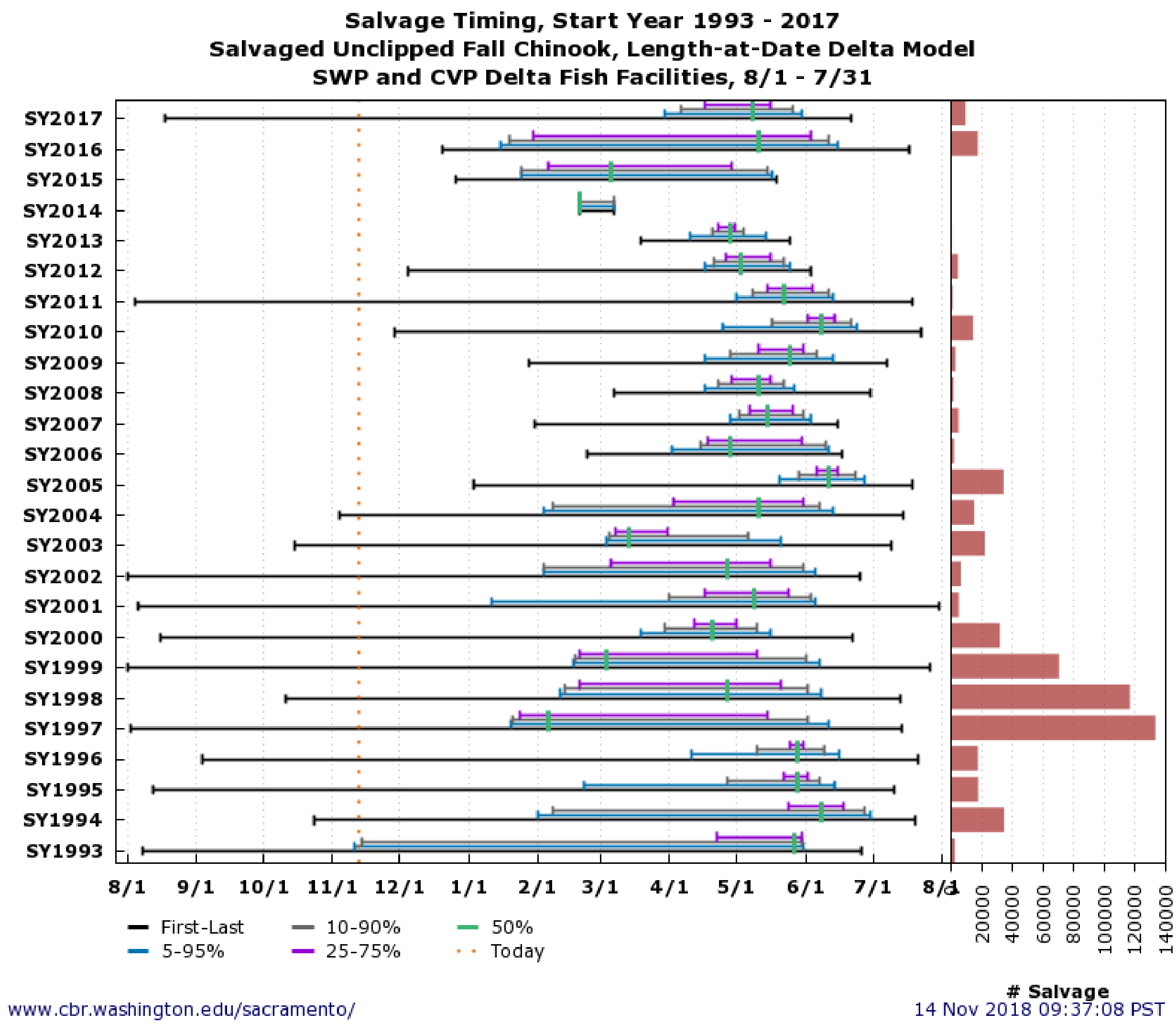


Figure 5.14-16. Fall-run Chinook Salmon Salvage, 1993-2017

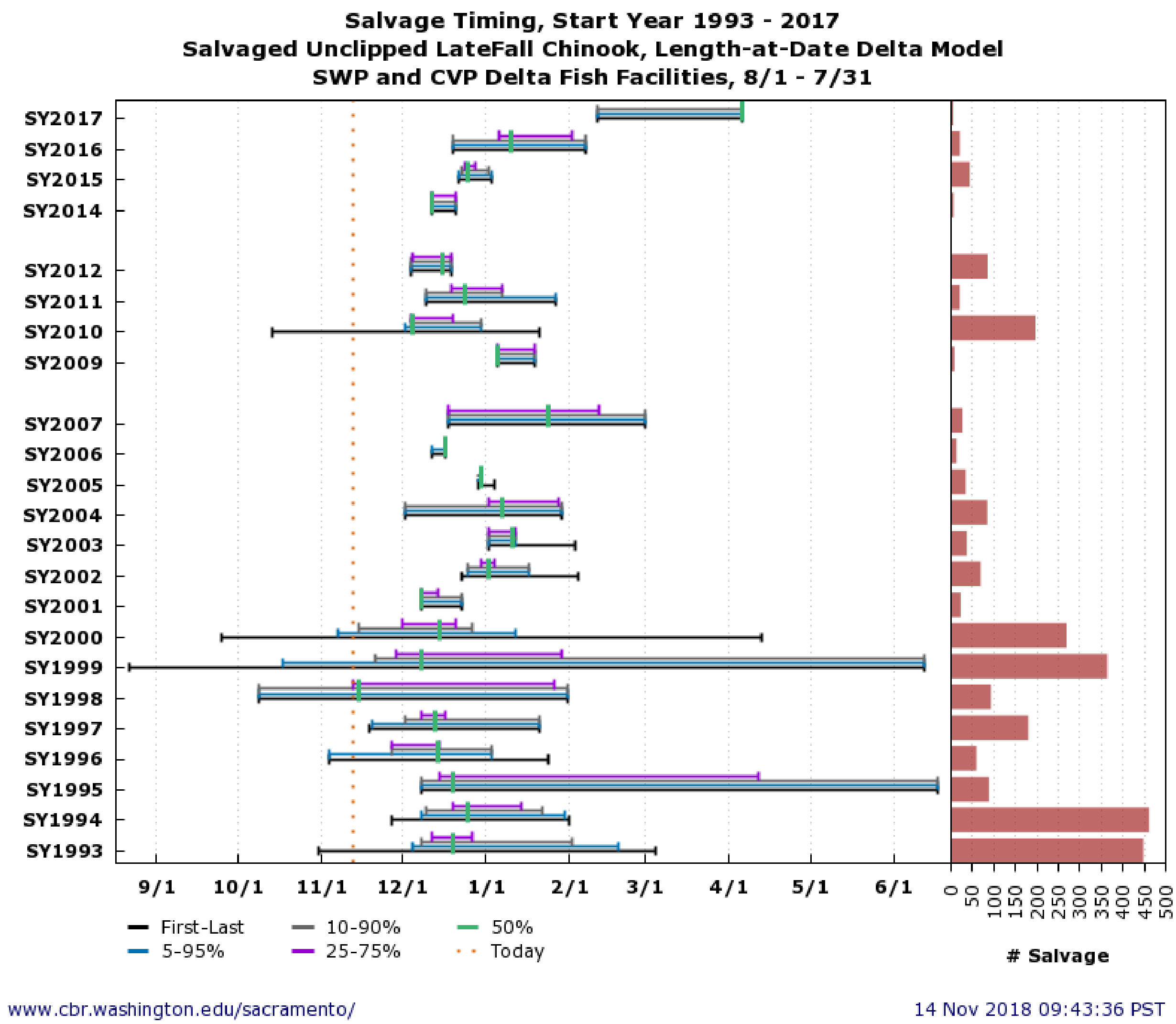


Figure 5.14-17. Late Fall-run Chinook Salmon Salvage, 1993-2017

5.14.5.3.10.2 Routing

Routing of juvenile Chinook Salmon into alternative migration routes is closely related to hydrodynamics (Perry et al. 2015; Cavallo et al. 2015; Steel et al. 2012). Changes to hydrodynamics in Delta channels resulting from the proposed action were evaluated using DSM2 as described above. Juvenile Fall-run Chinook Salmon abundance in the Delta is greatest between February and May and Late-Fall run are present in the Delta between November and July with peaks in January-February and April-May (Tables 5.14-1 and 5.14-2). In the December through February period, velocity overlap between the proposed action and COS in the Sacramento River main stem between the Sutter-Steamboat and DCC/Georgiana Slough Junctions, was >50% in all water year types (Figure H-3 – Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocities were higher under the proposed action in all water year types indicating routing into the interior Delta would be lower relative to COS (Perry et al. 2015). Comparing the proposed action to WOA in the Dec-Feb period revealed velocity overlap <50% in Dry, Above Normal and Wet years and <60% in Critical and Below Normal years (Figure H-4 – Appendix H, *Bay-Delta Aquatics Effects Figures*) with higher velocities in the WOA in all water year types. This pattern indicates routing into the interior Delta would be lower under WOA relative to the proposed action or COS (Perry et al. 2015). In the March to May period comparison of the proposed action and COS revealed similar patterns of velocity overlap as described for the December-February period (Figure H-5 – Appendix H, *Bay-Delta Aquatics Effects Figures*) indicating routing into the interior Delta would be lower under the proposed action during March-May. Comparing the proposed action with the WOA in March-May revealed low overlap in Sacramento main stem velocities between the Steamboat-Sutter Junction and the DCC-Georgiana Slough junction (Figure H-6 – Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocities were higher under the WOA indicating routing into the interior Delta under WOA would be lower than the proposed action or COS.

Fall–run and Late-Fall run juveniles originating from the Sacramento River that enter the interior Delta via Georgiana Slough and the Delta Cross Channel can be exposed to hydrodynamic project effects that could affect routing. Once these fish arrive at the junction of the Mokelumne River and the San Joaquin River, they can move south toward the export facilities or west toward the ocean. In the December-February period analysis of DSM2 data indicates that there is little change to velocities in the region of the junction of the Mokelumne and San Joaquin Rivers between the proposed action and both the COS and the WOA scenarios (Figures H-7 and H-8 – Appendix H, *Bay-Delta Aquatics Effects Figures*). Similar results were obtained when comparing the proposed action to COS and WOA in the March to May period (Figures H-9 and H-10 – Appendix H, *Bay-Delta Aquatics Effects Figures*).

Routing of juvenile Chinook Salmon into alternative migration routes is closely related to hydrodynamics (Perry et al. 2015; Cavallo et al. 2015; Steel et al. 2012). Changes to hydrodynamics in Delta channels resulting from the proposed action were evaluated using DSM2 as described above. When Fall–run Chinook salmon juveniles originating from the Mokelumne River arrive at the junction of the Mokelumne River and the San Joaquin River, they can move south toward the export facilities or west toward the ocean. In the December-February period analysis of DSM2 data indicates that there is little change to velocities in the region of the junction of the Mokelumne and San Joaquin Rivers between the proposed action and both the COS and the WOA scenarios (Figures H-7 and H-8 – Appendix H, *Bay-Delta Aquatics Effects Figures*). Similar results were obtained when comparing the proposed action to COS and WOA in the March to May period (Figures H-9 and H-10 – Appendix H, *Bay-Delta Aquatics Effects Figures*).

Juvenile Fall-run Chinook Salmon are present in the Mossdale Trawl between January and June with a peak between February and May (Table 5.14-1). Early studies using coded wire tags indicated that survival of San Joaquin River-origin juvenile Chinook Salmon was lower in the Old River Route relative to the San Joaquin main stem (Newman 2008). This finding led to strategies designed to keep larger proportions of fish in the San Joaquin River main stem including the Head of Old River rock barrier and non-physical barriers. Recent studies using acoustic technology have indicated that differences in survival among the two routes are not significant (Buchanan et al. 2013; Buchanan et al. 2018). Thus, fish that enter Head of Old River are unlikely to experience reduced survival. In the December-February period, velocity overlap between proposed action and COS at the Head of Old River was >89% in Critical, Dry, and Below Normal years, >72% in Wet years, and >53% in Above Normal years (Figure H-7 – Appendix H, *Bay-Delta Aquatics Effects Figures*). When proposed action was compared to WOA in the December-February period, velocity overlap was >50% in Critical and Dry years and >10% in all other water year types (Figure H-8 – Appendix H, *Bay-Delta Aquatics Effects Figures*). In the March-May period, velocity overlap patterns were similar to comparisons in the December-February period (Figures H-9 and H-10 – Appendix H, *Bay-Delta Aquatics Effects Figures*).

Fall–run Chinook Salmon originating from the San Joaquin River that remain in the San Joaquin River main stem at the Head of Old River are exposed to additional junctions that lead into the interior Delta including; Turner Cut, Columbia Cut, Middle River, Old River, Fisherman's Cut and False River. In the December-February period analysis of DSM2 data indicates that there is little change to velocities in the region of the junctions with San Joaquin Rivers between the proposed action and both the COS and the WOA scenarios (Figures H-7 and H-8 – *Appendix H, Bay-Delta Aquatics Effects Figures*). Similar results were obtained when comparing the proposed action to COS and WOA in the March to May period (Figures H-9 and H-10 – Appendix H, *Bay-Delta Aquatics Effects Figures*).

5.14.5.3.10.3 Through Delta Survival

Comparing between proposed action and WOA (Figure H-12 – Appendix H, *Bay-Delta Aquatics Effects Figures*), overlap in changes in velocity distributions were lower for each water year type (37.3 – 68.3%) with higher velocities under WOA relative to proposed action. At Steamboat Slough, when the proposed action was compared to WOA, overlap was moderate to high with values between 42.6% and 72.6 % (Fig H-14 – Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocities were higher under the WOA in all water year types (Figure H-14 – Appendix H, *Bay-Delta Aquatics Effects Figures*).

In the March through May period at Walnut Grove, when proposed action was compared to WOA in the March through May period, velocity overlap was variable among water year types from a low of 14.1% in Wet years to 56.9% in Critical years (Figure H-16 –Appendix H, *Bay-Delta Aquatics Effects Figures*). In all water year types, velocities were greater under the WOA relative to the proposed action. At Steamboat Slough in the March through May period, velocity overlap was lower when proposed action was compared to WOA (Figure H-18 – Appendix H, *Bay-Delta Aquatics Effects Figures*). The lowest value occurred in Wet years (19.1%) and highest in Critical years (69.5%).

A recent study by Perry et al. (2018) found that the effect of flow on survival is not uniform throughout the Delta. Relationships between flow and survival were significant only in reaches where flow changes from bi-directional to unidirectional when discharge increases. During the December to February period at the San Joaquin River at Highway 4, velocity distributions for proposed action relative to WOA exhibited velocity overlap decrease in all water year types, with higher velocities under WOA (Figure H-20 – Appendix H, *Bay-Delta Aquatics Effects Figures*). Overlap values ranged from a low of 59.6% in Wet years to 83.4% in Critical years (Figure H-20 – Appendix H, *Bay-Delta Aquatics Effects Figures*). At the Head of Middle River during the December-February period, overlap was low between the proposed action and WOA in all water year types (≤34.9%) with higher velocities under WOA (Figure H-22 – Appendix H, *Bay-Delta Aquatics Effects Figures*).

Spring flow pulses descibed in the PA to achieve flows >9100 cfs at Wilkins would also provide benefits to spring run in the Delta. Spring run in the Delta would experince greater survival as flow magnitude increases from the flow pulse passing through the Delta (Perry et al. 2018). Spring run Chinook Salmon are in high and moderate abundance in the Delta during the time period when the spring flow pulses are proposed.

In the March-May period in the San Joaquin River at Highway 4, there was high overlap in Critical years (92.8%) between the proposed action and WOA. In other water year types, overlap ranged between 54.5% in Wet years to 78.6% in Dry years with higher velocities under the WOA (Figure H-24 – Appendix H, *Bay-Delta Aquatics Effects Figures*). Comparison of the proposed action with WOA in March-May at Head of Middle River revealed overlap >50% in Critical years and overlap <35% in all other water year types (Figure H-26 – Appendix H, *Bay-Delta Aquatics Effects Figures*). In all water year types, velocities were higher under the WOA relative to the proposed action.

5.14.5.3.11 Delta Cross Channel

5.14.5.3.11.1 Rearing to Outmigrating Juveniles in the Bay-Delta

The Delta Cross Channel may be closed for up to 45 days from November through January for fishery protection purposes. From February 1 through May 20, the gates are closed for fishery protection purposes. The gates may also be closed for 14 days from May 21 through June 15 for fishery protection purposes.

The peak migration of juvenile Fall-run Chinook Salmon in the Sacramento River past West Sacramento, which is near the DCC, occurs from February through May (Table 5.14-1). Therefore, the DCC is closed for the majority of the juvenile Fall-run Chinook migration period in the Sacramento River and as such, the proportion of fish exposed to an open DCC would be low. Juvenile Fall-run which are entrained into an open DCC and transported to the interior Delta have reduced survival (Perry et al. 2010). Since the proportion of juvenile Fall-run Chinook salmon exposed to an open DCC would be low the potential negative effects of DCC operation would be low.

5.14.5.3.11.2 Adult Migration

The status of the DCC gates, open or closed, affects ability of Fall-run and Late Fall-run Chinook Salmon to migrate to their river of origin. Attraction flows from the Mokelumne River are often low, resulting in an open DCC path allowing salmon to stray to the Sacramento River and spawn in Sacramento River tributaries. This is hypothesized to result in lower Mokelumne escapement than would otherwise occur and increased homogenization of Fall-run Chinook salmon. No change in DCC operations in the Fall-run or Late Fall-run Chinook salmon adult migration season (August-October) are planned so effects would be unchanged from the current condition. Reclamation proposes to improve the DCC gates to enable a more real time operation to occur. This has potential to improve conditions for migrating adults in the future.

5.14.5.3.12 Agricultural Barriers

Under the proposed action, Middle River and Old River near Tracy can begin operating as early as April 15 but the tide gates are tied open from May 16 to May 31. After May 31, the barriers in Middle River, Old River near Tracy, and Grant Line Canal are permitted to be operational until they are completely removed by November 30.

The proportion of juvenile Fall-run Chinook salmon exposed to the agricultural barriers depends on their annual timing of installation and removal. Due to their location, primarily migrants originating from the San Joaquin River would be exposed to the agricultural barriers. The peak relative abundance of juvenile Fall-run Chinook salmon in the Delta at Mossdale is February through May (Table 5.14-1). If the agricultural barriers are operating as early as April 15 then they have the potential to expose a large proportion of the juvenile Fall-run Chinook salmon migrating down the San Joaquin River. When the Head of Old River barrier is not in place, which it is not under the proposed action, acoustically tagged juvenile Chinook Salmon have demonstrated a high probability of selecting the Old River route (Buchanan 2018), which would expose them to the agricultural barriers. When the agricultural barriers are operating with tidal flap gates down, a significant decline in passage and reach survival of acoustically tagged juvenile Fall-run Chinook Salmon migrating past the barrier has been observed compared to when the barrier is not present (DWR 2018). When flap gates are tied up, Chinook Salmon passage past the agricultural barrier was improved (DWR 2018). Flap gates tied up on agricultural barriers from May 16 to May 31 would help to reduce the negative effect of the barriers during this period. However, juveniles migrating before or after this period could be exposed to the agricultural barriers with flaps down which apparently decreases passage success and survival (DWR 2018). Therefore, the potential negative effects of the agricultural barriers depends on when they are installed and whether the flap gates are down or tied up but overall would be medium to high.

5.14.5.3.13 Contra Costa Canal Rock Slough Intake

As discussed in Section 4.9.5, CCWD's operations in the proposed action are consistent with the operational criteria specified in separate biological opinions and permits that govern operations at CCWD's intakes and Los Vaqueros Reservoir (NMFS 1993; NMFS 2007; NMFS 2010; NMFS 2017; USFWS 1993a; USFWS 1993b; USFWS 2000; USFWS 2007; USFWS 2010; USFWS 2017; CDFG 1994; CDFG 2009). Therefore, the operation of the Rock Slough Intake for the Proposed Action remains unchanged from the COS.

The Contra Costa Canal Rock Slough Intake is located on a dead-end slough, far from the main migratory route for Fall-run/Late Fall-run, approximately 10 miles from the San Joaquin River and 18 miles from the Sacramento River via the shortest routes. Three life stages (fry, juveniles, and adults) of Fall-run/Late Fall-run Chinook Salmon can be present in the Delta at various times. A portion of the Fall-run Chinook salmon fry population (length-40 to 50 mm) migrates downstream soon after emergence where they rear in the lower Delta river channels and Suisun Bay during the spring. These Fall-run Chinook salmon fry enter the estuary in January and peak in abundance in February and March. Juvenile Fall-run Chinook Salmon (length-80 to 90 mm long) can be in the Delta from Apri1–early June and adult Fall-run Chinook Salmon are in the Delta during late summer and fall (approximately late June–early December). Late Fall-run juveniles can be in the Delta Rock Slough from April–June and adults migrate from October–April (Reclamation 2016).

Fish monitoring prior to the construction of the RSFS indicates the timing and magnitude of CV Fall-run/Late Fall-run presence near the Rock Slough Intake. From 1999-2009, the 11 years prior to construction of the RSFS, CCWD's Fish Monitoring Program collected a total of 18 CV Fall-run/Late Fall-run near the Rock Slough Intake (Reclamation 2016). Since construction of the RSFS, operation of the hydraulic rake cleaning system has been shown to trap and kill adult Chinook Salmon and other non-listed fish (Reclamation 2016). From 2011-2018 47 Chinook salmon were recovered at the RSFS (Reclamation 2016, Appendix A; Tenera 2018a). Approximately 60 percent were of hatchery origin; the CWTs revealed that all were Fall-run/Late Fall-run Chinook Salmon released from either Mokelumne River (53 percent), Merced River (6 percent) or Nimbus (2 percent) fish hatcheries.

5.14.5.3.13.1 Juveniles

Due to the location of the Rock Slough Intake near the end of a dead-end slough, far from the main migratory routes, juvenile CV Fall-run/Late Fall-run are not likely to be in the vicinity of the Rock Slough Intake. However, according to NMFS (2017), juvenile salmon can be "drawn" into the south Delta under reverse flows and high CVP and SWP pumping rates. However, the water diversions at the Rock Slough Intake when combined with diversions at CCWD's Old River Intake and Middle River Intake have a negligible effect on velocity along the migratory path for juvenile Fall-run/Late Fall-run Chinook Salmon and are not likely to impact the movement of juvenile salmonids. Please see the Winter-run Chinook Salmon section for additional details.

5.14.5.3.13.2 Adults

Rock Slough is a relatively slow flowing, tidal waterway which ends at the Rock Slough Extension, approximately 1,700 feet upstream from the Rock Slough Intake. Rock Slough is poor habitat with relatively high water temperature and a prevalence of aquatic weeds. Due to the location of the Rock Slough Intake near the end of a dead-end slough, far from the main migratory routes, and due to the poor quality of habitat within the slough, adult Fall-run/Late Fall-run Chinook Salmon are not likely to be in the vicinity of the Rock Slough Intake. However, if some adults stray into Rock Slough, the water exiting the Contra Costa Canal on ebb tide may create a false attraction to adult salmon that are migrating upstream (NMFS 2017).

NMFS has advised Reclamation that salmonids will likely be less attracted to the area near the intake if tides can be reduced (Reclamation 2016). It is worth noting that the ebb tidal flow in Rock Slough will be substantially reduced when the Contra Costa Canal is encased in a pipeline. This ongoing, multi-phased project (the Canal Replacement Project) is being conducted as a separate action by CCWD and has undergone separate environmental review. Completion of the Canal Replacement Project will result in tidal flows being significantly reduced at the Rock Slough Intake. Modeling of the area indicates that with only the first two phases complete, ebb flows reach up to 160 cfs, but with the Contra Costa Canal fully encased, ebb flows would be greatly muted to about 10 cfs.

5.14.5.3.14 North Bay Aqueduct

Fall-run Chinook Salmon may be present in the waterways adjacent to the Barker Slough Pumping Plant, however several years of monitoring have failed to consistently capture any salmonids during the winter Delta Smelt surveys (1996 to 2004) in Lindsey Slough or Barker Slough. Captures of Chinook Salmon have usually occurred in the months of February and March and typically are only a single fish per net haul (http://www.delta.dfg.ca.goc/data/nba). Most Chinook Salmon captured have come from Miner Slough, which is a direct distributary from the Sacramento River via Steamboat and Sutter Sloughs. Few if any San Joaquin River-origin Fall-run Chinook Salmon are expected to be exposed to the North Bay aqueduct under the proposed action because it is not on the migration route of this species.

5.14.5.3.15 Water Transfers

As discussed in the Spring-run Chinook Salmon section, Reclamation's proposed action includes expanding the water transfer window to July to November. This could result in approximately 50 TAF of additional pumping in most water year types (Figure 5.8-47). This additional pumping could increase entrainment, routing, or through-Delta mortality for Fall-run Chinook Salmon.

5.14.5.3.15.1 Rearing to Outmigrating Juvenile

Rearing to outmigrating Fall-run/Late Fall-run Chinook salmon juveniles would be exposed to increased pumping due to the water transfer window expansion in the fall associated with the proposed action, although this is not at the peak of the juvenile outmigration window. Effects are the same as those discussed under OMR management and include entrainment and predation.

5.14.5.3.15.2 Migrating Adults

Adult Fall-run Chinook Salmon would be exposed to increased pumping due to the water transfer window expansion in the fall associated with the proposed action. Effects are the same as those discussed under OMR management.

5.14.5.3.16 Clifton Court Forebay Aquatic Weed Program

Few if any juvenile Fall-run Chinook Salmon would be expected to be exposed to the Clifton Court Forebay Aquatic Weed Control Program under the Proposed Action. Juvenile Fall-run and Late Fall-run Chinook Salmon are present in the Delta between mid-November and early June with a peak in April (Table5.6-1). The application of aquatic herbicide to the waters of Clifton Court Forebay will occur during the summer months of July and August. Thus, the probability of exposing Fall-run Chinook Salmon to the herbicide is very low. Based on typical water temperatures in the vicinity of the salvage facilities during this period, the water temperatures would be incompatible with salmonid life history preferences, generally exceeding 70◦F by mid-June. Mechanical harvesting would occur on an as-needed basis and therefore Fall-run Chinook Salmon could be exposed to this action, if entrained into the Forebay.

5.14.5.3.17 Suisun Marsh

5.14.5.3.17.1 Salinity Control Gates

Operation of the SMSCG from October through May coincides with downstream migration of juvenile Fall-run Chinook Salmon (Table 5.14-1). NMFS (2009) determined that operation of the SWSCG is unlikely to impede migration of juvenile salmonids or produce conditions that support unusually high numbers of predators.

5.14.5.3.17.2 Roaring River Distribution System

The RRDS' water intake (eight 60-inch-diameter culverts) under the proposed action is equipped with fish screens (3/32-inch opening, or 2.4 mm) operated to maintain screen approach velocity of 0.2 ft/s (for Delta Smelt protection) or 0.7 ft/s, so that juvenile Fall-run Chinook Salmon would be excluded from entrainment.

5.14.5.3.17.3 Morrow Island Distribution System

Although Fall-run Chinook Salmon have been entrained at this facility that is part of the proposed action, only a small proportion of total migrants are likely to encounter it.

5.14.5.3.17.4 Goodyear Slough Outfall

NMFS (2009: 438) concluded that it would be unlikely that Chinook Salmon would encounter or be negatively affected by the Goodyear Slough outfall given its location and design, which is intended to improve water circulation in Suisun Marsh and therefore was felt by NMFS (2009: 438) to likely be of benefit to juvenile salmonids by improving water quality and increasing foraging opportunities.

5.14.5.4 Effects of Maintenance

Under WOA, no maintenance would occur as the CVP and SWP are not operating. Implementation of the species avoidance and take minimization steps described in Appendix C, *ROC Real-Time Water*

Operations Charter in section *Routine Operations and Maintenance on CVP Activities* would be anticipated to minimize potential negative effects to Green Sturgeon adults from maintenance activities.

5.14.5.4.1 Operation of a Shasta Dam Raise

Reclamation would operate a raised Shasta Dam consistent with the rest of the proposed action. Therefore, effects described elsewhere in the document would also apply to the operation of a raised Shasta Dam, and there would be no operational changes.

5.14.5.5 Effects of Conservation Measures

Conservation measures would not occur under WOA.

5.14.5.5.1 Lower Intakes Near Wilkins Slough

5.14.5.5.1.1 Eggs to Fry Emergence

The installation of fish screens near Wilkins Slough would be beneficial to Fall-run and Late Fall-run Chinook salmon egg and fry. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning. Additionally, the installation of new diversions and screens that would operate at lower flows, would directly benefit fish of all life stages. Specifically, operation of diversions with fish screens near Wilkins Slough would:

- Improve water temperatures and increase DO.
- Increase habitat complexity.
- Increase side-channel rearing habitat.
- Increase floodplain habitat and increase connectivity of floodplains with the river mainstem.
- Increase refuge habitat.
- Increase availability and quality of prey organisms.
- Reduce crowding and competition.
- Decrease predation risk.
- Decrease entrainment risk.
- Decrease potential for pathogens and diseases.
- Lower concentrations of toxic contaminants.
- Increase emigration cues.

The egg and fry life stage of Fall-run and Late Fall-run Chinook salmon, as well as the population, would benefit from this action. The survival of this life stage would directly benefit the Southern Resident Killer Whale, by increasing its available prey.

Egg and fry of Fall-run/Late Fall-run Chinook salmon would not be affected by the construction of a new diversion and screens near Wilkins Slough. Peak spawning time for Fall-run and Late Fall-run Chinook Salmon is typically in October-November, but can continue through December and into January (CDFG date unknown - https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=104280). Juveniles typically emerge from the gravel in December through March. Construction would occur during an inwater work window between June 1 and October 1; therefore, egg and fry would not be affected.

5.14.5.5.1.2 Rearing to Outmigrating Juveniles

The installation of fish screens near Wilkins Slough would be beneficial to Fall-run and Late Fall-run Chinook Salmon. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning. Additionally, the installation of new diversions and screens that would operate at lower flows, would directly benefit fish of all life stages.

Rearing and outmigrating Fall-run and Late Fall-run Chinook Salmon would not be affected by the construction of a new diversion and screens near Wilkins Slough, based on Fall-run/Late Fall-run Chinook Salmon rearing between one to seven months after emerging between December through March (CDFW website). Juveniles typically move downstream quickly into large rivers within a few weeks. Salmon smolts initiate migration during storm events and flow is positively correlated with migration rate (McCormick et al. 1998, Michel et al. 2013 *as cited in* CDFG website).

If rearing salmon are present in Wilkins Slough during the June 1 through October 1 in-water work window, individuals may be exposed to temporary disturbances associated with the construction of a cofferdam. Water quality may be temporarily disturbed, in addition the noise associated with construction of the cofferdam may temporarily affect juvenile Fall-run Chinook Salmon. Additionally, fish rescue operations may need be conducted during the period when water within the coffered area needs to be pumped. However, implementation of AMM's identified in Appendix E, *Avoidance and Minimization Measures* would further minimize any effects to the salmon.

Outmigrating juvenile Fall-run/Late Fall-run Chinook Salmon in the Upper Sacramento River would not be affected by the construction of a new diversion and fish screens near Wilkins Slough associated with the proposed action, based juveniles emigrating quickly downstream. Construction of diversions and fish screens near Wilkins Slough would occur during an in-water work window (June 1 and October 1), avoiding the emigration period; therefore effects of construction on emigrating Fall-run and Late Fall-run are not expected.

5.14.5.5.1.3 Rearing to Outmigrating Juveniles in the Bay Delta

The installation of fish screens near Wilkins Slough would be beneficial to Fall-run/Late Fall-run Chinook. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning. Additionally, the installation of new diversions and screens that would operate at lower flows, would directly benefit fish of all life stages.

Rearing and outmigrating Fall-run and Late Fall-run Chinook Salmon in the Bay-Delta would not be affected by the construction of a new diversion and screens near Wilkins Slough, based on Fall-run and Late Fall-run Chinook Salmon being located far downstream of construction activities. Wilkins Slough is located outside of the legal Bay-Delta – no tidal influence.

5.14.5.5.1.4 Adult Migration

The installation of fish screens near Wilkins Slough under the Proposed Action would be beneficial to Fall-run/Late Fall-run Chinook Salmon. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning. Additionally, the installation of new diversions and screens that would operate at lower flows, would directly benefit fish of all life stages.

Yoshiyama *et al.* (1998) identifies the migration period for Fall-run Chinook Salmon as June through December, with a peak period of September through October. The migration period for Late Fall-run Chinook Salmon is October through April, with a peak in December (Yoshiyama *et al.* 1998). Construction activities would occur during an in-water work window from June 1 through October 1. Although migrating salmon may be present during the latter portion of the window, the migrating fish would not affected by construction windows, as the construction activities would occur in an already dewatered area. Flow would not be impeded; therefore, migration of salmon to upstream spawning habitats would not be prevented. The implementation of the in-water work wind-down and other AMM's identified in Appendix E, *Avoidance and Minimization Measures* would reduce the effects of construction activities on migrating salmon.

5.14.5.5.1.5 Adult Holding

Holding Fall-run/Late Fall-run Chinook Salmon, as well as the population, would benefit from the installation of fish screens near Wilkins Slough under the proposed action.

The construction activities associated with the diversions and associated fish screens under the proposed action are not expected to affect adults holding Fall-run/Late Fall-run Chinook Salmon, due to the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures*. Additionally, per Appendix E, *Avoidance and Minimization Measures*, Reclamation will implement an in-water work window of June 1 through October 11 to reduce further effects to holding individuals. Additionally, Fall-run and Late Fall-run Chinook Salmon typically need cold water temperatures for holding; however, Wilkins Slough does not have suitable holding habitat; therefore, would not be affected by the onset of construction activities within the in-water work window.

5.14.5.5.2 <u>Shasta Dam TCD Improvements</u>

5.14.5.5.2.1 Eggs to Fry Emergence

Improvements to the Shasta Dam TCD would accommodate relatively small raises to Shasta Dam and reduce leakage of warm water into the structure that increases of the water temperature of the cold water that is released to maintain suitable temperatures for Fall–run/Late Fall-run Chinook Salmon that spawn in the upper Sacramento River (from Keswick Dam to the Red Bluff Diversion Dam). Because there is some overlap between winter-run and Fall-run/Late Fall-run spawning and egg/alevin incubation periods, Fall-run/Late Fall-run eggs and alevins would be somewhat similarly affected by the upper Sacramento River water temperatures, and as described previously, the proposed action would in fact be more protective of Fall-/Late Fall-run Chinook Salmon than COS and WOA. The improved flow and water temperature management associated with the Shasta Dam TCD improvements under the proposed action would be expected to provide a moderate benefit to Fall-run/Late Fall-run Chinook Salmon eggs and alevin relative to the WOA.

5.14.5.5.2.2 Rearing to Outmigrating Juveniles

All water temperatures under COS and proposed action scenarios during the Fall-run/Late Fall-run juvenile rearing period are consistently below the 61 degrees Fahrenheit threshold, except for June through September. However, during June through September, water temperatures under the WOA would be substantially higher (~10 to 20 degrees Fahrenheit) than those under the proposed action and COS.

Therefore, in general, water temperature conditions under COS and the proposed action would provide high benefits relative to the WOA conditions to juvenile Fall-run/Late Fall-run rearing in the upper Sacramento River. The ability to better manage the cold water pool and cold water releases through the Shasta TCD improvements would result in increased probability and likelihood of maintaining suitable rearing temperatures within the middle reaches of the Sacramento River. Therefore, this action would have high-level population benefits on this life stage.

5.14.5.5.2.3 Adult Migration

Under the proposed action and COS, the monthly mean water temperatures in the middle Sacramento River below the Colusa Basin Drain would be below the 68 degrees Fahrenheit threshold for immigrating Fall-run/Late Fall-run Chinook Salmon (Figures 14-9, 14-10, 14-12, 14-13 in the HEC 5Q Tempertures section in Appendix D). The ability to better manage the cold water pool and cold water releases would result in increased probability and likelihood of maintaining suitable migrating water temperatures within the Sacramento River.

5.14.5.5.2.4 Adult Holding

Under the COS and proposed action scenarios, the monthly mean water temperatures in the upper Sacramento River at Keswick, under the COS and proposed action scenarios, the average water temperatures would be well below the 61 degrees Fahrenheit threshold for holding adults from December through May (Figures 5-9, 5-12, 5-15 in the HEC-5Q Temperatures section of Appendix D). The ability to better manage the cold water pool and cold water releases would result in increased probability and likelihood of maintaining suitable migrating ad holding temperatures within the Sacramento River.

5.14.5.5.3 Sacramento River Spawning and Rearing Habitat

5.14.5.5.3.1 Egg to Fry Emergence

Habitat restoration activities under the proposed action would benefit Fall-run Chinook Salmon by increasing available spawning habitat (by placement of additional spawning gravel). The plot below shows the available spawning habitat in the Sacramento River, along with the needed habitat to support various population sizes. Also shown is the CVPIA doubling goal for Fall-run Chinook Salmon on the Sacramento River.

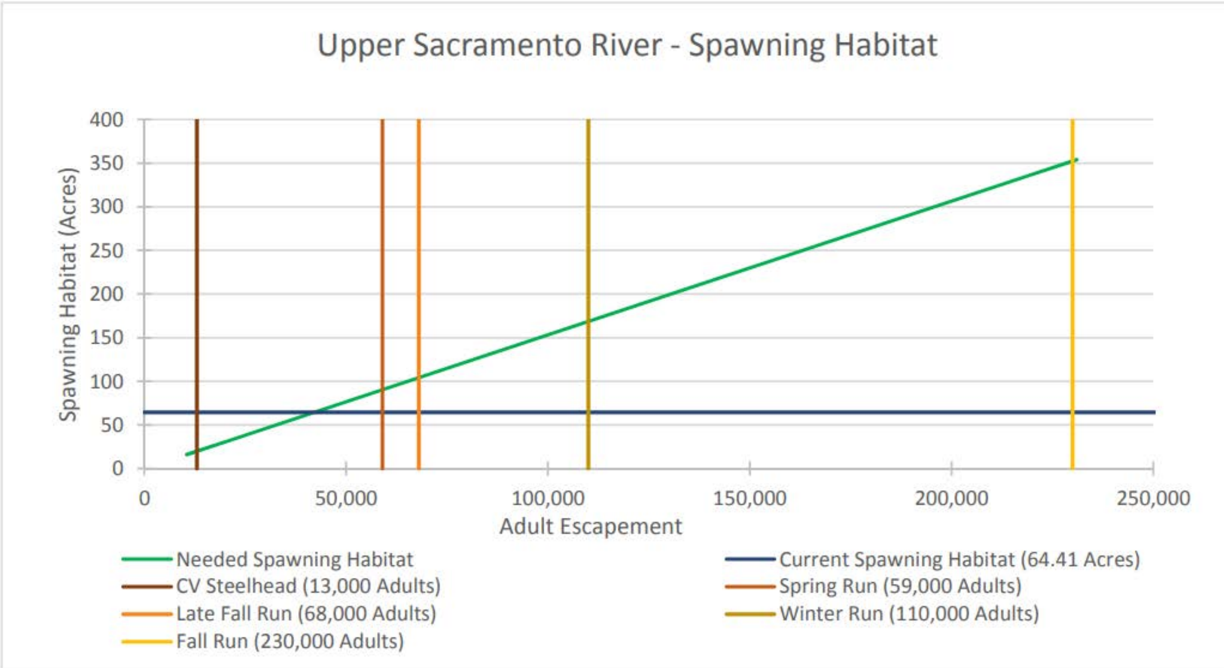


Figure 5.14-18. Estimated Salmonid habitat needed in the Sacramento River to support the range of escapement sizes (CVPIA 2018).

The construction activities associated with spawning habitat restoration under the proposed action are not expected to affect eggs and emerging fry due to the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures* and implementation of an in-water work window (July 15 through October 15t). The in-water work window will completely avoid the eggs and emerging fry life stage, as Fall-run/Late Fall-run Chinook Salmon typically spawn between October through November, and fry emerge between December and March (Table 5.14-2).

5.14.5.5.3.2 Rearing to Outmigrating Juveniles in the Rivers

Habitat improvement projects in the Sacramento River under the proposed action focus on increasing productivity of Fall-run Chinook Salmon and Steelhead. The in-river work occurs during low flows (less than about 5,000 cfs) in the July to October timeframe to avoid the most sensitive young juvenile and egg life stages of Steelhead and Chinook Salmon. Projects focus on rearing habitat and strive to provide spawning habitat close to the rearing habitat in the upper half of the river. Lower river projects (below River Bend) focus solely on rearing habitats and include side channel and floodplain types of habitat. Woody material is incorporated in all projects wherever possible.

Rearing and outmigrating individuals would benefit from increased side channel habitat, floodplain, gravel, and large wood resulting from habitat restoration in the Sacramento River. Effects would include an improved likelihood of rearing success due to an increase in total rearing habitat area, and rearing habitat quality. Figure 5.14-20 shows the amount of rearing habitat needed to support the range of Chinook Salmon escapement sizes in the Sacramento River along with the estimated amount of rearing habitat currently available. Rearing habitat appears particularly limited with habitat currently available to support the production of less than 500 Chinook Salmon. Rearing habitat improvements are particularly beneficial.

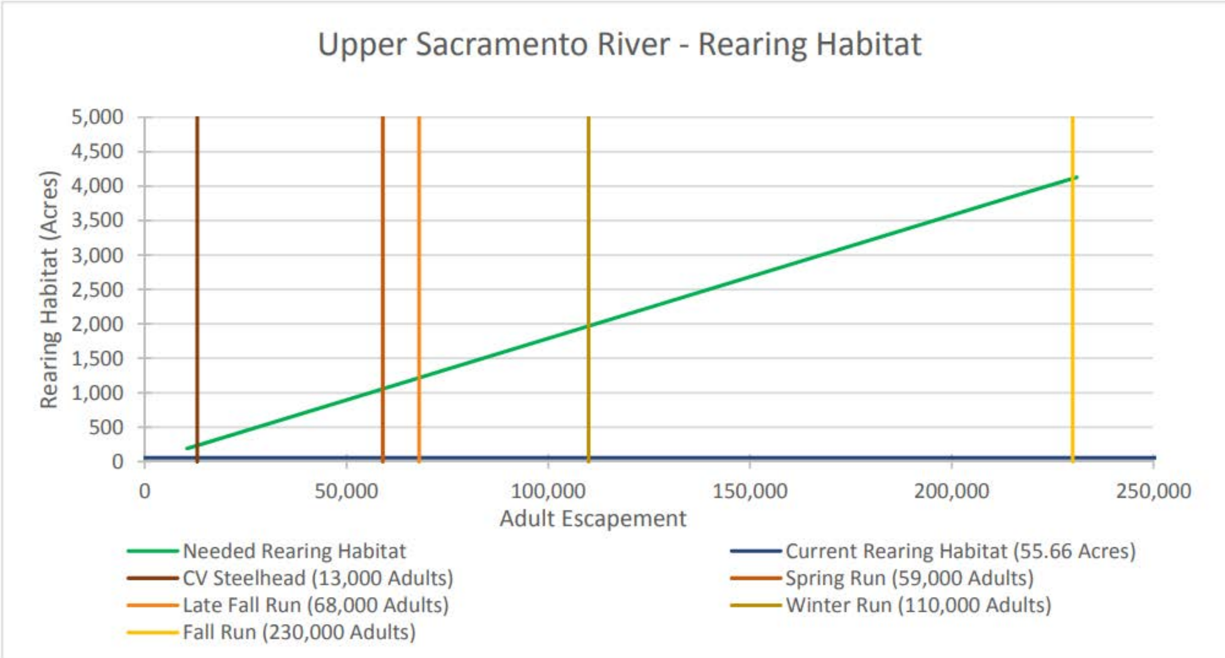


Figure 5.14-19. Estimated Salmonid rearing habitat needed in the Sacramento River to support the range of escapement sizes (CVPIA 2018).

Few rearing and outmigrating Fall-run/Late Fall-run Chinook salmon juveniles would be exposed to construction of side channel habitat, gravel augmentation, and large wood installation under the proposed action, based on the timing of the in-water work window (July 1-September 30) and seasonal occurrence of this life stage in the Sacramento River (year-round; Table 5.14-1). Most juveniles leave the river before July. Years when juvenile Chinook are present into July are wet years with high flows prohibiting in-river habitat improvement work from occurring. Construction activities in the Sacramento River could result in mortality of this life stage by crushing from heavy equipment in the stream channel, if individuals were stranded or isolated during dewatering, or if construction otherwise disturbed rearing juvenile habitat during manipulation of gravel, installation of large wood or creation of side channels. Individuals exposed to construction could also experience loss of aquatic habitat, leading to increased predation, increased water temperature, and reduced food availability. This life stage could also be negatively affected by degraded water quality from contaminant discharge by heavy equipment and soils and increased discharges of suspended solids and turbidity, leading to direct physiological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), loss of aquatic vegetation providing physical shelter, reduced foraging ability caused by decreased visibility, and impeded or delayed migration caused by elevated noise levels from machinery. Due to the juvenile life stage timing rarely overlapping with habitat work any effects would be minimal.

Any exposure to these effects would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. Exposure would be further minimized by implementing AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention, and containment. With application of AMM 1–5, the temporary, adverse effects that may result from the proposed construction activities under the proposed action would be minimized and affect a low number of individuals.

5.14.5.5.3.3 Adult Migration

Habitat restoration activities would benefit Fall-run/Late-Fall run Chinook Salmon by increasing available spawning habitat.

The construction activities under the proposed action associated with spawning habitat restoration are not expected to affect immigrating Fall-run/Late Fall-run Chinook Salmon because of the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures***.** Additionally, per Appendix E, Reclamation will implement an in-water work window of July 15 through October 15 to avoid effects to immigrating Fall-run/Late Fall-run Chinook Salmon.

5.14.5.5.3.4 Adult Holding

Habitat restoration activities under the proposed action would benefit Fall-run/Late Fall-run Chinook Salmon by increasing available spawning habitat.

The construction activities associated with spawning habitat restoration under the proposed action are not expected to impact adults Fall-run/Late Fall-run Chinook Salmon holding in the Sacramento River due to the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures*. Additionally, per Appendix E, Reclamation will implement an in-water work window of July 15 through October 15 to reduce further effects to holding individuals.

5.14.5.5.4 <u>Deer Creek Fish Passage</u>

DWR and Reclamation's installation of a nature-like fishway at the DCID diversion dam will provide salmonids access to approximately 25 miles of spawning habitat in Deer Creek upstream from the DCID dam.

Construction effects are the same as discussed above for Sacramento River spawning and rearing habitat. Exposure to these effects would be minimized with incorporation of the avoidance and minimization measures.

5.14.5.5.5 <u>Small Screen Program</u>

5.14.5.5.5.1 Egg to Fry Emergence

No egg-to-emergence Fall-run/Late Fall-run Chinook Salmon in the Sacramento River would be exposed to fish screens since they remain in the gravel. Therefore, there would be no effects from fish screen operation for this life stage.

Few if any Sacramento River Fall-run/Late Fall-run Chinook Salmon in the egg-to-emergence life stage would be expected to be exposed to the effects of construction of screens on water diversion intakes under the proposed action based on the seasonal occurrence of this life stage in the Sacramento River. The egg to fry emergence stage follows the fall and winter spawning period (Table 5.14-1 and 5.14-2), which is outside of the timing of in-water construction (July 15 – October 15). Since spawning occurs in gravel substrate in relatively fast-moving, moderately shallow riffles or along banks with relatively high water velocities (Fisher 1994), there is the potential for redds to occur in the work areas or in the direct vicinity of the construction sites. However, these work areas are localized and the number of redds in these areas is expected to be low. Potential short-term adverse impacts may include temporary, localized fine sediment disturbance and deposition in spawning and embryo incubation areas directly adjacent construction sites. There could be a minor effect to a small number of individuals, although the risk from these potential effects would be minimized through the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures*.

5.14.5.5.5.2 Rearing to Outmigrating Juveniles in Rivers

The operation of fish screens on water diversions under the proposed action would beneficially affect juvenile Fall-run/Late Fall-run Chinook Salmon rearing and migrating in the Sacramento River by reducing the entrainment of rearing and migrating fish into unscreened or poorly screened diversions. There is the potential for adverse effects to this life stage, including injury or mortality from exposure to screens that are not functioning properly due to lack of maintenance, occlusion, debris accumulation or other factors. However, the risk of this exposure will be minimized since the screens would be designed to meet NMFS and CDFW fish screen criteria and protect this life stage. Therefore, it is concluded that the operation of fish screens under the proposed action would result in beneficial effects for this life stage, due to the reduced risk of entrainment and injury.

Juvenile Fall-run/Late Fall-run Chinook Salmon rearing and migrating in the Sacramento River may be exposed to the effects of construction of screens on water diversion intakes due to their occurrence during the in-water construction season (July 15 – October 15) (Tables 5.14-1 and 5.14-21). However, the localized work area of these projects limits the potential for exposure to these projects. Potential short-term adverse effects may include temporary effects to water quality as result from in-water work, resulting in increased turbidity and suspended sediments and sediment deposition in the direct vicinity of the work area, and the temporary displacement of individual fish in the work area. If fish are present in the work area, flowing water will be isolated and fish captured and relocated to an appropriate location in an effort to minimize possible mortality. Juveniles would likely experience increased levels of stress and injury during handling, which could be exacerbated by poor water quality (increased temperatures, low dissolved oxygen saturation), and prolonged periods of holding between capture and release. There may be a minor effect to a small number of individuals, although the risk from these potential effects would be would be minimized through the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures.* In addition, the appropriate conservation measures and handling techniques will be employed to ensure that the stress resulting from handling and transport is short-lived and minor.

5.14.5.5.5.3 Rearing to Outmigrating Juveniles in the Bay-Delta

There may be moderate overlap Fall-run/Late Fall-run Chinook Salmon with the main late spring-fall irrigation period for small diversions, and small diversion screening under the proposed action could reduce entrainment of late migrating individuals.

Few if any juvenile Fall-run/Late Fall-run Chinook Salmon rearing and outmigrating in the Bay-Delta are expected to be exposed to the effects of construction of screens on water diversion intakes under the proposed action. Juvenile Sacramento River Fall-run/Late Fall-run Chinook Salmon primarily migrate from November through early May (NMFS 2014), largely outside of the timing of in-water construction (July 15 – October 15). In addition, the work area for these projects is small, limiting exposure to construction.

5.14.5.5.5.4 Adult Migration

Operational effects for adults are the same as those described above for juveniles. Adult Sacramento River Fall-run/Late Fall-run Chinook Salmon may be exposed to the effects of construction of screens on water diversion intakes based on the timing of in-water construction (August–October), the late-summer to early Fall seasonal occurrence of this life stage in the Sacramento River (Tables 5.14-1 and 5.14-2). AMMs would minimize risks.

5.14.5.5.5.5 Adult Holding

Operational effects for adults are the same as those described above for juveniles. Adult Fall-run/Late Fall-run Chinook Salmon in the holding in the Sacramento River may be exposed to the effects of construction of screens on water diversion intakes due the overlap of the timing of in-water construction (July 15 – October 15), and the July through April occurrence of this life stage (Tables 5.14-1 and 5.14-2). AMMs would minimize risks.

5.14.5.5.5.5.1 Adult Rescue

The operation of adult rescue is targeted towards adult salmonids and sturgeon, including adult Fall-run/Late Fall-run Chinook Salmon, that become trapped in the Yolo and Sutter bypasses, with the goal of increasing the number of adults returning to spawning areas; therefore, this effort could increase the number of Fall-run/Late Fall-run Chinook Salmon of all lifestages in the Sacramento River and its tributaries, and the ocean.

Exposure of this life stage to adult rescue effects would be restricted only to those adult Fall-run/Late Fall-run Chinook Salmon that become stranded in the Yolo and Sutter Bypasses and subsequently rescued and released to the Sacramento River. Adults that migrate in-river or that do not become stranded in the Yolo and Sutter bypasses would be unaffected by adult rescue activities. The number of adult Fall-run/Late Fall-run Chinook Salmon that would be expected to be exposed to the effects of adult rescue activities would be based on the abundance of adults that stray into the bypasses and the timing and frequency of stranding events in the bypasses. Individual adult Fall-run/Late Fall-run Chinook Salmon exposed to adult rescue activities would be at risk of increased stress, injury, and/or mortality, which could vary in intensity depending on the techniques used to capture individuals. Injury and increased stress associated with capture, handling and transport may affect survival of individuals after release. The risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*). As such, it is concluded that the overall population-level negative effects on this life stage of Fall-run/Late Fall-run Chinook Salmon from adult rescue activities would be low relative to the without action (no rescue of stranded adult Fall-run/Late Fall-run Chinook Salmon in Yolo and Sutter bypasses).

Given that eggs are in gravel substrates and adult rescue activities would occur downstream of Fall-run/Late Fall-run Chinook Salmon spawning areas in the Sacramento River and its tributaries, there would be no direct effects on this life stage from implementing adult rescue activities.

As discussed for Winter-run and Spring-run Chinook Salmon, juvenile Fall-run/Late Fall-run Chinook Salmon occur in the Yolo and Sutter Bypasses when Sacramento River flows overtop the Fremont and/or Tisdale Weirs. Although they are unlikely to occur in the bypasses during periods when flow does not overtop the weirs, proposed modifications to the Fremont Weir to increase inundation of the Yolo bypass for floodplain rearing would provide juveniles with more consistent access to the Yolo bypass. Therefore, these juveniles could be exposed to the effects of adult rescue activities if they become stranded with adults that are targeted by adult rescue activities. The number of juvenile Fall-run/Late Fall-run Chinook Salmon that would be expected to be exposed to the effects of adult rescue activities would be based on the timing of proposed adult rescue activities, gear type used to rescue adults, and the typical seasonal occurrence of this life stage in the Yolo and Sutter bypasses. Individual juvenile Fall-run/Late Fall-run Chinook Salmon exposed to adult rescue activities would be at risk of increased stress, injury, and/or mortality during efforts to capture stranded adults, handling, and transport. Injury and increased stress associated with capture, handling, and transport may reduce disease resistance, swimming ability, and osmoregulatory ability in juveniles, thereby adversely affecting survival of affected individuals after release. Furthermore, the risk of these effects to this life stage may be dependent on fish size (fish collected at a smaller [younger] size may be more susceptible to injury and stress) and timing of collection (fish collected later in the season when water quality conditions [e.g., water temperature] generally are more stressful for fish may make fish more susceptible to injury and stress-related effects). The risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*), and any potential adverse effects on individual juvenile Fall-run/Late Fall-run Chinook Salmon would be expected to be offset by benefits associated with increased numbers of adult Fall-run/Late Fall-run Chinook Salmon returning to spawning grounds. As such, it is concluded that the overall population-level negative effects on this life stage of Fall-run/Late Fall-run Chinook Salmon from adult rescue activities would be low relative to the without action (no rescue of adult Fall-run/Late Fall-run Chinook Salmon in Yolo and Sutter bypasses).

5.14.5.5.6 Juvenile Trap and Haul

The operation of the juvenile trap and haul is targeted towards juvenile Fall-run/Late Fall-run Chinook Salmon, with the goal of increasing the survival of juveniles and, ultimately, returning adults; therefore, this effort could increase the number of Fall-run/Late Fall-run Chinook Salmon of all lifestages in the Sacramento River and its tributaries.

The number of juvenile Fall-run/Late Fall-run Chinook Salmon that would be expected to be exposed to the effects of juvenile trap and haul activities under the proposed action would be based on the timing of proposed juvenile trap and haul activities (December 1 to May 31), trapping location and efficiency, and the typical seasonal occurrence of this life stage in the Sacramento River (Tables 5.14-1 and 5.14-2). Individual juvenile Fall-run/Late Fall-run Chinook Salmon exposed to juvenile trap and haul activities would be at risk of increased stress, injury, and/or mortality. Injury and increased stress associated with handling and transport may reduce disease resistance, swimming ability, and osmoregulatory ability in juveniles, thereby adversely affecting survival of affected individuals after release. Furthermore, the risk of these effects to this life stage may be dependent on fish size (fish collected at a smaller [younger] size may be more susceptible to injury and stress) and timing of collection (fish collected later in the season when water quality conditions [e.g., water temperature] generally are more stressful for fish may make fish more susceptible to injury and stress-related effects). The risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*), and any potential adverse effects on individual juvenile Fall-run/Late Fall–run Chinook Salmon would be expected to be offset by benefits associated with expected increased survival of the overall brood-year of Fall-run/Late Fall-run Chinook Salmon. As such, it is concluded that the overall population-level negative effects on this life stage of juvenile Fall-run/Late Fall-run Chinook Salmon from juvenile trap and haul activities would be low relative to the without action (no trapping and hauling of juvenile Fall-run/Late Fall-run Chinook Salmon during drought years) and would be potentially offset by benefits (increased juvenile survival and ultimately increased adult escapement) associated with the juvenile trap and haul program.

Given that eggs are in gravel substrates and temporary juvenile collection weirs would be placed downstream of Fall-run/Late Fall-run Chinook Salmon spawning areas in the Sacramento River and its tributaries, there would be no direct effects on this life stage from implementing juvenile trap and haul activities.

Transport may also result in earlier ocean arrival and reduced growth rates in juveniles, leading to increased mortality from predation.

Exposure of adults to trap and haul effects would be restricted only to those adult Fall-run/Late Fall-run Chinook Salmon that were trapped in the Sacramento River as juveniles and subsequently released to the lower Sacramento River and/or Bay-Delta as part of the juvenile trap and haul program. Ocean adults that had out-migrated in-river as juveniles would not be affected by juvenile trap and haul activities. Because transported juveniles are more likely to have impaired homing behavior as adults, juvenile trap and haul activities may increase the rate of straying by returning adults. Adults that stray into tributaries with unsuitable habitat may not survive or spawn successfully if habitat conditions are suitable. Adults that stray into tributaries with suitable habitat may compete with native-run adults for spawning space, excavate or superimpose their redds on the redds or native-run fish, or spawn with native-run fish, thereby introducing genes from neighboring populations that have strayed into the river.

5.14.5.5.7 Clear Creek Restoration Program

5.14.5.5.7.1 Eggs to Fry Emergence

Eggs and emerging fry of Fall-run/Late Fall-run Chinook Salmon would be exposed to the effects of increased gravel resulting from mechanical gravel mobilization under the proposed action in Clear Creek if geomorphic flows did not achieve sufficient gravel mobilization. Exposure to the effects of gravel mobilization would be beneficial, and include an increase in total incubation habitat area and reduced likelihood of redd superimposition.

A low number of eggs and emerging fry would be expected to be exposed to mechanical gravel mobilization under the proposed action, based on the timing of the in-water work window (to be determined in coordination with NMFS, USFWS, and DFW) and seasonal occurrence of this life stage in Clear Creek (December-April; Table 5.14-1). Mechanical gravel mobilization in Clear Creek could result in mortality of eggs and emerging fry by crushing if heavy equipment entered the stream channel or otherwise disturbed redds during manipulation of gravel. Individuals exposed to this activity could also experience loss of aquatic habitat, leading to increased predation, increased water temperature, and reduced food availability. Eggs and emerging fry could also be negatively affected by degraded water quality from contaminant discharge by heavy equipment and soils, and increased discharges of suspended solids and turbidity, leading to direct physiological effects on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), and loss of aquatic vegetation providing physical shelter.

The likelihood and magnitude of these effects and the risk of exposure by eggs and fry would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. Exposure would be further minimized by implementing AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention and containment. Including the precautions described in AMM 1–5, the temporary, adverse impacts that may result from the construction activities under the proposed action would be minimized and few individuals would be affected.

5.14.5.5.7.2 Rearing to Outmigrating Juveniles

Rearing Fall-run/Late Fall-run Chinook Salmon juveniles could be exposed to the effects of increased gravel resulting from mechanical gravel mobilization under the proposed action in Clear Creek if mechanical gravel mobilization affected existing gravels in suitable rearing habitat, including channel margins, side channels, or other shallow, slow-moving habitat with adequate cover. Assuming mechanical gravel mobilization is undertaken in areas of the channel more likely to be used for spawning nearer the mid-channel this action will have no effect on existing suitable juvenile rearing habitat.

Rearing and outmigrating juveniles would be exposed to mechanical gravel mobilization, based on the timing of the in-water work window (to be determined in coordination with NMFS, USFWS, and DFW) and peak seasonal occurrence of this life stage in Clear Creek (year-round; Table 5.14-1). Construction activities in Clear Creek could result in mortality of this life stage by crushing if heavy equipment entered the stream channel, if individuals were stranded or isolated during dewatering, or if construction otherwise disturbed rearing juvenile habitat during manipulation of gravel. Individuals exposed to construction could also experience loss of aquatic habitat, leading to increased predation, increased water temperature, and reduced food availability. This life stage could also be negatively affected by degraded water quality from contaminant discharge by heavy equipment and soils and increased discharges of suspended solids and turbidity, leading to direct physiological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), loss of aquatic vegetation providing physical shelter, reduced foraging ability caused by decreased visibility, and impeded or delayed migration caused by elevated noise levels from machinery.

Exposure to these effects under the proposed action would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. Exposure would be further minimized by implementing AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention, and containment. With application of AMM 1–5, the temporary, adverse impacts that may result from the proposed construction activities would be minimized and affect a low number of individuals.

5.14.5.5.7.3 Adult Migration from Ocean to Rivers

Few, if any, migrating adults would be exposed to the effects of increased gravel resulting from mechanical gravel mobilization under the proposed action in Clear Creek. Adult migration habitat is typically situated in deeper water near mid-channel and away from shallower riffles, and pool tails where most mechanical gravel mobilization would occur.

A low number of migrating adults would be expected to be exposed to mechanical gravel mobilization under the proposed action, based on the timing of the in-water work window (to be determined in coordination with NMFS, USFWS, and DFW) and seasonal occurrence of this life stage in Clear Creek (October-December; Table 5.14-1). Construction activities in Clear Creek could result in mortality of migrating adults by crushing if heavy equipment entered the stream channel or otherwise disturbed suitable habitat during manipulation of gravel. Individuals exposed to construction could also experience loss of aquatic habitat, including loss or degradation of habitat used for resting or sheltering from predators. Migrating adults could also be negatively affected by degraded water quality from contaminant discharge by heavy equipment and soils, and increased discharges of suspended solids and turbidity, leading to direct physiological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), loss of aquatic vegetation providing physical shelter, and impediments and delay in migration caused by elevated noise levels from machinery.

Exposure to these effects would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. Exposure would be further minimized by implementing AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention and containment. With application of AMM 1–5, the temporary, adverse effects that may result from the proposed construction activities would affect few if any individuals of this life stage.

5.14.5.5.7.4 Adult Holding in Rivers

Few, if any, holding adults would be exposed to the effects of increased gravel resulting from mechanical gravel mobilization under the proposed action in Clear Creek. Holding habitat is typically situated in deep water near mid-channel and away from shallower riffles, and pool tails where most mechanical gravel mobilization would occur. Therefore, an increase in gravel would have no effect on this life stage of Fall-run/Late Fall-run Chinook Salmon.

A low number of Fall-run/Late Fall-run Chinook Salmon holding adults would be expected to be exposed to mechanical gravel mobilization under the proposed action, based on the timing of the in-water work window (to be determined in coordination with NMFS, USFWS, and DFW) and seasonal occurrence of this life stage in Clear Creek (July-December; Table 5.14-1). Construction activities in Clear Creek could result in mortality of holding adults by crushing if heavy equipment entered the stream channel or otherwise disturbed suitable habitat during manipulation of gravel. Individuals exposed to construction could also experience loss of aquatic habitat, including loss or degradation of holding pools required as hiding cover and resting areas by adult Fall-run/Late Fall-run Chinook Salmon during the gamete maturation period prior to spawning. Holding adults could also be negatively affected by degraded water quality from contaminant discharge by heavy equipment and soils, and increased discharges of suspended solids and turbidity, leading to direct toxicological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), loss of aquatic vegetation providing physical shelter, and reduced foraging ability caused by decreased visibility; impediments and delay in migration caused by elevated noise levels from machinery.

Exposure to these effects would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. Exposure would be further minimized by implementing AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention, and containment, as well as AMM1 and AMM2. Including the precautions described in AMM 1-5, the temporary, adverse effects that may result from the proposed construction activities would affect a low number, if any, individuals of this life stage.

5.14.5.5.8 American River Spawning and Rearing Habitat

5.14.5.5.8.1 Eggs to Fry Emergence

Eggs and emerging fry would be exposed to the effects of increased side channel habitat, gravel, and large wood resulting from habitat restoration under the proposed action in the American River. Effects of this exposure would be beneficial and include an increase in total spawning habitat area and reduced likelihood of redd superimposition. Figure 5.14-21 shows the amount of spawning habitat needed to support the range of Chinook escapement sizes in the lower American River along with the estimated amount of spawning habitat currently available. Projects in the upper half of the lower American River under the proposed action strive to provide rearing habitat and spawning habitat adjacent to each other so that when fry emerge from the gravel they are able to move quickly into suitable habitats. Despite the plentiful spawning habitat in the upper 18 miles of the lower American River, the fish congregate in the upper three miles of the river resulting in high levels of superimposition on the riffles at Nimbus Basin, Sailor Bar, and around Sunrise Avenue. Habitat improvements in these areas under the proposed action help to distribute fish among available habitat and increase survival by reducing superimposition and providing nearby rearing habitat. These projects should be a net benefit to productivity of Fall-run/Late Fall-run Chinook Salmon and Steelhead that spawn and rear in the lower American River.

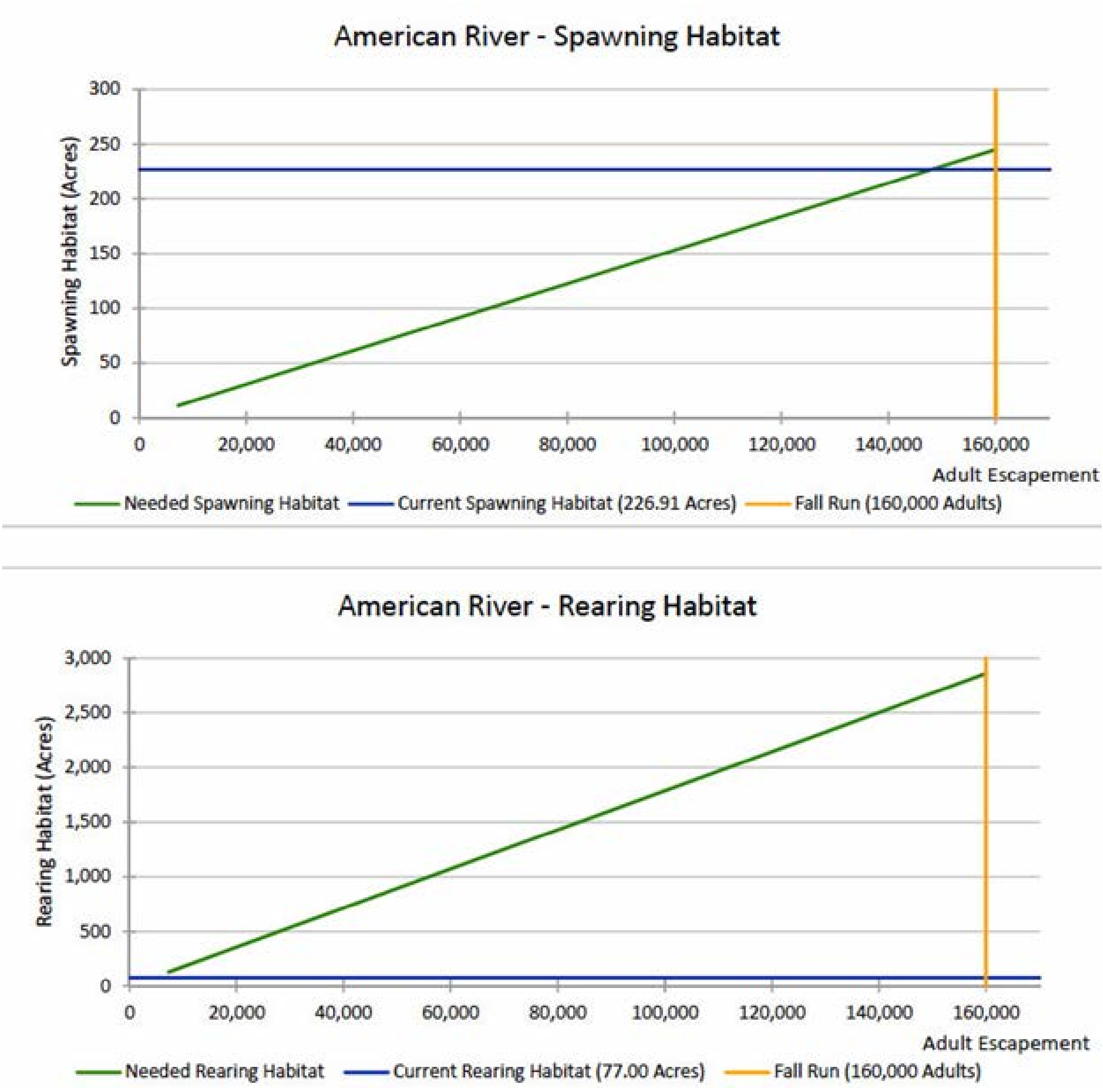


Figure 5.14-20. Estimated Chinook spawning and rearing habitat needed in the lower American River to support the range of escapement sizes (CVPIA 2018).

Construction activity occurs between July and October when no Fall-run or Late Fall-run Chinook Salmon eggs or fry are present.

5.14.5.5.8.2 Rearing to Outmigrating Juveniles

Habitat improvement projects in the lower American River under the proposed action focus on increasing productivity of Fall-run Chinook Salmon and Steelhead. The in-river work occurs during low flows (less than about 5,000 cfs) in the July to October timeframe to avoid the most sensitive young juvenile and egg life stages of Steelhead and Fall-run Chinook Salmon. Projects focus on rearing habitat and strive to provide spawning habitat close to the rearing habitat in the upper half of the lower American River. Projects on the lower part of the lower American River (below River Bend) focus solely on rearing habitats and include side channel and floodplain types of habitat. Woody material is incorporated in all projects wherever possible.

Rearing and outmigrating individuals would benefit from increased side channel habitat, floodplain, gravel, and addition of large woody material resulting from habitat restoration in the lower American River under the proposed action. Effects would include an improved likelihood of rearing success due to an increase in total rearing habitat area, and rearing habitat quality. Figure 5.14-22 shows the amount of rearing habitat needed to support the range of Chinook escapement sizes in the lower American River along with the estimated amount of rearing habitat currently available. Rearing habitat appears particularly limited with habitat currently available to support the production of less than 10,000 Chinook Salmon. Hence, rearing habitat improvements under the proposed action are particularly beneficial.

Few rearing and outmigrating Fall-run/Late Fall-run Chinook Salmon juveniles would be exposed to construction of side channel habitat, gravel augmentation, and large wood installation, based on the timing of the in-water work window (July 1-September 30) and seasonal occurrence of this life stage in the lower American River (year-round; Table 5.14-1). Most juvenile Fall-run Chinook Salmon leave the river before July. Years when juvenile Fall-run/Late Fall-run Chinook Salmon are present into July are wet years with high flows prohibiting in-river habitat improvement work from occurring. Construction activities under the proposed action in the lower American River could result in mortality of this life stage by crushing from heavy equipment in the stream channel, if individuals were stranded or isolated during dewatering, or if construction otherwise disturbed rearing juvenile habitat during manipulation of gravel, installation of large wood or creation of side channels. Individuals exposed to construction could also experience loss of aquatic habitat, leading to increased predation, increased water temperature, and reduced food availability. This life stage could also be negatively affected by degraded water quality from contaminant discharge by heavy equipment and soils and increased discharges of suspended solids and turbidity, leading to direct physiological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), loss of aquatic vegetation providing physical shelter, reduced foraging ability caused by decreased visibility, and impeded or delayed migration caused by elevated noise levels from machinery. Due to the juvenile life stage timing rarely overlapping with habitat work, effects would be minimal.

Exposure to these effects would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. Exposure would be further minimized by implementing AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention, and containment. With application of AMM 1–5, the temporary, adverse effects that may result from the proposed action construction activities would be minimized and affect a low number of individuals.

5.14.5.5.8.3 Adult Migration from Ocean to Rivers

Early migrating adult Fall-run Chinook Salmon would be exposed to construction of side channel and floodplain habitat, gravel augmentation, and large wood installation under the proposed action. Low numbers of Fall-run Chinook Salmon enter the lower American River through the summer with the peak immigration in October. The behavior of these fish depends on conditions in the river. During higher flow years with cooler than average water temperatures, the fish hold throughout the lower American River but wet years with high flows prohibit in-river habitat improvement work from occurring. Even if construction occurred during high flow years, during these years, fish are generally in healthy conditions and readily able to avoid in-water activities and temporary turbidity increases. During dryer years, water temperatures are warmer and flows are typically lower. These conditions are more stressful for the fish and they migrate quickly to the upstream most accessible area, either in Nimbus Basin or below the hatchery weir. The only project site that would affect these fish would be the work in Nimbus Basin.

Exposure to effects of activities under the proposed action would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. Exposure would be further minimized by implementing AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention and containment. With application of AMM 1–5, the temporary, adverse effects that may result from the proposed action construction activities would affect few if any individuals to Fall-run/Late Fall-run Chinook Salmon immigrating into the lower American River.

5.14.5.5.8.4 Adult Holding in Rivers

Early arriving adult Fall-run Chinook Salmon would be exposed to construction of side channel and floodplain habitat, gravel augmentation, and large wood installation under the proposed action. Low numbers of Fall-run Chinook Salmon enter the lower American River through the summer with the peak immigration in October. The behavior of these fish depends on conditions in the river. During higher flow years with cooler than average water temperatures, the fish hold throughout the lower American River and are more likely to be holding close to activities, although construction actions are less likely to occur. During these years, Fall-run Chinook Salmon are in healthy conditions and readily able to avoid in-water activities and temporary turbidity increases. During dryer years, water temperatures are warmer and flows are typically lower. These conditions are more stressful for the fish and they migrate quickly to the upstream most accessible area, either in Nimbus Basin or below the hatchery weir. The only project site that would affect these fish would be the work in Nimbus Basin.

Exposure to effects of habitat construction under the proposed action would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. Exposure would be further minimized by implementing AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention and containment. With application of AMM 1–5 the temporary, adverse effects that may result from construction of side channel habitat, gravel augmentation, and large wood installation would affect few if any holding Fall-run Chinook Salmon adults.

5.14.5.5.9 Drought Temperature Facility Improvements (American River)

5.14.5.5.9.1 Eggs to Fry Emergence

Reclamation proposes to evaluate and implement alternative shutter configurations at Folsom Dam under the proposed action to allow temperature flexibility in severe droughts, thereby reducing water temperatures in the lower American River. Excessively high water temperatures has been identified as one the factors threatening Fall-run/Late Fall-run Chinook Salmon in the Central Valley (NMFS 2014). Cool water temperatures are important for embryo survival; water temperatures reportedly must be between 41°F and 55.4°F maximum survival (Moyle 2002). The implementation of the proposed drought temperature management measures under the proposed action would improve Reclamation's ability to manage water temperatures in the lower American River and meet water temperature requirements for Fall-run Chinook Salmon during drought conditions and improve conditions for this life stage. Therefore, it is concluded that this proposed action would likely beneficially affect the egg-to-emergence life stage of Fall-run Chinook Salmon in the lower American River by reducing the effects of drought conditions on water temperatures.

5.14.5.5.9.2 Rearing to Outmigrating Juveniles

Reclamation proposes to evaluate and implement alternative shutter configurations at Folsom Dam under the proposed action to allow temperature flexibility in severe droughts, thereby reducing water temperatures in the lower American River. A few Juvenile Fall-run/Late Fall-run Chinook Salmon may be present in the American River year-round since they may reside in freshwater for 12 to 16 months (Tables 5.14-1 and 5.14-2), however, some migrate to the ocean as young-of-the-year in the winter or spring months within eight months of hatching (CALFED 2000). The implementation of the proposed drought temperature management measures under the proposed action would improve Reclamation's ability to manage water temperatures in the lower American River and meet water temperature requirements for rearing Fall-run/Late Fall-run Chinook Salmon during drought conditions and improve conditions for this life stage.

5.14.5.5.9.3 Adult Migration from Ocean to Rivers

Adult Central Valley Fall-run/Late Fall-run Chinook Salmon are present in summer through winter and in relatively high abundance primarily in October through March, spawning soon after entering their natal streams (Tables 5.14-1 and 5.14-2) (Moyle 2002; Yoshiyama et al. 1998). Central Valley Fall-run/Late Fall-run Chinook Salmon require cool freshwater. In the Central Valley, fall water temperatures are reportedly suitable for Chinook Salmon only above 150 to 500-m elevations, and most of that high elevation habitat is now upstream of impassable dams (Schick et al. 2005). The implementation of the proposed drought temperature management measures under the proposed action would improve Reclamation's ability to manage temperatures in the lower American River and meet water temperature requirements for Chinook Salmon during drought conditions and improve conditions for this life stage. Therefore, it is concluded that this proposed action would likely beneficially affect this life stage of Fall-run/Late Fall-run Chinook Salmon in the lower American River by reducing the effects of drought conditions on water temperatures.

5.14.5.5.9.4 Adult Holding in Rivers

The implementation of the proposed drought temperature management measures under the proposed action would improve Reclamation's ability to manage temperatures in the lower American River and meet water temperature requirements for Fall-run/Late Fall-run Chinook Salmon holding in the lower American River during drought conditions and improve conditions for this life stage.

5.14.5.5.10 Stanislaus River Spawning and Rearing Habitat

5.14.5.5.10.1 Eggs to Fry Emergence

Habitat restoration activities under the proposed action would benefit Fall-run Chinook Salmon by increasing available spawning habitat (by placement of additional spawning gravel). The plot below shows the available spawning habitat in the Stanislaus River, along with the needed habitat to support various population sizes. Also shown is the CVPIA doubling goal for Fall-run Chinook Salmon the Stanislaus River.

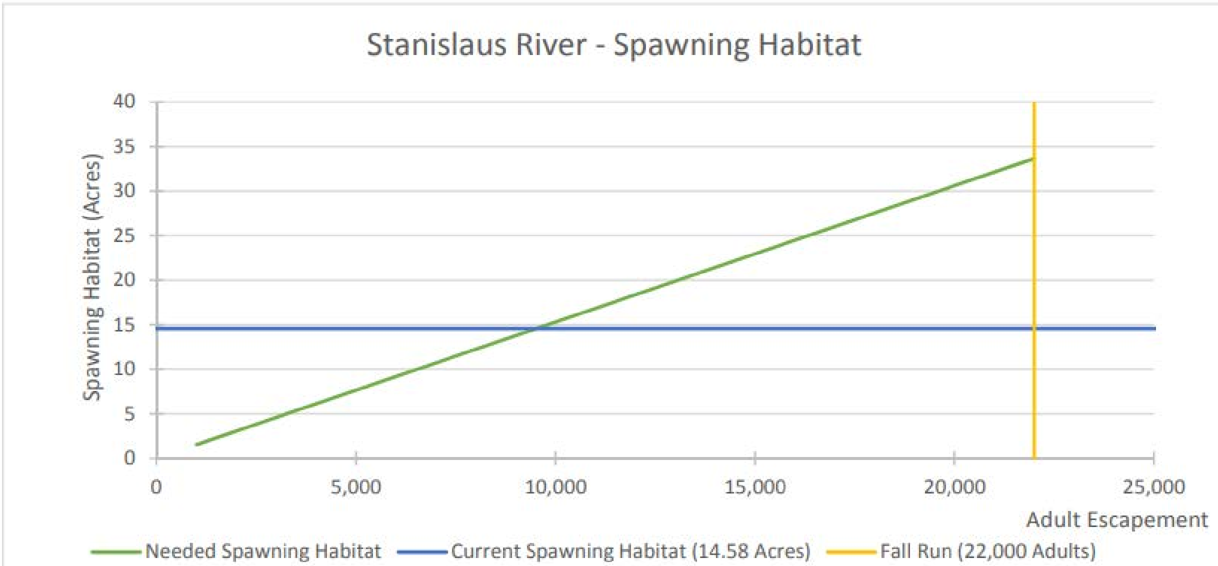


Figure 5.14-21. Estimated Chinook spawning habitat needed in the Stanislaus River to support the range of escapement sizes (CVPIA 2018).

The construction activities associated with spawning habitat restoration are not expected to affect eggs and emerging fry due to the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures* and implementation of an in-water work window (July 15 through October 15th). The in-water work window will completely avoid the eggs and emerging fry life stage, as Fall-run/Late Fall-run Chinook Salmon typically spawn between October through November, and fry emerge between December and March (Table 5.14-2).

5.14.5.5.10.2 Rearing to Outmigrating Juveniles

Habitat restoration activities would benefit Fall-run/Late Fall-run Chinook Salmon by increasing available rearing habitat. Reclamation expects that the additional rearing habitat would support the progeny of an additional 2,800 adult salmon. The plot below shows the available rearing habitat in the Stanislaus River, along with the needed habitat to support various population sizes. Also shown is the CVPIA doubling goal for Fall-run Chinook Salmon in the Stanislaus River. The creation of side channel and rearing habitat would increase the quality and quantity of off channel rearing (and spawning areas). The habitat restoration activities would improve the riparian habitat available for, Fall-run Chinook Salmon rearing.

The benefit of the habitat restoration activities within the Stanislaus River would yield increasing riparian vegetation, which provides:

- instream object and overhanging object cover;
- new shaded riverine habitat; and
- additional area for food source.

The creation of side-channel and floodplain rearing habitat would also increase the aquatic habitat complexity and diversity within the Stanislaus River and provide additional predator escape cover.

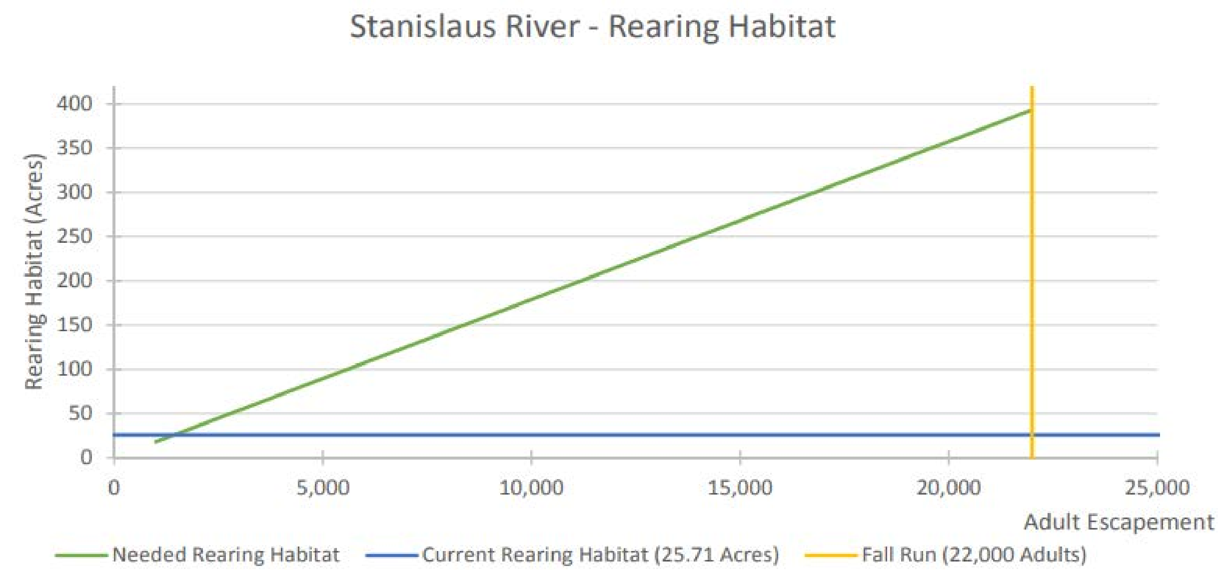


Figure 5.14-22. Estimated Chinook rearing habitat needed in the Stanislaus River to support the range of escapement sizes (CVPIA 2018).

The construction activities associated with spawning and rearing habitat restoration under the proposed action are not expected to affect rearing and outmigrating Fall-run Chinook Salmon due to the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures* and implementation of an in-water work window (July 15 through October 15).

5.14.5.5.10.3 Adult Migration from Ocean to Rivers

Habitat restoration activities under the proposed action would benefit Fall-run/Late Fall-run Chinook Salmon by increasing available spawning habitat.

The construction activities associated with spawning habitat restoration are not expected to affect immigrating Fall-run/Late Fall-run Chinook Salmon to the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures*. Additionally, per Appendix E, Reclamation will implement an in-water work window of July 15 through October 15 to avoid effects to immigrating individuals.

5.14.5.5.10.4 Adult Holding in Rivers

Habitat restoration activities would benefit Fall-run/Late Fall-run Chinook Salmon by increasing available spawning habitat.

The construction activities associated with spawning habitat restoration are not expected to affect adults holding Fall-run/Late Fall-run Chinook Salmon in the Stanislaus River due to the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures*. Additionally, per Appendix E, Reclamation will implement an in-water work window of July 15 through October 15 to reduce further effects to holding individuals.

5.14.5.5.11 Lower SJR Habitat

Under the proposed action, restoration of lower San Joaquin River spawning and rearing habitat for salmonids, including a large extent of floodplain habitat, would have the potential to increase rearing habitat for Fall-run Chinook Salmon on the San Joaquin River. Increased rearing habitat provides cover from predators and habitat complexity as well as food. Construction impacts to Fall-run Chinook salmon due to potential outmigrating juveniles would be minimized with AMMs.

5.14.5.5.12 Tracy Fish Facility Improvements

5.14.5.5.12.1 Rearing to Outmigrating Juveniles in the Bay-Delta

A small proportion of juvenile Fall-run Chinook Salmon are expected to be exposed to the Tracy Fish Facility improvements (Zeug and Cavallo 2014). However, for fish that arrive at the facility, the proposed improvements are likely to increase survival through the facility.

Few juvenile Fall-run or Late-Fall run Chinook Salmon would be expected to be exposed to construction of the CO2 injection device proposed for the Tracy Fish Facility Improvements, based on lack of observed salvage during the August–October in-water work window (Figures WR_salvage_unclipped_date, WR_salvage_clipped_date, and WR_salvage_clipped_CWT_race in Appendix F, *Juvenile Salmonid Monitoring, Sampling, and Salvage Summary from SacPAS*). To the extent that the construction affects the ability of juvenile Fall-run, and Late-Fall run Chinook Salmon to be efficiently salvaged (as part of the entrainment risk habitat attribute in the SAIL conceptual model; Figure WR_CM4), there could be a minor effect to a small number of individuals, although risk would be minimized through appropriate AMMs (Appendix E, *Avoidance and Minimization Measures*).

5.14.5.5.13 Suisun Marsh Salinity Control Gates Operation

5.14.5.5.13.1 Rearing to Outmigrating Juveniles in the Delta

Under the proposed action, Reclamation would operate the SMSCG to provide food for Delta Smelt in Suisun Marsh. Operation of the SMSCG from June through October under the proposed action coincides with a portion of the downstream migration of Fall-run Chinook Salmon. Montezuma Slough provides an alternative route to their primary migration corridor through Suisun Bay. However NMFS (2009) determined that operation of the SWSCG is unlikely to impede migration of juvenile salmonids or produce conditions that support unusually high numbers of predators.

5.14.5.5.13.2 Adult Migration from Ocean to Rivers

Operation of the SMSCG from June through October under the proposed action coincides with a portion of the upstream migration of Fall-run Chinook Salmon. Montezuma Slough provides an alternative route to their primary migration corridor through Suisun Bay. Due to their strong swimming ability and migratory route, the operation of the Suisun Marsh Salinity Control Gate is unlikely to impede the migration of adult salmonids or produce conditions that support unusually high numbers of predators.

5.14.5.5.14 Summer-Fall Delta Smelt Habitat

Some juvenile Fall-run Chinook Salmon are anticipated in the Delta in the summer and fall, during the time period that Reclamation would be operating for Summer-Fall Delta Smelt habitat. However, actions Reclamation would take under this are unlikely to affect Fall-run Chinook Salmon.

5.14.5.5.15 Clifton Court Predator Management

Predator control efforts in Clifton Court Forebay under the proposed action could reduce pre-screen loss of juvenile Fall-run Chinook Salmon entrained into Clifton Court Forebay. Larger proportions of Late Fall-run Chinook Salmon are lost at the facilities and this action would have a larger beneficial effect for this run.

5.14.5.5.16 Sacramento Deepwater Ship Channel

Moderate to high proportions of juvenile Fall-run Chinook Salmon are expected to be exposed to the Sacramento Deepwater Ship Channel (SDWSC) conservation measure under the proposed action. This conservation measure would hydrologically connect the Sacramento River with the SDWSC via the Stone Lock facility from mid-spring to late fall (Wood Rodgers 2018), allowing food to enter the Delta and an alternate migration pathway. Juvenile Fall-run Chinook Salmon abundance in the Delta is moderate in peaks in April and May (Table 5.14-1). Juvenile Fall-run Chinook Salmon passing the Stone Lock facility when there is a hydrologic connection between the waterways could potentially be entrained into the SDWSC. Estimates of salmonid survival in the SDWSC are not available to compare with rates in the Sacramento River route. However, fish entering the SDWSC would not be exposed to entrainment into the interior Delta through the DCC or Georgiana Slough which would provide a benefit if survival rates are similar.

No San Joaquin River-origin Fall-run are expected to be exposed to the Sacramento Deepwater Ship Channel.

5.14.5.5.17 North Delta Food Subsidies/Colusa Basin Drain

Provision of north Delta food subsidies by routing Colusa Basin drain water to the Cache Slough area through the Yolo Bypass would occur in summer/fall, and possibly could contribute food to increase food web productivity during Fall-run Chinook Salmon juvenile outmigration.

5.14.5.5.18 Suisun Marsh Roaring River Distribution System Food Subsidies Study

Under the proposed action, provision of Suisun Marsh food subsidies through coordination of managed wetland flood and drain operations in Suisun Marsh and draining of RRDS to Grizzly Bay/Suisun Bay in conjunction with reoperation of the SMSCG would occur in summer/fall and therefore would have limited effects on Spring-run Chinook Salmon, who are in the Delta between January – February for adults, and November through June for juveniles, with a peak of juvenile migration from March to April.

5.14.5.5.19 Tidal and Channel Margin Restoration

A large proportion of juvenile Fall-run and Late-Fall run Chinook Salmon are expected to be exposed to 8,000 acres of tidal habitat restoration in the Delta. Tidal habitat restoration is expected to benefit juvenile Fall-run/Late Fall-run Chinook Salmon in several aspects represented by the Winter-run conceptual model (5.6-4) including, increased food availability and quality and refuge habitat from predators. These benefits can manifest in higher growth rates and increased survival through the Delta. Migration through the Delta represents a short period in the migration of juvenile and Late Fall-run Chinook Salmon.

Few juvenile Fall-run or Late-Fall run Chinook Salmon would be expected to be exposed to the effects of construction of 8,000 acres of tidal habitat restoration, based on the timing of in-water construction (August–October) and the typical seasonal occurrence of this life stage in the Delta (Tables 5.14-1 and 5.14-2). Individuals being exposed to construction could experience risk of potential effects similar to those suggested in recent restoration projects such as the Lower Yolo Restoration Project (NMFS 2014). This includes temporary loss of aquatic and riparian habitat leading to increased predation, increased water temperature, and reduced food availability; degraded water quality from contaminant discharge by heavy equipment and soils, and increased discharges of suspended solids and turbidity, leading to direct toxicological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), loss of aquatic vegetation providing physical shelter, and reduced foraging ability caused by decreased visibility; impediments and delay in migration caused by elevated noise levels from machinery; and direct injury or mortality from in-water equipment strikes or isolation/stranding within dewatered cofferdams. Many of these are elements highlighted in the SAIL conceptual model (Figure 5.6-4). The risk from these potential effects would be minimized through application of AMMs (Appendix E, *Avoidance and Minimization Measures*).

5.14.5.5.20 Predator Hot Spot Removal

Predator hot spot removal under the proposed action is primarily focused on providing positive effects to downstream-migrating juvenile salmonids including Fall-run and Late-Fall run Chinook Salmon. Although the action would not be limited to existing identified hot spots (e.g., those identified by Grossman et al. 2013), the existing hotspots that may be representative of where removal efforts may be most concentrated are in the primary migratory routes of juvenile Fall-run Chinook. All hotspots are limited in scale relative to overall available habitat and previous research has not found a consistent positive effect of predator removal on juvenile salmon survival (Cavallo et al. 2012, Michel et al. 2017, Sabal et al. 2017).

5.14.5.5.21 San Joaquin River Scour Hole Predation Reduction

Fall-run Chinook salmon outmigrating from the San Joaquin River are exposed to predation at the junction of the San Joaquin River and Old River. This action would reduce predation at this site, improving juvenile San Joaquin origin Fall-run Chinook salmon survival.

Few Fall-run Chinook Salmon are expected to be exposed to in-water construction impacts due to observance of species protective work windows. Impacts of construction to adjust bathymetry would be minimized in accordance with Appendix E, Avoidance and Minimization Measures.

5.14.5.5.22 Knight's Landing Outfall Gates Fish Barrier

Reclamation and DWR's fish barrier at the Knight's Landing Outfall Gates would prevent possible entrainment of salmonids into the Colusa Basin Drain. This project would reduce entrainment and therefore increase survival of Fall-run Chinook salmon adults.

Few Fall-run Chinook salmon are expected to be exposed to in-water construction impacts due to observance of species protective work windows. Impacts of construction would be minimized in accordance with Appendix E, Avoidance and Minimization Measures.

5.14.5.5.23 Delta Cross Channel Gate Improvements

Few Fall-run and Late-Fall run Chinook Salmon are expected to be exposed to improvements to the Delta Cross Channel. Seasonal closure periods would still be in place to protect migrating salmonids. Potential diurnal operation during closure periods could increase exposure of Fall-run and Late-Fall run juvenile to entrainment into the interior Delta. However, improved biological and physical monitoring associated with improvements would likely minimize potentially increased entrainment. Greater operational flexibility and increased gate reliability resulting from improvements would reduce the risk of gate failure that could result in higher rates of entrainment.

5.14.5.5.24 Tracy Fish Facility Improvements

Although these actions could positively affect juvenile Fall-run Chinook Salmon through greater salvage efficiency, only small proportions of Fall-run Chinook Salmon are lost at the CVP (Zeug and Cavallo 2014).

5.14.5.5.25 Skinner Fish Facility Improvements

Skinner fish facility improvements from predator control efforts to reduce predation following entrainment into Clifton Court Forebay could reduce pre-screen loss of Fall-run/Late Fall-run juvenile Chinook Salmon entrained into Clifton Cout Forebay. However, only small proportions of Fall-run Chinook Salmon are lost at the SWP (Zeug and Cavallo 2014). Larger proportions of Late Fall-run Chinook Salmon are lost at the facilities and this action would have a larger effect for this run.

5.14.5.5.26 Delta Fishes Conservation Hatchery

Potential effects of the Delta Fishes Conservation Hatchery include inadvertent propagation and release of nuisance species and reduced water quality resulting from hatchery discharge. Mitigation and minimization measures are detailed in the EIR/EIS for the facility (Horizon Water and Environment 2017) Potential exposure of juvenile Fall-run Chinook Salmon would be restricted to a small spatial area within the primary migration route.

As with the other proposed construction activities under the proposed action in the Bay-Delta, few juvenile Fall-run or Late-Fall run Chinook Salmon would be expected to be exposed to the effects of construction of the Delta Fishes Conservation Hatchery based on the timing of in-water construction (August–October) and the typical seasonal occurrence of this life stage in the Delta (Tables 5.14-1 and 5.14-2). The relatively few individuals occurring near the construction site could be subject to effects similar to those previously described for habitat restoration (e.g., temporary loss of habitat leading to predation, degraded water quality, reduced foraging ability caused by reduced visibility, noise-related delay in migration, and direct effects from contact with construction equipment or isolation/stranding within enclosed areas). The risk from these potential effects would be minimized through application of

AMMs (Appendix E, *Avoidance and Minimization Measures*). The application of AMMs will reduce effects, and the in-water construction is of a small scale.

5.14.5.6 Monitoring

Effects to Fall-run Chinook Salmon from monitoring would be similar to those discussed for Winter-run and Spring-run Chinook Salmon, as discussed in those sections.

5.15 Effects on Southern Resident Killer Critical Habitat

Critical habitat for the Southern Resident Killer Whale was designated in November 2006 (71CFR 229). Three specific areas are designated, (1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; (2) Puget Sound; and (3) the Strait of Juan de Fuca, which comprise approximately 2,560 square miles (6,630 sq km) of marine habitat. The designation includes the following PBFs essential for conservation of the Southern Resident Killer Whale:

1. Water quality to support growth and development; and
2. Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and
3. Passage conditions to allow for migration, resting, and foraging.

Southern Resident Killer Whales rely on 23 different species as prey, with salmon being the preferred prey (71 CFR 229). Given that critical habitat occurs within Puget Sound and the Strait of Juan de Fuca, the majority of prey consumed within critical habitat consists of populations native to rivers tributary to that habitat. The precise proportion of Central Valley-origin Chinook salmon consumed in the Southern Resident Killer Whale diet when they are feeding within critical habitat has not been determined, but fewer than 10% of Central Valley-origin Chinook salmon are collected from as far north as Tillamook Head on the northern Oregon coast (Satterthwaite et al. 2013). Southern Resident Killer Whale critical habitat is several hundred kilometers north of that area. The principal source of prey for Southern Resident Killer Whale within critical habitat is Fraser River-origin Chinook salmon, with chum salmon also important for fall foraging in Puget Sound (National Marine Fisheries Service 2014b).

In summary, the proposed action has no potential to affect water quality within Southern Resident Killer Whale critical habitat. The proposed action is unlikely to affect the production of Central Valley–origin Chinook salmon; and the proportion of Central Valley-origin Chinook salmon occurring within designated critical habitat is very low and thus has negligible potential to affect the Southern Resident Killer Whale prey base within critical habitat.

5.16 Delta Smelt

The effects of seasonal operations in the proposed action, as compared to without action, include entrainment into the central and south Delta, salvage loss in the export facilities, lower Delta outflow during the spring, and higher Delta outflow in the summer and fall. The effects of lower flows reduce food production and transport. OMR management as part of the proposed action Core Water Operation seeks to minimize and/or avoid entrainment risk and salvage loss. The proposed action includes the Summer-Fall Delta Smelt Habitat action, Suisun Marsh Salinity Control Gate Operation, and restoration of tidal marsh habitat. These conservation measures seek to provide a low salinity zone within productive

Delta Smelt habitat. Conservation measures under the proposed action also include food subsidy studies aiming to meet the needs of Delta Smelt for food production and retention that would otherwise occur in lost habitat.

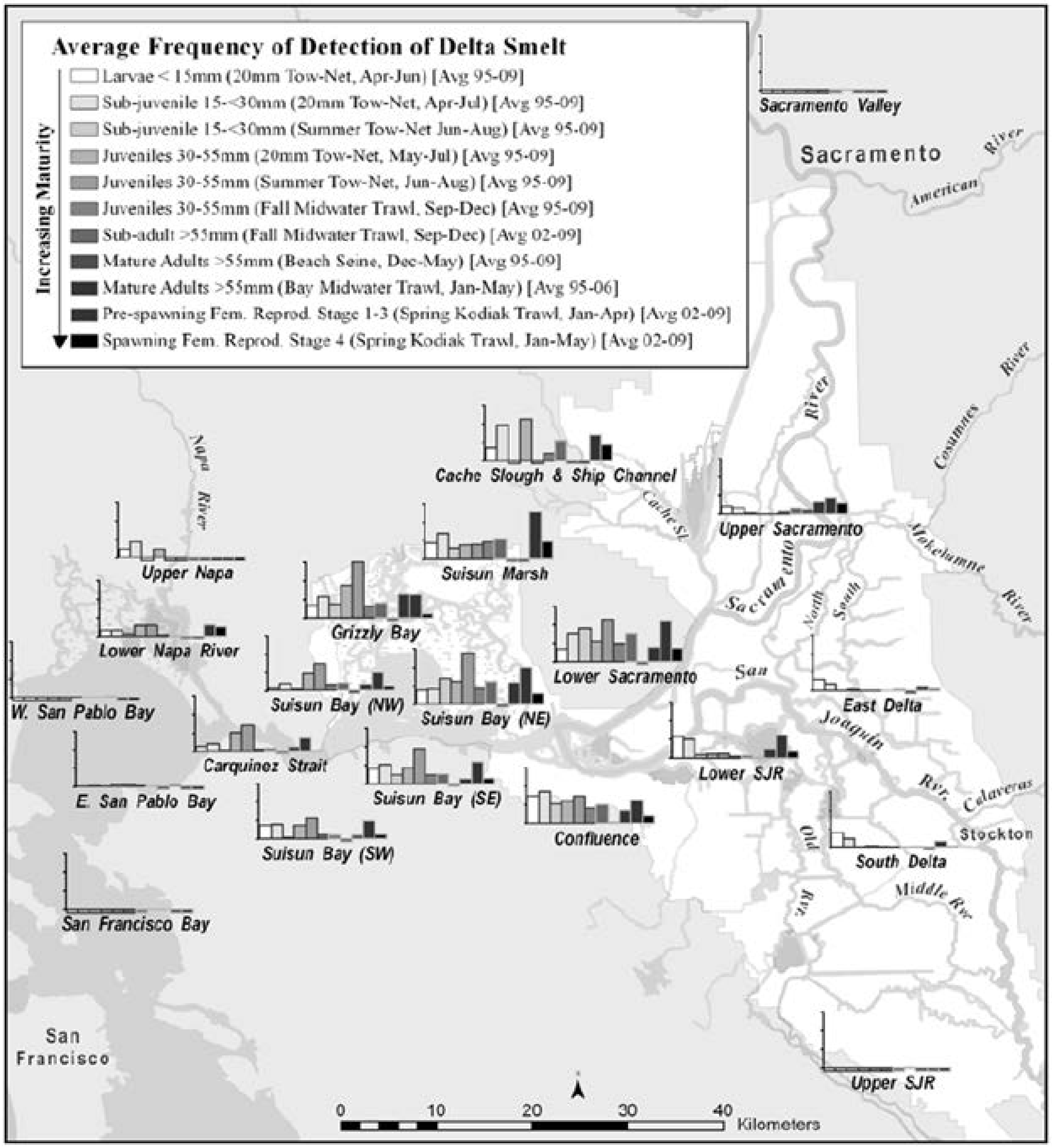
OMR management for Delta Smelt under the proposed action establishes protective criteria to avoid entrainment based on work from the Delta Smelt Scoping Team under the Collaborative Science and Adaptive Management Team. Additional protective measures occur when environmental criteria indicate that entrainment is more likely. Enhanced monitoring in real-time and predictive tools provide additional information that allows for more flexible water operations.

The legacy of levees and dredging of channels reduced the availability of high quality habitat to areas within a “north Delta arc” (habitats within the north portion of the Delta along the Sacramento River) and downstream of the confluence of the Sacramento and San Joaquin Rivers into Suisun Marsh and Suisun Bay. The absence of habitat throughout the Delta requires higher Delta outflow to maintain suitable water quality in the remaining areas that Delta Smelt can rear. The proposed action is structured to respond to this degraded environmental baseline. Management of the low salinity zone into the confluence provides low salinity water quality and food export into the remaining areas of high productivity. Operation of the Suisun Marsh Salinity Control Gate provides low salinity habitat at a lower water cost. Tidal habitat restoration increases the areas of high quality habitat. Food subsidy projects address stresses on populations due to food limited conditions in the absence of productive habitat.

Other stressors continue to impact Delta Smelt including contaminants, invasive species and warm water temperatures. These factors will continue to reduce the ability of Delta Smelt to reproduce and rebuild populations. Reintroduction from the U.C. Davis Fish Conservation and Culture Laboratory jump starts rebuilding the population to buffer against external factors. In the long-term, the Delta Fish Species Conservation Hatchery under the proposed action can support the population.

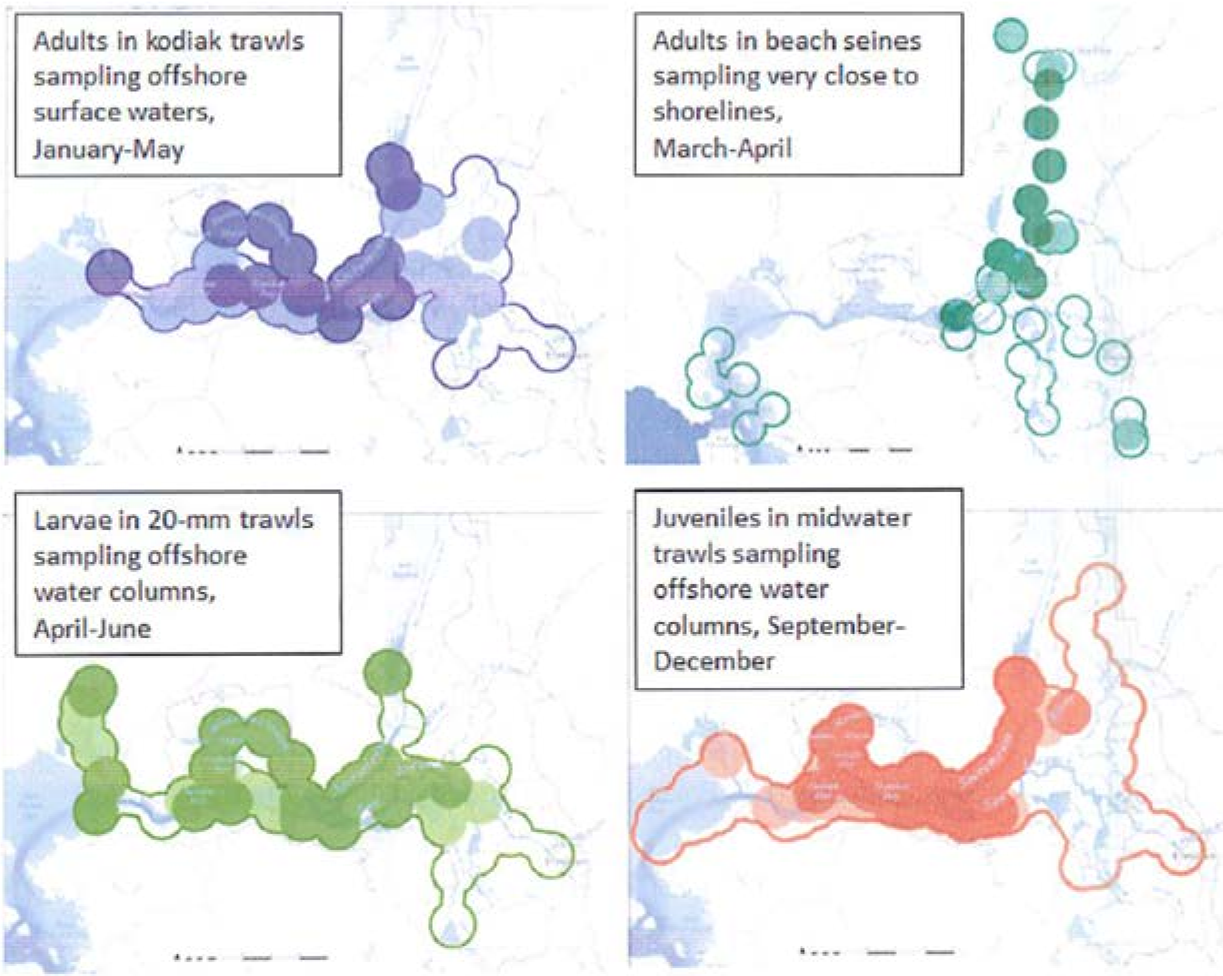
5.16.1 Lifestage Timing and Distribution

The effect analysis considers where the proposed action overlaps with the life stage timing and distribution of Delta Smelt in the action area, as illustrated in Figures 5.16-1 and 5.16-2.



Source: Merz et al. (2011, p.178). Note: Regions where the average frequency of detection for a given life stage was zero are indicated by no data column being present. Regions that were not sampled for a given life stage are indicated by a data column suspended slightly below the x-axis. Y-axis ticks indicate frequencies of 0, 25, 50, 75, 100 percent.

Figure 5.16-1. Average Annual Percentage of Sampling Events Where Delta Smelt Were Observed by Life Stage and Region for Interagency Ecological Program Surveys.



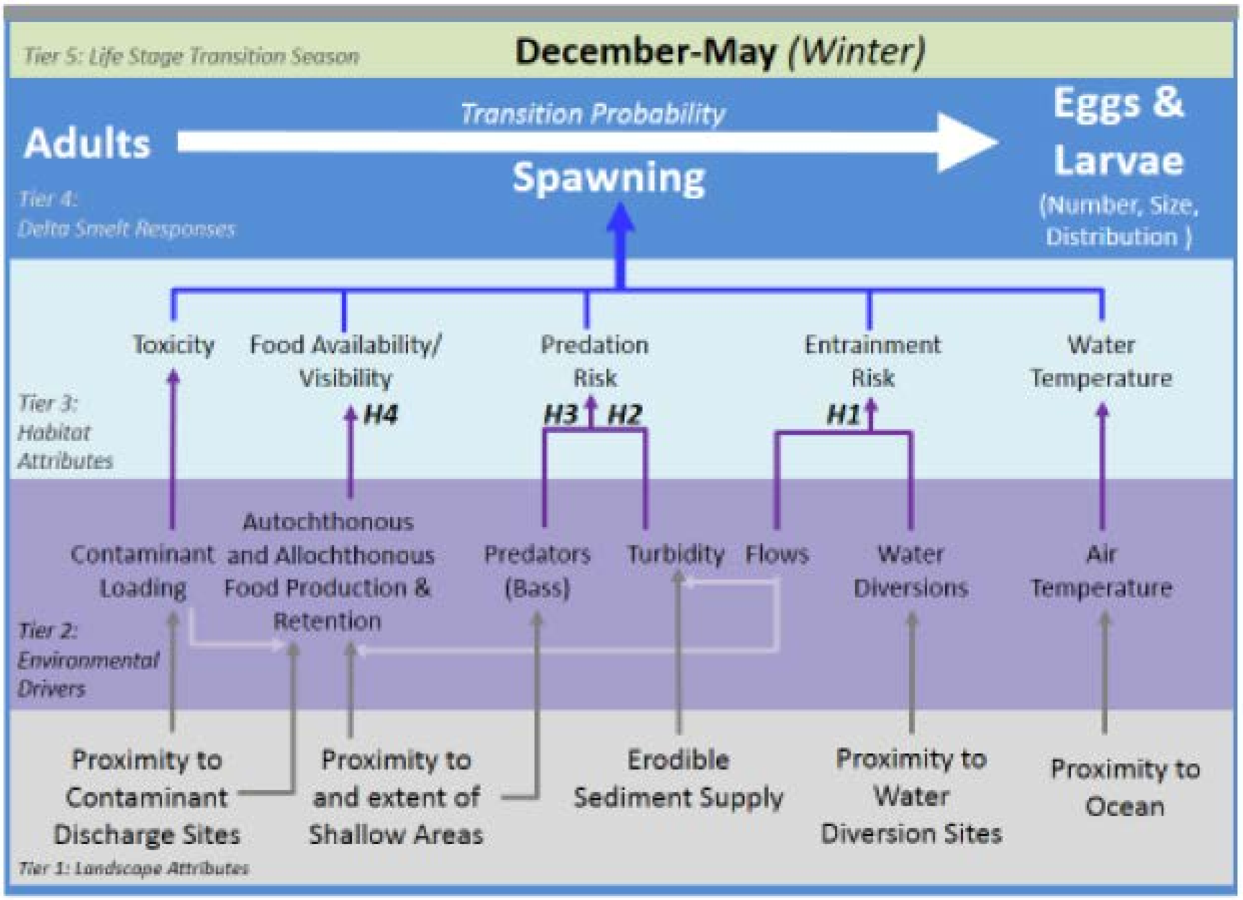
Source: USFWS (2017a, p.141). Note: The sampling regions covered by each survey are outlined. The areas with dark shading surround sampling stations in which 90 percent of the Delta Smelt collections occurred, the areas with light shading surround sampling stations in which the next 9 percent of delta smelt collections occurred.

Figure 5.16-2. Maps of Multi-Year Average Distributions of Delta Smelt Collected In Four Monitoring Programs

5.16.2 Conceptual Models

The IEP MAST (2015) developed "a general life cycle conceptual model for the four Delta Smelt life stages (adults, eggs and larvae, juveniles, and subadults) that includes stationary landscape attributes and dynamic environmental drivers, habitat attributes, and Delta Smelt responses".

A life stage transition in the December–May period addresses adults transitioning to eggs and larvae. Adults seldom if ever fully mature in December, but begin dispersing at that time. Additionally, there is limited impact to eggs/larvae until February. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.16-3.

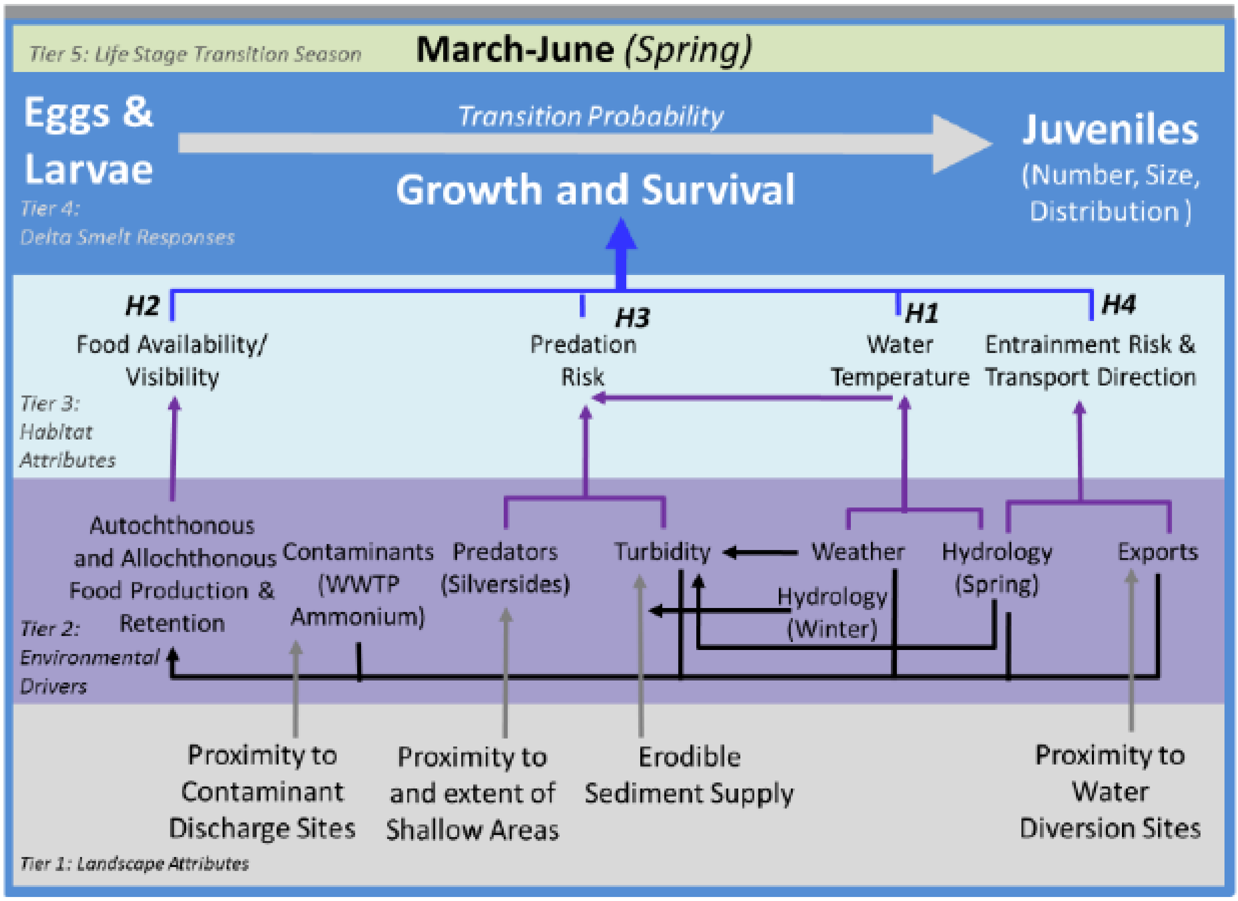


Source: IEP MAST (2015). Note: Hypotheses are referenced by the H-number for habitat attributes.

Figure 5.16-3. Conceptual Model of Drivers Affecting the Transition of Delta Smelt Adults to Eggs/Larvae.

Adult habitat attributes and environmental drivers related to the proposed action are primarily entrainment risk due to exports and food availability.

A life stage transition in the March–June period address eggs/larvae transitioning to juveniles. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.16-4.

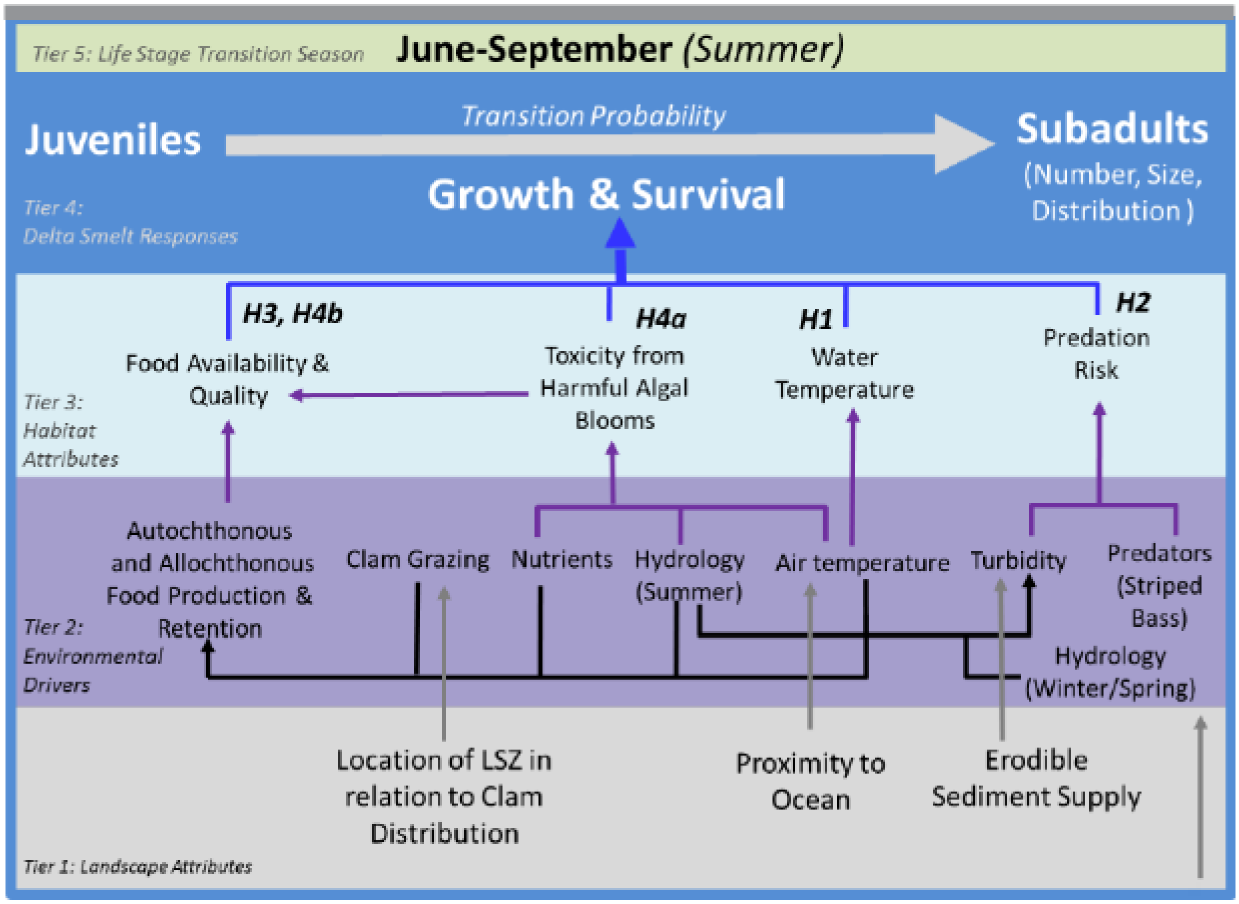


Source: IEP MAST (2015). Note: Hypotheses are referenced by the H-number for habitat attributes.

Figure 5.16-4. Conceptual Model of Drivers Affecting the Transition of Delta Smelt Eggs/Larvae to Juveniles.

Larvae habitat attributes and environmental drivers related to the proposed action are primarily food availability from food production and retention and entrainment risk due to exports.

A life stage transition in the June–September period addresses juveniles transitioning to subadults. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.16-5.

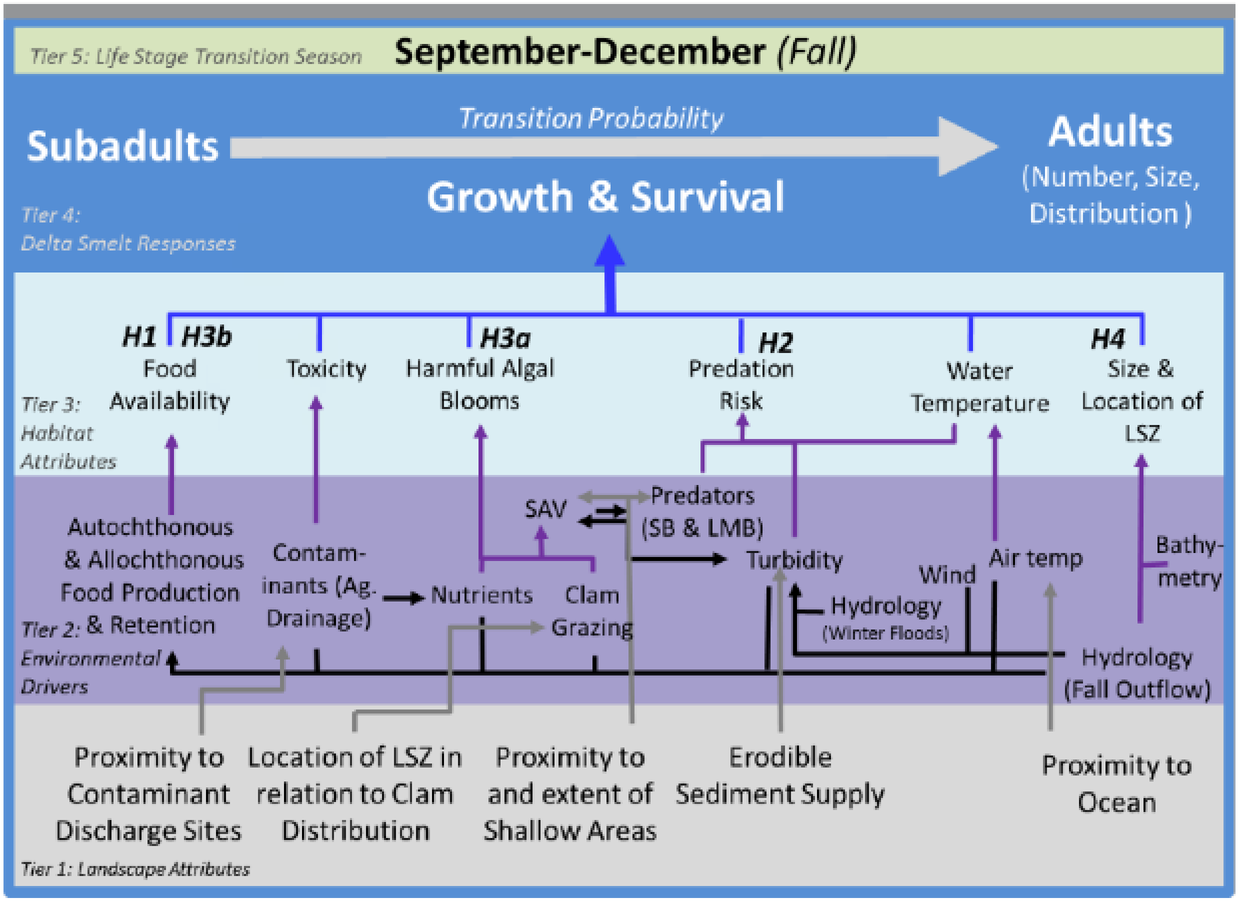


Source: IEP MAST (2015). Note: Hypotheses are referenced by the H-number for habitat attributes.

Figure 5.16-5. Conceptual Model of Drivers Affecting the Transition of Delta Smelt Juveniles to Subadults.

Juvenile habitat attributes and environmental drivers related to the proposed action are primarily food availability from food production and retention, as well as sediment changes relating to predation, and algal blooms.

A life state transition in the September–December period addresses subadults transitioning to adults. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.16-6.



Source: IEP MAST (2015). Note: Hypotheses are referenced by the H-number for habitat attributes.

Figure 5.16-6. Conceptual Model of Drivers Affecting the Transition of Delta Smelt Subadults to Adults.

Subadult habitat attributes and environmental drivers relates to the proposed action are primarily food availability from food production and retention.

5.16.3 Effects of Operations and Maintenance

5.16.3.1 Seasonal Operations

The storage and diversion of water under the proposed action results in changes to the low salinity zone as represented in the position of X2. The position of X2 for the proposed action is further upstream than without action on average (Figure 5.16-7).

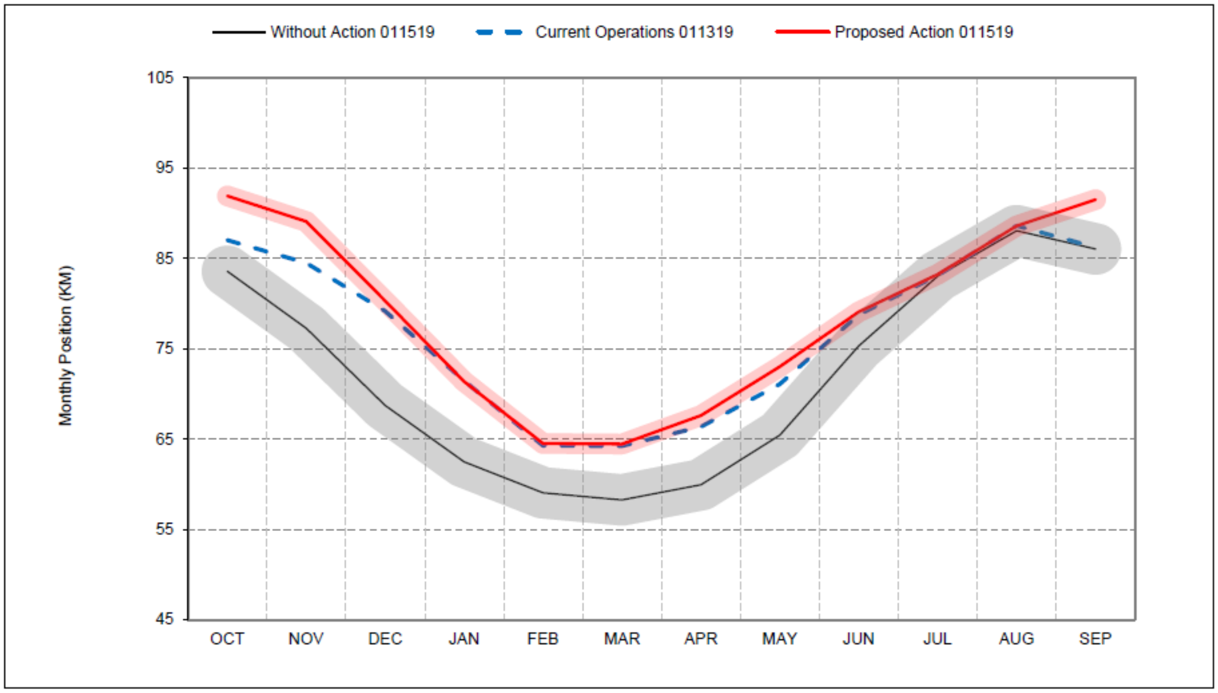


Figure 5.16-7. X2 Long-term Average Position by Month

The differences between the proposed action and without action depend upon the water year type and season (Figure 5.16-8 and 5.16-9).

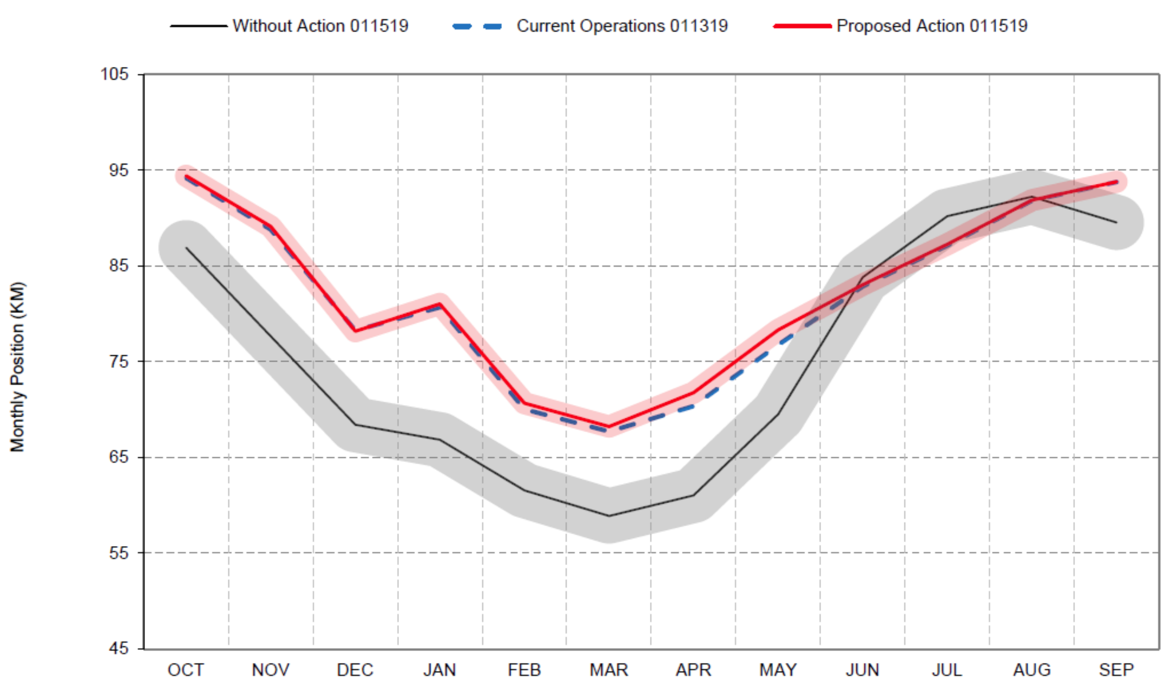


Figure 5.16-8. X2 Dry Year Position by Month

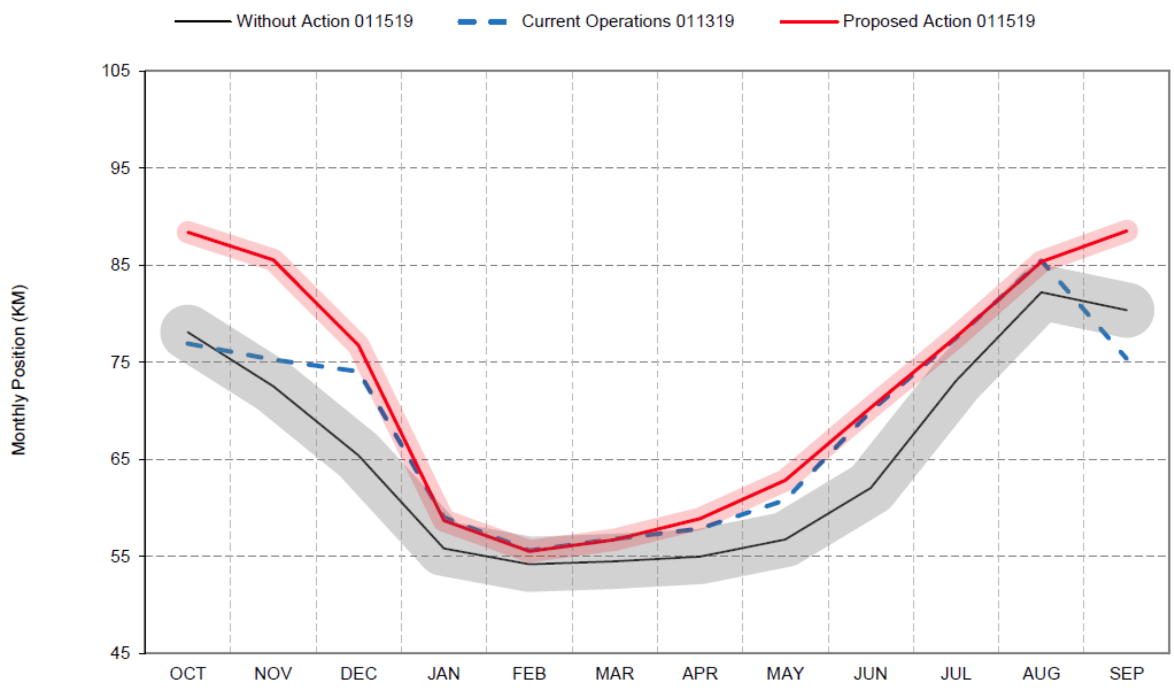


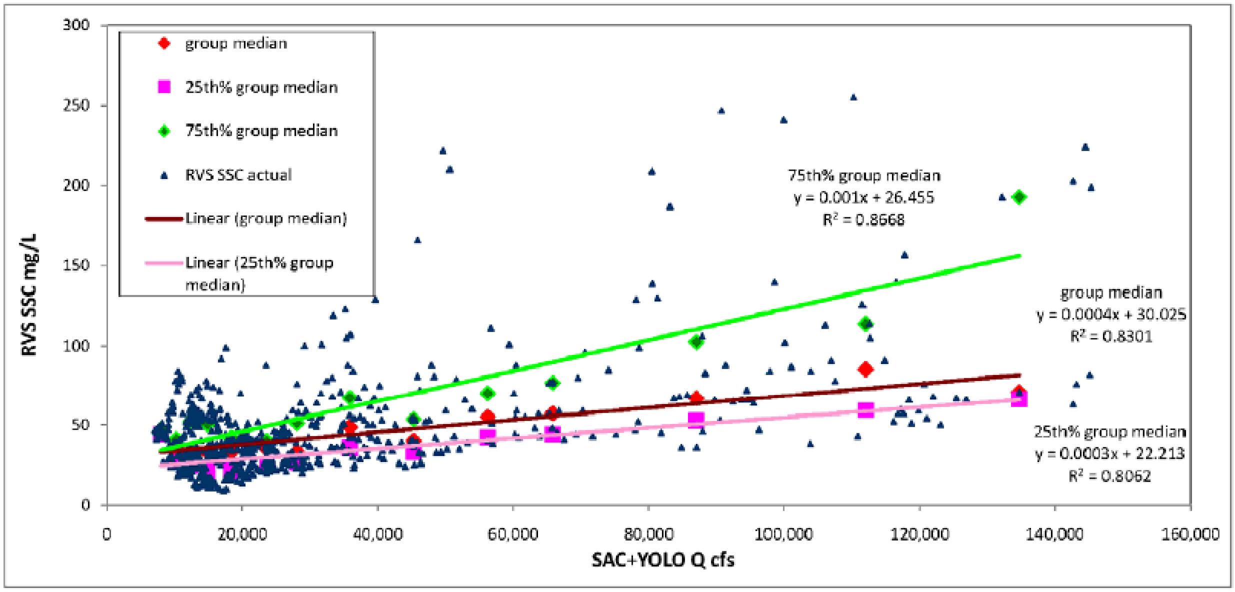
Figure 5.16-9. X2 Wet Year Position by Month

The effect of seasonal operations in the proposed action as compared to without action is to reduce the frequency of the low salinity zone being located within the productive habitat of Suisun Marsh and bay during some seasons and hydrologic year types, and increase the frequency in others.

5.16.3.1.1 <u>Adults to Eggs and Larvae</u>

5.16.3.1.1.1 Predation Risk

The IEP MAST (2015) conceptual model identifies predation risk as a habitat attribute affecting Delta Smelt egg survival (Figure 5.16-3). Flows interact with erodible sediment supply to affect turbidity. In general, greater turbidity is thought to lower the risk of predation on delta smelt. Large amounts of sediment enter the Delta from winter and spring storm runoff, with resuspension by tidal and wind action. A conceptual model of sedimentation in the Delta includes a submodel for river supply, which notes that dams and reservoirs have contributed to decreased sediment supply to the Delta (Schoellhamer et al. 2012, their Figure 4). Under the without action scenario, the dams and reservoirs continue to block sediment supply. Greater flow passing through reservoirs may pass greater amounts of sediment supply than under current operations and the proposed action. Cloern et al. (2011, their Figure S1) developed a rating curve of Sacramento River at Rio Vista suspended sediment concentration as a function of Sacramento River at Freeport + Yolo Bypass flows to the Delta (reproduced as Figure 5.16-10, below). Based on this curve, differences between the proposed action and without action scenarios in suspended sediment concentration as a function of mean winter-spring Rio Vista flows (Figures 32-9, 32-10, 32-11, 32-12, 32-13, and 32-14 in Appendix D, *Modeling*) are suggested to potentially be low during the high flow winter months (December–February), whereas differences in spring (April-May) could be greater.



Source: Cloern et al. (2011, their Figure S1).

Figure 5.16-10. Sediment Rating Curve for the Sacramento River at Rio Vista, 1998-2002

Available estimates of sediment removal by the south Delta export facilities are low, i.e., ~2% of sediment entering the Delta at Freeport in 1999–2002 (Wright and Schoellhamer 2005). These estimates were made at similar ratios of south Delta exports to Sacramento River + Yolo Bypass inflow as were modeled for the proposed action scenario suggesting that south Delta exports under the proposed action would remove only a small percentage of sediment entering the Delta. Given the limited expected difference in suspended sediment entering the Delta under the proposed action relative to without action, as well as the small percentage of sediment that would be expected to be removed by the south Delta export facilities, the potential negative effect of the proposed action on turbidity generally would be expected to be low. Per the MAST conceptual model, high turbidity relates to low predation risk for Delta Smelt. There is uncertainty in this conclusion given the complexity of sedimentation mechanisms in the Delta (Schoellhamer et al. 2012, their Figure 7), and the fact that quantitative analyses of the effects of exports on predation risk and turbidity have not been conducted (IEP MAST 2015, p.52).

5.16.3.1.1.2 Food Availability

Although food availability during other life stages has been suggested to be important from various statistical and modeling analyses (e.g., Miller et al. 2012; Kimmerer and Rose 2018), food availability is also posited by the IEP MAST (2015) conceptual model to affect the probability of adults spawning and transitioning to egg/larval production (Figure 5.16-3). The draft Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project EIS/EIR suggests that implementation of the Fremont Weir notch could increase food web productivity and therefore benefit growth and survival of Delta Smelt adults occurring downstream of the Yolo Bypass during the winter (DWR and Reclamation 2017, p.8-111 to p.8-112). This potential positive effect could improve the likelihood of adult Delta Smelt successfully spawning, per the mechanism described by the IEP MAST (2015) conceptual model (Figure 5.16-3). Flow is needed in the Yolo Bypass to create this food effect. The Yolo Bypass was assumed to be operational in this biological assessment, therefore all modeling scenarios show flow through Yolo Bypass, providing for this potential positive effect on Delta Smelt spawning (see Appendix D, *Modeling* for the mean modeled flow through Yolo Bypass in various months).

5.16.3.1.2 Eggs and Larvae to Juveniles (March – June)

5.16.3.1.2.1 Food Availability

The IEP MAST (2015) conceptual model suggests that south Delta exports could affect food availability for larval Delta Smelt (Figure 5.16-4), due to entrainment of food (Jassby and Cloern 2000; Kimmerer and Rose (2018 Trans Am Fish Soc)). There is a positive correlation between the density of the important Delta Smelt larval/juvenile zooplankton prey *Eurytemora affinis* in the low salinity zone and Delta outflow (as indexed by X2) during the spring (March–May; Kimmerer 2002, Greenwood 2018). Also, outflow is required to continuously flush *P. forbesi*, a relatively recent important Delta Smelt food source, from freshwater areas where it grows (Kimmerer et al. 2018 SFEWS) into Delta Smelt habitat, where it is eaten by larval Delta Smelt once it is abundant in May–June (Nobriga 2002; Slater and Baxter 2014). Therefore, the mechanism suggested by the conceptual model for the effects of south Delta exports on food availability could be related to hydrodynamic effects of Delta outflow. As shown in Figure X2_marmay, Delta outflow would be lower under the PA than the WOA scenario, and therefore X2 would be greater (i.e., further upstream). Based on the negative relationship between *Eurytemora affinis* density and X2, the modeling results suggest that food density for *Eurytemora affinis* under the proposed action could be negatively affected, which could potentially affect individual Delta Smelt growth and survival per the MAST conceptual model assuming other interactions in the relationship are fixed. As noted by Greenwood (2018, p.4-5), there is appreciable uncertainty in the predictions of *Eurytemora affinis* density as a function of X2, with 95% prediction intervals typically spanning several orders of magnitude. This correlation may be reflecting a water temperature influence of high flow conditions and the loss of mysids which were a historical predator whose abundance was high when flow was high.

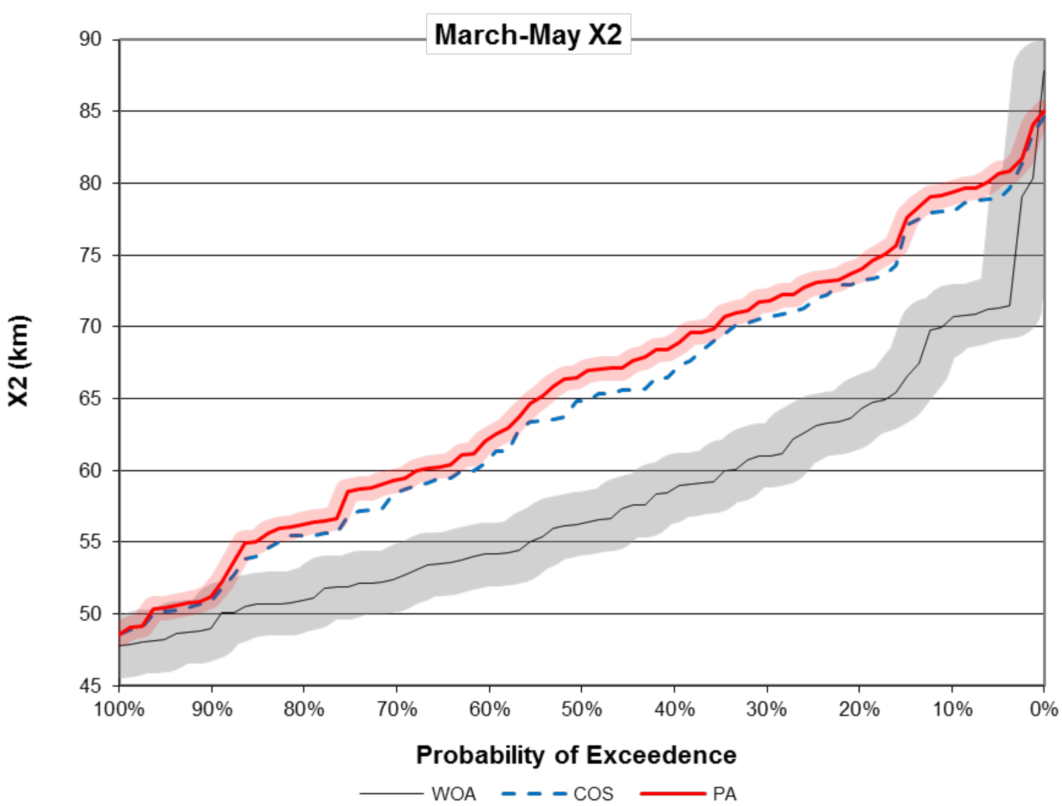


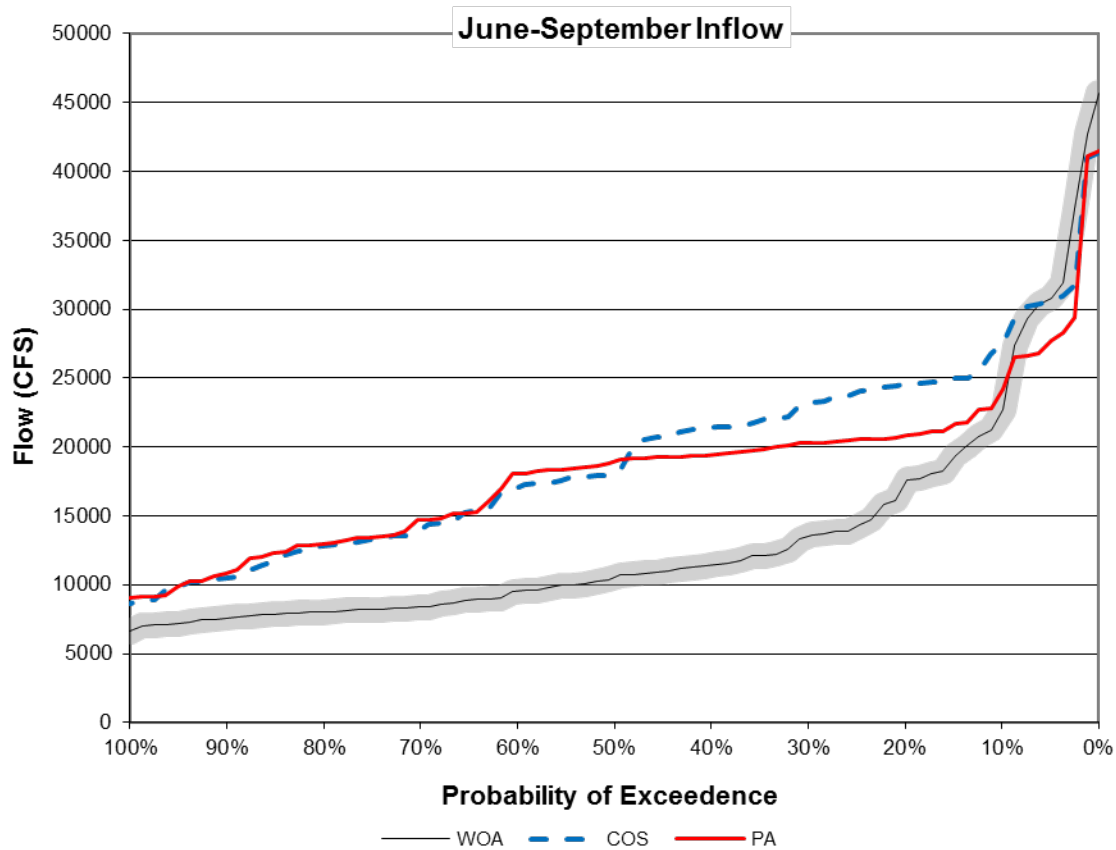
Figure 5.16-11. Mean Modeled X2 from CalSim, March–May

The proposed action includes construction of the rest of the 8,000 acres of tidal habitat restoration to offset potential negative effects on food availability based on the hydrodynamic influence of the south Delta export facilities during the spring larval and early juvenile Delta Smelt period (Kratville 2010); these factors could reduce the potential negative effects from the proposed action on larval/early juvenile Delta Smelt food availability. Under WOA, habitat restoration would not occur.

5.16.3.1.2.2 Predation Risk

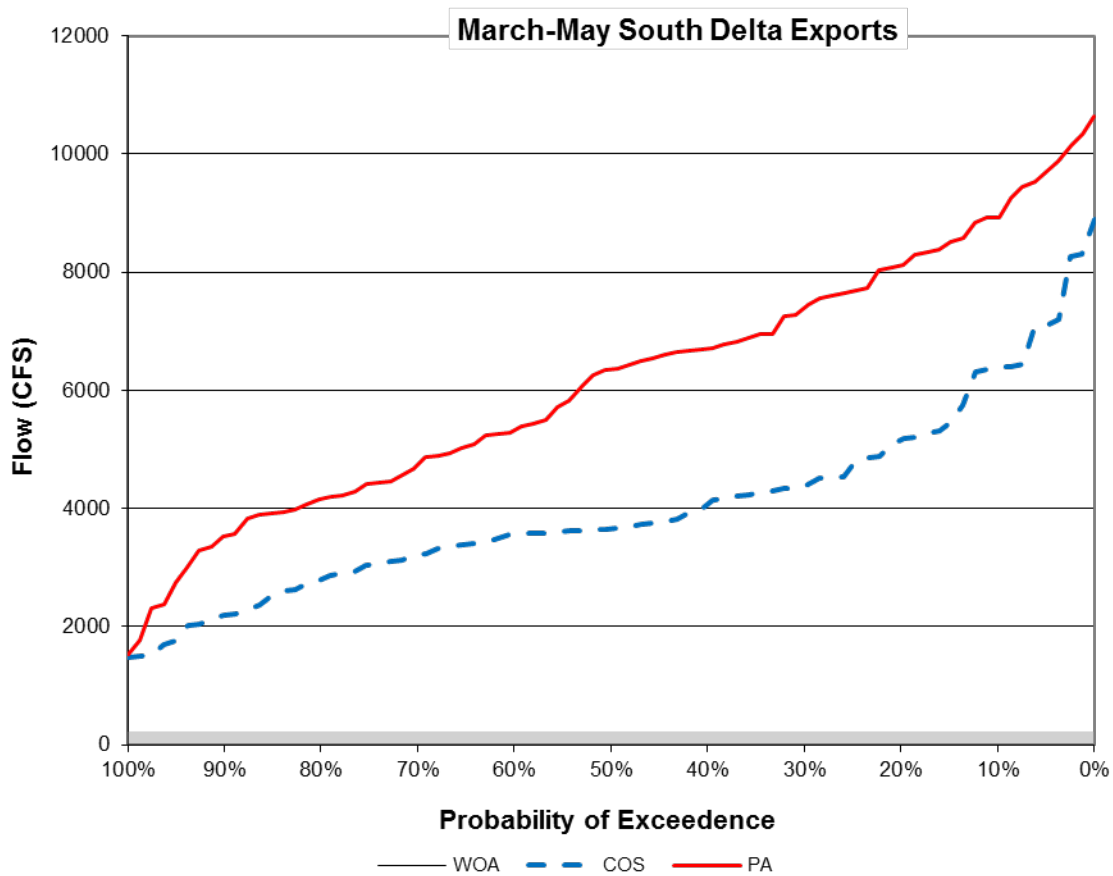
The IEP MAST conceptual model (2015) suggests that the probability of egg/larval Delta Smelt surviving to juveniles is influenced by predation risk, which may involve different factors such as turbidity, water temperature, and predators (silversides) (Figure 5.16-4). As previously described for adult Delta Smelt, potential effects of the proposed action on turbidity as a result of reduced upstream supply and removal by south Delta exports are concluded to be low, although this is uncertain. Wild detection of embryos and larvae are sparse, which reduces the certainty of any conclusions, although silversides have been found with Delta Smelt in their guts during the larval period (Schreier et al. 2016). As discussed by USFWS (2017a, p.274), water temperature in the San Francisco Estuary is driven mainly by air temperature and even in the Delta the water temperature is only slightly affected by freshwater inflow; flow-related effects on Delta water temperature are expected to be minor (Wagner et al. 2011).

With respect to silversides, Mahardja et al. (2016) found in a multivariate model that summer (June–September) Delta inflow and spring (March–May) south Delta exports had the strongest correlations with cohort strength; both relationships were negative. Mahardja et al. (2016, p.12) cautioned that the relationships are not meant to imply causality, given that the mechanisms could not be identified, and that further investigation is merited. In addition, beach seines (used in the study) only sample upstream of the confluence, so if high flow moves silversides downstream, then the inverse correlation of flow and abundance is misleading. Recognizing this uncertainty, the proposed action would not be expected to result in greater silverside cohort strength than without action, given that both spring south Delta exports and summer inflow to the Delta generally are greater under the PA compared to WOA , as shown in Figure 5.16-13 and Figure 5.16-14. A similar situation exists for the comparison of COS to the WOA.



Note: Delta inflow is represented by Freeport + Yolo + Mokelumne + Vernalis flow.

Figure 5.16-12. Mean Modeled Delta Inflow, June–September



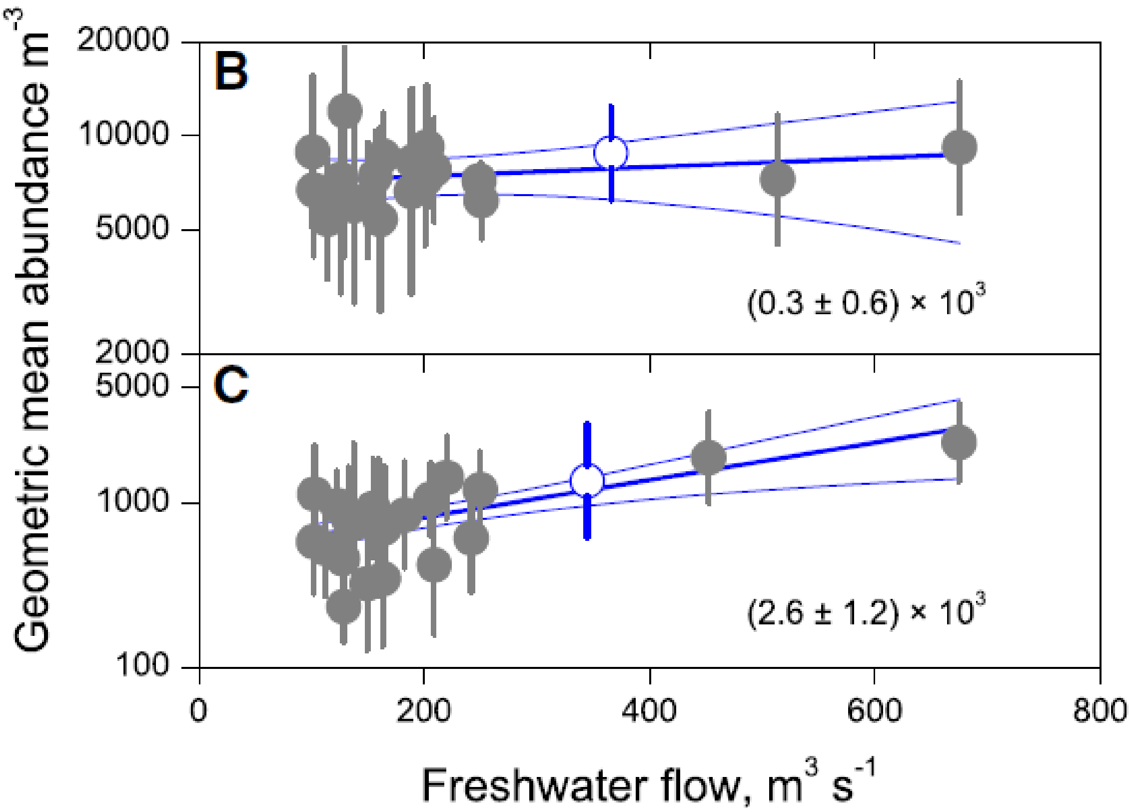
Note: South Delta exports under the WOA scenario are zero.

Figure 5.16-13. Mean Modeled South Delta Exports, March–May

5.16.3.1.3 Juveniles to Subadults (June – September)

5.16.3.1.3.1 Food Availability

As described in the IEP MAST (2015) conceptual model, food availability and quality is a key component of the June–September transition probability of juvenile Delta Smelt to subadulthood through growth and survival of individuals (Figure 5.16-5). The south Delta exports influence the subsidy of the Delta Smelt zooplankton prey *Pseudodiaptomus forbesi* to the low salinity zone from the freshwater Delta (Kimmerer et al. 2018a), with these potential negative effects probably being of particular importance on the San Joaquin River side of the Delta given the high density of *P. forbesi* there (Kimmerer et al. 2018b). South Delta exports may entrain *P. forbesi* (USFWS 2008, p.228; Kimmerer et al. 2018b), resulting in a positive correlation between July–September Delta outflow and *P. forbesi* density in the low salinity zone (Kimmerer et al. 2018a; Figure pforbes1). Given the suggested importance of the San Joaquin River side of the Delta for spatial subsidy of *P. forbesi* to the low salinity zone and modeled losses of *P. forbesi* to entrainment by the south Delta export facilities (Kimmerer et al. 2018b), modeled flows in the lower San Joaquin River (DSM2 outputs RSAN018 + SLTRM004 + SLDUT007, which is a representation of QWEST) may offer some perspective on relative differences in this potential negative effect between operational scenarios. QWEST is defined as the average daily flow traveling past Jersey Point. As shown in the figures below (Figures 5.16-16 to 5.16-18), July–September QWEST flows generally would be positive under WOA, whereas the PA would have positive QWEST flows in a small percentage of years (similar to COS), possibly indicating a lower potential for spatial subsidy of *P. forbesi* to the low salinity zone under the proposed action relative to without action.



Source: Kimmerer et al. (2018b). Note: Error bars are 95% confidence limits based on all samples from the selected stations, and points for 2011 are shown as open circles. Lines with error bounds are from least-squares models of log of abundance versus flow, weighted by the inverse of variance. Values are slopes with 95% confidence intervals; only the slope for the low salinity zone stations was statistically significant.

Figure 5.16-14. July-–September Geometric Mean Abundance of *Pseudodiaptomus forbesi* Copepodites and Adults for 1994–2016 in (B) Freshwater Stations (Salinity < 0.5) and (C) Low Salinity Zone Stations (Salinity 0.5–5), Excluding Suisun Marsh and the Central to Eastern Delta.

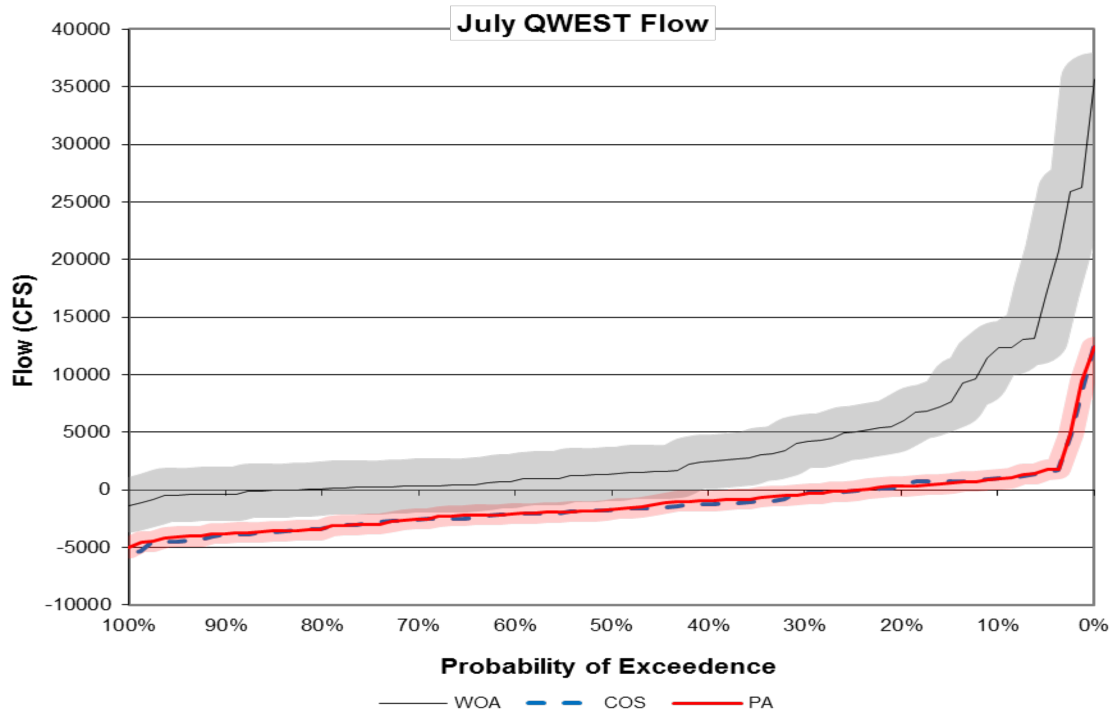


Figure 5.16-15. Mean Modeled QWEST Flow, July

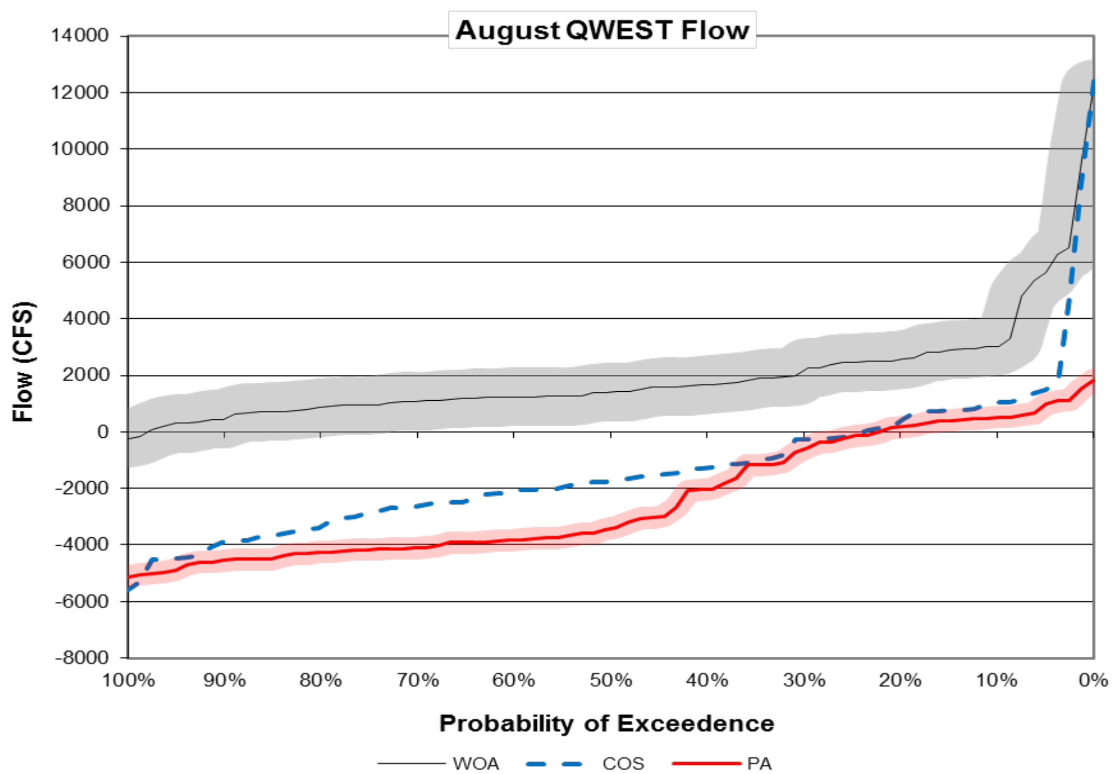


Figure 5.16-16. Mean Modeled QWEST Flow, August

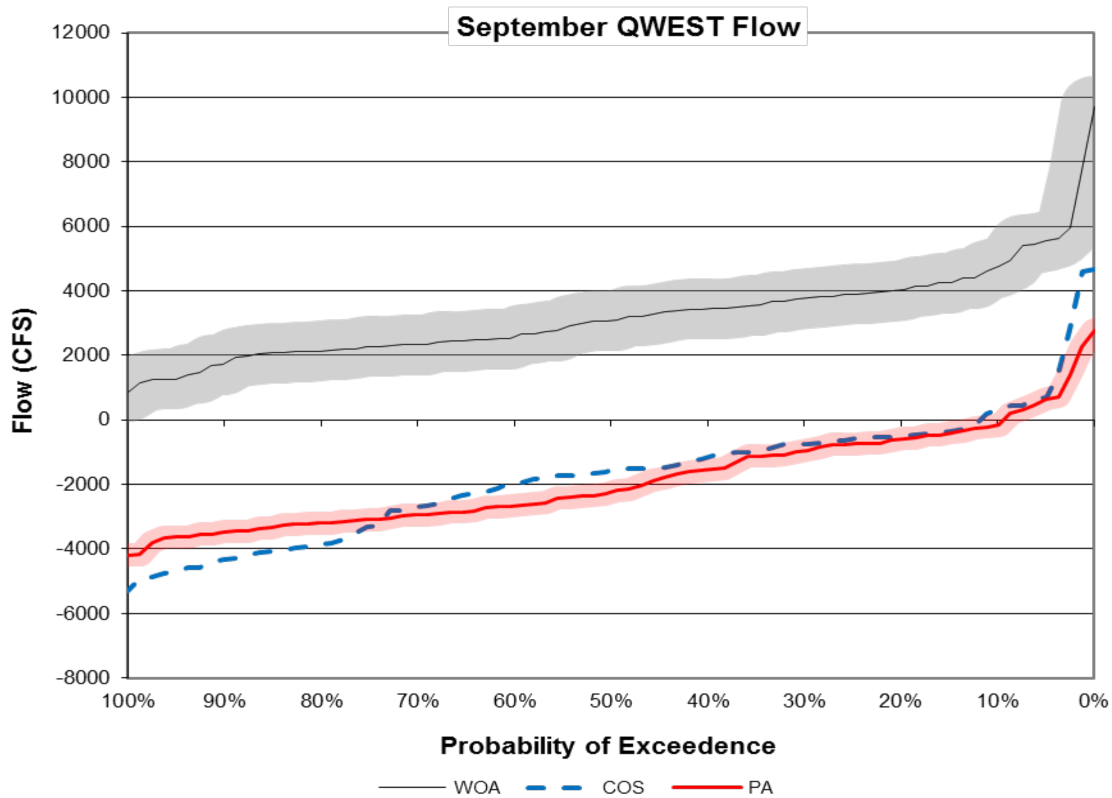


Figure 5.16-17. Mean Modeled QWEST Flow, September

P. forbesi suffers from high mortality rates on its nauplii (larvae) when it resides in the low salinity zone. This mortality is not caused by salinity, but by predation on the nauplii (larvae) (Kayfetz et al. 2017). This means that *P. forbesi* abundance in the low-salinity zone would crash similarly to *E. affinis* if it were not for an upstream subsidy from the Delta where *P. forbesi* densities are higher (Kimmerer et al. 2018; E&C). Delta outflow appears to provide this subsidy by facilitating the transport of *P. forbesi* from the Delta into Suisun Bay; Kimmerer et al. (2018; Hydrobiologia) demonstrated that although system-wide, *P. forbesi* density does not correlate with Delta outflow, its density in the low-salinity zone does. Therefore, there is some evidence for potential OMR management effects on *P. forbesi* transport to the low salinity zone, but not for overall calanoid copepod density in the low salinity zone.

Potential effects from the proposed action related to both the SMSCG action (beneficial effects, discussed below) and the south Delta export facilities on food availability would be expected to have the potential to affect a sizable portion of the Delta Smelt population. Bush (2017) demonstrated that on average 77 percent of adult Delta Smelt either migrate to the low salinity zone as early juveniles or are resident in the low salinity zone throughout their lives. In contrast, an average of 23 percent of Delta Smelt surviving to adulthood are resident in the Cache Slough Complex/Sacramento Deepwater Ship Channel region throughout their lives. Those Delta Smelt resident in the Cache Slough Complex/Sacramento Deepwater Ship Channel region would not be expected to be affected by seasonal flows of the proposed action in terms of SMSCG operations and the south Delta export facilities. During and just after the August 2018 pilot implementation of the SMSCG action, EDSM data from surveys between August 6 and September 7 suggest an average of 20 percent (range 0–100%) of juvenile Delta Smelt were in Suisun Marsh, although there is appreciable uncertainty in the estimates given low numbers of fish caught (USFWS 2018_EDSM). The IEP MAST (2015) conceptual model posited link between summer hydrology and clam grazing (Figure 5.16-5) was not supported by an examination of *P. amurensis* biomass and grazing rate during the fall (Brown et al. 2014, p.50-56), so it is unclear what effect differences in hydrology might have on clam grazing.

Overall, it is concluded with some uncertainty that OMR management under the proposed action would have negative effects on transport of *P. forbesi* to the low salinity zone relative to without action. However, operations of the SMSCG under the proposed action would provide greater access to the relatively food-rich Suisun Marsh habitat in above normal and below normal water years (further discussed below). Moreover, tidal habitat restoration (an additional approximately 6,000 acres) would be undertaken as part of the proposed action, and has the potential to reduce some of the negative effects from OMR management on food availability.

5.16.3.1.3.2 Harmful Algal Blooms

The IEP MAST (2015) conceptual model posits a linkage between various factors (nutrients, summer hydrology, and air temperature) and toxicity from harmful algal blooms to Delta Smelt and their prey (Figure 5.16-5). Based on this conceptual model (see also additional discussion in IEP MAST 2015, p.85-86), differences in flows could influence harmful algal blooms. Lehman et al. (2013) reported on *Microcystis* blooms observed from 2004-2008. During these years, median QWEST flows differed by only 6 m^3/s between the two wetter years and the two drier years and *Microcystis* density showed no response to this flow variable. Lehman et al. (2013) described the range of QWEST flow at which *Microcystis* occurred in their study (-8,500 to 1,800 cfs). It is uncertain if QWEST greater than this range would result in lower likelihood of *Microcystis* blooms, but if so, there may be greater potential for blooms under the PA than WOA given that flows above the range noted by Lehman et al. (2013) occur less frequently under the PA during the main *Microcystis* summer/early fall months (Figures 5.16-16 to 5.16-18). The pattern is essentially the same for the COS compared to WOA. However, consideration only of flow does not account for other factors that could be affected by water operations that may be important in affecting *Microcystis*, such as channel velocity (RBI 2017). Note also that this analysis does not account for other factors shown to correlate with occurrence of *Microcystis* blooms that are not greatly affected by water operations such as water temperature and nutrients (RBI 2017).

A previous analysis by RBI (2017) examined DSM2-HYDRO-modeled maximum daily absolute velocity during June–November at various locations in the south Delta which are susceptible to *Microcystis* blooms, in relation to a critical velocity of threshold of 1 ft/s, above which turbulent mixing may disrupt *Microcystis* blooms. Note that there is uncertainty in this threshold given that it was developed for a different system and velocity below this threshold has been shown to disrupt blooms in other systems (RBI 2017). Applying a similar analysis for the present effects analysis suggested that along the mainstem San Joaquin River from Antioch to Brandt Bridge, current operations and the proposed action would differ little from without action in terms of having channel velocity that potentially could disrupt *Microcystis* blooms (Figure 5.16-19, Figure 5.16-20, Figure 5.16-21). In Old River at Tracy Road and Middle River at Bacon Island, maximum velocity under the PA and COS would be lower than WOA, although all scenarios generally would have maximum velocity below 1 ft/s and, therefore, may not differ in terms of potentially providing conditions unlikely to disrupt *Microcystis* blooms (Figure 5.16-22 and Figure 5.16-23). In contrast, maximum velocity at Grant Line Canal downstream of the temporary barrier, Old River at Bacon Island, and Old River at Highway 4 generally was below 1 ft/s under PA and COS, but close to or above 1 ft/s under WOA (Figure 5.16-24, Figure 5.16-25, Figure 5.16-26). Greater maximum velocity under WOA reflects the absence of agricultural barriers, which reduce tidal flows under current operations and the proposed action. A greater frequency of maximum velocity below 1 ft/s may indicate greater potential for *Microcystis* blooms not to be disrupted in Old River and Grant Line Canal close to the agricultural barriers under the proposed action compared to without action. However, even if *Microcystis* blooms were disrupted less under the proposed action, these blooms would not necessarily directly or indirectly (through effects on prey) affect juvenile Delta Smelt in the low salinity zone given that the prevailing direction of movement would be upstream because of south Delta export pumping (e.g., Figures 5.16-16 through 5.16-18). The IEP MAST conceptual model also notes that relatively clear water is a factor thought to cause more intensive *Microcystis* blooms (IEP MAST 2015, p.85). The proposed action has less sediment supply and, therefore, potentially less sediment for resuspension in the Bay-Delta during the summer/fall period when *Microcystis* blooms occur.

There is a difference in flows between the proposed action and without action scenarios, as well as possibly greater potential for lower velocity to limit *Microcystis* bloom disruption, and the potential for higher water clarity as a result of reduced sediment supply.

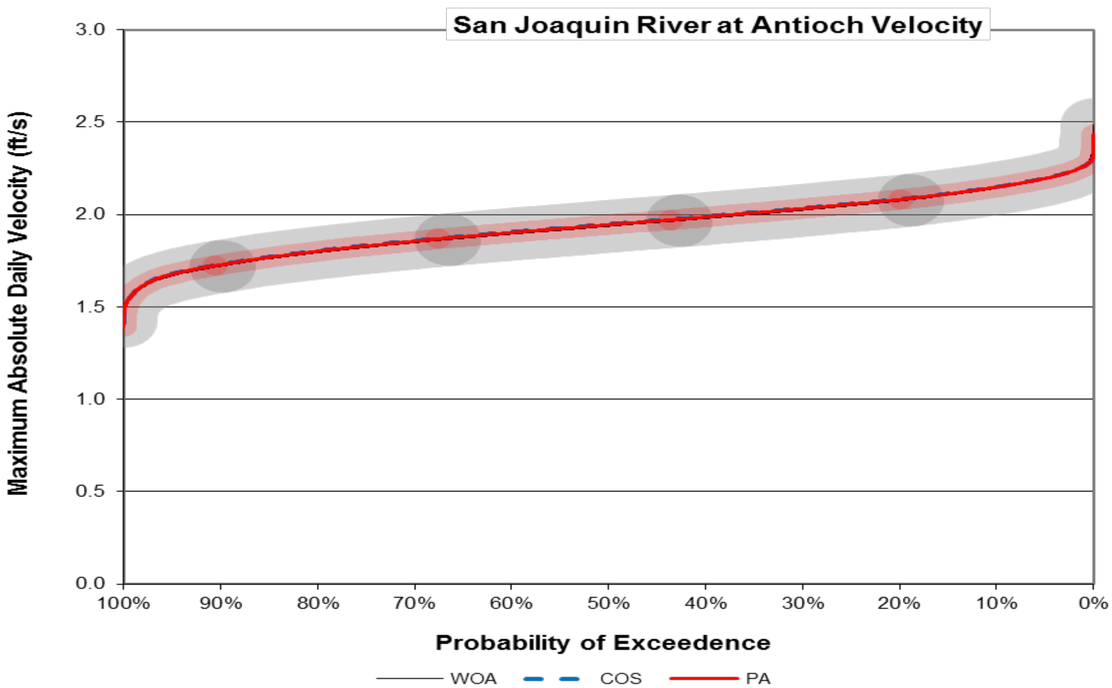


Figure 5.16-18. Modeled Maximum Absolute Daily Velocity in the San Joaquin River at Antioch, June–November

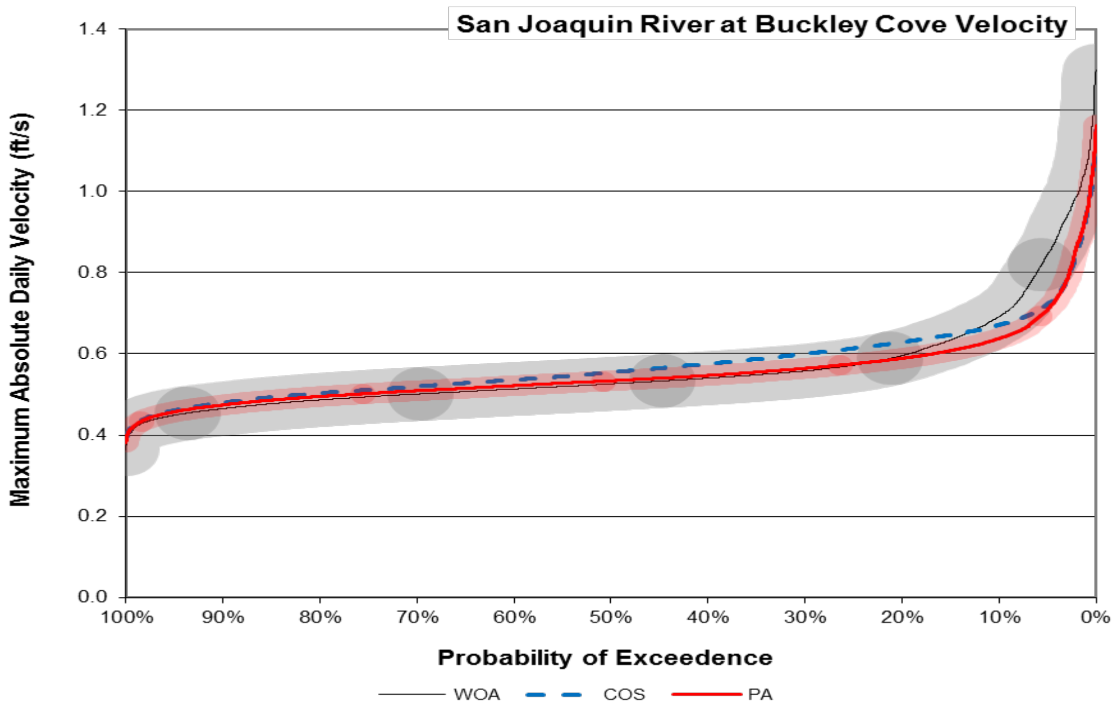


Figure 5.16-19. Modeled Maximum Absolute Daily Velocity in the San Joaquin River at Buckley Cove, June–November

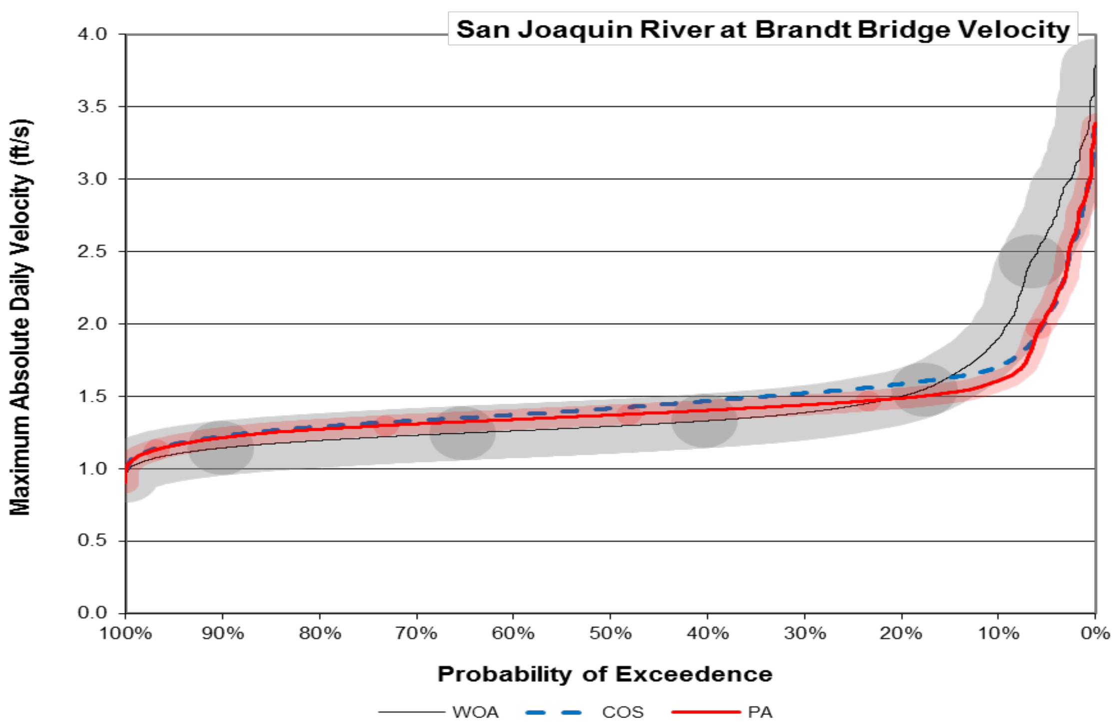


Figure 5.16-20. Modeled Maximum Absolute Daily Velocity in the San Joaquin River at Brandt Bridge, June–November

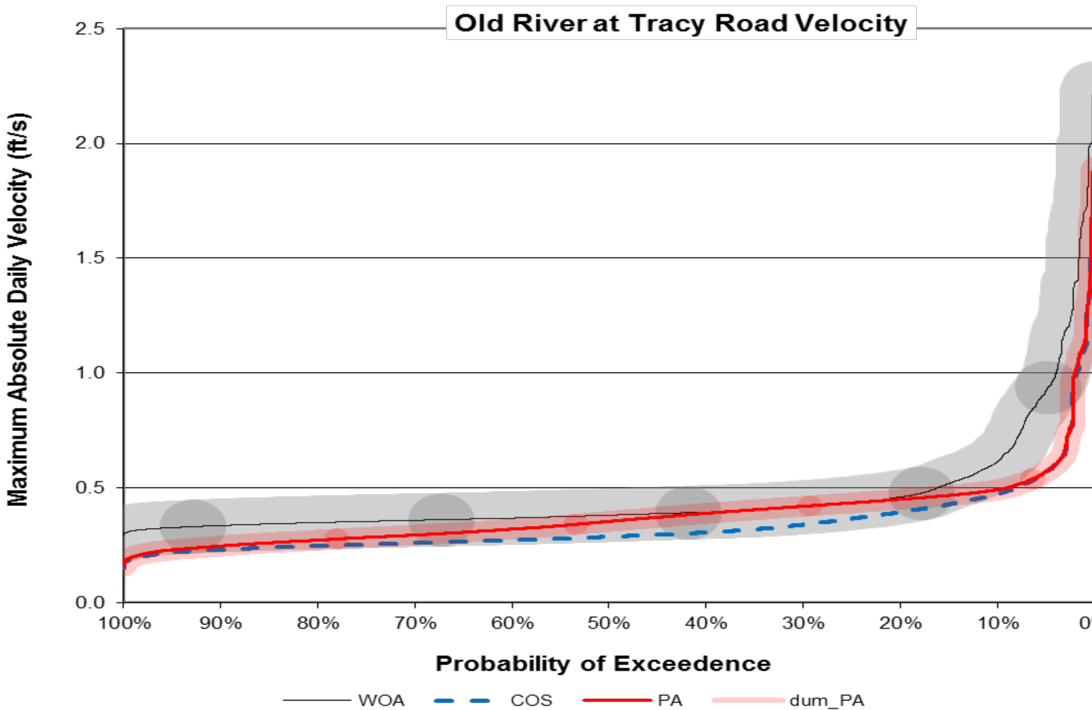


Figure 5.16-21. Modeled Maximum Absolute Daily Velocity in Old River at Tracy Road, June–November

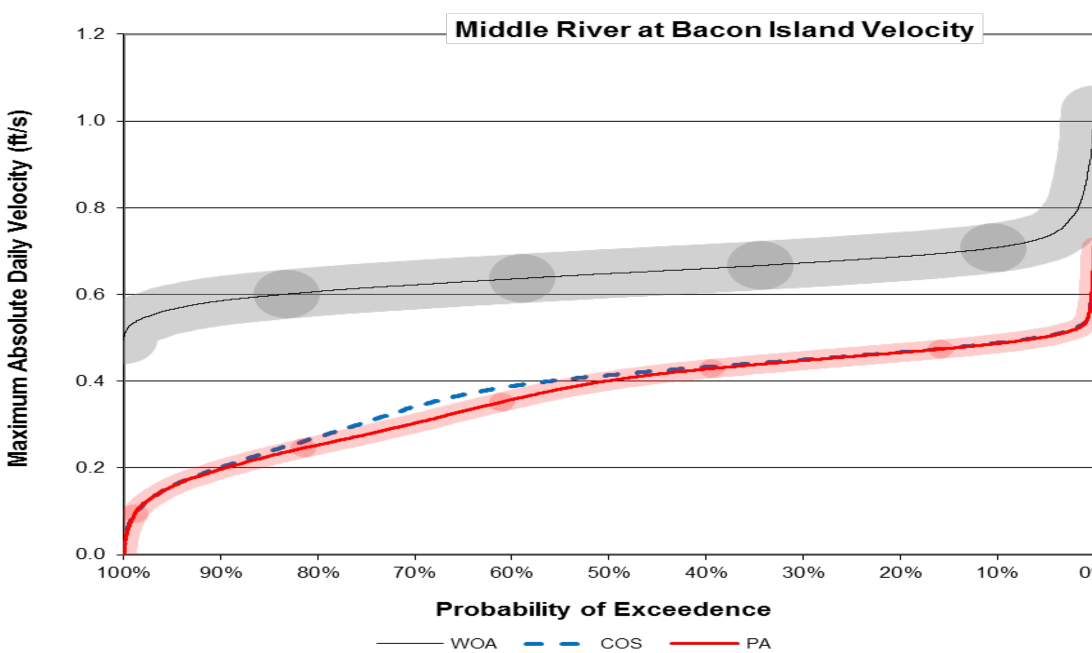


Figure 5.16-22. Modeled Maximum Absolute Daily Velocity in Middle River at Bacon Island, June–November

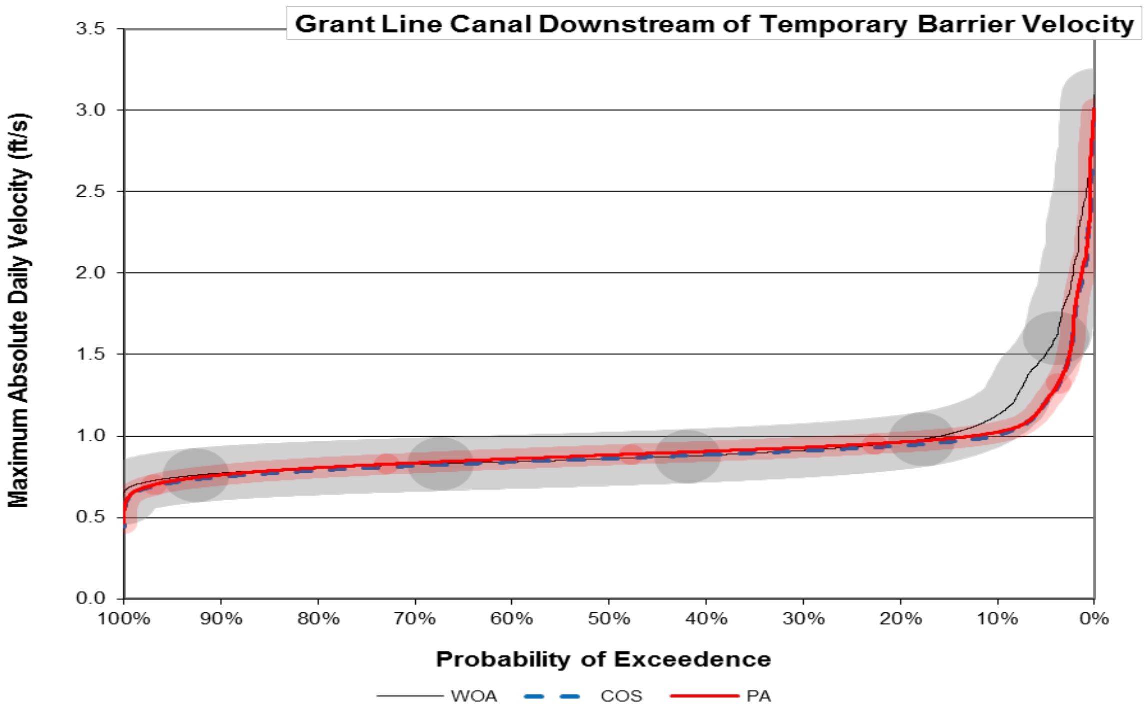


Figure 5.16-23. Modeled Maximum Absolute Daily Velocity in Grant Line Canal Downstream of the Temporary Barrier, June–November

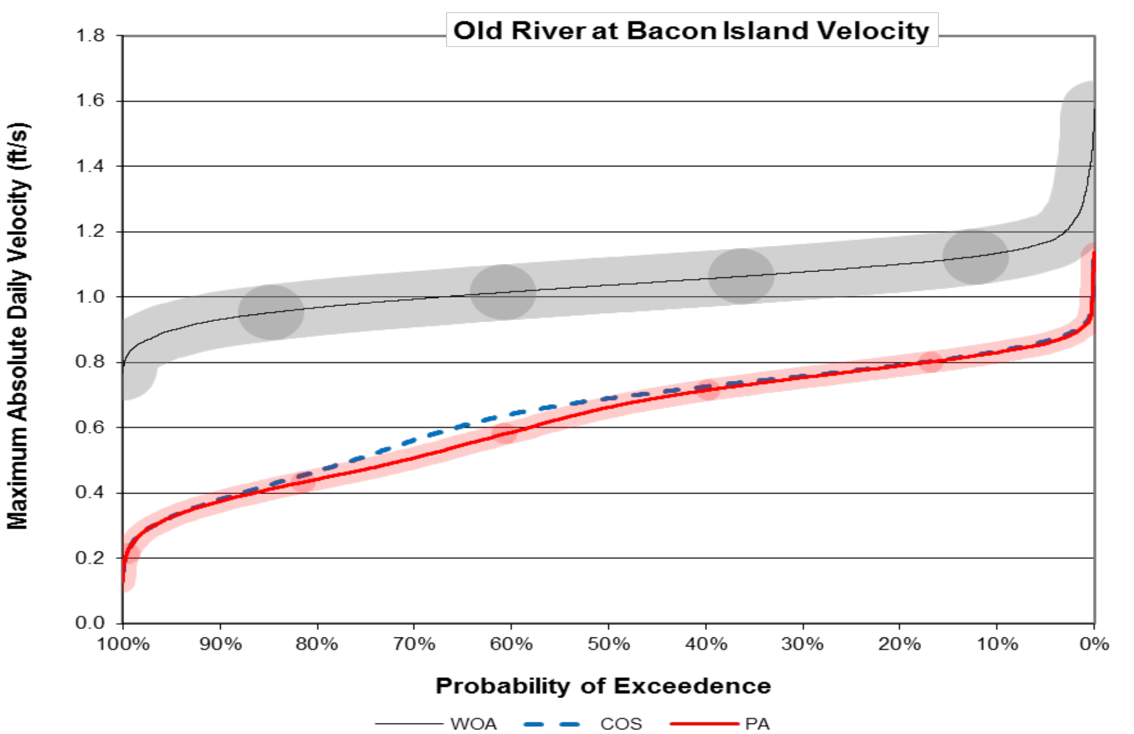


Figure 5.16-24. Modeled Maximum Absolute Daily Velocity in Old River at Bacon Island, June–November

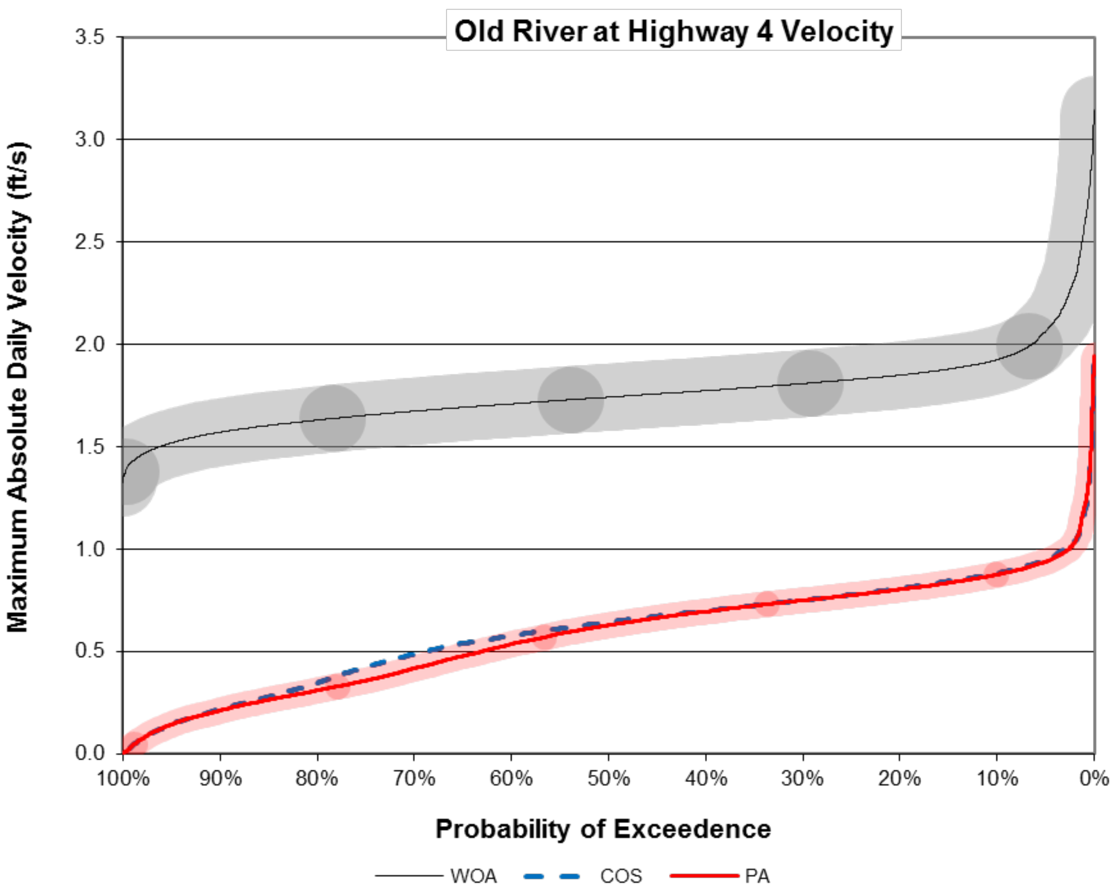


Figure 5.16-25. Modeled Maximum Absolute Daily Velocity in Old River at Highway 4, June–November

5.16.3.1.3.3 Predation Risk

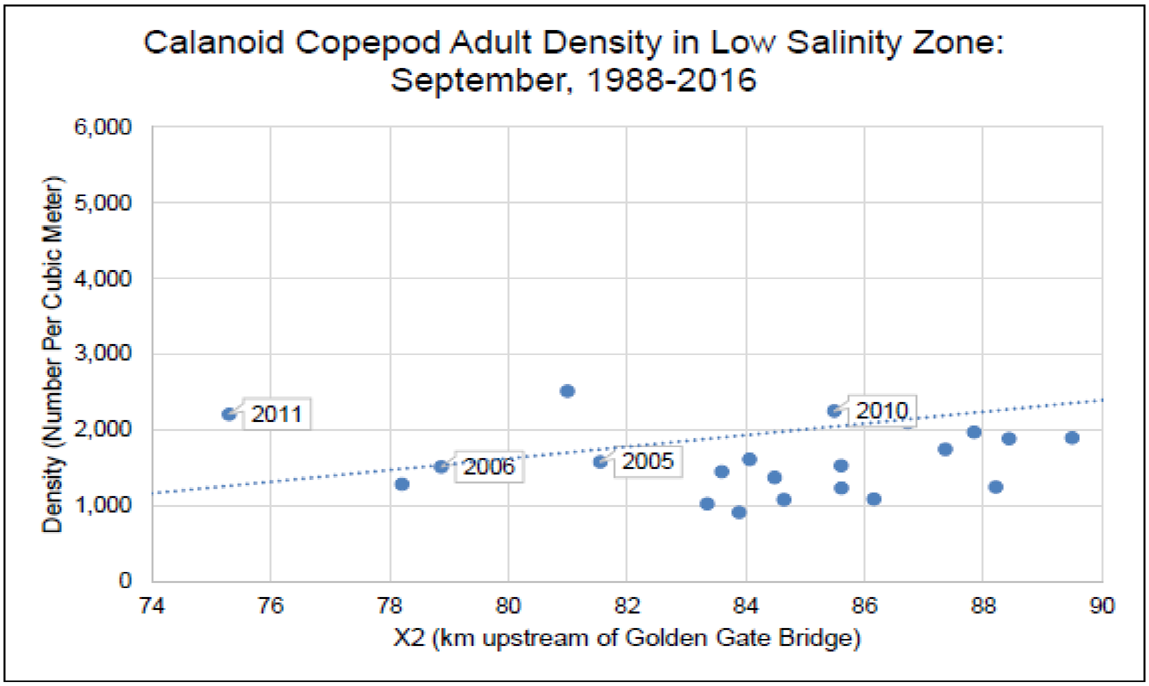
The IEP MAST (2015) conceptual model posits that predation risk for juvenile Delta Smelt is a function of predators (in particular Striped Bass), turbidity, and water temperature (Figure 5.16-5). As previously discussed for larval Delta Smelt, effects on water temperature from the proposed action relative to without action would be negligible. Turbidity during the low-flow summer and fall periods is partly a function of sediment delivery during the high-flow winter/spring periods, for it influences the amount of sediment for available (see summary by IEP MAST 2015, p.50). As discussed previously for adult Delta Smelt, differences in winter/spring flows and sediment delivery may result in a negative effect as a result of the proposed action potentially providing less sediment for resuspension in the summer/fall compared to without action. The IEP MAST (2015) conceptual model does not include factors affecting the abundance of predators (Striped Bass). Recent studies suggest that greater fall Delta outflow (represented by X2) and lower water clarity are positively linked to age-0 abundance (Mac Nally et al. 2010; Thomson et al. 2010), although there is uncertainty in the extent to which such effects would translate to changes in abundance of Striped Bass ages 1 to 3 (i.e., the subadults suggested to prey on Delta Smelt by IEP MAST 2015, p.132) given relatively low correspondence in abundance trends for age 0 and age 1 (Sommer et al. 2011) and apparent density dependence between ages 1 and 2 (Kimmerer et al. 2000).

5.16.3.1.4 Subadults to Adults (September – December)

The proposed action's OMR management during the Delta Smelt subadult to adult transition period (September–December) has the potential to influence several habitat attributes posited to be affected by Delta outflow in the IEP MAST (2015) conceptual model. These include food availability, size and location of the low salinity zone, and turbidity affecting predation risk (Figure 5.16-6).

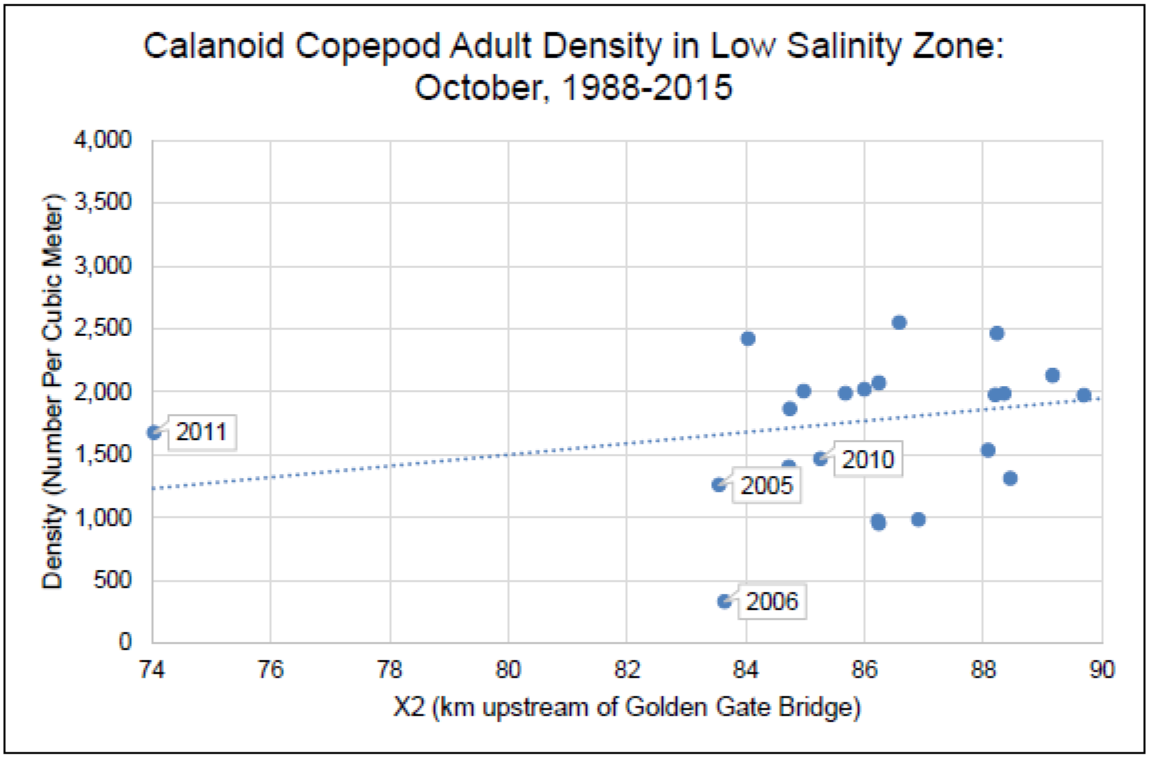
5.16.3.1.4.1 Food Availability

As also discussed for juvenile Delta Smelt, seasonal south Delta export operations have the potential to negatively affect Delta Smelt food availability through reduced *P. forbesi* subsidy to the low salinity zone rearing habitat occupied by most Delta Smelt reaching adulthood. Although the FLaSH investigations predicted that Delta Smelt food availability (as represented by calanoid copepods) in the fall low salinity zone would be greater with lower X2 (i.e., higher outflow) (Brown et al. 2014, p.25), this was not found to be the case either for the post--*Potamocorbula amurensis* invasion period (1988–2015/2016; Figure 5.16-27; Figure 5.16-28; Figure 5.16-29; Figure 5.16-30; Figure 5.16-31; Figure 5.16-32) or for the period following onset of the Pelagic Organism Decline (2003-—2015/2016; ICF 2017, p.78–82). Therefore, as noted for juvenile Delta Smelt, there is some evidence for potential negative OMR management-related effects on *P. forbesi* transport to the low salinity zone, but not for overall calanoid copepod density in the low salinity zone.



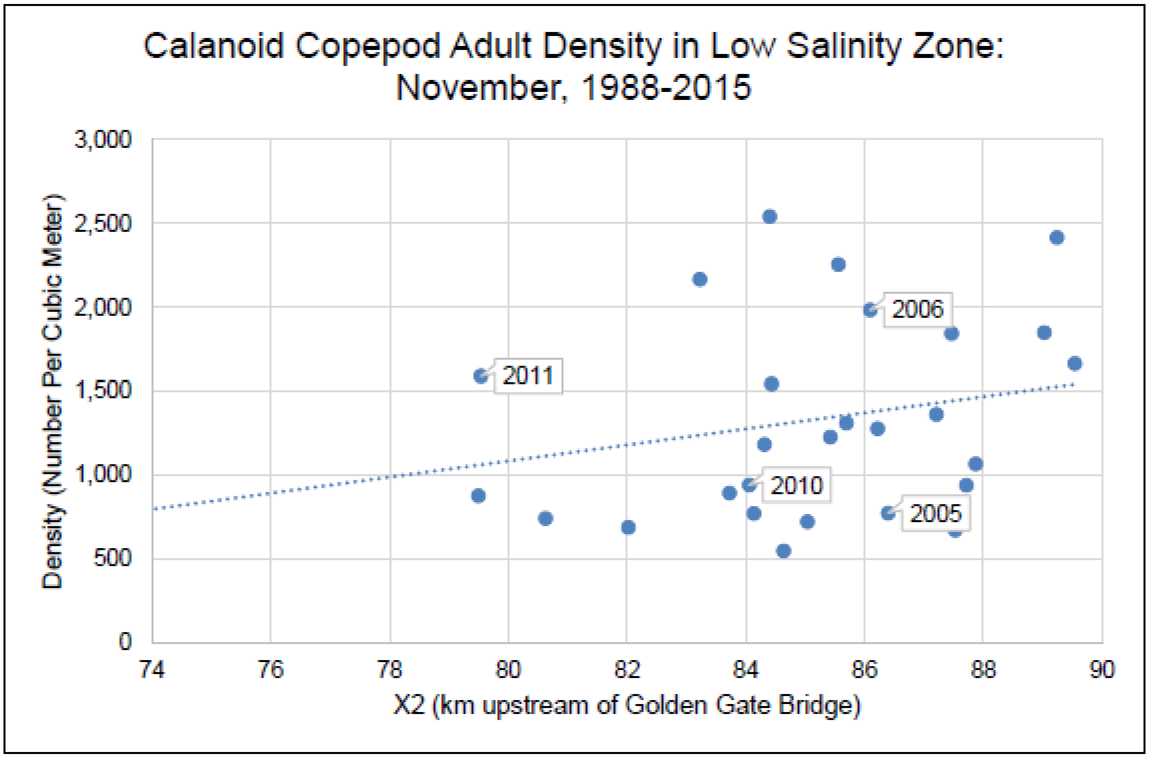
Source: ICF (2017, p.74). Note: Trend line shows non-significant linear regression.

Figure 5.16-26. Mean September Calanoid Copepod Adult Density in the Low Salinity Zone (Salinity = 1 to 6) from Environmental Monitoring Program Zooplankton Survey Data (Clarke-Bumpus Net) versus Mean X2 from 1988-2016.



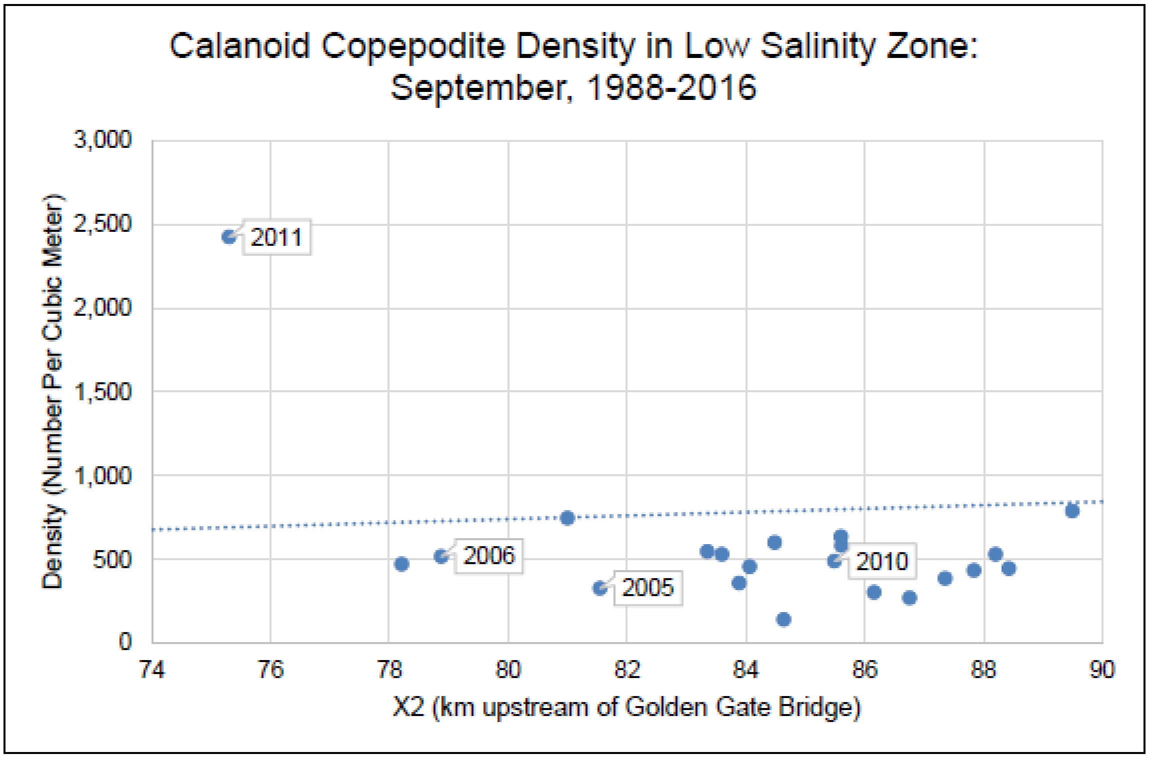
Source: ICF (2017, p.74). Note: Trend line shows non-significant linear regression.

Figure 5.16-27. Mean October Calanoid Copepod Adult Density in the Low Salinity Zone (Salinity = 1 to 6) from Environmental Monitoring Program Zooplankton Survey Data (Clarke-Bumpus Net) versus Mean X2 from 1988-2016.



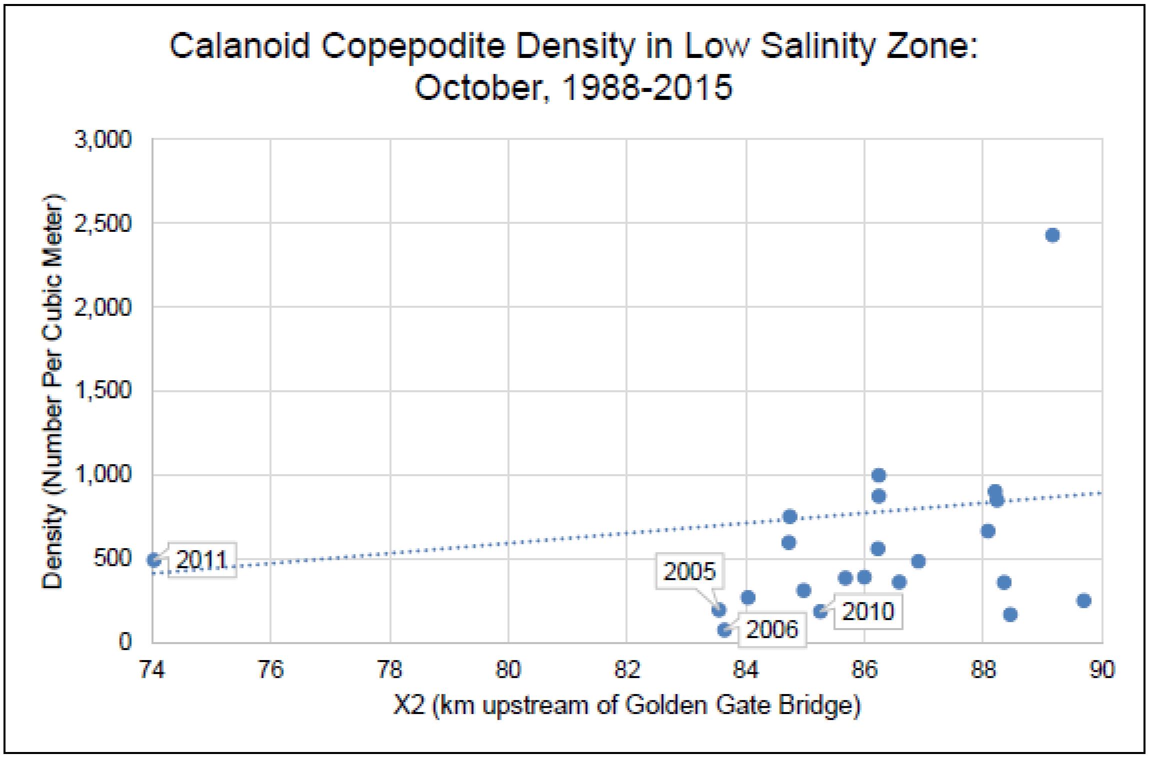
Source: ICF (2017, p.75). Note: Trend line shows non-significant linear regression.

Figure 5.16-28. Mean November Calanoid Copepod Adult Density in the Low Salinity Zone (Salinity = 1 to 6) from Environmental Monitoring Program Zooplankton Survey Data (Clarke-Bumpus Net) versus Mean X2 from 1988-2016.



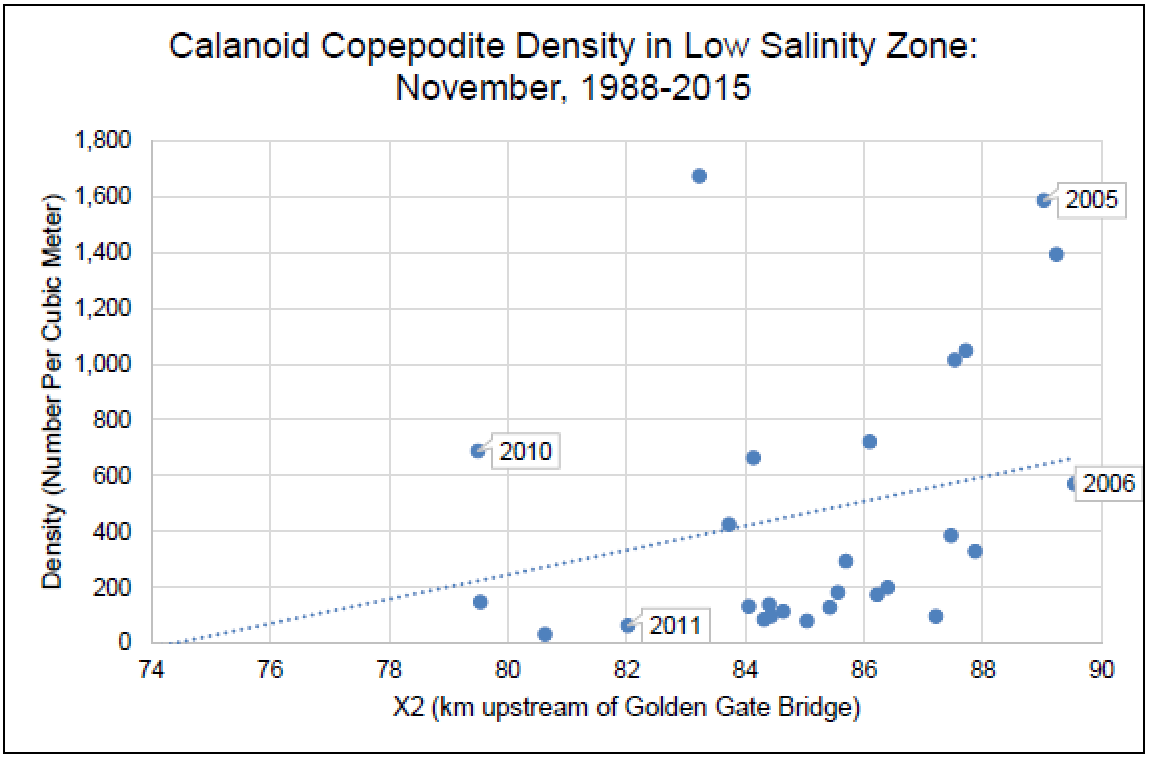
Source: ICF (2017, p.75). Note: Trend line shows non-significant linear regression.

Figure 5.16-29. Mean September Calanoid Copepod Copepodite Density in the Low Salinity Zone (Salinity = 1 to 6) from Environmental Monitoring Program Zooplankton Survey Data (Clarke-Bumpus Net) versus Mean X2 from 1988-2016.



Source: ICF (2017, p.76). Note: Trend line shows non-significant linear regression.

Figure 5.16-30. Mean October Calanoid Copepod Copepodite Density in the Low Salinity Zone (Salinity = 1 to 6) from Environmental Monitoring Program Zooplankton Survey Data (Clarke-Bumpus Net) versus Mean X2 from 1988-2016.



Source: ICF (2017, p.76). Note: Trend line shows non-significant linear regression.

Figure 5.16-31. Mean November Calanoid Copepod Copepodite Density in the Low Salinity Zone (Salinity = 1 to 6) from Environmental Monitoring Program Zooplankton Survey Data (Clarke-Bumpus Net) versus Mean X2 from 1988-2016.

5.16.3.1.4.2 Size and Location of the Low Salinity Zone

Pertaining to the indication that subadult Delta Smelt abundance, survival and growth are affected by the size and position of the low salinity during fall, as posited by the IEP MAST conceptual model, IEP MAST (2015, p.142) concluded: "The limited amount of available data provides some evidence in support of this hypothesis, but additional years of data and investigations are needed." Others have found that low salinity zone habitat may not be a predictor of Delta Smelt survival (Reclamation, 2017).

The proposed action does not include the fall X2 action from the 2008 biological opinion, which results in X2 under the PA being essentially the same as COS in drier years, but greater (more upstream) than WOA and COS in wet and above normal years. Given these caveats, the model shows September X2 would tend to be ≥ 85 km in around 95% or more of years, which would give a predicted low salinity zone area of around 11,000 acres (4,480 hectares; Figure 5.16-36, as developed from the X2-low salinity zone area look-up table from Brown et al. 2014, p.79) or less. X2 greater than or equal to 85 km results in the low salinity zone generally not occurring in the broader, shallower habitat in Suisun Bay (specifically Honker Bay) that provides an increase in the area of the lower salinity zone (DMA 2014, p.38). By way of comparison, September X2 under WOA would be around 75–83 km at 50–95% exceedance, giving a predicted low salinity zone area of 12,500–20,800 acres (5,100–8,400 hectares; Figure 5.16-36), and the low salinity zone occurring in Suisun Bay in around two thirds of years (Figure 5.16-33). Similar patterns (i.e., appreciably lower predicted low salinity zone area in wetter years under the PA relative to WOA) would also generally be evident in October (Figure 5.16-37), whereas larger differences between the PA and WOA would tend to occur in 60% of years in November (Figure 5.36-38). Operation of the SMSCG and additional Delta outflow to ensure no net upstream movement of X2 during proposed SMSCG operation in June–October of wet, above normal and below normal years was not modeled in CalSim; it is not expected that these factors would have a large influence on X2 relative to the modeling results from CalSim.

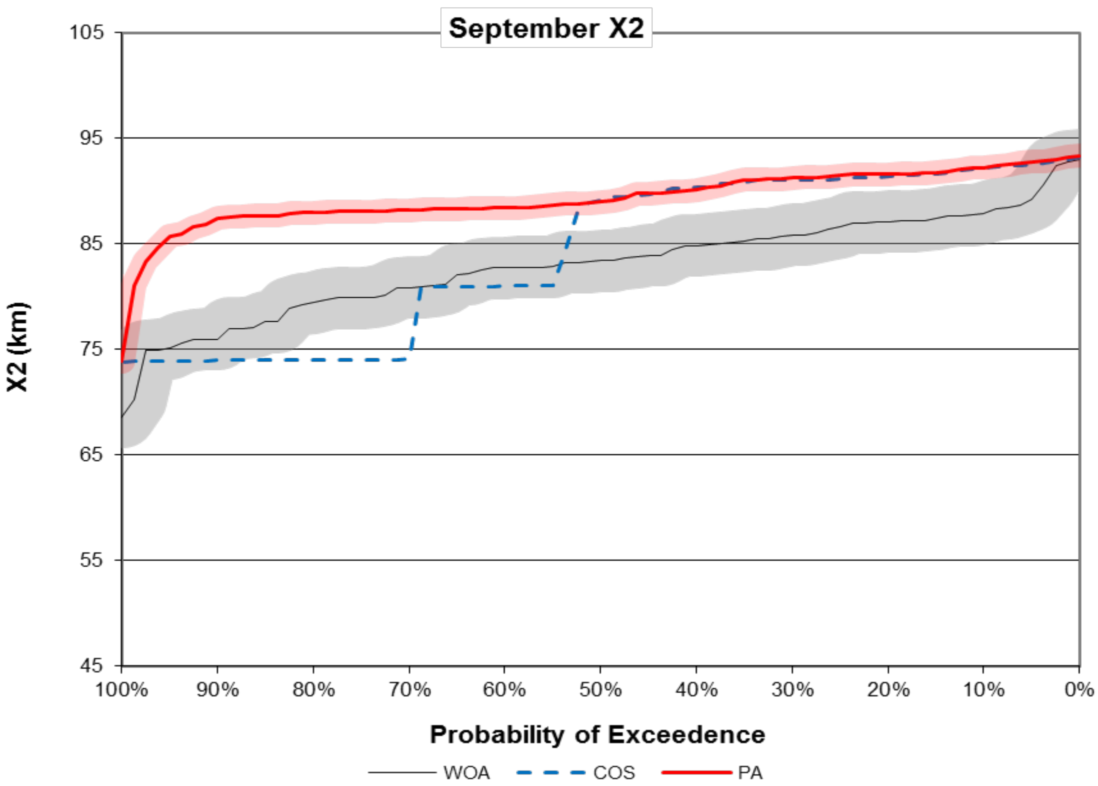


Figure 5.16-32. Mean Modeled X2 from CalSim, September.

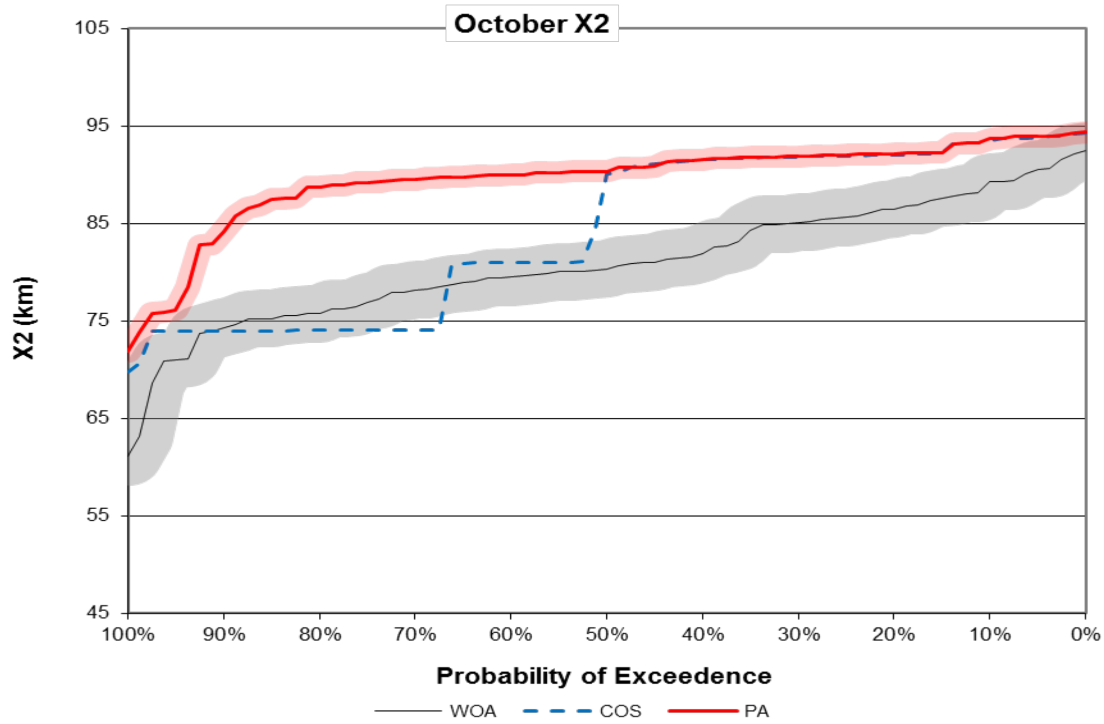


Figure 5.16-33. Mean Modeled X2 from CalSim, October.

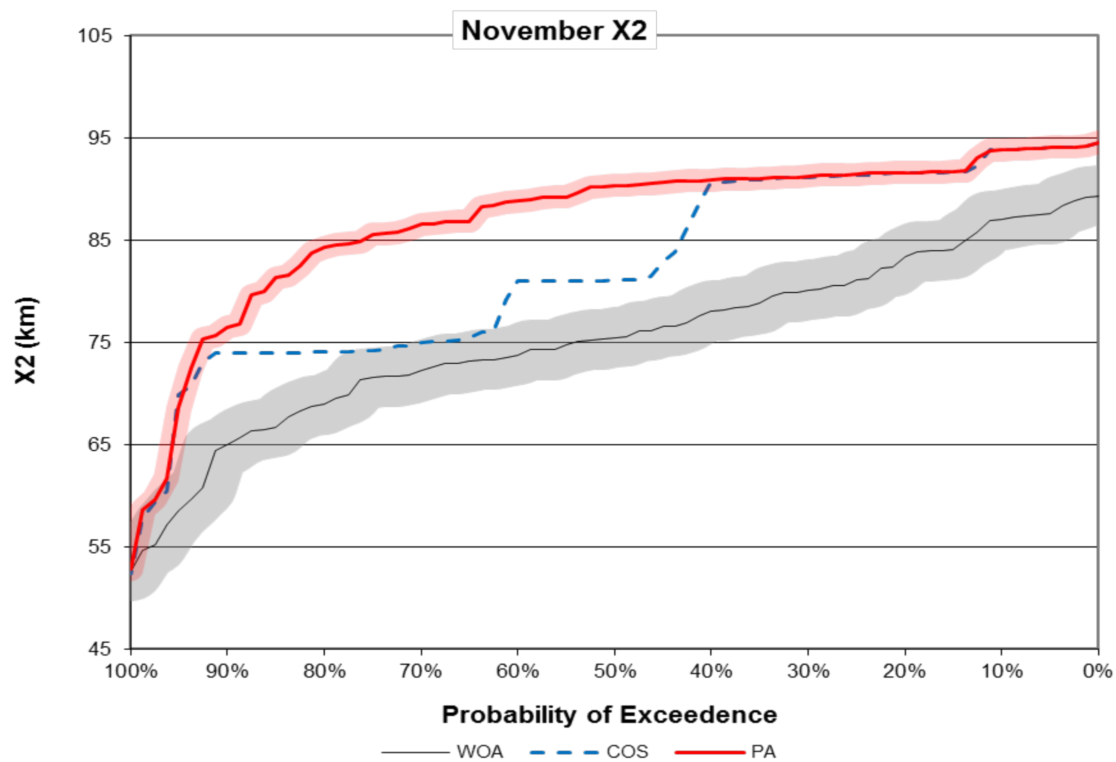


Figure 5.16-34. Mean Modeled X2 from CalSim, November.

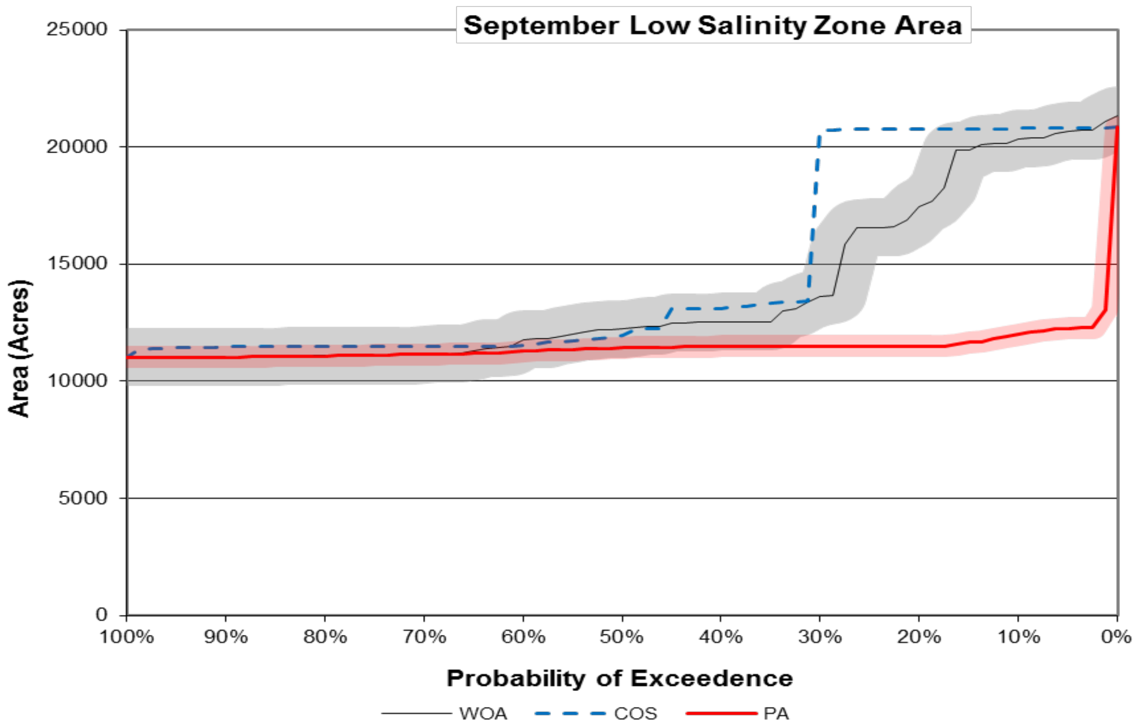


Figure 5.16-35. Mean Modeled Low Salinity Zone Area, September.

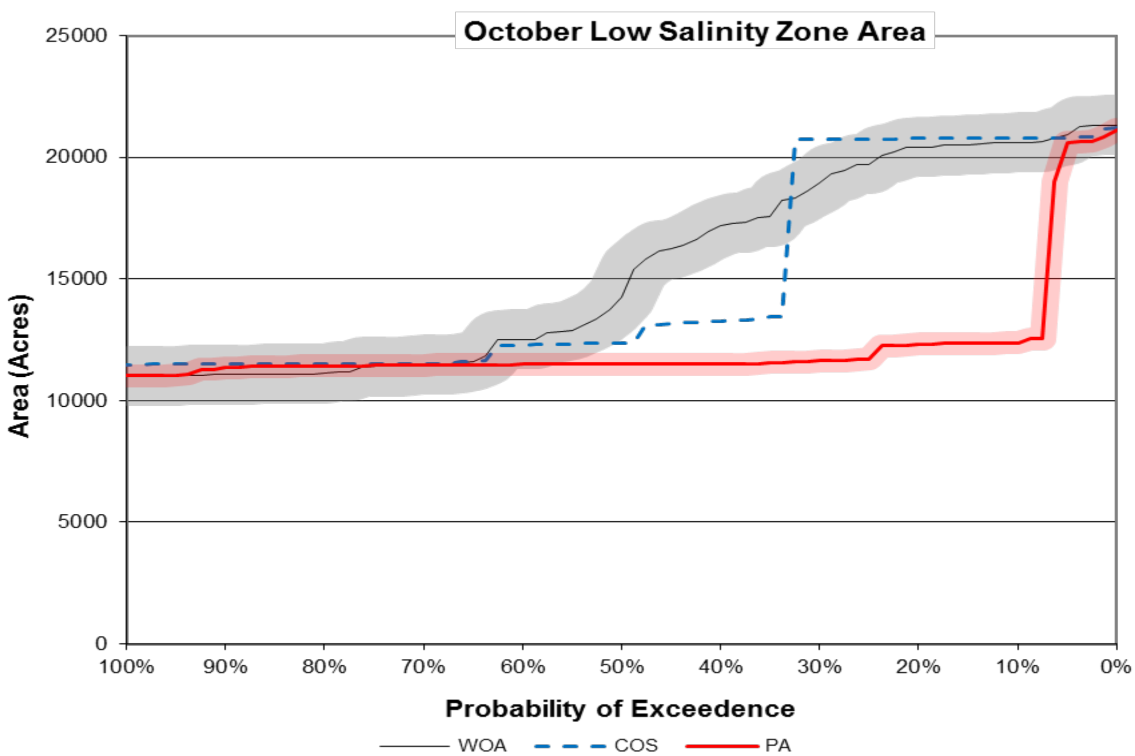


Figure 5.16-36. Mean Modeled Low Salinity Zone Area, October.

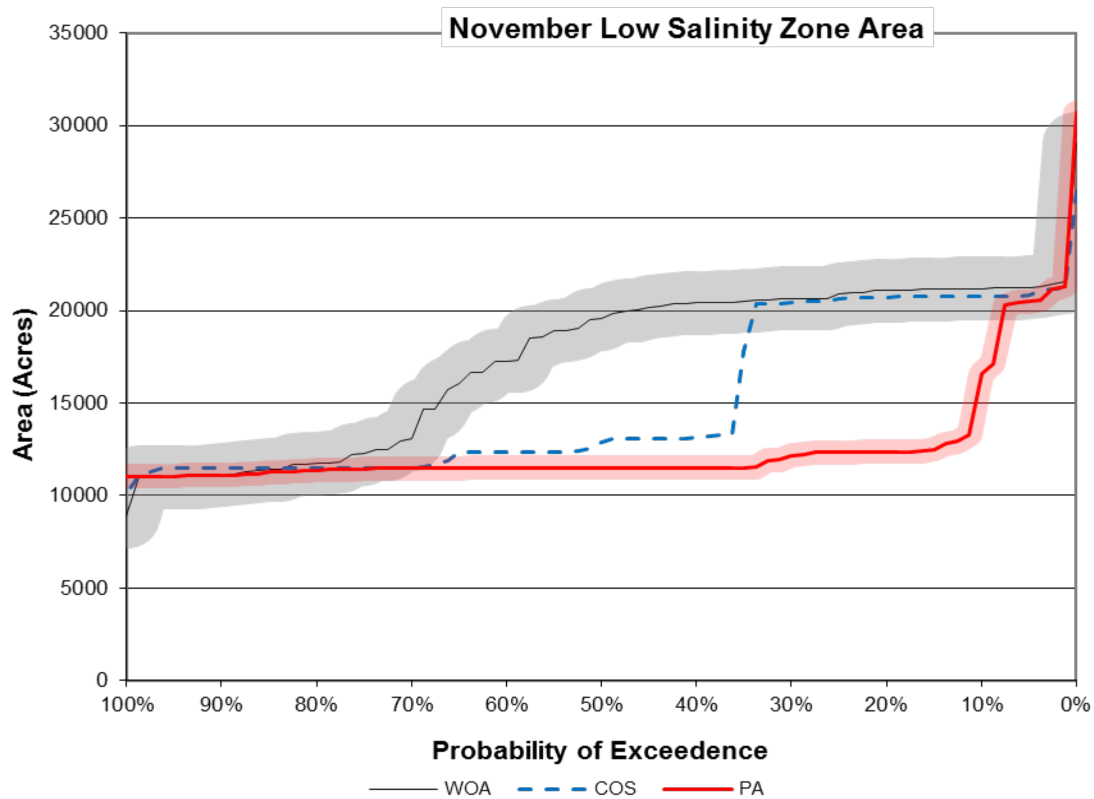


Figure 5.16-37. Mean Modeled Low Salinity Zone Area, November.

The overall potential reduction in the size of the low salinity zone and its general placement outside of Suisun Bay under the proposed action as summarized above from CalSim modeling has the potential to result in adverse impacts to Delta Smelt, per the hypothesis from the IEP MAST (2015) conceptual model (Figure 5.16-6).

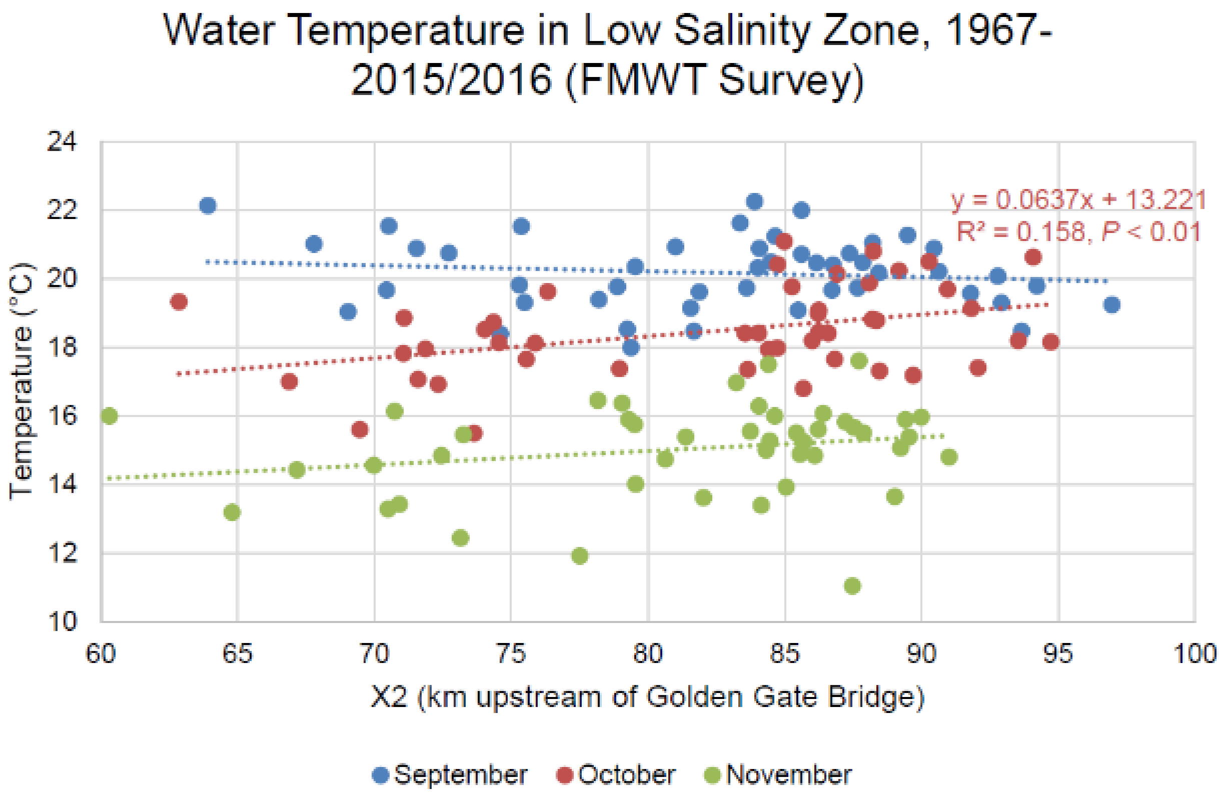
5.16.3.1.4.3 Harmful Algal Blooms

As described in more detail for juvenile Delta Smelt, differences in Delta flows, velocity, and water clarity could affect the occurrence of *Microcystis* blooms. Increases in harmful algal blooms resulting from the proposed action relative to without action could potentially result in negative impacts to subadult Delta Smelt, although this is uncertain.

5.16.3.1.4.4 Predation Risk

Turbidity could be affected by the proposed action relative to without action. Thus, potentially less sediment supply during the winter/spring could give less sediment for resuspension during the fall subadult period. With greater (more upstream) X2 under the PA (see Figure 5.16-33, 5.16-34, 5.16-35), the low salinity zone potentially could overlap areas with greater water clarity (i.e., lower turbidity) that are more likely to have wind-wave sediment resuspension (IEP MAST 2015, p.50), which could then translate into greater predation risk. The extent to which observed negative correlations between fall X2 and water clarity in the low salinity zone are the result of antecedent conditions (i.e., sediment supply during high-flow months) is uncertain (ICF 2017, p.106), although recent science indicates that wind may control turbidity (Bever et al., 2018).

As previously described for other life stages, water temperature would not be expected to be greatly affected by the proposed action, as illustrated by the low to no correlation between water temperature in the low salinity zone and X2 (Figure 5.16-39). Any effects would be well within the tolerance of subadult Delta Smelt (Komorske et al. 2014).

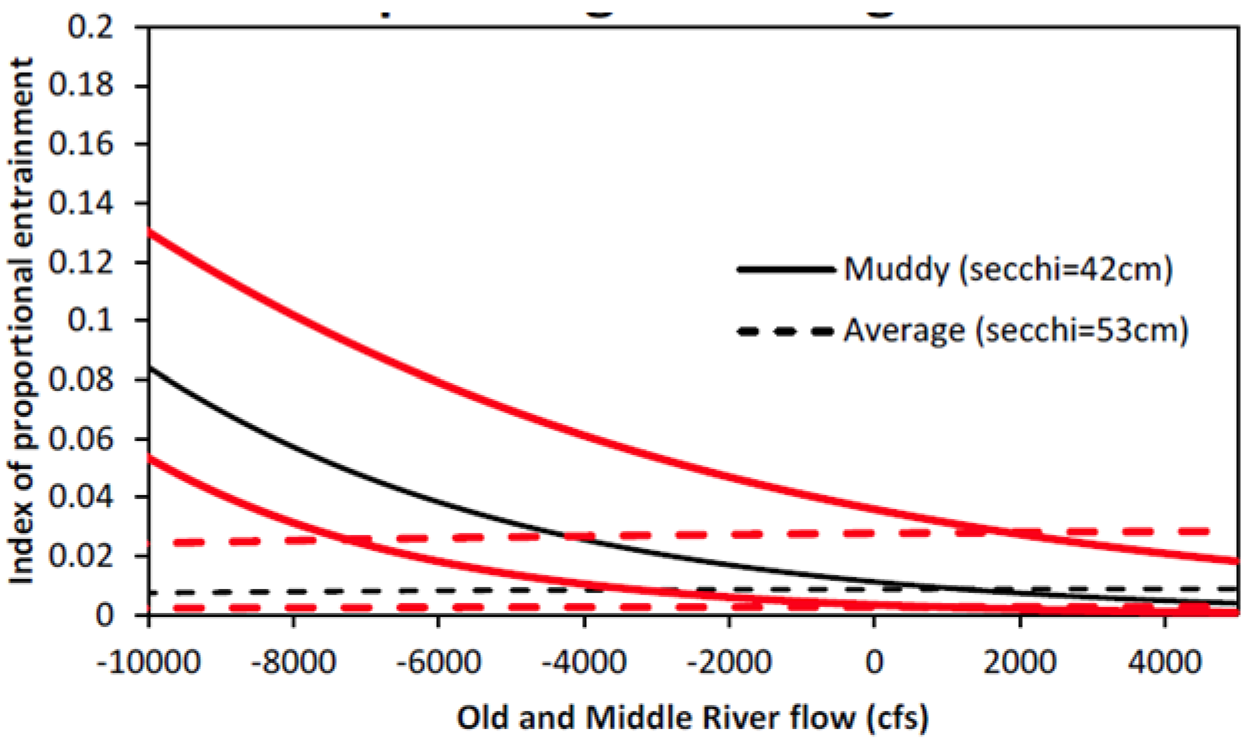


Source: ICF (2017, p.118). Note: Lines show regressions, but only October was statistically significant.

Figure 5.16-38. Mean Water Temperature in the Low Salinity Zone (Salinity = 1 to 6) from Fall Midwater Trawl Survey Data versus Mean X2, 1967 to 2015/2016

5.16.3.2 OMR Management

For adult Delta Smelt moving to spawn and transition to the egg/larval life stage, water diversions and flows (hydrology) together act to affect entrainment risk (Figure 5.16-3). In general, Delta Smelt salvage increases as increasing net OMR flow reversal (i.e., more negative net OMR flows) interacts with turbidity exceeding 10–12 NTU during December–March (USFWS 2008, Grimaldo et al. 2009). Analyses by Grimaldo et al. (2017) confirmed previous observations of relationships with OMR flows, and provided refined understanding of other factors influencing entrainment risk (expressed as number of adult Delta Smelt salvaged). Increased entrainment risk (defined as 50% of salvage) can occur following winter first flush events when precipitation increases flow and turbidity in the Delta and adult Delta Smelt move upstream into the Delta to spawn (Grimaldo et al. 2009; 2017). When water of higher turbidity (≥12 NTU) entering the Delta from the Sacramento River forms a continuous “bridge” between the central Delta (lower San Joaquin River) and Old and Middle Rivers, and negative OMR flows are relatively high, the risk of entrainment can increase. OMR flows alone do not predict entrainment risk; turbidity is also a key consideration, along with precipitation, exports and population size. For predictions of proportional loss of adult Delta Smelt during the post-2008 biological opinion period, using data for 2009–2015, proportional entrainment is predicted to be fairly insensitive to OMR flows at an average turbidity (Secchi depth), but steeply increases as OMR becomes more negative when turbidity is elevated (Figure 5.16-40).



Source: USFWS (2018). Note: Red lines indicate 95% Confidence Intervals.

Figure 5.16-39. Model Predictions of Adult Delta Smelt December–March Proportional Entrainment Index as a Function of Mean December–February Old and Middle River Flows and Secchi Depth During Delta Fish Surveys.

5.16.3.2.1 Adults to Eggs and Larvae (December – May)

5.16.3.2.1.1 Entrainment Risk

The without action conditions of no south Delta export would not entrain adult Delta Smelt. The lack of south Delta export pumping is reflected in OMR flows under the WOA scenario generally being positive (Figures 5.16-41, 5.16-42, 5.16-43, 5.16-44).

Based on the typical distribution of Delta Smelt, few individuals would be expected to occur in the south Delta (Figures 5.16-1 and 5.16-22). CalSim modeling suggests that OMR flows under the proposed action generally would be similar to current operations, reflecting the onset of OMR management after December 1 during which OMR generally would be ≥ -5,000 cfs. As reflected in Figures OMR_Jan and OMR_Feb, OMR flows under the PA have the potential to be slightly more negative than COS, but additional exports would only occur within the scope of protective criteria, which are described in the *OMR Management* section of the *Proposed Action* description. The monthly CalSim modeling does not reflect real-time criteria that are included in the proposed action, but does make assumptions to account for turbidity bridge avoidance actions in the overall monthly results. Overlapping protections also exist for NMFS-managed species, which could be triggered even when triggers have not occurred for Delta

Smelt, and would offer incidental protection to Delta Smelt. Operation to the OMR flow criteria included in the proposed action would be expected to limit the risk of entrainment loss.

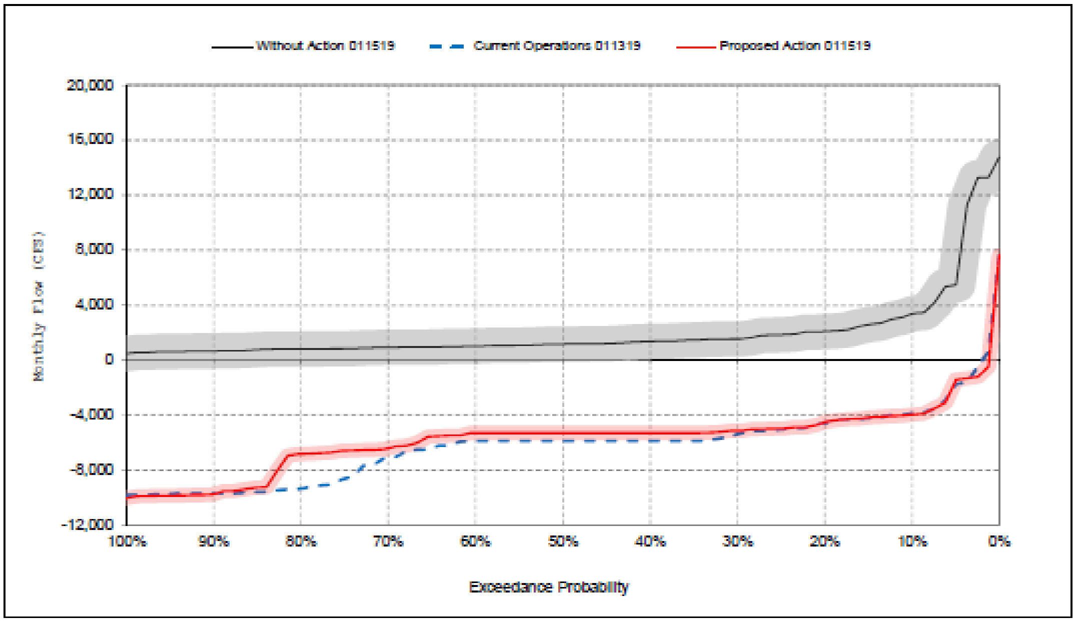


Figure 5.16-40. Mean Modeled Old and Middle River Flows, December

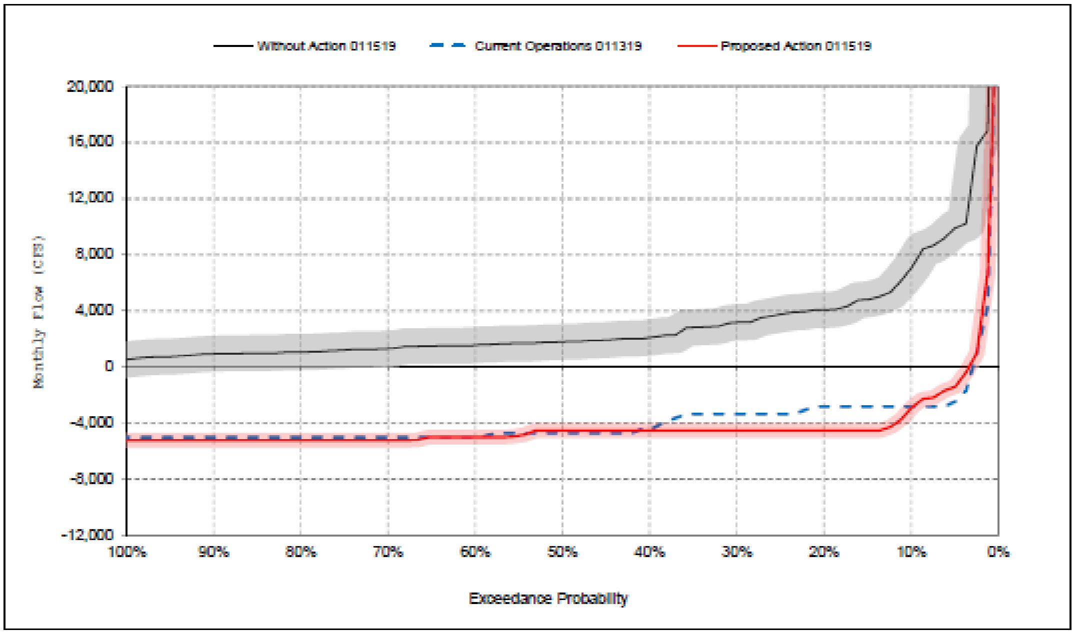


Figure 5.16-41. Mean Modeled Old and Middle River Flows, January.

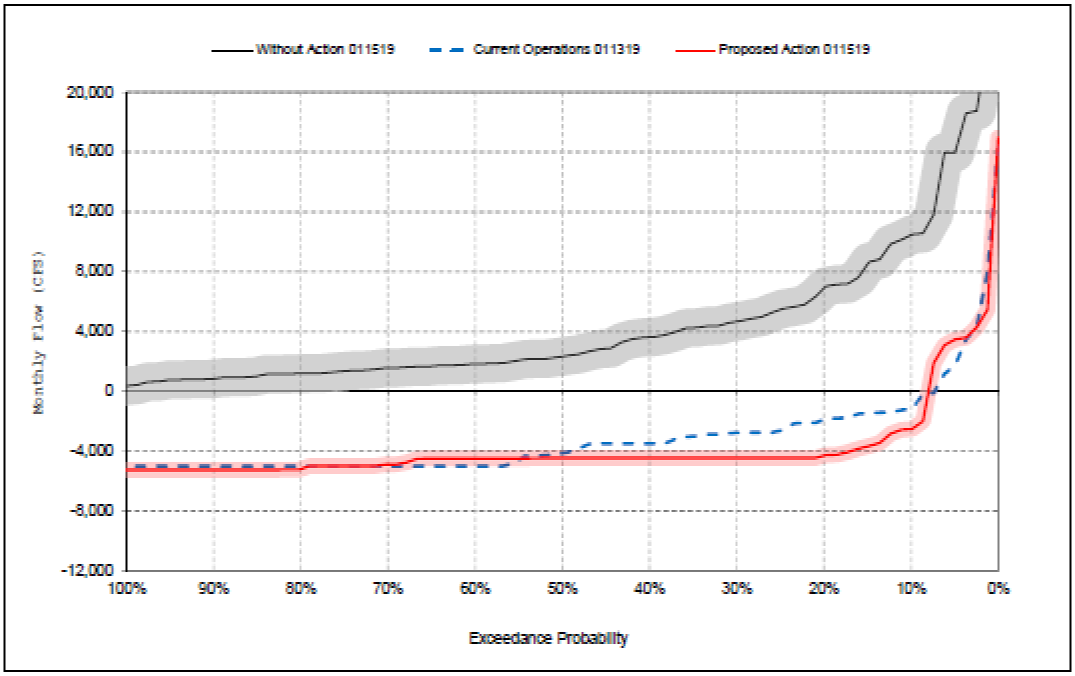


Figure 5.16-42. Mean Modeled Old and Middle River Flows, February.

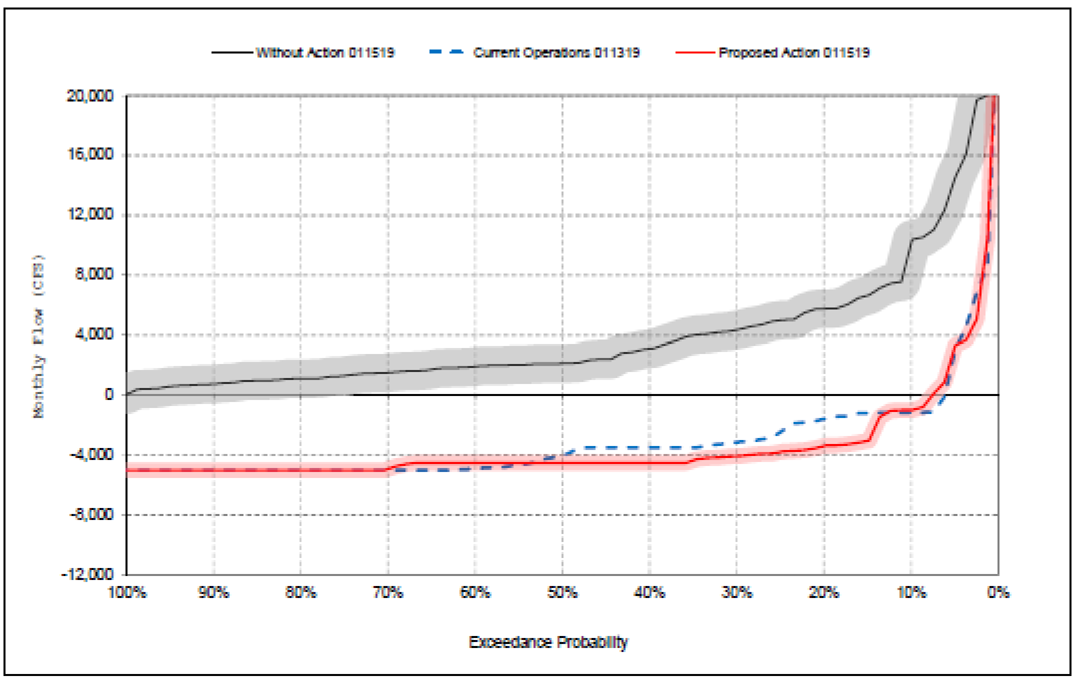


Figure 5.16-43. Mean Modeled Old and Middle River Flows, March.

5.16.3.2.2 Eggs and Larvae to Juveniles (March – June)

5.16.3.2.2.1 Entrainment Risk

The IEP MAST (2015) conceptual model suggests that larval and early juvenile Delta Smelt entrainment risk is related to exports and spring hydrology (Figure 5.16-4). Under without action conditions of no south Delta export pumping, there would be no entrainment of larval/early juvenile Delta Smelt at the south Delta exports for the CVP and SWP. The lack of south Delta export pumping is reflected in OMR flows under the WOA scenario generally being positive during March–June (Figures 5.16-44, 5.16-45, 5.16-46, 5.16-47). Current operations limit entrainment risk per the requirements of the 2008 biological opinion RPA Action 3. OMR flows are limited to protective levels ≥ -5,000 cfs during the main period of larval/early-juvenile entrainment risk (March-–June), as shown in the long-term modeling for the COS (Figures 5.16-44, 5.16-45, 5.16-46, 5.16-47).

Current operations management has kept salvage (take) of early juvenile Delta Smelt below the protective low limits prescribed in the 2008 biological opinion. However, salvage is inefficient for fish smaller than 30 millimeters in length. Therefore, larval juveniles less than 30 mm in size may not be accounted for accurately. As with adult Delta Smelt, CalSim modeling suggests that OMR flows under the PA generally would be similar to the OMR flows under COS in March (Figure 5.16-44), or generally be lower in April–June (Figures 5.16-45, 5.16-46, 5.16-47). As described further in the *OMR Management* section of the *Proposed Action by Basin* description, when larval or juvenile smelt are within the entrainment zone of the pumps based on monitoring group assessment and net flow in the lower San Joaquin River (QWEST) is negative, it is proposed that hydrodynamic models informed by survey data (e.g., EDSM or 20-mm Survey) would be run to estimate the percentage of larval and juvenile smelt that could be entrained, and operations would be adjusted such that modeling indicates that no greater than 10% loss of modeled larval and juvenile cohort Delta Smelt would be entrained. Similar to current operations, the proposed action would cease OMR management by the earlier of a) June 30, or b) when daily mean water temperature at Clifton Court Forebay reaches 25°C for three consecutive days—an indicator of poor habitat conditions and low likelihood of Delta Smelt presence in the south Delta (USFWS 2008, p.365)—and more than 95% of juvenile salmonids have migrated past Chipps Island (or Mossdale water temperatures have exceeded 72 degrees Fahrenheit for 7 days in June). Inclusion of these measures in the proposed action suggests that relatively few larval and juvenile Delta Smelt individuals would be lost to entrainment at the south Delta export facilities.

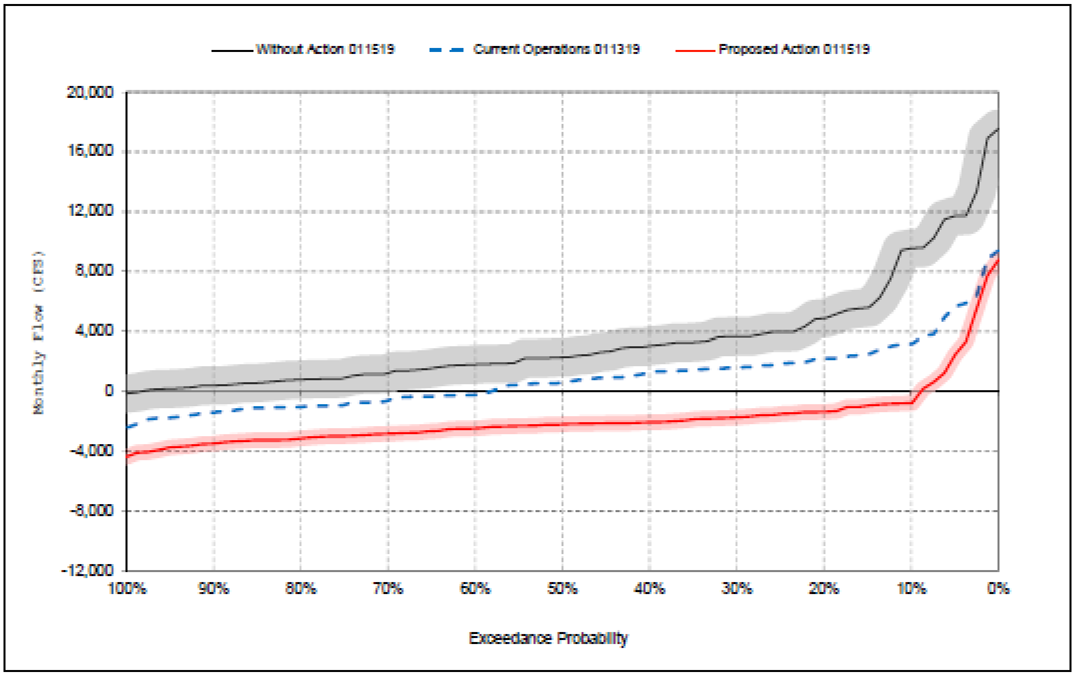


Figure 5.16-44. Mean Modeled Old and Middle River Flows, April.

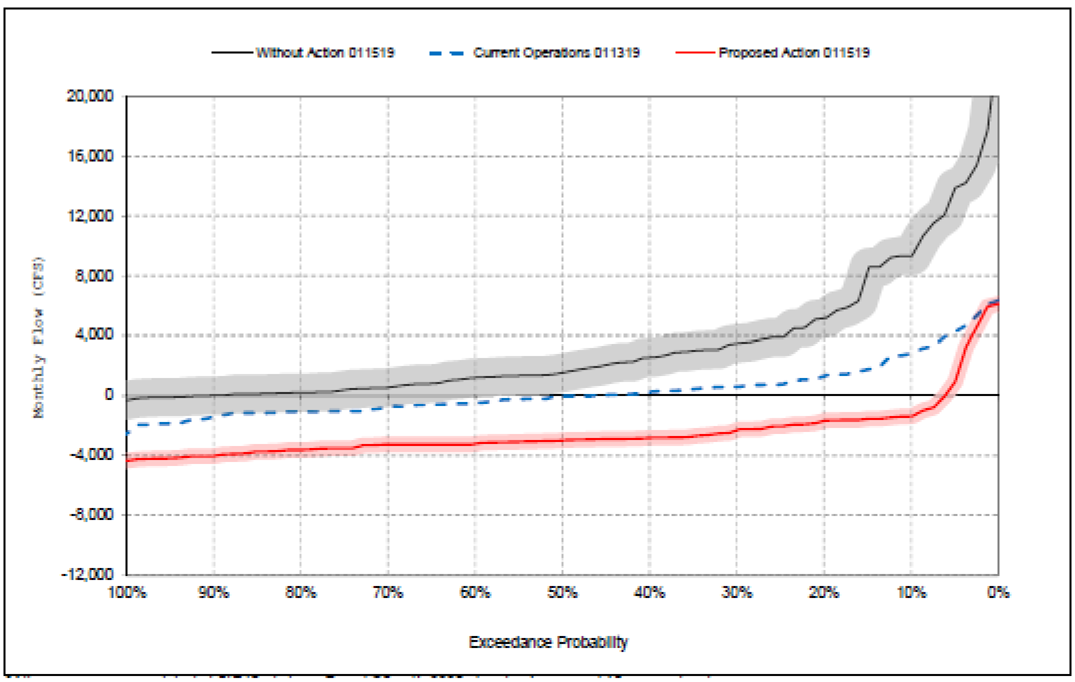


Figure 5.16-45. Mean Modeled Old and Middle River Flows, May.

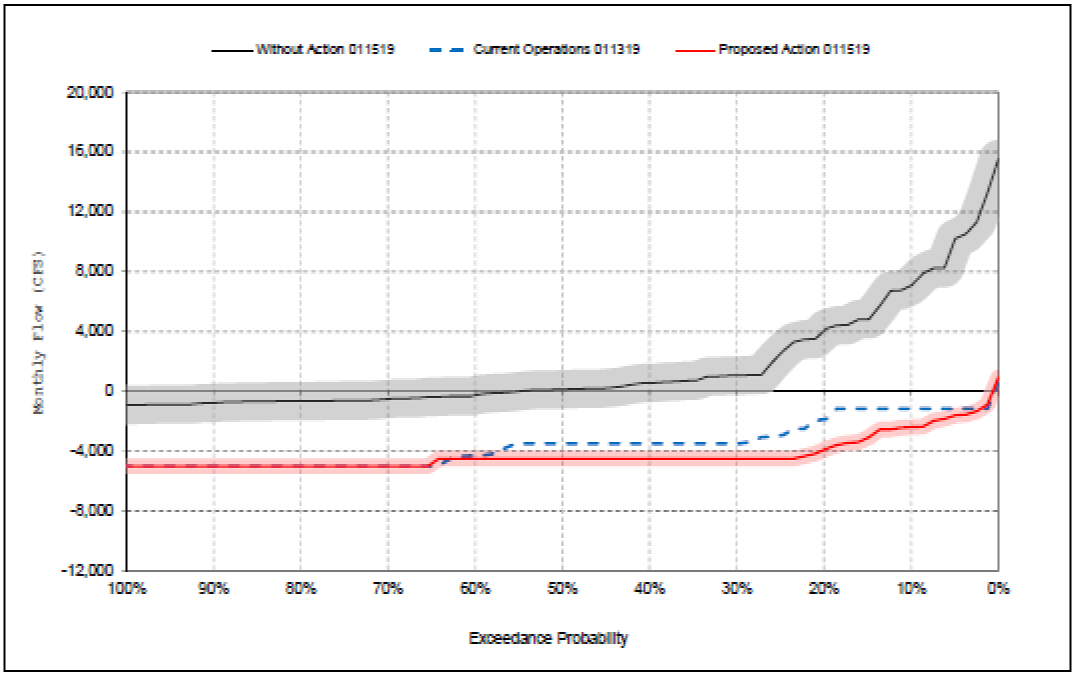


Figure 5.16-46. Mean Modeled Old and Middle River Flows, June.

5.16.3.3 Delta Cross Channel

<u>5.16.3.3.1 Adults to Eggs and Larvae (December – May)</u>

As discussed by USFWS (2017a, p.265), it is unknown what, if any, direct impacts occur to Delta Smelt as a result of opening or closing the DCC gates. USFWS (2017a, p.265) considered the region near the DCC gates to only be transiently used during movement of some adult Delta Smelt upstream. USFWS (2017a, p.265) suggested that it may be possible that opening or closing the DCC gates changes the migration path of some Delta Smelt, but noted that it is unknown if there may be a change in predation risk or likelihood of successful spawning, for example. During the adult Delta Smelt upstream migration period (principally December–March; USFWS 2017a, p.265), the DCC gates under the proposed action would largely be closed as a result of adherence to D-1641 criteria as well as real-time operations as a function of juvenile salmonid catch indices and projected water quality in the central/south Delta. Under without action conditions, DCC gates are permanently closed. USFWS (2017a, p.265) suggested that closure of the DCC would create more natural hydrology for migrating adult Delta Smelt by keeping flow in the Sacramento River and Georgiana Slough. Under the proposed action, the DCC gates are open for periods, possibly impacting Delta Smelt; however, there is limited occurrence of adult Delta Smelt near the DCC.

<u>5.16.3.3.2 Eggs and Larvae to Juveniles (March – June)</u>

Under the proposed action, the DCC would be expected to be largely closed during the March–June egg/larval transition period to juveniles. As described in more detail for adults, it is not known what effect the gates have on migration paths of Delta Smelt, but any effects would be expected to be limited given the low occurrence near the DCC (Figures 5.16-1 and 5.16-2; see also USFWS 2017a, p.159). Potential hydraulic effects on flows toward the south Delta export facilities would be taken into consideration when assessing south Delta entrainment risk, for example.

5.16.3.3.3 Juveniles to Subadults (June – September)

The distribution of juvenile Delta Smelt is downstream of the DCC (Figures 5.16-1 and 5.16-2) and so any near-field effects of the DCC would not occur. Under the proposed action and consistent with current operations, the DCC would largely be open during the June–September transition from juveniles to subadults. The IEP MAST (2015) conceptual model does not specifically address habitat attributes that would be affected by this difference, which is a change in flow distribution rather than a change in overall summer hydrology, an environmental driver included in the conceptual model. More flow entering the lower San Joaquin River through the DCC presumably could lead to greater potential for flux of *P. forbesi* to the low salinity zone, given the important of the San Joaquin River side of the Delta as a source of *P. forbesi* (Kimmerer et al. 2018c). However, the effect of south Delta exports on the flux of *P. forbesi* to the low salinity zone may be more important than any effect of the DCC, as suggested by QWEST flows (Figures 5.16-16 through 5.16-18).

5.16.3.3.4 Subadults to Adults (September – December)

As described for juvenile Delta Smelt, the distribution of subadult Delta Smelt is downstream of the DCC (Figures DS-1 and DS-2) and so any near-field effects of the DCC would not occur. Under the proposed action and consistent with current operation, the DCC would largely be open during the September–December transition from subadults to adults, prior to upstream migration as adults. It could be argued that an open DCC would provide more flow to the lower San Joaquin River and, therefore, increase the potential for flux of *P. forbesi* to the low salinity zone (Kimmerer et al. 2018c). However, as described for juvenile Delta Smelt, south Delta exports appear to be a more important effect than the effect of the DCC given the generally negative QWEST flows (Figure 5.16-18).

5.16.3.4 Temporary Barriers Program

5.16.3.4.1 Adults to Eggs and Larvae (December – May)

As discussed by USFWS (2008, p.225-226), the TBP under the proposed action has the potential to influence south Delta hydraulics by blocking flow entering the Delta from the San Joaquin River. Blocking this flow has the potential to increase entrainment risk of adult Delta Smelt during the later spring months after the barriers are installed. However, the Head of Old River barrier would not be installed under the proposed action. Adult Delta Smelt occurring in the vicinity of the barriers could be subjected to predation (USFWS 2008, p.226), although based on the typical distribution, few individuals would be expected to occur in the south Delta (Figures 5.16-1 and 5.16-2).

5.16.3.4.2 Eggs and Larvae to Juveniles (March – June)

As described for adult Delta Smelt, entrainment risk of larval Delta could be affected by the TBP, although the Head of Old River barrier would not be installed under the proposed action, thereby avoiding potential effects of that facility (USFWS 2008, p.225-226). The other barriers could also have effects such as trapping Delta Smelt upstream where they could be susceptible to entrainment, but effects would be limited given the low occurrence in the area (Figures 5.16-1 and 5.16-2).

5.16.3.4.3 Juveniles to Subadults (June – September)

Given occurrence outside of the south Delta, the TBP under the proposed action would not have direct effects on juvenile Delta Smelt, although USFWS (2008, p.226) suggested that there could be an effect on the flux of *P. forbesi* to the low salinity zone. Any such effect presumably would be small relative to the effect of south Delta exports on this flux, which was previously discussed in relation to seasonal operations.

5.16.3.4.4 Subadults to Adults (September – December)

As described for juvenile Delta Smelt, given occurrence outside of the south Delta, the TBP under the proposed action would not have direct effects on subadult Delta Smelt, although USFWS (2008, p.226) suggested that there could be an effect on the flux of *P. forbesi* to the low salinity zone. Any such effect presumably would be small relative to the effect of south Delta exports on this flux, which was previously discussed in relation to seasonal operations.

5.16.3.5 Contra Costa Water District Rock Slough Intake

Rock Slough is a relatively slow flowing, tidal waterway which ends at the Rock Slough Extension, approximately 1,700 feet upstream from the Rock Slough Intake. Rock Slough is generally poor habitat with relatively high water temperature and a prevalence of aquatic weeds (USFWS 2008; Reclamation 2016). Fish monitoring at the Rock Slough facilities, including the Rock Slough Headworks, RSFS, and Pumping Plant 1, from 1999 through 2018 has collected very few smelts of any life stage: two larval smelts, one delta smelt (8.3 mm TL collected May 2012) and one longfin smelt (7.3 mm TL collected March 2008); no juvenile smelts; and one adult smelt (66 mm FL delta smelt on February 2005) (Reclamation 2016; Tenera 2018b; ICF 2018). No smelts have been collected at the Rock Slough facilities since 2012.

Based upon poor habitat quality, the limited number delta smelt collected near the Rock Slough Intake, and the design criteria for the RSFS (approach velocity of 0.2 ft/sec), it is concluded that any near-field effect on hydrodynamics (i.e., near the Rock Slough Intake) and any entrainment of delta smelt at the Rock Slough Intake would be negligible. The following sub-sections address “far-field” effects resulting from altered Delta hydrodynamics for each life stage.

5.16.3.5.1 Adults to Eggs and Larvae (December – May)

Rock Slough Intake is located on Rock Slough, approximately 3.5 miles west of the junction of Rock Slough and Old River, which is over 12 river miles north of the gates to the SWP Clifton Court Forebay. Given its location, the Rock Slough Intake does not affect net reverse flow in Old and Middle Rivers (OMR), and any effect that diversions at Rock Slough Intake would have in the Old and Middle River corridor would be to increase the northerly (positive) flow away from the Banks and Jones Pumping Plants.

However, diversions at the Rock Slough Intake could affect flows in the San Joaquin River at Jersey Point, which is approximately 14 river miles from the Rock Slough Intake (via the shortest route through Franks Tract). The following analysis quantifies the maximum effect of Rock Slough diversions on velocity in the San Joaquin River at Jersey Point. The maximum effect of Rock Slough diversions on the channel velocity would be the maximum diversion rate (350 cfs) divided by the minimum cross-sectional area of the channel. This calculation assumes that all water diverted at Rock Slough comes from the San Joaquin River at Jersey Point, which is a conservative assumption (i.e., overestimates the effect on velocity).

The cross-sectional area of the San Joaquin River at Jersey Point is approximately 60,500 square feet (sf), but varies depending on the tidal stage from approximately 56,000 sf to 68,000 sf as calculated from USGS measurements of flow and velocity at Jersey Point (Station: 11337190) every 15 minutes for Water Years 2014 through 2018 (see Winter-run section). The maximum effect of water diversions at Rock

Slough Intake on velocity in the San Joaquin River at Jersey Point is calculated as 350 cfs divided by 56,000 sf, resulting in 0.00625 feet per second (ft/sec). For comparison, the most stringent fish screening requirement in the Delta (i.e., USFWS screening criteria for Delta Smelt) is 0.2 ft/sec, which is 32 times the maximum possible contribution from Rock Slough diversions. Furthermore, the actual effect is likely to be much lower than 0.00625 ft/sec because the water diverted at the Rock Slough Intake does not all come from the San Joaquin River west of Jersey Point.

Recognizing that CCWD owns and operates two additional intakes in the south Delta, this analysis examines the combined effect of all three intakes. CCWD's Old River Intake and Middle River Intake have a physical capacity of 250 cfs at each intake. If CCWD were to divert at all three intakes at the maximum capacity at the same time, total CCWD diversions would be 850 cfs. The corresponding effect on velocity in the San Joaquin River at Jersey Point would be 0.015 ft/sec. The velocity threshold used to protect Delta Smelt from diversions in the vicinity of fish screens (0.2 ft/sec) is over 13 times greater than the maximum possible contribution from CCWD's combined physical capacity. The water diversions at the Rock Slough Intake when combined with diversions at CCWD's Old River Intake and Middle River Intake have a negligible effect on velocity in the San Joaquin River at Jersey Point.

Nonetheless, even extremely small changes in velocity can affect the movement of neutrally buoyant particles such as phytoplankton. To examine the effect on neutrally buoyant particles, Reclamation calculated the distance that a particle would travel due to the maximum permitted Rock Slough diversions over the course of a day. A change in velocity of 0.00625 ft/sec could move a neutrally buoyant particle approximately 540 ft over the course of the day (0.00625 ft/sec * 86,400 sec/day). For comparison, the tidal excursion on the San Joaquin River at Jersey Point during a flood tide (i.e., the distance a particle will travel tidally upstream during a flood tide) is about 34,000 ft on average (or 6.4 miles), which is about 63 times the distance that diversions at Rock Slough could move a particle at the same location over the course of a full day. Therefore, the maximum possible contribution of diversions at Rock Slough on movement of neutrally buoyant particles such as phytoplankton is insignificant in comparison to the tidal excursion and mixing at this location.

Although the diversions at the Rock Slough Intake under the proposed action are not likely to impact adult Delta Smelt, the aggregate effects of all water diversion in the Delta, including exports at Jones and Banks Pumping Plants can affect channel velocity.

5.16.3.5.2 <u>Eggs and Larvae to Juveniles (March – June)</u>

As described for adult Delta Smelt above, the maximum diversion rate at Rock Slough would have an insignificant effect on Delta hydrodynamics. Although the diversions at the Rock Slough Intake under the proposed action are not likely to impact larvae and juvenile Delta smelt, the aggregate effects of all water diversion in the Delta, including exports at Jones and Banks Pumping Plants can affect channel velocity.

5.16.3.5.3 <u>Juveniles to Subadults (June – September)</u>

Juvenile Delta Smelt would not be expected to occur near the Rock Slough Intake in the south Delta (Figures 5.16-1 and 5.16-2) and so there would be no near-field individual or population-level effects from this diversion on this life stage. Furthermore, as described for adult Delta Smelt above, the maximum diversion rate at Rock Slough would have an insignificant effect on far-field Delta hydrodynamics. Although the diversions at the Rock Slough Intake under the proposed action are not likely to impact juvenile and subadults Delta smelt, the aggregate effects of all water diversion in the Delta, including exports at Jones and Banks Pumping Plants can affect channel velocity.

5.16.3.5.4 Subadults to Adults (September – December)

Subadult Delta Smelt would not be expected to occur near the Rock Slough Intake in the south Delta (Figures 5.16-1 and 5.16-2) and so there would be no near-field individual or population-level effects from this diversion on this life stage. Although the diversions at the Rock Slough Intake under the proposed action are not likely to impact subadults and adult Delta smelt, the aggregate effects of all water diversion in the Delta, including exports at Jones and Banks Pumping Plants can affect channel velocity.

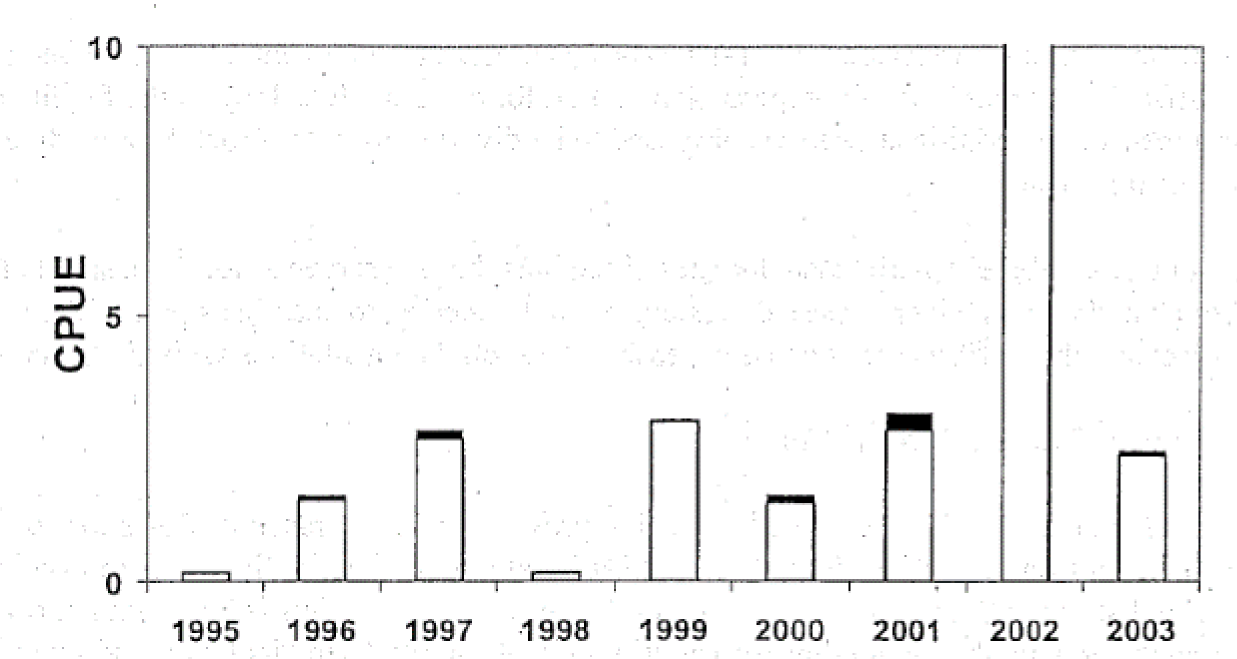
5.16.3.6 North Bay Aqueduct

5.16.3.6.1 Adults to Eggs and Larvae (December – May)

Under without action conditions, there would be no pumping at the Barker Slough Pumping Plant (BSPP). Under the proposed action, operational criteria at the BSPP would be the same as under current operation. Consistent with modeling assessed in the 2008 biological opinion, the CalSim modeling this biological assessment assumes that the current operations and the proposed action divert approximately 71,000 acre-feet of water per year as part of SWP operations, based on contracted amounts. Actual diversions during 2009-–2016 were lower (~33,000–50,000 acre-feet per year from the DAYFLOW database). As summarized by USFWS (2017a, p.269), the Cache Slough Complex from which the BSPP diverts water is an area of high adult Delta Smelt density (see also Figures 5.16-1 and 5.16-2). However, that does not mean catches are high everywhere in the complex. For instance, historical catch rates of Delta Smelt larvae in Barker Slough were consistently low during surveys undertaken following the issuance of the 1995 SWP/CVP biological opinion (USFWS 2005; Figure NBA_ds), indicating that a relatively small portion of the Delta Smelt population in the Cache Slough Complex is susceptible to entrainment/impingement from NBA diversions (USFWS 2017a, p.270). The BSPP intakes are screened to 3/32-inch opening, which excludes Delta Smelt >25 mm and therefore would be expected to preclude the potential for adult entrainment (USFWS 2017a, p.269). Approach velocity of ~0.2 ft/s at two of the ten units minimizes impingement potential on the screens (USFWS 2017a, p.269-270), whereas impingement potential presumably is greater at the eight larger units with approach velocity of ~0.44 ft/s (California Department of Fish and Game 2009, p.3). As a result of the California Department of Fish and Game (2009) ITP for operations of the SWP, diversion rates are limited to 50 cfs from January 15 to March 15 of dry and critically dry years (per the current forecast based on D-1641) if Longfin Smelt are detected at Station 716 during the annual Smelt Larval Survey. These restrictions reduce NBA diversions during the period of potential adult Delta Smelt occurrence and the early part of the delta smelt spawning season as well. However, the North Bay Aqueduct may have effects on predation (e.g., near the fish screens) and food availability (entrainment of plankton) in addition to direct entrainment.

5.16.3.6.2 Eggs and Larvae to Juveniles (March – June)

Historical catch rates of larval and early juvenile Delta Smelt in Barker Slough were low (USFWS 2005; Figure 5.16-48), suggesting limited exposure to potential effects of the proposed action from the BSPP. The 3/32-inch openings of the BSPP intakes mean that individual larval and early juvenile Delta Smelt are susceptible to entrainment, but there would be relatively low occurrence in the area.



Source: USFWS (2005, p.181). Note: The NBA values are the mean annual CPUE for stations 720, 721, and 727. The nearby North Delta sites are the mean annual CPUE for stations 718, 722, 723, 724, and 726 (https://www.wildlife.ca.gov/Portals/0/Images/Conservation/Delta/nbabase.gif)

Figure 5.16-47. Delta Smelt Catch Per Unit Effort (CPUE; Fish Per Trawl) for North Bay Aqueduct Monitoring in Barker Slough (Dark Bars) Compared to Nearby North Delta Sites (Lindsay, Cache, and Miner Sloughs; White Bars).

5.16.3.6.3 Juveniles to Subadults (June – September)

Available monitoring suggests infrequent occurrence in Barker Slough (Figure NBA_ds), and the majority of juveniles reaching adulthood would tend to rear in the low salinity zone in most years (Bush 2017), suggesting limited exposure to potential effects of the proposed action from the BSPP. The 3/32-inch openings of the BSPP intakes would be expected to exclude most juvenile Delta Smelt from entrainment.

5.16.3.6.4 Subadults to Adults (September – December)

The majority of subadults reaching adulthood would tend to rear in the low salinity zone in most years (Bush 2017), suggesting limited exposure to potential effects of the proposed action from the BSPP, and the 3/32-inch openings of the BSPP intakes would exclude subadult Delta Smelt from entrainment.

5.16.3.7 Water Transfers

As discussed in Spring-run Chinook Salmon section, Reclamation's proposed action to expand the transfer window to July to November could result in additional pumping of approximately 50 TAF per year in most water year types. As shown in Figures 5.16-1 and 5.16-2, larvae and sub-adults are the main lifestages of Delta Smelt found in the south Delta, and both of these lifestages would occur in the South Delta mostly in the spring. The water transfer window therefore does not overlap with anticipated Delta Smelt presence in the South Delta. However, an occasional Delta Smelt could potentially be exposed to increased pumping as result of water transfers, which could cause entrainment, or predation risk. Effects would be the same as those discussed for OMR management above.

5.16.3.8 Clifton Court Forebay Aquatic Weed Program

In the without action scenario, Clifton Court Forebay (CCF) gates are not operated and Banks Pumping Plant is not run, and therefore there would be no removal of aquatic weeds from CCF. This program does occur under current operations as removal of aquatic weeds is necessary for operation of the CVP and SWP to allow for drawing water into the pumping plants and avoiding physical blockage at the trashracks, reducing pumping rates to prevent pump cavitation.

5.16.3.8.1 Adults to Eggs and Larvae (December – May)

For control of aquatic weeds (predominantly *Egeria densa*) in CCF, the proposed action includes application of herbicides (see proposed action for more details) after water temperatures within CCF are above 25°C or after June 28 and prior to the activation of Delta Smelt and salmonid protective measures following the first flush rainfall event in fall/winter, and mechanical harvesting as needed. Given the timing of the action, individual adult Delta Smelt would not be exposed to any toxic effects of the herbicides, as adult Delta Smelt would not be in CCF after water temperatures are above 25°C or after June 28 and before activation of Delta Smelt protection measures. Mechanical removal of aquatic weeds in CCF would occur on an as needed basis and therefore could coincide with occurrence of migrating adult Delta Smelt. Delta Smelt generally would not be expected to found near aquatic weeds (Ferrari et al. 2014), but could occur near the weeds if both fish and weeds are concentrated into particular areas by prevailing water movement in the CCF. Any potential adverse effects to individual Delta Smelt from mechanical removal of water hyacinth or other aquatic weeds (e.g., injury from contact with cutting blades) possibly would be offset to some extent by the reduced probability of predation by weed-associated predatory fishes and increases in salvage efficiency at the Skinner Fish Delta Fish Protective Facility because of reduced smothering by weeds. However, as noted by USFWS (2017a, p.271), mortality in CCF is very high for adults (Castillo et al. 2012), so that any effects of weed control would be limited as Delta Smelt in CCF would already have deceased. In addition, as previously described in the *Entrainment Risk* section, south Delta exports would be managed to limit the occurrence and therefore entrainment risk of Delta Smelt at the south Delta export facilities, thus limiting the number of individuals entering CCF that could be exposed to the weed control program.

5.16.3.8.2 Eggs and Larvae to Juveniles (March – June)

Control of aquatic weeds in CCF with herbicides under the proposed action (i.e., after water temperatures within CCF are above 25°C or after June 28 and prior to the activation of Delta Smelt and salmonid protective measures following the first flush rainfall event in fall/winter) would not affect larval Delta Smelt, given their life stage timing (March–June). Although mechanical removal activities under the proposed action could in theory affect larval Delta Smelt in CCF, they already have poor chances of survival in CCF (as discussed previously in the *Entrainment Risk* section) as salvage is only effective for larger fish.

5.16.3.8.3 Juveniles to Subadults (June – September)

Juvenile Delta Smelt occur in the low salinity zone or in the north Delta and not in the south Delta (Figures 5.16-1 and 5.16-2); there would not be effects on juvenile Delta Smelt from the CCF aquatic weed control program under the proposed action.

5.16.3.8.4 Subadults to Adults (September – December)

Subadult Delta Smelt occur in the low salinity zone or in the north Delta and not in the south Delta (Figures 5.16-1 and 5.16-2); there would not be effects on juvenile Delta Smelt from the CCF aquatic weed control program under the proposed action.

5.16.3.9 Suisun Marsh Facilities

Under the without action scenario, DWR would not operate the Suisun Marsh Salinity Control Gate, Roaring River Distribution System, Morrow Island Distribution System, or Goodyear Slough Outfall leading to a saltier Suisun Marsh and decreased Delta Smelt habitat. However, depending on the time of year, the without action scenario would result in much higher Delta outflow than the proposed action and current operations; thereby resulting in overall increases in Delta Smelt habitat.

5.16.3.9.1 Adults to Eggs and Larvae (December – May)

5.16.3.9.1.1 Suisun Marsh Salinity Control Gates

Operations of the SMSCG under the proposed action includes current operations (i.e., 0 - 253 days per year from October through May) plus an additional 60 days in June–October of wet, above normal and below normal water years to benefit juvenile and subadult Delta Smelt. In Wet year types, the average number of gate operation days between October and May is 50. In Below Normal years 72 days, in Dry water year types 52 days is the average number of days of gate operation, and in Critical water year types, DWR operates the SMSCG on average 156 days between October and May. In 2011, DWR did not need to operate the SMSCG at all. In 2015, DWR operated the gates for 253 days between October and May to help meet water quality criteria during that drought year. As such, the recent analysis of potential effects by USFWS (2017a, p.266-267) is relevant. Potential blockages of the migration of adult Delta Smelt individuals by SMSCG operations, previously the primary concern of USFWS (2008), were found to be of lesser concern by USFWS (2017a, p.267), given that Delta Smelt can spawn in Montezuma Slough (see adult distribution and frequency of occurrence in Figures 5.16-1 and 5.16-2). USFWS (2017a, p.267) also suggested that aggregation of predators such as Striped Bass near the SMSCG could increase predation rates, and operation of the SMSCG could increase risk of entrainment in diversions. There is limited risk of entrainment as the Roaring River Distribution System is screened, and little evidence for small diversions resulting in considerable entrainment of juvenile Delta Smelt (Nobriga et al. 2004).

5.16.3.9.1.2 Roaring River Distribution System

Water diversion operations of the RRDS under the proposed action would not change relative to current operations (although draining of the RRDS to Grizzly Bay/Suisun Bay would change in summer/fall, in coordination with the SMSCG action). As noted by USFWS (2017a, p.267-268), the RRDS is screened (3/32-inch opening), therefore excluding Delta Smelt of ~30 mm and larger and operated to maintain an approach velocity of 0.7 or 0.2 ft/s to minimize effects to Delta Smelt from entrainment, impingement, and screen contact.

Other effects of the Roaring River Distribution System could include increased predation near the fish screen and entrainment of plankton affecting food availability, as discussed above under North Bay Aqueduct. However, due to the relatively small capacity of the Roaring River Distribution System, these effects are anticipated to be small.

5.16.3.9.1.3 Morrow Island Distribution System

No changes in current MIDS operations are included in the proposed action. As discussed by USFWS (2017a, p.268-269), entrainment of individual adult Delta Smelt by the three MIDS unscreened 48-inch intakes could occur, but the effects would be expected to be limited to wet years (Enos et al. 2007), per spawner distributions found by Hobbs et al. (2005). No Delta Smelt were collected during entrainment sampling at MIDS in 2004-2006 (Enos et al. 2007). MIDS is often closed or diversions are small during the spring spawning period of adult Delta Smelt, which may offer protection given that Delta Smelt microhabitat occupancy tends to be in open water away from structures. Beach seine data has shown some Delta Smelt along the shore, which could be affected by MIDS.

Other effects of the Morrow Island Distribution System could include increased predation and negative effects on food availability through entrainment of plankton, as discussed above for the Roaring River Distribution System. However, due to the relatively small capacity of the Morrow Island Distribution System, these effects are anticipated to be small.

5.16.3.9.1.4 Goodyear Slough Outfall

Operation of the flap gates at the Goodyear Slough outfall under the proposed action would continue as under current operations. As discussed by USFWS (2017a, p.269), individual adult Delta Smelt could be entrained into Goodyear Slough by the flap gates' creation of a small southerly net flow, but the Goodyear Slough area is generally too saline for Delta Smelt and occurrence would only be likely in wet years (Enos et al. 2007, p.17).

The small southerly net flow could create other effects including such as increased predation near the flap gates. However, due to the relatively small capacity of the Goodyear Slough Outfall, these effects are anticipated to be small.

5.16.3.9.2 Eggs and Larvae to Juveniles (March – June)

5.16.3.9.2.1 Suisun Marsh Salinity Control Gates

As described for adult Delta Smelt, operations of the SMSCG under the proposed action would be unchanged from current operations during March–June. Gate operations could change movement patterns of larval Delta Smelt, potentially increasing risk of entrainment by diversions within Suisun Marsh, although existing modeling for RRDS suggests this risk to be limited as discussed in the life stage above.

5.16.3.9.2.2 Roaring River Distribution System

Effects to larval and young juvenile Delta Smelt from the RRDS under the proposed action would be limited and unchanged from current operations. Delta Smelt smaller than 30 mm could be susceptible to entrainment, whereas slightly larger fish could be susceptible to impingement (USFWS 2017a, p.268). Available particle tracking modeling suggests that entrainment risk would be low (USFWS 2017a, p.268).

5.16.3.9.2.3 Morrow Island Distribution System

As noted for adult Delta Smelt, there would be no changes to current MIDS operations under the proposed action, and any potential effects (in particular entrainment) would be expected to be limited given that conditions are generally too saline for Delta Smelt (limiting exposure to wet years) and the MIDS intakes are often closed or diversions are small during the spring larval period (USFWS 2017a, p.268-269).

5.16.3.9.2.4 Goodyear Slough Outfall

As described for adult Delta Smelt, operation of the Goodyear Slough outfall under the proposed action would continue as under current operations. Larval Delta Smelt individuals could be entrained into Goodyear Slough by the flap gates’ creation of a small southerly net flow. However, the Goodyear Slough area is generally too saline for Delta Smelt and occurrence would only be likely in wet years (Enos et al. 2007, p.17).

5.16.3.9.3 Juveniles to Subadults (June – September)

5.16.3.9.3.1 Suisun Marsh Salinity Control Gates

As summarized for adult Delta Smelt, operation of the SMSCG under the proposed action could affect individual juvenile Delta Smelt through increased entrainment at local diversions or predation near the gates. There is limited risk of entrainment as the Roaring River Distribution System is screened, and little evidence for small diversions resulting in considerable entrainment of juvenile Delta Smelt (Nobriga et al. 2004).

5.16.3.9.3.2 Roaring River Distribution System

As discussed for adult Delta Smelt, juvenile Delta Smelt of ~30 mm and greater would be expected to be excluded from entrainment at RRDS under the proposed action, and the 0.7 or 0.2-ft/s approach velocity is protective of Delta Smelt.

5.16.3.9.3.3 Morrow Island Distribution System

No juvenile Delta Smelt were collected during entrainment monitoring at MIDS in 2004-–2006 by Enos et al. (2007), and juvenile Delta Smelt of ~30 mm and greater would be excluded from entrainment associated with the MIDS under the proposed action.

5.16.3.9.3.4 Goodyear Slough Outfall

As described for adult Delta Smelt, only in wet years would the Goodyear Slough outfall under the proposed action be expected to have potential effects to individual juvenile Delta Smelt as a result of entrainment into Goodyear Slough.

5.16.3.9.4 Subadults to Adults (September – December)

5.16.3.9.4.1 Suisun Marsh Salinity Control Gates

Operation of the SMSCG could result in increased entrainment at local diversions of individual subadult Delta Smelt or predation near the gates. However, the RRDS will be screened under the proposed action and there is little evidence that small diversions result in considerable entrainment of juvenile Delta Smelt (Nobriga et al. 2004).

5.16.3.9.4.2 Roaring River Distribution System

As discussed for other life stages, Delta Smelt of ~30 mm and greater and therefore all subadults would be expected to be excluded from entrainment at RRDS associated with the proposed action, and the 0.7 or 0.2-ft/s approach velocity is protective of Delta Smelt.

5.16.3.9.4.3 Morrow Island Distribution System

No subadult Delta Smelt were collected during entrainment monitoring at MIDS in 2004-–2006 by Enos et al. (2007) and those authors concluded that conditions are generally too saline, except for spawners (i.e., during the wet season) of wetter years. Therefore, effects of operation under the proposed action are expected to be negligible.

5.16.3.9.4.4 Goodyear Slough Outfall

As described for other life stages, only in wet years would the Goodyear Slough outfall under the proposed action be expected to have potential effects to individual Delta Smelt as a result of entrainment into Goodyear Slough. Given the seasonality of subadult occurrence during what is a low-flow portion of the year, exposure to the effects of Goodyear Slough outfall would be expected to be negligible.

5.16.3.10 Effects of Maintenance

Maintenance effects include crushing, impingement, noise, and harassment from in-water work to repair facilities. Implementation of the species avoidance and take minimization steps described in Appendix E, *Avoidance and Minimization Measures* would be anticipated to minimize potential negative effects to Delta Smelt from maintenance activities.

5.16.4 Effects of Conservation Measures

The following are proposed conservation measures that are intended to offset or reduce the effects of operations and maintenance under the proposed action. These conservation measures would only occur due to the implementation of the proposed action and are beneficial in nature. The following analysis examines the construction related effects of the measures but also the benefits to the population once completed. Conservation measures would not occur under the without action scenario.

While conservation measures are beneficial, they may involve construction, which may have temporary impacts to Delta Smelt. Actions involving construction (i.e., Delta habitat restoration, Yolo Bypass project, the small screen program, predator hot spot removal, habitat restoration, improvements to the Delta Cross Channel, Tracy Fish Facility, Skinner Fish facility, reconstruction of the lock at the upstream end of the Sacramento Deepwater Ship Channel, restoration of lower San Joaquin River spawning and rearing habitat, and construction of the Delta Smelt Conservation Hatchery) would not be expected to overlap the occurrence of adult Delta Smelt given the timing of in-water construction (August–October) and the typical seasonal occurrence of this life stage in the Delta (December–May; Figure 5.16-3). Therefore, construction-related effects under the proposed action are not expected to impact adult Delta Smelt.

In addition, larval Delta Smelt would not be expected to be exposed to the effects of construction associated with the proposed action, based on the timing of in-water construction (August–October) and the typical seasonal occurrence of this life stage in the Delta (March–June; Figure 5.16-4).

Juvenile and subadult Delta Smelt have the potential to be exposed to the effects of construction under the proposed action, based on the timing of in-water construction (August–October) and the occurrence of this life stage in the lower Sacramento River where some construction of conservation measures would occur. Effects to individual Delta Smelt could include temporary or permanent loss of habitat; exposure to increased suspended sediment and turbidity leading to changes in habitat quality and foraging ability; potential harm from accidental release of construction-related hazardous materials, chemicals, and waste; and effects from inadvertent spread of invasive or nuisance species. Such effects include some of the habitat attributes hypothesized to be of importance to this life stage (Figure 5.16-5). The risk from these potential effects would be minimized through application of measures such as those described in Appendix E, *Avoidance and Minimization Measures*.

5.16.4.1 Suisun Marsh Salinity Control Gates

5.16.4.1.1 Adults to Eggs and Larvae (December – May)

Adult Delta Smelt are not affected by the SMSGC operation under the proposed action as they are not generally in Suisun Marsh during June through September when the action would occur (see Figures 5.16-1 and 5.16-2).

5.16.4.1.2 Eggs and Larvae to Juveniles (March – June)

Larvae Delta Smelt are not affected by the SMSCG operation under the proposed action as they are not generally in Suisun Marsh during June through September when the action would occur (see Figures 5.16-1 and 5.16-2).

5.16.4.1.3 Juveniles to Subadults (June – September)

As described in the IEP MAST (2015) conceptual model, food availability and quality is a key component of the June–September transition probability of juvenile Delta Smelt to subadulthood through growth and survival of individuals (Figure 5.16-5). The proposed action includes SMSCG operations in 60 days during June–October of wet, above normal and below normal water year types in order to increase Delta Smelt food availability and quality through increased access to, and provision of low salinity Delta Smelt juvenile habitat in, the relatively food-rich Suisun Marsh habitat. The operation of the SMSCG would be combined with operation of the RRDS in order to allow productivity from the RRDS to be exported to the Grizzly Bay/Suisun Bay area (as described for the Delta Smelt Resiliency Strategy; California Natural Resources Agency 2016). As described further below, this action can also provide benefit to the subsequent, subadult life stage.

Evidence from a pilot 2018 application of the SMSCG action provides support for predicted habitat benefits. The SMSCG were operated during August 2018 and it was found that Delta Smelt entered the marsh and, therefore, had access to more productive habitat, better water quality conditions (lower salinity and higher turbidity) occurred, and the benefits extended well beyond the period of gate operations (Sommer et al. 2018). Thus, the proposed SMSCG action potentially increases Delta Smelt habitat suitability in an area with relatively high food availability and growth potential, as reflected by Delta Smelt individual-level responses such as stomach fullness (Hammock et al. 2015). The 2018 pilot implementation of the SMSCG action illustrated that the action could provide salinity conditions in Suisun Marsh during below normal years that, from the perspective of Delta Smelt juveniles, were similar to or better than in wet years (Sommer et al. 2018). This may be of particular importance during periods of several drier years in a row.

Seasonal operations of the SMSCG as part of the proposed action potentially provide a positive effect to Delta Smelt juveniles through increased food availability that would provide some offsetting of potential negative effects from seasonal water operations. The south Delta exports influence the subsidy of the Delta Smelt zooplankton prey *Pseudodiaptomus forbesi* to the low salinity zone from the freshwater Delta (Kimmerer et al. 2018a), with these potential negative effects probably being of particular importance on the San Joaquin River side of the Delta given the high density of *P. forbesi* there (Kimmerer et al. 2018b).

Potential effects from the proposed action related to the SMSCG action would be expected to have the potential to affect a sizable portion of the Delta Smelt population. Bush (2017) demonstrated that on average 77 percent of adult Delta Smelt either migrate to the low salinity zone as early juveniles or are resident in the low salinity zone throughout their lives. During and just after the August 2018 pilot implementation of the SMSCG action, EDSM data from surveys between August 6 and September 7 suggest an average of 20 percent (range 0–100%) of juvenile Delta Smelt were in Suisun Marsh, although there is appreciable uncertainty in the estimates given low numbers of fish caught (USFWS 2018_EDSM).

5.16.4.1.4 Subadults to Adults (September – December)

As described in more detail for Delta Smelt juveniles, the proposed SMSCG operation in June–October of wet, above normal and below normal years has the potential to increase Delta Smelt habitat suitability through lower salinity in the relatively food-rich Suisun Marsh, in conjunction with export of food to Grizzly Bay/Suisun Bay through operation of the RRDS. As described for juvenile Delta Smelt, the IEP MAST (2015) conceptual model posited link between fall hydrology and clam grazing (Figure 5.16-6) was not supported by an examination of *P. amurensis* biomass and grazing rate during the fall (Brown et al. 2014, p.50-56), so it is unclear what effect differences in hydrology might have on clam grazing and food availability.

As applied during the pilot 2018 implementation of the proposed SMSCG action discussed previously, additional Delta outflow is required to ensure that Delta salinity is maintained within D-1641 required levels, and that there is no net effect on X2. It is expected that this requires a few tens of thousands of acre-feet of additional Delta outflow (Zhou 2018); the required amount in 2018 was 37,000 acre-feet (Sommer et al. 2018). As illustrated with modeling for representative above normal (2005) and below normal (2012) years, operation of the SMSCG in August coupled with outflow augmentation to prevent no net X2 effect leads to a small increase in the overall Delta Smelt abiotic habitat Station Index (Table 5.16-1), a metric that includes salinity, turbidity, and current velocity (Bever et al. 2016).

Table 5.16-1. Monthly-Averaged Delta Smelt Station Index for with and without Suisun Marsh Salinity Control Gates Reoperation With Outflow Augmentation Scenarios.

Month	Year	Delta Smelt Station Index without SMSCG Reoperation	Incremental Change with SMSCG Reoperation With Outflow Augmentation
August	2005	0.54	0.03
August	2012	0.24	0.03
September	2005	0.48	0.04
September	2012	0.20	0.01
October	2005	0.39	0.01
October	2012	0.18	0.01

Source: Anchor QEA (2018, p.98-99). Notes: SMSCG Reoperation With Outflow Augmentation scenario shown in the table is the ‘Reoperation + Variable Outflow’ scenario from Anchor QEA (2018, p.8). Index shown is for entire area. SMSCG assumed to be operated in August.

5.16.4.2 *Summer-Fall Delta Smelt Habitat*

Reclamation proposes to conduct actions as described in the proposed action to target creation of summer and fall Delta Smelt habitat.

The plots below in Figure 5.16-49 show raw daily electrical conductivity and chlorophyll from the sensors at False River (FAL), Antioch (ANH), and Mallard Island (MAL) from 2007 to the present. These physical parameters would be used to determine whether Reclamation has created Delta Smelt Summer-Fall Habitat under this action. Delta Outflow relates best to salinity, as expected, with slight relationships for the other variables. Chlorophyll is rarely above 10 ug/L at any of these stations, which per Mueller-Solger et al. (2002) is an indicator of conditions for good zooplankton growth.

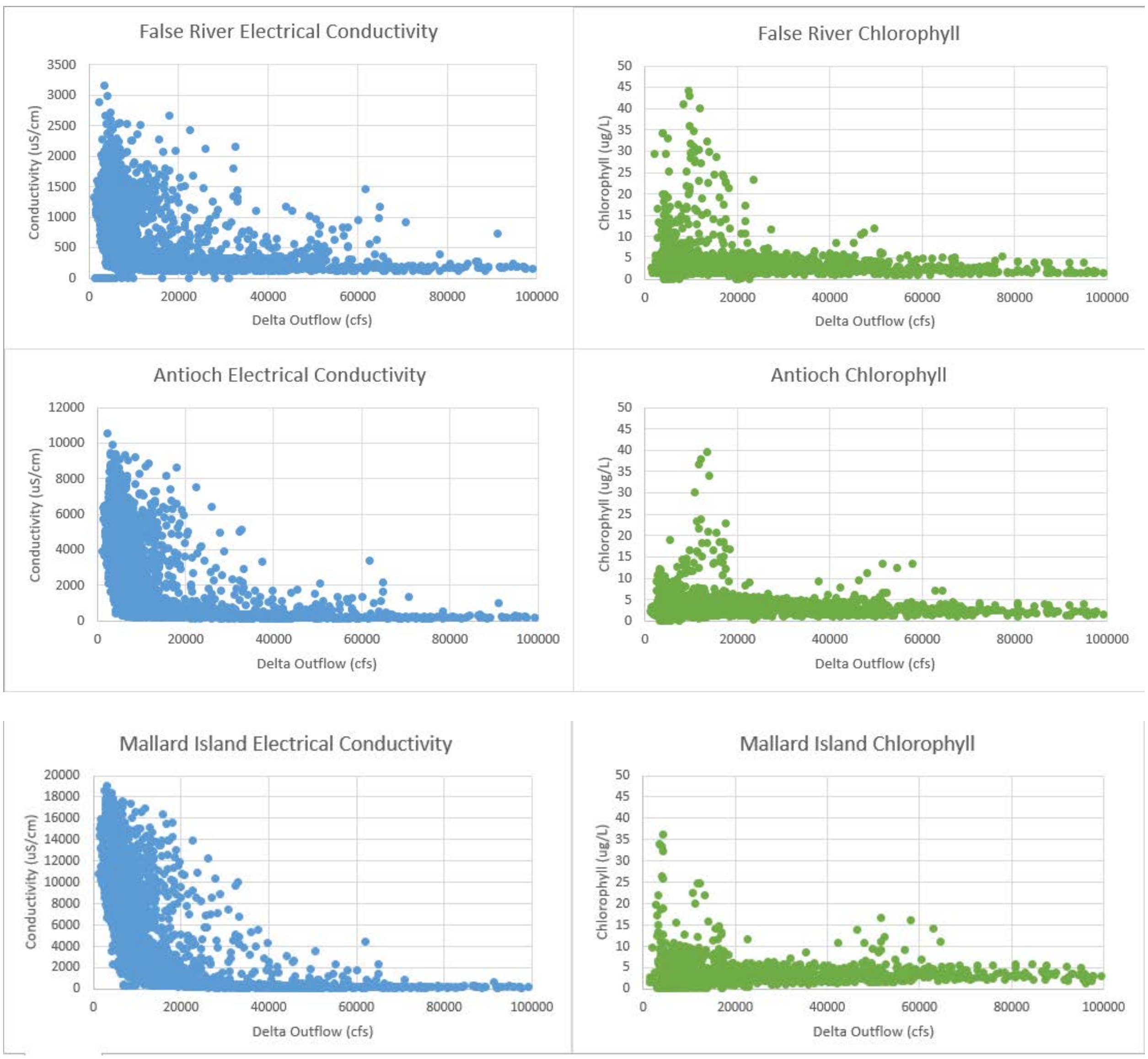
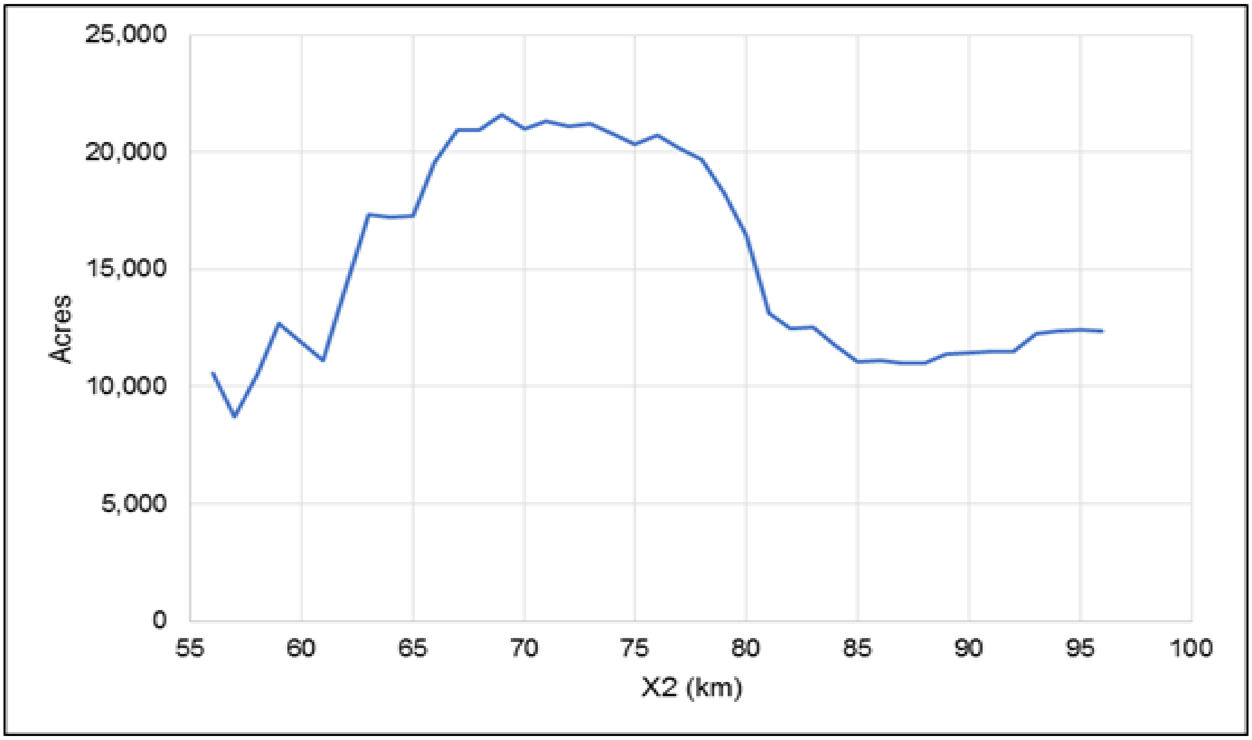


Figure 5.16-48. Raw daily electrical conductivity and chlorophyll from the sensors at False River, Antioch, and Mallard Island from 2007 onwards.

In the Without Action, X2 is at 86 km on average in September and 84 km on average in October. Under the proposed action, X2 is at 92 km on average in September and October; however, the modeling does not include the Delta Smelt Habitat action, so under the proposed action in wetter year types it is expected that X2 would be further downstream. As can be seen from Figure 5.16-52, there is very little difference in the acres of the low salinity zone between 84 and 92 km X2. Under the current operations scenario, X2 is at 86 km on average in September and 87 km on average in October, and is also within the same range of approximately 11,000 acres of low-salinity zone habitat as the proposed action and the without action. At X2 below 81 km, acres of low salinity zone increases, with a substantial water supply impact. Meeting Delta Smelt Summer-Fall Habitat physical and biological features using alternate mechanisms may allow smelt benefits not modeled in the proposed action.



Source: Brown et al. (2014, p.79).

Figure 5.16-49. Acres of low salinity zone (1-6ppt) versus X2 in kilometers from the Golden Gate Bridge

Summer-Fall Delta Smelt Habitat has no effect on Delta Smelt adults, eggs, larvae or juveniles. Summer-Fall Delta Smelt Habitat could benefit subadult to adult Delta Smelt by improving turbidity, food, low salinity zone area, or temperatures, depending on the actions Reclamation and DWR take to implement the action.

5.16.4.3 Clifton Court Predator Removal

Predator control efforts under the proposed action to reduce predation on listed fishes following entrainment into Clifton Court Forebay could reduce salvage-related loss of adult Delta Smelt. Entrainment risk under the proposed action would be managed to limit the potential for adult Delta Smelt to occur in the south Delta and be entrained. Depending on the gear type of Clifton Court predator control efforts, predator control efforts may also catch Delta Smelt (that would likely have been salvaged or lost).

5.16.4.3.1 Eggs and Larvae to Juveniles (March – June)

Depending on the geartype of Clifton Court predator control efforts, predator control efforts under the proposed action may also catch Delta Smelt that would likely have been salvaged or lost.

5.16.4.3.2 Juveniles to Subadults (June – September); Subadults to Adults (September – December)

Juvenile and subadult Delta Smelt do not occur in the south Delta (Figure 5.16-1).

5.16.4.4 San Joaquin Steelhead Telemetry Study

The San Joaquin Steelhead telemetry study does not affect Delta Smelt as it would be primarily in the San Joaquin River upstream, and also does not involve trapping or other mechanisms to affect Delta Smelt of any lifestage.

5.16.4.5 Food Subsidies (Sacramento Deepwater Ship Channel, Colusa Basin Drain, and Roaring River Distribution System)

These beneficial conservation measures would not occur under the without action scenario. The Colusa Basin Drain action was undertaken as a pilot implementation in 2016.

5.16.4.5.1 Adults to Eggs and Larvae (December – May)

Under the proposed action, provision of Suisun Marsh food subsidies through coordination of managed wetland flood and drain operations in Suisun Marsh and draining of RRDS to Grizzly Bay/Suisun Bay in conjunction with reoperation of the SMSCG has the potential to positively affect the food availability attribute posited to be of importance for adult Delta Smelt, thereby improving growth and survival (Figure 5.16-3). The timing of this action may be largely outside the adult Delta Smelt December–May time period given that increased SMSCG operations under the proposed action would occur in June–September of above normal and below normal years, although the Delta Smelt Resiliency Strategy notes that coordinated draining operations could benefit all Delta Smelt life stages (California Natural Resources Agency 2016, p.9).

Provision of north Delta food subsidies by routing Colusa Basin drain water to the Cache Slough area through the Yolo Bypass would occur in summer/fall and therefore would have limited effects on adult Delta Smelt during December–May. Any adults that survive the spawning season could be affected.

Hydraulic reconnection of the Sacramento Deepwater Ship Channel with the Sacramento River through modification of the West Sacramento lock system would allow downstream transport of foodweb materials from the Ship Channel during the summer and therefore would have no effects on adult Delta Smelt during December-–May. Any adults that survive the spawning season could be exposed to the action, but would not be affected by the increasing food. This action could also increase the mobilization of accumulated sediment in the channel, which could have historical pesticides in it, possibly affecting Delta Smelt.

5.16.4.5.2 Eggs and Larvae to Juveniles (March – June)

As described for adult Delta Smelt, provision of Suisun Marsh food subsidies through coordination of managed wetland flood and drain operations in Suisun Marsh and draining of RRDS draining to Grizzly Bay in conjunction with reoperation of the SMSCG under the proposed action has the potential to positively affect growth and survival of Delta Smelt larvae through increased food availability (Figure 5.16-4). The timing of this action may be largely outside the larval Delta Smelt March–June time period given that increased SMSCG operations under the proposed action would occur in June–September of above normal and below normal years, although the Delta Smelt Resiliency Strategy notes that coordinated draining operations could benefit all Delta Smelt life stages (California Natural Resources Agency 2016, p.9).

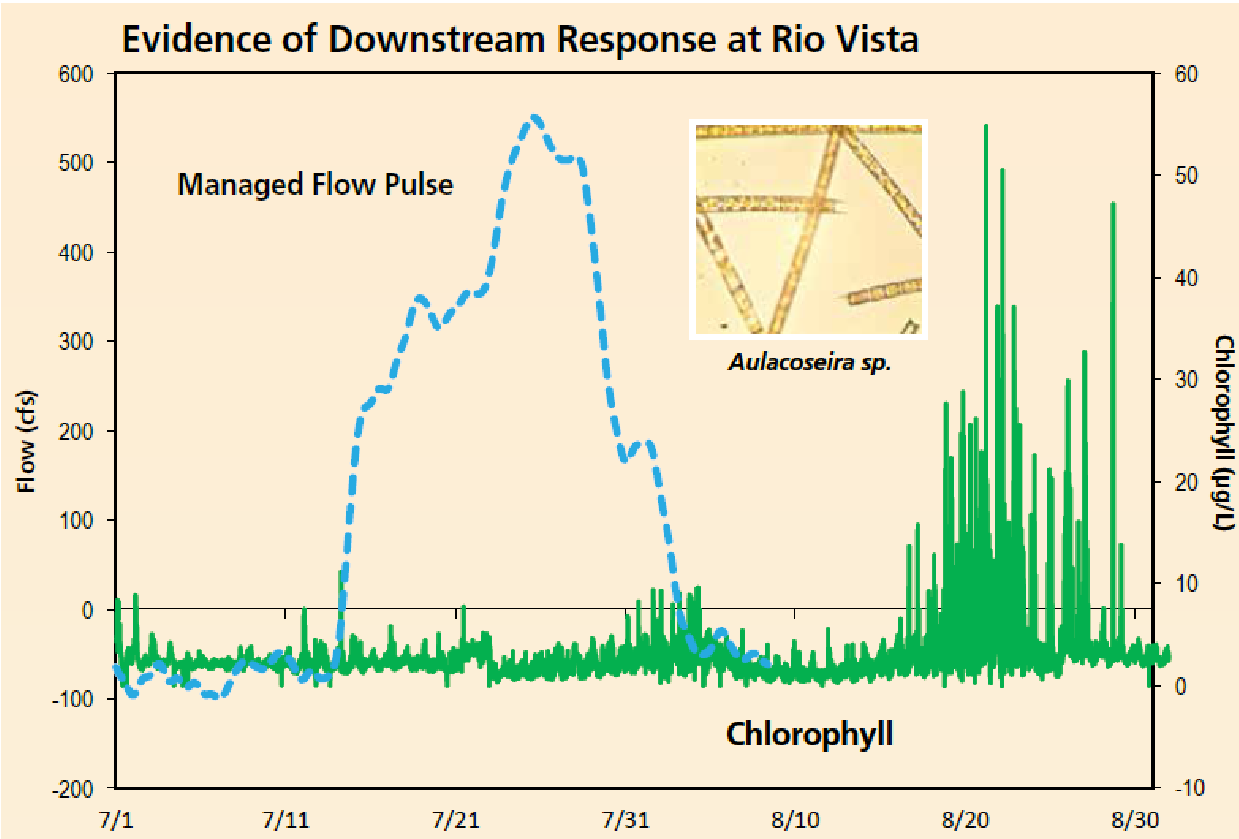
Provision of north Delta food subsidies by routing Colusa Basin drain water to the Cache Slough area through the Yolo Bypass would occur in summer/fall and therefore would have no effects on larval Delta Smelt during March–June.

Hydraulic reconnection of the Sacramento Deepwater Ship Channel with the Sacramento River through modification of the West Sacramento lock system would allow downstream transport of foodweb materials from the Ship Channel during the summer and, therefore, would have no effects on larval Delta Smelt during spring (March–June).

5.16.4.5.3 Juveniles to Subadults (June – September)

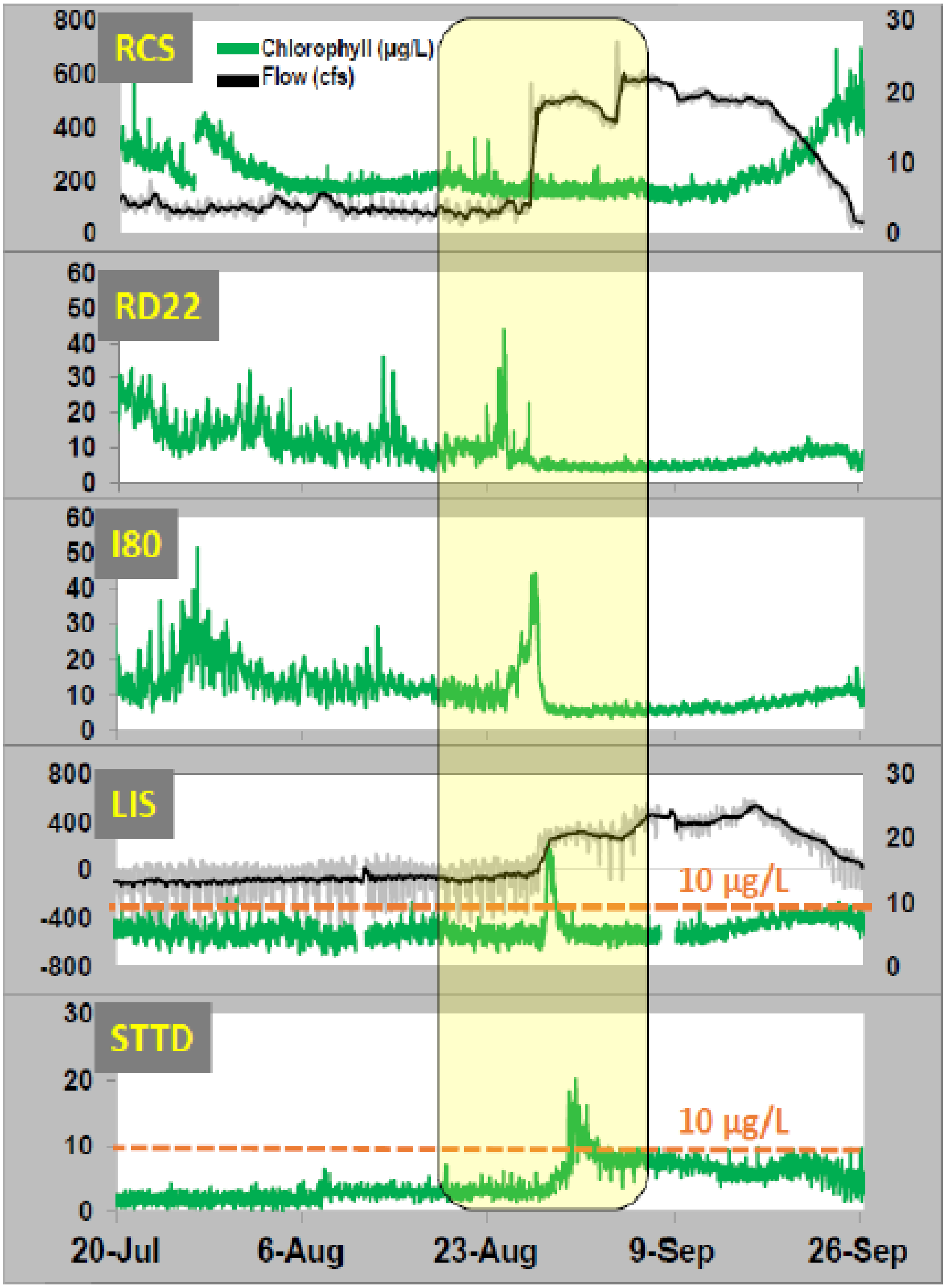
As noted for adult Delta Smelt, under the proposed action, provision of Suisun Marsh food subsidies through coordination of managed wetland flood and drain operations in Suisun Marsh and draining of RRDS to Grizzly Bay/Suisun Bay in conjunction with reoperation of the SMSCG has the potential to positively affect the food availability attribute posited to be of importance for juvenile Delta Smelt, thereby improving growth and survival (Figure 5.16-5). Increased SMSCG operations would occur in June–September of above normal and below normal years, and coordinated draining operations could benefit all Delta Smelt life stages, including juveniles (California Natural Resources Agency 2016, p.9). As described further in the analysis of conservation measure effects, during and just after the August 2018 pilot implementation of the SMSCG action, EDSM data from surveys between August 6 and September 7 suggest an average of 20% (range 0–100%) of juvenile Delta Smelt were in Suisun Marsh, although there is appreciable uncertainty in the estimates given low numbers of fish caught (USFWS 2018_EDSM).

Augmentation of flow from the Colusa Basin drain during summer/early fall could increase transfer of food web materials to the north Delta, thereby potentially increasing the food availability habitat attribute suggested hypothesized to be important for juvenile Delta Smelt (Figure 5.16-5). As previously described, an average of 23% of Delta Smelt surviving to adulthood are resident in the Cache Slough Complex/Sacramento Deepwater Ship Channel region throughout their lives, whereas the remainder either migrate to the low salinity zone or are resident there (Bush 2017). The proportion of the population resident in the north Delta would be most likely to benefit from the north Delta food subsidies action. A pilot implementation of this action in 2016 found that primary production in the north Delta increased as a result of the action (Figure 5.16-53; as had been observed in previous years without pilot implementation; Frantzich et al. 2018), with enhanced zooplankton growth and egg production (California Natural Resources Agency 2017). Reclamation (2018, p.2) suggested that a chlorophyll concentration of 10 µg/l of chlorophyll, as achieved in 2016 for a number of days during the action (Figure 5.16-53), could support relatively high zooplankton production (Mueller-Solger et al. 2002) without adversely affecting water quality (e.g., dissolved oxygen concentration). Analyses are underway to determine the potential effectiveness of a 2018 pilot implementation of the action, but preliminary information suggests that chlorophyll concentration above 10 µg/l was limited in duration in the Yolo Bypass (Figure 5.16-54) and there was no increase at Rio Vista (Figure 5.16-55).



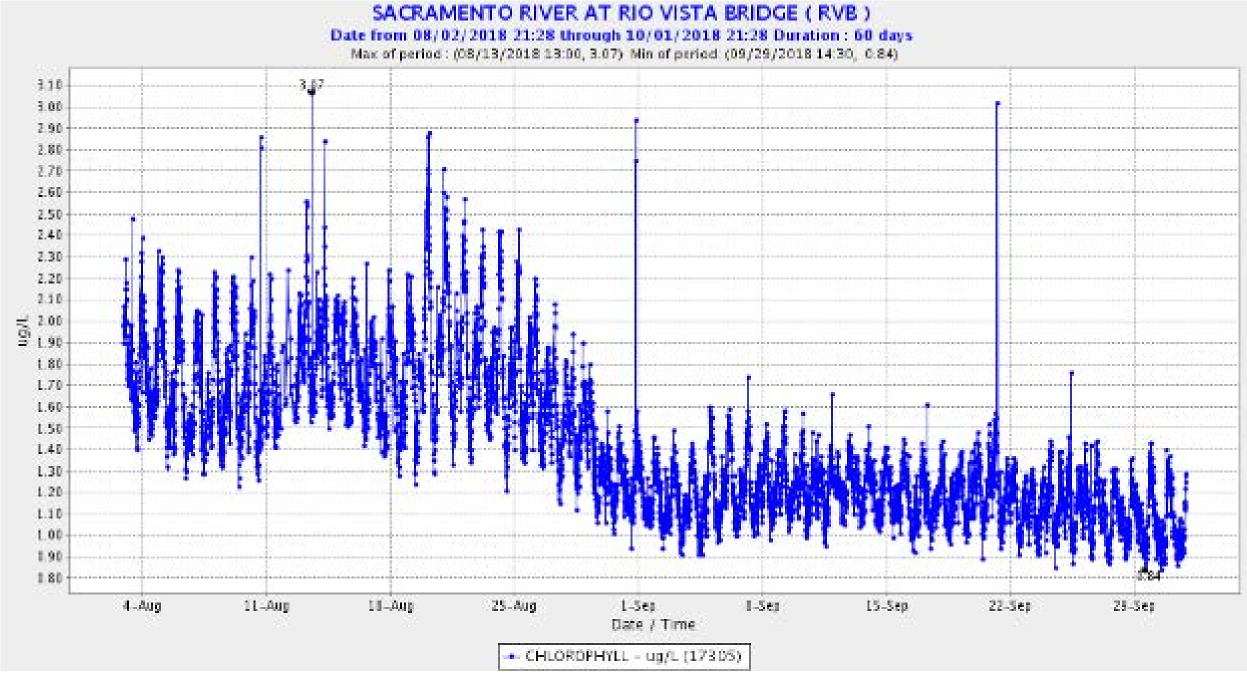
Source: California Natural Resources Agency (2017).

Figure 5.16-50. Managed Flow Pulse in the Yolo Bypass Toe Drain at Lisbon Weir and Chlorophyll Concentration at Rio Vista During 2016 Pilot North Delta Food Subsidies Action.



Source: NCWA (2018). Note: Yellow box indicates flow pulse into Yolo Bypass from Colusa Basin Drain.

Figure 5.16-51. Managed Flow Pulse in the Yolo Bypass Toe Drain at Lisbon Weir and Chlorophyll Concentration from North (RCS) to South (STTD) in the Yolo Bypass During 2018 Pilot North Delta Food Subsidies Action.



Source: California Data Exchange Center, http://cdec.water.ca.gov/jspplot/jspPlotServlet.jsp?sensor_no=17305&end=10%2F01%2F2018+21%3A28&geom=huge&interval=60&cookies=cdec01, accessed January 2, 2019.

Figure 5.16-52. Chlorophyll Concentration at Rio Vista Before, During, and After 2018 Pilot North Delta Food Subsidies Action.

Hydraulic reconnection of the Sacramento Deepwater Ship Channel with the Sacramento River through modification of the West Sacramento lock system, together with nutrient additions, potentially would allow downstream transport of foodweb materials from the Ship Channel during the summer. This could provide a benefit to individual Delta Smelt juveniles through increased growth and survival per the food availability attribute suggested hypothesized to be important in the IEP MAST (2015) conceptual model (Figure 5.16-5). The efficacy of the proposed action has yet to be tested with pilot studies (Reclamation 2018).

5.16.4.5.4 Subadults to Adults (September – December)

As described for Delta Smelt juveniles, this action could positively affect an appreciable portion of Delta Smelt subadults given operation of the SMSCG potentially in September, in conjunction with RRDS draining to Grizzly Bay/Suisun Bay. The extent of the potential positive effect would be dependent on the scale of managed wetland operations that could be coordinated for draining to habitats occupied by subadult Delta Smelt.

Hydraulic reconnection of the Sacramento Deepwater Ship Channel with the Sacramento River through modification of the West Sacramento lock system would allow downstream transport of foodweb materials from the Ship Channel during the summer. Therefore, the proposed action could result in positive effects on subadult Delta Smelt during early fall, if, as suggested by Reclamation (2018, p.2), any resulting phytoplankton/zooplankton bloom is self-sustaining for up to a month. The efficacy of the proposed action has yet to be tested with pilot studies.

5.16.4.6 Habitat Restoration

Completion of the 8,000 acres of habitat restoration would not occur under WOA. This action is currently underway, and the proposed action proposes to continue this ongoing work.

5.16.4.6.1 <u>Adults to Eggs and Larvae (December – May)</u>

Tidal habitat restoration associated with the proposed action has the potential to positively affect Delta Smelt adults through increased food availability, as well as also resulting in potential negative effects from contaminants, although the latter would be expected to be less than in areas previously used for agriculture. As previously noted, net export of food from restored areas may be limited (Lehman et al. 2010; Kimmerer et al. 2018c) and the greatest density of food export will be to areas within one tidal excursion of restored areas (Hartman et al. 2017, p.95).

5.16.4.6.2 <u>Food Availability</u>

The proposed action includes tidal habitat restoration of approximately an additional 6,000 acres. This tidal habitat restoration has the potential to increase food availability for Delta Smelt. For adult Delta Smelt, this relates directly to the food availability habitat attribute linked to the probability of spawning in the IEP MAST (2015) conceptual model (Figure 5.16-3). Recent studies indicate that net export of food from restored lands may be limited (Lehman et al. 2010; Kimmerer et al. 2018c), and the conceptual model indicates that the greatest density of food export will be to areas within one tidal excursion of restored areas (Hartman et al. 2017, p.95). Restored habitat may be occupied by adult Delta Smelt given suitable habitat features (Sommer and Mejia 2013).

5.16.4.6.3 <u>Contaminants</u>

Tidal habitat restoration under the proposed action has the potential to produce negative effects to Delta Smelt related to contaminants from the initial construction, although it also may reduce contaminant loading in the long term. As described in the recent biological opinion for the Yolo Flyway Farms restoration project, habitat restoration may result in an initial export of on-site contaminants (e.g., agricultural pesticides, organic pollutants and mercury) to downstream areas (USFWS 2017b). Contaminants would have the potential to negatively affect individual Delta Smelt or their prey (e.g., by reducing swimming ability (see brief review by IEP MAST 2015, p.66-67)). The potential for other contaminant issues (methylmercury) will be addressed through AMM10 *Methylmercury Management* (Appendix E, *Avoidance and Minimization Measures*). As mentioned above, pesticides like organophosphates and pyrethroids are likely to have a net loss after habitat restoration due to biomediation and sequestration of the pesticide in the restored habitat.

5.16.4.6.4 <u>Eggs and Larvae to Juveniles (March – June)</u>

As previously described for adult Delta Smelt, the additional approximately 6,000 acres of tidal habitat restoration in the north Delta under the proposed action has the potential to increase food availability for Delta Smelt. For larval/early-juvenile Delta Smelt, this relates directly to the food availability habitat attribute linked to the probability of growth and survival in the IEP MAST (2015) conceptual model (Figure 5.16-4). Recent studies indicate that net export of food from restored lands may be limited (Lehman et al. 2010; Kimmerer et al. 2018c), but the restored habitat may be occupied by larval/early juvenile Delta Smelt given suitable habitat features (Sommer and Mejia 2013) in which food could be accessed.

Contaminant related impacts are discussed above in the Adults to Eggs and Larvae section.

5.16.4.6.5 Juveniles to Subadults (June – September)

As previously described for the adult and larval/early juvenile Delta Smelt life stages, the additional approximately 6,000 acres of tidal habitat restoration under the proposed action could potentially increase food availability, which is also an important factor noted for juvenile Delta Smelt in the IEP MAST (2015) conceptual model (Figure 5.16-5). Export of food from restored areas may be limited.

5.16.4.6.6 Subadults to Adults (September – December)

As with the other life stages, habitat restoration under the proposed action has the potential to increase food availability, which is an important factor noted in the IEP MAST (2015) conceptual model. However, food export from restored areas may be limited.

5.16.4.7 Predator Hot Spot Removal

5.16.4.7.1 Adults to Eggs and Larvae (December – May)

Predator hot spot removal under the proposed action is primarily focused on providing positive effects to downstream-migrating juvenile salmonids but could also reduce predation of individual adult Delta Smelt. Although the action would not be limited to existing identified hot spots (e.g., those identified by Grossman et al. 2013), the existing hotspots that may be representative of where removal efforts may be most concentrated tend to mostly be at the periphery of Delta Smelt habitat; and all hotspots are limited in scale relative to overall available habitat. However, in these periphery areas it is possible that predation control could affect competitors of Delta Smelt, benefiting Delta Smelt.

5.16.4.7.2 Eggs and Larvae to Juveniles (March – June)

Although predator hot spot removal under the proposed action is expected to result in some benefits to Delta Smelt eggs and larvae, these benefits would be limited. The predator hot spot removal action would be most likely to reduce habitat for larger predators that are a threat to juvenile salmonids as opposed to smaller predators of Delta Smelt eggs/larvae such as silversides.

5.16.4.7.3 Juveniles to Subadults (June – September)

As discussed further for adult Delta Smelt, predation hot spots have limited spatial extent. Moreover, existing identified predation hot spots generally are on the margins of habitat that would be occupied by juvenile Delta Smelt.

5.16.4.7.4 Subadults to Adults (September – December)

As discussed further for adult Delta Smelt, existing identified predation hot spots generally are on the margins of habitat that would be occupied by subadult Delta Smelt. Also, predator hotspots have a limited spatial extent.

5.16.4.8 Delta Cross Channel Operations and Improvements

Under the proposed action, Reclamation would operate the DCC for improving central Delta salinity, and would close the DCC when fish may be impacted as described in the proposed action. Reclamation would also use modeling to predict when D-1641 salinity standards would be exceeded, and open the DCC to avoid the exceedances. This would result in increased instances when the DCC is open under the proposed action as compared to current operations. However, as part of DCC improvements, Reclamation would construct a project to allow for diurnal or more frequent operation of the DCC than currently possible due to infrastructure limitations. This improved operational flexibility may allow future adjustments to DCC operations to benefit fish species in the Delta.

5.16.4.8.1 Adults to Eggs and Larvae (December – May)

As discussed by USFWS (2017a, p.265), it is unknown what, if any, impacts occur to Delta Smelt as a result of opening or closing the DCC gates. USFWS (2017a, p.265) considered the region near the DCC gates to only be transiently used during movement of some adult Delta Smelt upstream. USFWS (2017a, p.265) suggested that it may be possible that opening or closing the DCC gates changes the migration path of some Delta Smelt, but noted that it is unknown if there may be a change in predation risk or likelihood of successful spawning, for example. During the adult Delta Smelt upstream migration period (principally December–March; USFWS 2017a, p.265), the DCC gates would largely be closed as a result of adherence to D-1641 criteria as well as real-time operations as a function of juvenile salmonid catch indices and projected water quality in the central/south Delta. USFWS (2017a, p.265) suggested that closure of the DCC would create more natural hydrology for migrating adult Delta Smelt by keeping flow in the Sacramento River and Georgiana Slough. Potential far-field effects of the DCC on Delta hydraulics and how these could affect adult Delta Smelt entrainment risk would be considered when managing south Delta exports.

5.16.4.8.2 Eggs and Larvae to Juveniles (March – June)

Under the proposed action, the DCC would be expected to be largely closed during the March–June egg/larval transition period to juveniles. As described in more detail for adults, it is not known what effect the gates have on migration paths of Delta Smelt, but any effects would be expected to be limited given the low occurrence near the DCC (Figures 5.16-1 and 5.16-2; see also USFWS 2017a, p.159). Potential hydraulic effects on flows toward the south Delta export facilities would be taken into consideration when assessing south Delta entrainment risk, for example.

5.16.4.8.3 Juveniles to Subadults (June – September)

The distribution of juvenile Delta Smelt is downstream of the DCC (Figures 5.16-1 and 5.16-2), so any near-field effects of the DCC would not occur. Under the proposed action and consistent with current operations, the DCC would largely be open during the June–September transition from juveniles to subadults. The IEP MAST (2015) conceptual model does not specifically address habitat attributes that would be affected by this difference, which is a change in flow distribution rather than a change in overall summer hydrology, an environmental driver included in the conceptual model. More flow entering the lower San Joaquin River through the DCC presumably could lead to greater potential for flux of *P. forbesi* to the low salinity zone, given the important of the San Joaquin River side of the Delta as a source of *P. forbesi* (Kimmerer et al. 2018c). However, the effect of south Delta exports on the flux of *P. forbesi* to the low salinity zone may be more important than any effect of the DCC, as suggested by QWEST flows (Figures 5.16-16 through 5.16-18).

5.16.4.8.4 Subadults to Adults (September – December)

The distribution of subadult Delta Smelt is downstream of the DCC (Figures 5.16-1 and 5.16-2) and so any near-field effects of the DCC would not occur. Under the proposed action and consistent with current operations, the DCC would largely be open during the September–December transition from subadults to adults, prior to upstream migration as adults. As noted for juvenile Delta Smelt, the IEP MAST (2015) conceptual model does not specifically address habitat attributes that would be affected by DCC gates being opened vs. closed, but it could be argued that an open DCC would provide more flow to the lower San Joaquin River and therefore increase the potential for flux of *P. forbesi* to the low salinity zone (Kimmerer et al. 2018c). However, as described for juvenile Delta Smelt, south Delta exports appear to be a more important effect than the effect of the DCC given the generally negative QWEST flows (Figure 5.16-18).

5.16.4.9 Tracy Fish Facility Operations and Improvements

5.16.4.9.1 Adults to Eggs and Larvae (December – May)

The proposed action includes operating the TFCF, as well as TFCF improvements to reduce entrainment loss for salmonids through predator removal with carbon dioxide or angling. As summarized by USFWS (2017a, p.259), prescreen loss of adult Delta Smelt at the TFCF has not been quantified and whole facility salvage efficiency is low (Table 5.16-2; see also Sutphin and Svoboda 2016). Reduction in prescreen loss could improve salvage efficiency by reducing predation of adult Delta Smelt individuals.

Table 5.16-2. Factors Affecting Delta Smelt Entrainment and Salvage at the South Delta Export Facilities (Source: USFWS 2017a, p.259).

Factor	Adults	Larvae < 20 mm	Larvae >20 mm and Juveniles	Source
Pre-screen loss (predation prior to encountering fish salvage facilities)	CVP: unquantified; SWP: 89.9–100%	Unquantified	CVP: unquantified; SWP: 99.9% (based on only one juvenile release)	SWP: Castillo et al. (2012)
Fish facility efficiency	CVP: 13%; SWP: 43–89%	~0%	CVP: likely < 13% at all sizes, << 13% below 30 mm (based on adult data); SWP: 24–30%	CVP (Kimmerer 2008; adults only); SWP: Castillo et al. (2012)
Collection screens efficiency	~100%	~0%	<100% until at least 30 mm	USFWS (2011)
Identification protocols	Identified from subsamples, then expanded in salvage estimates	Not identified	Identified from subsamples, then expanded in salvage estimates	USFWS (2011)
Collection and handling	48-hour experimental mean survival of 93.5% (not statistically different from control) in 2005; 88.3% in 2006 (significantly less than 99.8% of control)	Unquantified	48-hour experimental mean survival of 61.3% in 2005 and 50.9% in 2006 (both significantly less than mean control survival of 82.0–85.9%)	Morinaka (2013)

Factor	Adults	Larvae < 20 mm	Larvae >20 mm and Juveniles	Source
Trucking and release (excluding post-release predation)	No significant additional mortality beyond collection and handling (above)	Unquantified	No significant additional mortality than collection and handling (above), although mean survival was 37.4% in 2005	Morinaka (2013)

Under the proposed action, a number of programmatic actions are proposed to improve salvage efficiency of TFCF. These actions could positively affect adult Delta Smelt through greater salvage efficiency. The entrainment risk under the proposed action would be managed to limit the potential for adult Delta Smelt to occur in the south Delta and be entrained.

5.16.4.9.2 Eggs and Larvae to Juveniles (March – June)

Larval Delta Smelt are unlikely to be salvaged and therefore the Tracy Fish Facility improvements under the proposed action would have no effects on this life stage.

5.16.4.9.3 Juveniles to Subadults (June – September)

Few if any juvenile and no subadult Delta Smelt would be expected to be exposed to the effects of operation of the carbon dioxide injection device or other Tracy Fish Facility improvements associated with the proposed action, given that these life stages are largely downstream of Tracy Fish Facility and juvenile entrainment risk during June would be managed to limit exposure to the facility.

5.16.4.9.4 Subadults to Adults (September – December)

Subadult Delta Smelt would not occur in the south Delta (Figure 5.16-1) and therefore there would be no effects from Skinner Fish Facility improvements under the proposed action on this life stage.

5.16.4.10 Skinner Fish Facility Operations and Improvements

5.16.4.10.1 Adults to Eggs and Larvae (December – May)

Skinner fish facility improvements from predator control efforts under the proposed action to reduce predation on listed fishes following entrainment into CCF could reduce salvage-related loss of adult Delta Smelt. However, entrainment risk under the proposed action would be managed to limit the potential for adult Delta Smelt to occur in the south Delta and be entrained. Depending on the gear type of Clifton Court predator control efforts, predator control efforts may also catch Delta Smelt that would likely have been salvaged or lost).

5.16.4.10.2 Eggs and Larvae to Juveniles (March – June)

Larval Delta Smelt are unlikely to be salvaged and therefore the Skinner Fish Facility improvements under the proposed action would have no effects on this life stage. Depending on the gear type of Clifton Court predator control efforts, predator control efforts may also catch Delta Smelt that would likely have been salvaged or lost.

5.16.4.10.3 Juveniles to Subadults (June – September); Subadults to Adults (September – December)

Juvenile and subadult Delta Smelt do not occur in the south Delta (Figure 5.16-1) and therefore there would be no effects from Skinner Fish Facility improvements under the proposed action on this life stage. Depending on the gear type of Clifton Court predator control efforts, predator control efforts may also catch Delta Smelt that would likely have been salvaged or lost.

5.16.4.11 Small Screen Program

Screening of small diversions (< 150 cfs) under the proposed action would be anticipated to have limited positive effects on individual adult Delta Smelt through reductions in entrainment. This life stage largely occurs outside of the main late spring-fall season when diversions typically occur (Siegfried et al. 2014), although there are a large number of small diversions. Based on factors such as observed limited entrainment of Delta Smelt at a small diversion in a field study (Nobriga et al. 2004) and the small hydrodynamic effect of such diversions, the DRERIP Delta Smelt conceptual model considered small diversions to be of minimal or no importance to Delta Smelt (Nobriga and Herbold 2009).

There may be some overlap of larval Delta Smelt with the main late spring-fall irrigation period for small diversions. Small diversion screening could reduce entrainment of sufficiently large (>20 mm or so) Delta Smelt larvae/early juvenile individuals. Similarly small diversion screening could reduce entrainment of Delta Smelt juveniles and subadults. However, entrainment by small diversions is posited to be of minimal importance to Delta Smelt (Nobriga and Herbold 2009).

5.16.4.12 Increased Production and Release from UC Davis Fish Culture and Conservation Laboratory (FCCL)

Under the proposed action, the existing UC Davis Fish Culture and Conservation Laboratory (FCCL) would be used to produce and release up to 50,000 adult Delta Smelt annually into the Sacramento-San Joaquin Delta to supplement the existing population. Release of cultured Delta Smelt to supplement the wild population would only be done following implementation of a number of risk reduction strategies (Table 5.16-3) and regulatory decisions made by USFWS and with genetic diversity in released cultured fish equivalent to that of the native stock. Supplementation of the wild population with hatchery-reared individuals could benefit individual adult Delta Smelt by making finding mates easier and, thereby, reducing the potential for Allee effects, which are declines in growth rate per fish at low population size (IEP MAST 2015, p.98). Given that wild Delta Smelt abundance may be of a similar magnitude—i.e., adult abundance in 2016–2018 as low as 16,000–48,000, with 95% confidence intervals of ~3,400–92,000 (see Figure 2.14-1 in Chapter 2)—as the abundance of adult fish that could be reared in the FCCL, the potential for benefits to the Delta Smelt are significant.

Potential negative effects of increased production at the FCCL include propagation and spread of invasive or nuisance species, which could affect Delta Smelt individuals through changes in food web structure. Increased production would be managed to avoid risks.

5.16.4.13 Delta Smelt Conservation Hatchery

Under the proposed action, Reclamation proposes to partner with DWR to construct and operate a conservation hatchery for Delta smelt in Rio Vista. The conservation hatchery would breed and propagate a stock of fish with equivalent genetic resources of the native stock and at sufficient quantities to effectively augment the existing wild population, so that they can be returned to the wild to reproduce naturally in their native habitat.

5.16.4.13.1 Adults to Eggs and Larvae (December – May)

Operation of the Delta Fish Species Conservation Hatchery has the potential to affect adult Delta Smelt in positive and negative ways, which are discussed here. By 2030, the likelihood of negative effects could be negligible.

5.16.4.13.1.1 Potential Positive Effects

The existing FCCL has a maximum capacity of just over 50,000 adult Delta Smelt. Operation of the Delta Fish Species Conservation Hatchery under the proposed action would substantially increase this capacity, although specific details are to be developed. Release of cultured Delta Smelt to supplement the wild population would only be done following implementation of a number of risk reduction strategies (Table 5.16-3) and regulatory decisions made by USFWS and with genetic diversity in released cultured fish equivalent to that of the native stock. Of particular importance will be the need to minimize hatchery domestication. Supplementation of the wild population with hatchery-reared individuals could benefit individual adult Delta Smelt by making finding mates easier and thereby reducing the potential for Allee effects, which are declines in growth rate per fish at low population size (IEP MAST 2015, p.98). Given that wild Delta Smelt abundance may be of a similar magnitude—i.e., adult abundance in 2016–2018 as low as 16,000–48,000, with 95% confidence intervals of ~3,400–92,000 (see Figure 2.14-1 in Chapter 2)—as the abundance of adult fish that could be reared in the Delta Fish Species Conservation Hatchery, the potential positive effect on adult Delta Smelt from release of Delta Smelt from the hatchery is high. Uncertainty in the potential positive effect stems from risks that would be reduced by a number of different strategies (Table 5.16-3).

Table 5.16-3. Risk Reduction Strategies for Implementation of Delta Smelt Culture at the Delta Fish Species Conservation Hatchery (Source: Lessard et al. 2018, p.9).

Risk type	Risk factor	Risk reduction strategies
Ecological	Interspecific interactions	Scale and adjust (via adaptive management program) release numbers to optimize production while avoiding significant, density-related, intraspecific effects or interspecific ecological risks. Requires monitoring program and adaptive management decision loop on an annual basis.
	Intraspecific interactions	
	Pathogen transfer	Use best management practices to minimize or eliminate pathogen transfer; implement rigorous fish health screening and maintenance program.
	Lack of suitable habitat for reintroduction	Don't release hatchery-reared Delta smelt in areas where habitat conditions or capacity are insufficient (this is still an unknown for Delta Smelt spawning habitat).
	Lack of suitable spawning or early life habitat conditions	Experimentally release a range of life stages and use a monitoring and adaptive management program to guide decision-making on life stage releases to increase post-release survival for demographic enhancement of recipient wild population.
	Behavioral changes	Develop, refine, and employ best management practices that integrate hatchery-produced Delta Smelt with the natural genetic and life history diversity of wild Delta Smelt to minimize possible behavioral changes in progeny.
Demographic	Broodstock mining	Because the effect of broodstock mining depends on the likelihood that fish would reproduce successfully if left in the wild, consider reducing broodstock take during high water years. There is no risk if there is no natural production.
	Broodstock selection	Collect 100 wild broodstock annually (based on current take limit) across greatest available temporal and spatial ranges to maximize diversity of broodstock and resulting phenotypes, genotypes and adaptive plasticity among progeny groups. Broodstock requirement could change with scale of the hatchery and genetic diversity in the wild.
	Spawner disruption	Refine and implement most efficient means of wild broodstock collection to minimize disturbance to wild spawners/spawning in the river.
Genetic	Loss of diversity	If feasible, continue to annually supplement captive refuge population with 100 new wild-origin broodstock annually (based on current take limit). Broodstock requirement could change with scale of propagation and genetic diversity in the wild. Continue to define and implement breeding matrices annually, using empirical genetic data to minimize kinship in broodstock crosses and resulting progeny groups, and to minimize risk of selection.
	Inbreeding depression	
	Selection	
Uncertainty	Measurement error	Conduct hatchery supplementation in an experimental framework that includes a robust monitoring and evaluation program, relevant measurable benchmarks to evaluate benefits and risks, and a clear decision structure for future adaptive management.
	Process error	
	Implementation error	Promote and evaluate tools and techniques that facilitate improved evaluation of the contribution and survival of cultured fish in the wild. Review practices with expert hatchery evaluation team to ensure use of best available information, operations, and protocols to minimize implementation error.

5.16.4.13.1.1.1 <u>Potential Negative Effects</u>

Potential negative effects of the Delta Fish Species Conservation Hatchery under the proposed action include propagation and spread of invasive or nuisance species, which could affect Delta Smelt individuals through changes in food web structure. Hatchery operations would require implementation of a Hazard Analysis and Critical Control Points plan, or similar control mechanism, which would include methods to prevent the introduction of invasive or nuisance species into the hatchery and operational practices that prevent the spread of these species within and outside of the facility, should prevention efforts fail. Hatchery operations would include actions to minimize the spread of invasive or nuisance species by sampling to determine whether such species are present and, if so, taking extra precautions to prevent spread. Sampling would be conducted on a quarterly basis at locations such as intake structures, raceway head boxes, settling ponds, and any other areas of concern. If suspect or questionable snails or mussels are found, specimens would be sent to the regional invasive-species scientist for identification (California Department of Fish and Game 2015), so that hatchery operations are not anticipated to result in the spread of invasive or nuisance species.

Discharges of water from the Delta Fish Species Conservation Hatchery could affect adult Delta Smelt individuals through changes in water quality, including increased water temperature, decreased dissolved oxygen, changes in water chemistry (pH and salinity), increased nutrient inputs, increased suspended solids, and release of other undesirable constituents such as parasites, disease microorganisms, and related treatment chemicals, but all of these factors would be managed to minimize effects. Water for the hatchery would mostly be sourced from a groundwater well and is anticipated to be consistent with Sacramento River water temperature adjacent to the hatchery. Dissolved oxygen levels of discharge water would be monitored and kept above applicable criteria (5 mg/l), with filtration to reduced biological oxygen demand. Salinity and pH would not be expected to be greatly affected, as analysis of larger scale salmonid hatchery facilities in California found limited evidence for increases (ICF Jones and Stokes 2010). Nutrient inputs and other constituents would be limited because effluent would pass through a water treatment facility for filtration and disinfection. Discharge of suspended solids such as uneaten feed and biological waste would be limited through treatment at an onsite treatment system consisting of drum filters, an underground holding tank between rearing tanks and drum filters, and settling ponds. Should it be necessary, a portable system to treat effluent could also be installed for specific individual rearing tanks, or a centralized holding tank and activated carbon filtration system. Overall, groundwater and surface water quality used at the hatchery would be monitored to protect the health of the fish being reared, and discharged water would be treated in accordance with required permits and protocols. This, coupled with the very small size of the discharge (5.5–11 cfs) in relation to tidal flows in the Sacramento River near the hatchery location (peak tidal flows of ± 100,000 cfs; http://cdec.water.ca.gov/dynamicapp/QueryF?s=SRV), suggests minimal effects.

Construction of the Delta Fish Species Conservation Hatchery in Rio Vista could benefit Delta Smelt through removal of creosote-treated wood pilings, that would remove a source of contaminants, as well as in-water structure that could provide habitat for predatory fishes. Potential negative effects would occur from operation of the marina and docks for research vessels, which could provide habitat for predatory fishes and increase predation on adult Delta Smelt. Loss of shallow-water habitat from construction of the facility could affect adult Delta Smelt spawning habitat availability, but would be compensated offsite at an appropriate mitigation ratio for the project footprint.

5.16.4.13.2 Eggs and Larvae to Juveniles (March – June)

Given appropriate application of risk reduction strategies (Table 5.16-3), potential negative effects from the Delta Fish Species Conservation Hatchery under the proposed action such as pathogen transfer from cultured to wild individuals would be minimized. Following application of these risk reduction strategies, release of cultured larval Delta Smelt presumably would have little effect on wild individuals (in contrast to adults, for example, for which increased numbers of individuals could lead to increased spawning opportunities, for example). As discussed for adults, potential negative effects on individual Delta Smelt such as propagation and spread of invasive/nuisance species leading to food web changes, and discharge of hatchery effluent resulting in water quality effects, could occur but would be limited.

5.16.4.13.3 Juveniles to Subadults (June – September)

As discussed for other life stages of Delta Smelt, given appropriate application of risk reduction strategies (Table 5.16-3), potential negative effects from the Delta Fish Species Conservation Hatchery under the proposed action such as pathogen transfer from cultured to wild juvenile Delta Smelt would be minimized. Following application of these risk reduction strategies, release of cultured juvenile Delta Smelt presumably would have little effect on wild individuals, given that interspecific associations appear to not be strong: Bennett (2005, p.22) suggested that "[j]uveniles and adults may occur in loose aggregations rather than tight schools, judging from the patchiness of fish catch in the monitoring surveys". As discussed for adults, potential negative effects on individual Delta Smelt such as propagation and spread of invasive/nuisance species leading to food web changes and discharge of hatchery effluent resulting in water quality effects, could occur but would be limited.

In-water construction work for the hatchery intake and outfall could result in effects to individual Delta Smelt such as temporary or permanent loss of habitat; exposure to increased suspended sediment and turbidity leading to changes in habitat quality and foraging ability; potential harm from accidental release of construction-related hazardous materials, chemicals, and waste; and effects from inadvertent spread of invasive or nuisance species. Such effects include some of the habitat attributes hypothesized to be of importance to this life stage (Figure 5.16-5). The risk from these potential effects would be minimized through application of AMMs (Appendix E, *Avoidance and Minimization Measures*). There is low potential exposure because of the in-water work window, minimized by application of AMMs, and the small scale of the in-water construction.

5.16.4.13.4 Subadults to Adults (September – December)

As discussed for other life stages, given appropriate application of risk reduction strategies (Table 5.16-3), potential negative effects from the Delta Fish Species Conservation Hatchery under the proposed action such as pathogen transfer from cultured to wild Delta Smelt would be minimized. Following application of these risk reduction strategies, release of cultured subadult Delta Smelt presumably would have little effect on wild individuals, given the loose aggregations rather than tight schooling behavior suggested by Bennett (2005, p.22). As discussed for adults, potential negative effects on individual Delta Smelt such as propagation and spread of invasive/nuisance species leading to food web changes, and discharge of hatchery effluent resulting in water quality effects, could occur but would be limited.

5.16.4.14 Lower SJR Habitat Restoration

5.16.4.14.1 Adults to Eggs and Larvae (December – May)

Under the proposed action, restoration of lower San Joaquin River spawning and rearing habitat for salmonids, including a large extent of floodplain habitat, would have the potential to produce food web materials that could be exported downstream to areas where Delta Smelt adults would occur, thereby positively affecting growth and survival per the IEP MAST (2015) conceptual model (Figure 5.16-3). However, transport downstream of productivity from this restoration to areas where Delta Smelt adults are likely to occur in greater numbers (See Figures 5.16-1 and 5.16-2) may be limited for two reasons. First, food web materials transported in flow entering the interior Delta through junctions such as Old River would be unlikely to move far downstream because of the prevailing hydrodynamics created by the south Delta export facilities (as shown by OMR reverse flows). In addition, river flows sufficiently large to inundate the floodplains frequently would tend to be somewhat limited in occurrence (ESA PWA 2012).

There would be no construction impacts of the Lower SJR habitat restoration under the proposed action on Delta Smelt, as Delta Smelt do not occur upstream in the San Joaquin River.

5.16.4.14.2 Eggs and Larvae to Juveniles (March – June)

As discussed in more detail for adult Delta Smelt, potential food availability effects on Delta Smelt may be low from Lower San Joaquin River spawning and rearing habitat restoration under the proposed action because enhanced productivity from inundated floodplains may occur relatively infrequently and export downstream may be limited by the hydrodynamic effects of the south Delta export facilities.

5.16.4.14.3 Juveniles to Subadults (June – September)

There would be no effects from food material production and export as a result of lower San Joaquin River spawning and rearing habitat restoration under the proposed action because the winter/spring inundation period of this habitat would not overlap the Delta Smelt juvenile period (June-–September).

5.16.4.14.4 Subadults to Adults (September – December)

As noted for juvenile Delta Smelt, there would be effects from food material production and export as a result of lower San Joaquin River spawning and rearing habitat restoration including floodplain habitat under the proposed action because the winter/spring inundation period of this habitat would not overlap the Delta Smelt subadult period (September–December, prior to transition to adulthood and movement triggered by the initial first flush of precipitation and flow).

5.16.4.15 Effects of Monitoring

5.16.4.15.1 Adults to Eggs and Larvae (December – May)

A number of monitoring activities described in Appenidx E – ROC Real Time Water Operations Charter, in the section *Monitoring Program for Core CVP and SWP Operation* would have the potential to capture adult Delta Smelt. USFWS (2017, p.186) suggested that historically, take of Delta Smelt in survey collections was low compared to estimated population abundance, but that given the combination of recent population decline and substantial increase in survey effort, scientific take of Delta Smelt may be reaching a relevant fraction of Delta Smelt in some seasons. A summary by USFWS (2017, p.195) showed, for example, that the total number of juvenile and adult Delta Smelt captured in IEP studies (which form much of the basis for the monitoring program) per year ranged from 447 in 2016 to 4,713 in 2005 (Table 5.16-4). Corresponding estimates of adult population size in these years were 477,775 in 2005 and 16,159 in 2016, which, accounting for the fact that not all individuals shown in Table 5.16-4 were adults, that the percentage collected was < 1% in 2005 and < 2.8% in 2016. As noted by USFWS (2017, p.186), some surveys have been modified to limit incidental catches of Delta Smelt. Although Table 5.16-4 does not account for other surveys that would capture individual adult Delta Smelt, in particular EDSM (take for EDSM is about 0.5% to 1% per year), it is anticipated that through consideration of overall potential take, sampling effort in monitoring activities would be limited. Importantly, monitoring would enable effects of the proposed action to be limited, e.g., by informing real-time operations for OMR adjustment.

Table 5.16-4. Number of Juvenile and Adult Delta Smelt Individuals (≥20-mm Fork Length) Captured from 2005 to 2016 for Interagency Ecological Program Studies (Source: USFWS 2017, p.195).

Survey	Year											
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Fall Midwater Trawl	28	39	27	21	32	54	344	47	21	11	7	7
Townet Survey	120	83	45	0	0	2	318	28	0	1	23	6
SF Bay Study	85	21	64	45	20	49	181	95	77	43	51	6
20-mm	15	0	2	1	2	5	8	63	9	1	0	2
Yolo Bypass	4	17	4	26	88	19	31	133	134	46	50	18
Broodstock Collections (FCCL)	2297	2418		70	23	80		2	198			
Delta Juvenile Fish Monitoring	761	954	245	119	136	445	956	710	464	301	245	103
New Technologies and Release Sites, Element 2 (Electrofishing)				2								
Indicators to Predict Adverse Effects to Salvaged Delta Smelt	64											
Fish Predation in the CHTR Phase	19											
Acute Mortality Associated with CHTR		28										
Directed Fish Collections	5	371	4									
Upper estuary zooplankton						1	2	2	0	1	0	0
Investigation of Antioch and Pittsburg Power Plants				2	14		0					
Spring Kodiak Trawl	1311	473	708	339	671	659	445	1204	339	356	107	260
Morrow Island Distribution	2	1										
UCD Suisun Marsh	2	1	3	1	4	2	22	10	6	7	3	0
Smelt Larva Survey		1	0	0	2	0	2	10	4	0	2	0
Mossdale Spring Trawl						1			0	0	0	0
Fish Community Monitoring			3	3	8		9					
Effects of Largemouth Bass on Delta Ecosystem						5						
Pilot Mark-recap to Estimate Pre-screen Loss and Salvage Efficiency				189	10							
Smelt Migration Study (AKA First Flush)**						659		822				
Gear Efficiency Evaluation in Support of Delta Smelt Modeling								721	863	890	185	0
FRP Tidal Wetland Monitoring Study											0	2
USGS Early Warning											0	42
USGS Physical and Biological Drivers												1
TOTAL	4713	4407	1105	818	1010	1981	2318	3847	2115	1657	673	447

*Smelt Migration sampling in year 2010 includes one day of sampling in 2011

5.16.4.15.2 <u>Eggs and Larvae to Juveniles (March – June)</u>

A number of monitoring activities under the proposed action described in Appendix C, *ROC Real Time Water Operations Charter*, in section *Routine Operations and Maintenance on CVP Activities* would have the potential to capture larval Delta Smelt. A summary by USFWS (2017, p.195) showed, for example, that the total number of larval Delta Smelt captured in IEP studies (which form much of the basis for the monitoring program) per year ranged from 108 in 2015 to 1,564 in 2012 (Table 5.16-5). There are no estimates of overall larval population size in these years, but given that a) estimates of adult Delta Smelt captured were < 1–3% of the adult population, b) the total number of individual larvae captured was of similar or lower order magnitude as the number of adults captured per year (i.e., hundreds to thousands of individuals per year), and c) the population size of larvae would logically be appreciably greater than that of adults (Bennett 2005, p.12), then the overall population-level loss of larval Delta Smelt would be expected to be much lower than that of adults. Additional monitoring activities such as EDSM may increase the population-level capture above that suggested by the above analysis, but it would not be anticipated that this would be a substantial increase. Importantly, and as noted for adult Delta Smelt, monitoring would enable effects of the under the proposed action to be limited by informing real-time operations for OMR adjustment.

Table 5.16-5. Number of Larval Delta Smelt Individuals (<20-mm Fork Length) Captured from 2005 to 2016 for Interagency Ecological Program Studies (Source: USFWS 2017, p.194).

Survey	Year											
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Fall Midwater Trawl	0	0	0	0	10	0	0	0	0	0	0	0
Townet Survey			10	82	49	198	470	246	171	75	0	0
SF Bay Study	0	0	0	0	0	0	0	0	0	0	0	1
South Delta fish investigations	8		277									
20-mm*	644	978	135	274	435	633	1162	1076	1125	256	99	126
Yolo Bypass	0	0	0	0	0	0	0	0	0	0	0	0
Delta Juvenile Fish Monitoring	14										0	0
Directed Fish Collections			2									
Upper estuary zooplankton			2	17		10	3	3	5	1	0	0
Investigation of Antioch and Pittsburg Power Plants				17	10	1	1					
Spring Kodiak Trawl	26					1		1	2	53	3	26
Morrow Island Distribution			1									
UCD Suisun Marsh										2	0	0
Smelt Larva Survey		79	274	0	0	6	3	238	118	24	6	8
Mossdale Spring Trawl											0	0
Fish Community Monitoring				22								
Pilot Mark-recap to Estimate Pre-screen Loss and Salvage Efficiency					111							
Gear Efficiency Evaluation in Support of Delta Smelt Modeling									85	147	0	0
FRP Tidal Wetland Monitoring Study											0	0
USGS Early Warning											0	0
USGS Physical and Biological Drivers												0
TOTAL	692	1057	701	412	615	1049	1639	1564	1506	558	108	161

*20mm Study reports larvae and juveniles together (age-0). Age-1+ reported as adults.

5.16.4.15.3 Juveniles to Subadults (June – September)

As described for adult Delta Smelt, capture of Delta Smelt in recent years may be a greater percentage of the population than historically occurred as a result of lower population size and greater survey effort. However, as concluded for adult Delta Smelt, impacts across all surveys would be considered when determining sampling effort in order to limit potential negative effects.

5.16.4.15.4 Subadults to Adults (September – December)

As described for adult Delta Smelt, capture of Delta Smelt in recent years may be a greater percentage of the population than historically occurred as a result of lower population size and greater survey effort. However, as concluded for adult Delta Smelt, impacts across all surveys would be considered when determining sampling effort in order to limit potential negative effects.

5.17 Delta Smelt Critical Habitat

USFWS (2017a, p.298-299) summarized the primary constituent elements (PCEs) as defined in the critical habitat rule. These include physical habitat (i.e., spawning substrate and possibly depth variation in relation to pelagic habitat), water (i.e., water of suitable quality, including certain conditions of temperature, turbidity, and food availability, which can be degraded by high entrainment risk and contaminant exposure, for example), river flow (transport flow to facilitate spawning migrations and transport of offspring to low salinity zone rearing habitats), and salinity (the low salinity zone nursery habitat, which generally increases as Delta outflow increases and X2 decreases). Volume of low salinity zone does not necessarily translate to increased survival as habitat may not be the limiting factor on Delta Smelt. Multiple other abiotic and biotic factors also affect Delta Smelt at all times. The analysis below considers potential positive and negative effects to these PCEs by various life stage habitat functions used by USFWS (2017a, p.304-323), i.e., spawning habitat (physical habitat), larval and juvenile transport habitat (river flow), rearing habitat (salinity), and adult migration habitat (physical habitat and river flow).

5.17.1 PCE 1 – Physical Habitat

With respect to the physical habitat PCE of Delta Smelt critical habitat, the proposed action could potentially reduce the supply of sand for spawning substrate during the high-flow winter/spring period relative to the without action. As suggested by a sedimentation conceptual model provided by Schoellhamer et al. (2012, p.4), lower Sacramento River sediment samples have a greater percentage of sand than lower San Joaquin River sediment, probably because of larger river floods and greater sand supply from the Sacramento River watershed. As Schoellhamer et al. (2012, p.4) went on to note: “At Rio Vista, Thompson and others (2000) observed that large floods increased the percent of sand on the bed (up to nearly 100% from nearly 0%)…During the intervals between floods, finer sediment deposited, the bed sediment became finer...At two other sites in the Sacramento and San Joaquin rivers, however, the fraction of sand varied over a similar range but appeared unrelated to flow, perhaps because of spatial heterogeneity.” Thus, while there is the potential for a negative effect of the proposed action on supply of sand spawning substrate, the extent of this potential effect is uncertain given likely site-specific differences and the lack of relationships predicting sandy substrate spawning habitat as a function of flow. Implementation of tidal and channel margin restoration may provide additional Delta Smelt spawning habitat (USFWS 2017, p.111), which would contribute to reducing the potential negative effect of the proposed action.

Construction of proposed facilities and other actions—principally the Delta Fish Species Conservation Hatchery, as well as some of the programmatic actions— under the proposed action has the potential to reduce the extent of physical habitat in terms of spawning substrate. The extent of this loss is dependent on site-specific conditions. It is anticipated that construction of tidal habitat restoration would more than address any loss of physical habitat from the proposed action, given the need to include areas meeting likely Delta Smelt spawning habitat characteristics in the restored areas (USFWS 2017, p.111).

5.17.2 PCE 2 – Water

Potential positive effects to food availability may occur from SMSCG operations under the proposed action during June–September of above normal and below normal water years (reducing salinity to improve habitat conditions in the relatively food-rich Suisun Marsh) and tidal restoration (an additional approximately 6,000 acres.

Relative to the without action scenario, reduced winter-spring inflow to the Delta under the proposed action has the potential to reduce sediment supply and therefore turbidity during winter-spring, as well as during summer/fall when resuspension of sediment supplied in the winter/spring is important. Under the proposed action, greater South Delta exports, less spring Delta outflow, and possibly agricultural barriers have the potential to negatively affect food availability in the low salinity zone by reducing *E. affinis* in spring and reducing the subsidy of *P. forbesi* from the lower San Joaquin River to the low salinity zone in summer/fall.

During summer/fall, there is the potential for effects to flow, velocity, and water clarity under the proposed action to negatively affect the water quality PCE relative to the without action scenario by increasing the potential for harmful algal blooms, although this is uncertain.

Effluent from the Delta Fish Species Conservation Hatchery under the proposed action could have a negative effect on water quality, although such effects would be minimized through factors such as filtration, and the effluent discharge rate would be small. Water temperature effects from operations of the proposed action are expected to be minor.

Tidal habitat restoration will benefit other PCEs, but could result in increased exposure to contaminants and noise and vibration from in-water work. Tracy Fish Facility improvements, the Delta Fish Species Conservation Hatchery, and programmatic actions under the proposed action have benefits to the species, but include increased exposure to contaminants and noise and vibration from in-water work. These temporary potential negative effects would be avoided, minimized, and mitigated using project-specific measures including those described in Appendix E, *Avoidance and Minimization Measures*.

5.17.3 PCE 3 – River Flow

The proposed action directly influences the river flow PCE for adult migration and larval and juvenile transport of Delta Smelt as a result of south Delta exports. As described previously, OMR reverse flows would be managed to minimize impacts to Delta Smelt by avoiding turbidity bridges, and allowing more positive OMR flows during integrated early winter pulse protection. Limited negative effects on river flow for adult migration and larval and juvenile transport which could result in entrainment also would stem from proposed action operations of the Suisun Marsh Facilities and Ag Barriers. The proposed action operations of the Rock Slough Intake and the North Bay Aqueduct will not affect OMR as these facilities are located outside of the OMR region. Rock Slough Intake and the North Bay Aqueduct could have minimal effects on river flow in the vicinity of each intake (near-field effects), but such effects are mitigated by operations that meet low approach velocity at the fish screens. Finally, Rock Slough Intake and the North Bay Aqueduct have negligible effect on far-field Delta hydrodynamics. Potential negative effects on river flow could occur as a result of tidal restoration effects on channel hydrodynamics, although modeling and design of restoration would be done so as to minimize such effects.

It is not anticipated that construction components of the proposed action would affect river flow.

5.17.4 PCE 4 – Salinity

The proposed action has the potential to positively and negatively affect the salinity PCE related to the low salinity zone nursery habitat for Delta Smelt. As described previously, operations of the SMSCG in June–October of above normal and below normal years have the potential to provide lower salinity and therefore positively affect habitat conditions for juvenile and subadult Delta Smelt in the Suisun Marsh, with additional Delta outflow provided to avoid movement of X2 upstream as a result of SMSCG operation. In addition, the addition of Delta outflow in Above Normal and Wet years has the potential to provide lower salinity and therefore positively affect habitat conditions.

South Delta exports and water flow into the Delta under the proposed action have the potential to affect the low salinity zone rearing habitat. USFWS (2017a, p.307–316) assessed this in terms of the proportion of CalSim-modeled months (June–December) that the low salinity zone (i.e., salinity at or below 6) would be outside of Suisun Bay, as indicated by X2 ≥ 85 km (DMA 2014, p.38). Performing this analysis in the context of the proposed action suggests that relative to the WOA, there could be positive effects to low salinity zone rearing habitat during June–September (lower percentage of years with X2 ≥ 85 km), no effect in October, and negative effects in November-–December (higher percentage of years with X2 ≥ 85 km; Figure 5.17-1). To the extent that tidal restoration (i.e., the additional approximately 6,000 acres as part of tidal habitat restoration) provides new low salinity zone habitat that is occupied by rearing Delta Smelt, this could provide some offsetting of potential reductions resulting from operations.

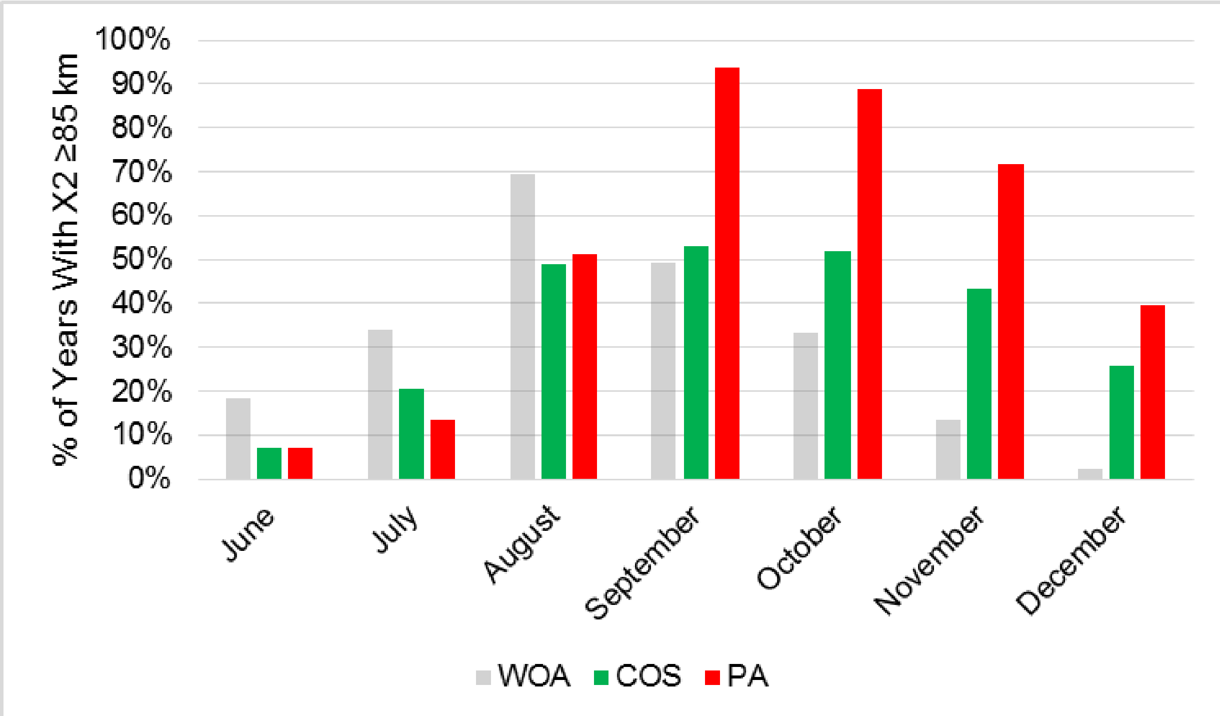


Figure 5.17-1. Percentage of Years with Mean X2 ≥ 85 km, June–September.

It is not anticipated that construction components of the proposed action would affect salinity.

5.17.5 Effects of Maintenance

Implementation of the species avoidance and take minimization steps described in Appendix C, *ROC Real Time Water Operations Charter* in section *Routine Operations and Maintenance on CVP Activities* would be anticipated to minimize potential negative effects to Delta Smelt critical habitat.

5.17.6 Effects of Monitoring Activities

The activities under the proposed action described in Appendix C, *ROC Real Time Water Operations Charter* in section *Monitoring Program for Core CVP and SWP Operation* would be expected to have limited effects on Delta Smelt critical habitat. The physical habitat PCE could be affected by placement of equipment such as anchors holding the acoustic receiver network or by benthic sampling as part of the Environmental Monitoring Program, but the effects would be very small relative to the extent of critical habitat. The water quality PCE could be minimally affected, for example, by trawling or benthic gear contacting the substrate and disturbing sediment, although again these effects would be expected to be limited. As described in the section discussing effects of monitoring on Delta Smelt, capture of individual Delta Smelt would occur but would be limited by consideration of take limits in relation to population status.

5.18 Coho Salmon, Southern Oregon/Northern California Coastal ESU

The proposed action provides beneficial effects to Coho Salmon due to higher flows and lower temperatures in the summer and fall, as compared to WOA. The proposed action affects Coho Salmon in the spring as compared to WOA, by reducing flows during egg incubation, fry emergence, and decreasing available habitat for juvenile rearing through less inundated area in natal habitats on the Trinity River.

The ongoing implementation of the Trinity River Restoration Program ROD, included in the proposed action but previouxsly consulted on, helps to address these effects.

5.18.1 Lifestage Timing

Coho Salmon enter the Klamath/Trinity River Basin as sexually mature adults and disperse into the various tributaries to spawn. In the Trinity River, adults return from September to December (Figure 5.18-1) and spawn from November to January (Leidy and Leidy 1984; USFWS and Hoopa Valley Tribe 1999). Juvenile Coho Salmon spend up to one year in the Trinity system prior to emigration to the ocean. Spawning generally occurs in low gradient tributaries rather than the mainstem of the Trinity River (NMFS 2014). Coho Salmon fry emerge from the gravel the following spring from February to May. Juveniles rear in the Trinity system through the summer and winter (age 0). Coho smolts emigrate from the system in their second spring (age 1). Their extended freshwater residency prior to emigration (compared to Chinook salmon) makes them vulnerable to adverse summer water temperature and scarcity of low water velocity, off-channel habitat during winter (NMFS 2014).

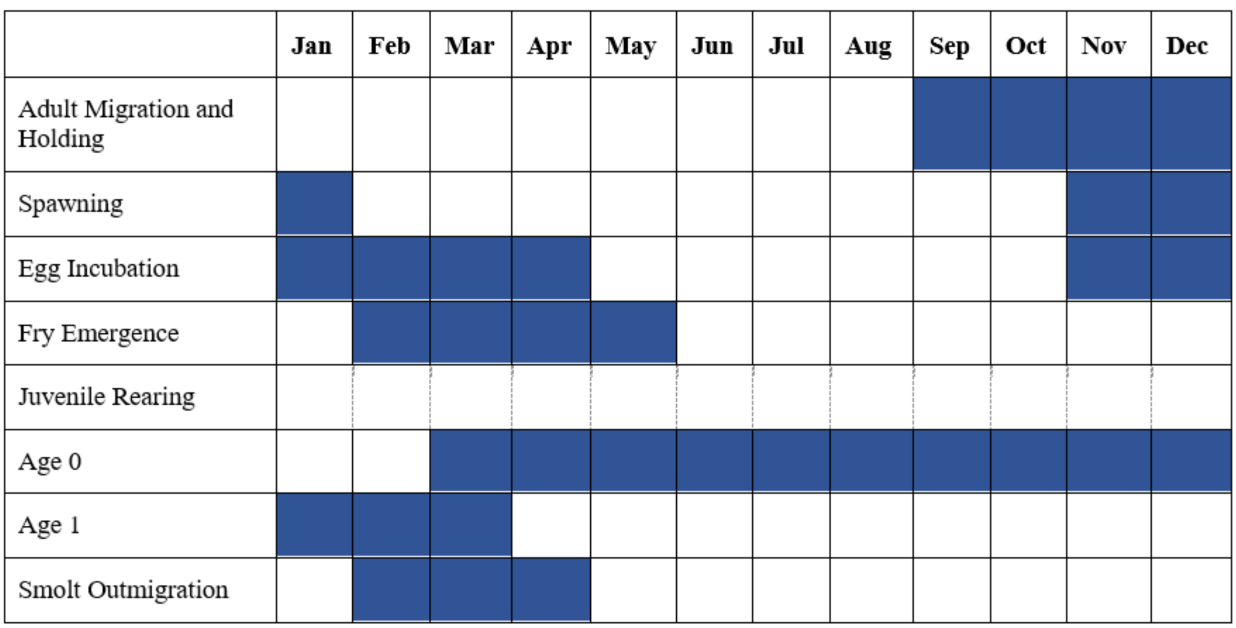


Figure 5.18-1. Life History Schedule of Trinity River Salmonids based on Leidy and Leidy (1984)

5.18.2 Conceptual Model Linkages

There is no conceptual model for Coho Salmon which describes in detail the hypothetical mechanistic pathways that underlie the relationships between environmental stressors and salmonid survival comparable to the "Salmon and Sturgeon Assessment of Indicators by Life stage" as has been developed for Winter-run Chinook salmon in the Sacramento River (Windell et al 2017). But, adapting a general conceptual model based on Windell et al. (2017) (Figure5.18-2) provides a framework for assessing the effects of the proposed action on SONCC Coho.

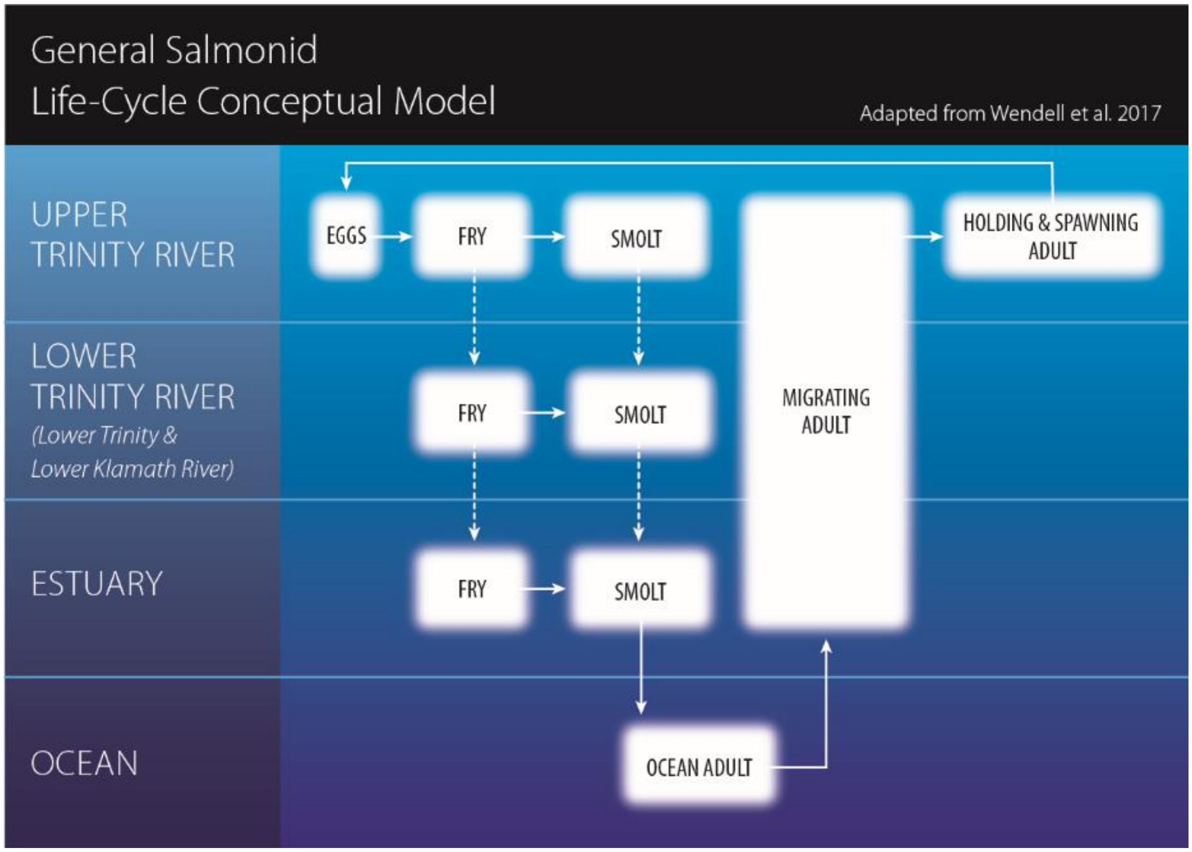


Figure 5.18-2. Conceptual Model of Habitat use by Life Stage

According to NMFS (2014), adverse hatchery effects are a very high stressor on SONCC Coho in the Trinity River. Altered hydrologic function and lack of channel and floodplain structure are also very high or high stressors in the lower and upper Trinity River. One of the most important ecological requirements of Coho Salmon is cold, clean, well oxygenated water. Increased water temperature, changes in pH above or below optimum levels, reduced dissolved oxygen, increased nutrient loading, and increased extent or duration of turbidity all may affect Coho Salmon. Water temperature influences Coho Salmon growth and feeding rates (partly through increased metabolism) and development of embryos and alevins (McCullough 1999), as well as timing of life-history events such as freshwater rearing, seaward migration (Holtby and Scrivener 1989), and upstream migration and spawning (Spence et al. 1996). Increased water temperature can be detrimental to the survival of most life stages of Coho Salmon, but summer-rearing juveniles are the most likely to be affected by elevated water temperatures. Elevated water temperature can result in increased levels of stress hormones in Coho Salmon, often resulting in mortality (Ligon et al. 1999). Increased water temperature, even at sub-lethal levels, can inhibit migration, reduce growth, stress fish, reduce reproductive success, inhibit smoltification, contribute to outbreaks of disease, and alter competitive dominance (Elliott 1981). Environmental changes include altered timing and magnitude of high and low flows, alteration of temperature and dissolved oxygen levels, and changed cues for seasonal migration. EPA (2003) recommends 13 degrees Celsius or 55 degrees Fahrenheit for salmonid spawning and egg incubation (November to April for Coho), 61 degrees Fahrenheit for juvenile rearing (year-round), 64 degrees for non-core juvenile rearing, and 68 degrees for adult migration (September – December).

The juvenile life stage of the lower Klamath population of Coho Salmon is limited by the lack of quality rearing habitat, Juvenile summer rearing habitat is impaired mostly from subsurface flow conditions in the tributaries caused by heavy sediment loads and winter rearing habitat is severely lacking because of channel simplification, disconnection from the floodplain, degraded riparian conditions, poor large wood availability, and an estuary which has been altered and reduced in size due to development, channelization, and diking. Poor water quality of the mainstem Klamath River (e.g., high water temperatures resulting from degraded riparian conditions and water withdrawals upstream) affects both juveniles and adult Coho Salmon.

5.18.3 Effects of Operations and Maintenance

Under WOA Trinity and Lewiston dams would remain in place but would not be operated to store water and diversion of Trinity Basin water into the Sacramento River system would not occur. This scenario would restore much of the pre-dam hydrograph dominated by late spring snow melt hydrology. Lewiston Dam would remain in place and continue to impound sediment behind the dam as well as block upstream passage.

Under WOA, temperatures would be above juvenile holding temperature thresholds in the mainstem Trinity River. Much of the refugia habitat was blocked by Lewiston Dam or degraded by land use practices and sedimentation (USFWS and HVT 1999). Thus, under WOA juvenile Coho would need to find refuge habitat downstream in the Lower Klamath reach or in tributary streams. High water temperatures in September could also create barriers to upstream migrating adults and or reduce the amount of suitable holding habitat available for use prior to spawning.

5.18.3.1 Seasonal Operations

Environmental changes of altered hydrology include altered timing and magnitude of high and low flows, alteration of temperature and dissolved oxygen levels, and changed cues for seasonal migration. In terms of the timing and magnitude of high and low flows, the proposed action is the same as COS. The proposed action would result in much lower flows from October through April, and higher flows from May through September relative to WOA. As Coho Salmon spawn from February to April, this reduction in flow would reduce the amount of available spawning habitat and increase competition, with detrimental effects on Coho Salmon. Competition with hatchery fish released from Trinity River Hatchery limits rearing and spawning capacity in the Upper Trinity River for naturally produced Coho (NMFS 2014). For those redds that are laid, higher survival of Coho Salmon eggs and emerging alevins is expected under the proposed action relative to WOA due to reduced fine sediment in the channel substrate, and an increased food base for these fish due to increased macroinvertebrate production. See Figures 5.18-3 and Figure 5.18-4.

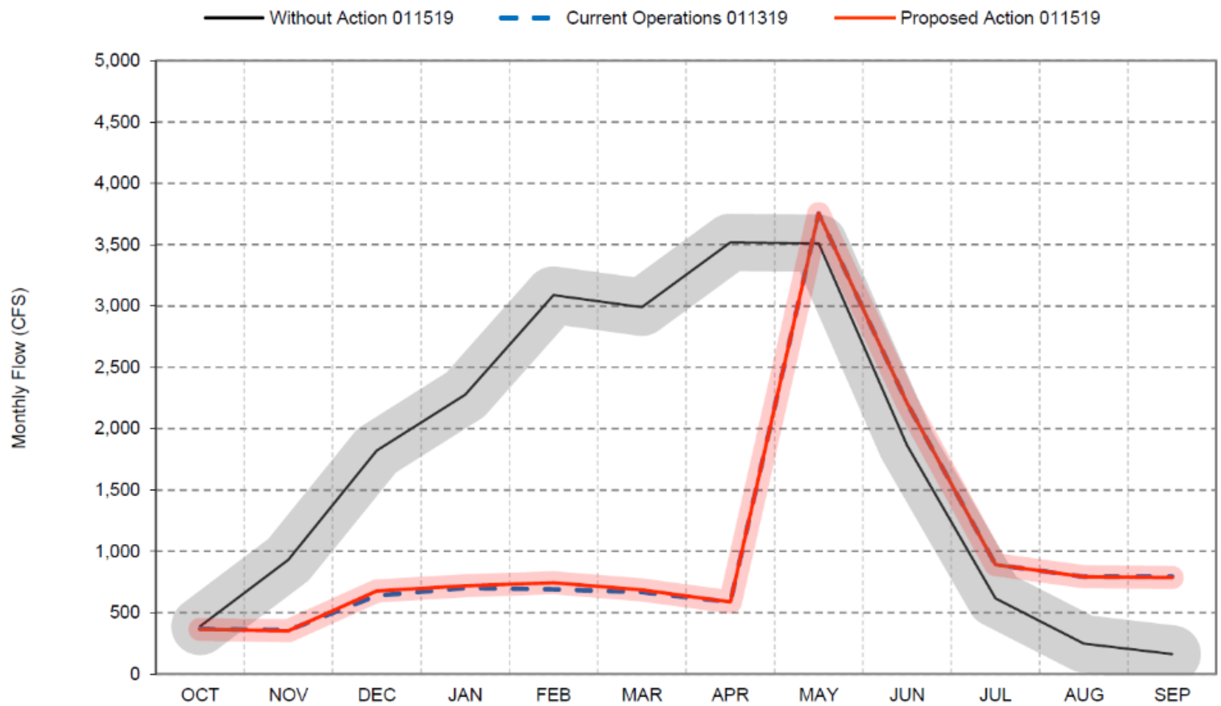


Figure 5.18-3. Average Monthly Flow below Lewiston for the Proposed Action, without Action, and Current Operations

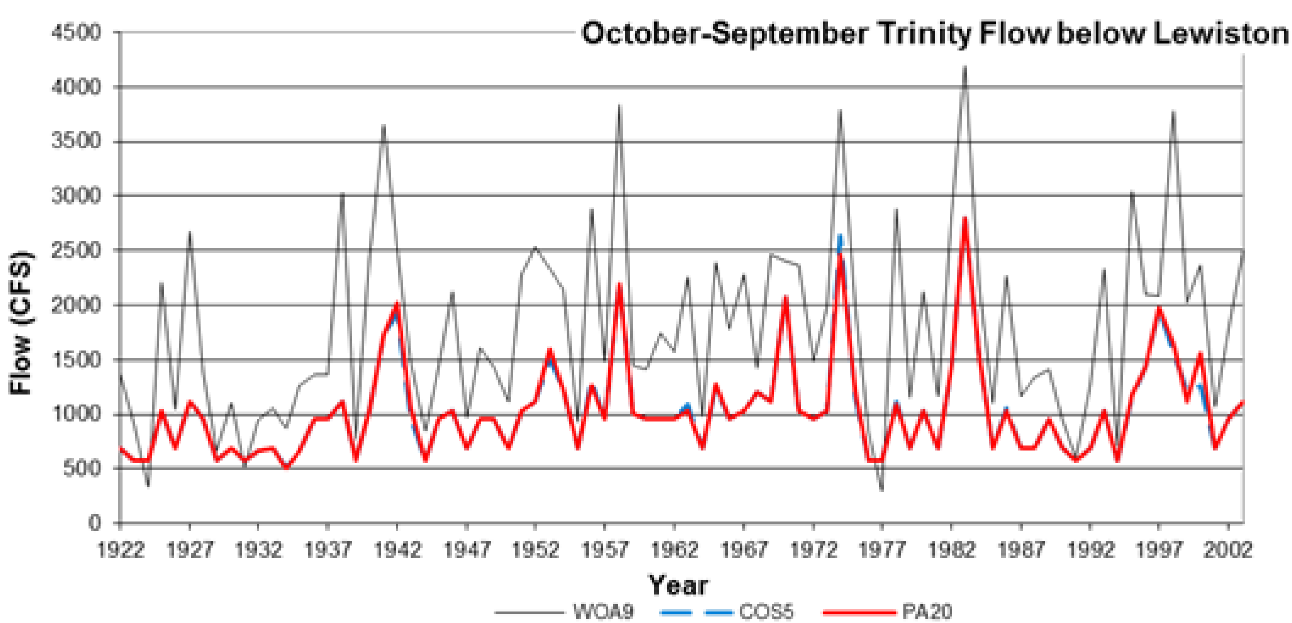


Figure 5.18-4. CalSim II Simulated Annual Flow in the Trinity River below Lewiston Dam under the Without Action (WOA9), Current Operations (COS5) and Proposed Action (PA20) Scenarios

As discussed in the conceptual model section above, increased water temperature can be detrimental to the survival of most life stages of Coho Salmon, but in the SONCC Coho Salmon ESU summer-rearing juveniles are the most likely to be affected by elevated water temperatures. Increased water temperature, even at sub-lethal levels can inhibit migration, reduce growth, stress fish, reduce reproductive success, inhibit smoltification, contribute to outbreaks of disease, and alter competitive dominance (Elliott 1981). EPA (2003) recommends 13 degrees Celcius or 55 degrees Fahrenheit for salmonid spawning and egg incubation (November to April for Coho), 61 degrees Fahrenheit for juvenile rearing (year-round), 64 degrees for non-core juvenile rearing, and 68 degrees for adult migration (September – December).

Compared to WOA, the proposed action would result in higher water temperatures during November - April, and much lower water temperatures from May through October. Higher water temperatures during the winter are not expected to negatively impact Coho Salmon life stages, since water temperatures are expected to stay within the suitable range for these life stages (below 55 degrees, see figures below). Conversely, significantly lower water temperatures during the summer and fall months should provide a benefit to over summering juvenile Coho Salmon rearing. Under the proposed action, temperatures are below 55 degrees year-round nearly all of the time, except for in some Critical years. This is a substantial benefit of the proposed action as compared to WOA.

See Figures 5.18-5 and 5.18-6.

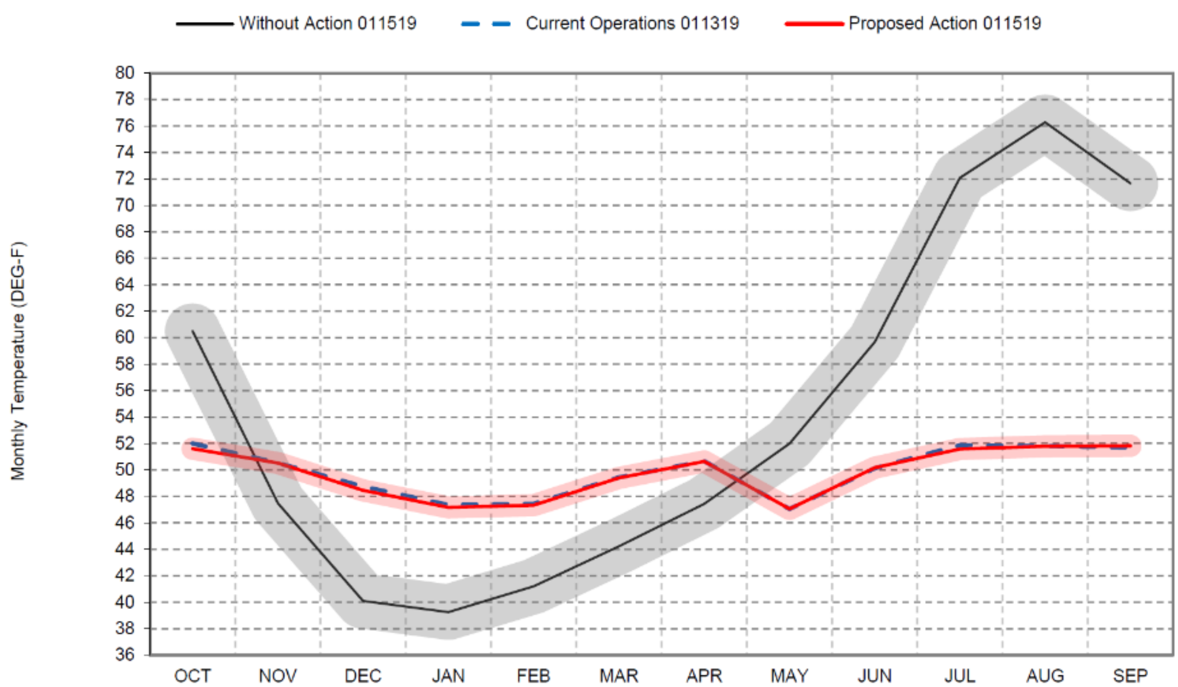


Figure 5.18-5. Monthly Mean Temperatures in the Trinity River below Lewiston Dam under the Proposed Action, without Action, and Current Operations

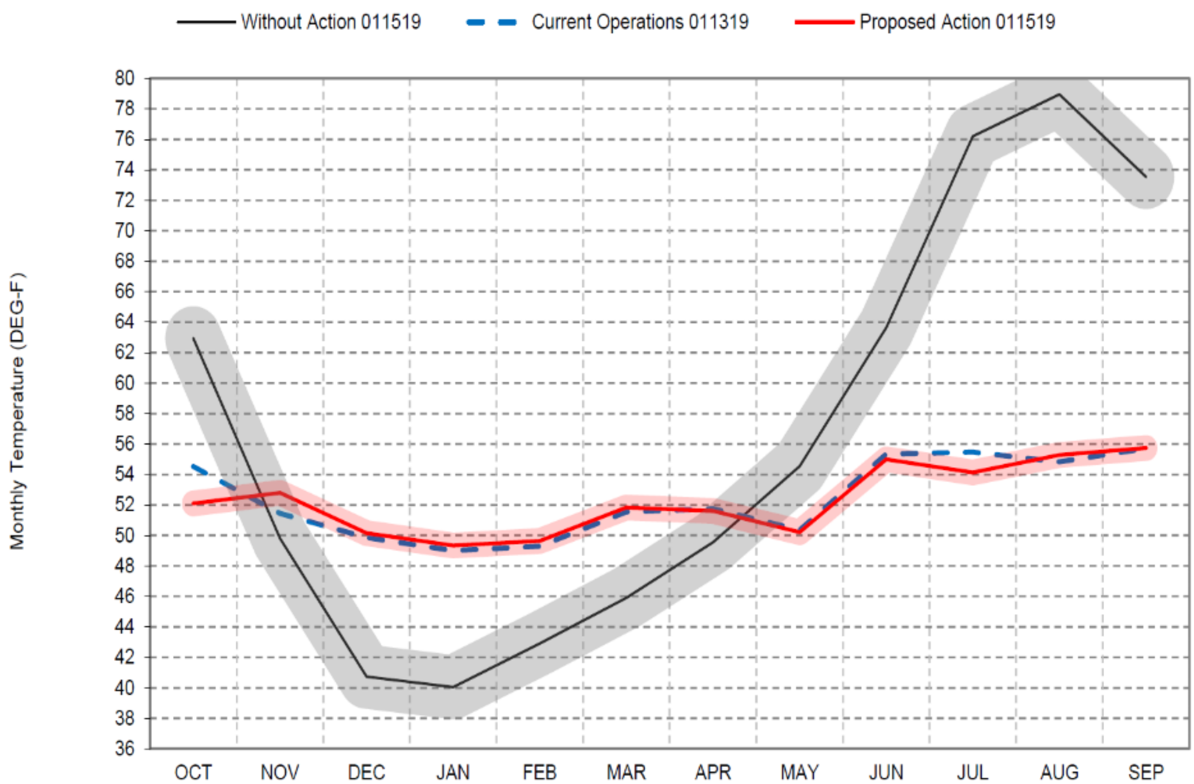


Figure 5.18-6. Critical Water-year Type Mean Temperatures in the Trinity River below Lewiston Dam under the Proposed Action, without Action, and Current Operations

5.18.4 Conservation Measures

Conservation measures under the proposed action described in the Winter-run Chinook Salmon section would not overlap with the Coho Salmon spatial distribution and, therefore, are not expected to affect Coho Salmon.

5.19 Coho Critical Habitat, Southern Oregon/Northern California Coastal ESU Critical Habitat

Prior to the construction of the TRD, the Trinity River was an unregulated, meandering, dynamic alluvial river within floodplain habitat. High flows periodically changed the size, shape, and location of river bars. Flow regulation by the TRD removed nearly all high flows that were responsible for forming and maintaining dynamic alternate bar sequences that supported development of rearing habitat in the mainstem trinity. No longer scoured by winter floods downstream of the TRD, streambank (riparian) vegetation encroached into the river channel and formed riparian berms along the channel margins. Reduced flows, loss of coarse sediment impounded by the dam, and riparian encroachment caused the mainstem of the river downstream from the TRD to change from a series of alternating riffles and deep pools that provided high-quality salmonid habitat to a largely monotypic run habitat confined between riparian berms (a trapezoid-shaped channel). The loss of alluvial features and diverse riverine habitats reduced the quantity and quality of salmonid habitats and the populations that relied upon them (USFWS and HVT 1999).

5.19.1 Seasonal Operations

Under the WOA, uncontrolled flows would be released to the Trinity River, however the dam would continue to impound sediment. Without sediment to rebuild the bar, pool, and riffle habitat that supports coho spawning and rearing, the uncontrolled flow would likely continue to degrade habitat that has been designated as critical for the conservation of SONCC Coho.

Compared to WOA, the proposed action would improve habitat by continuing implementation of a normal (reduced) hydrograph, and restoration of functioning alluvial river and connected floodplain habitat. Because the expected outcome of implementation of the proposed action is improved fish habitat conditions (including necessary Coho Salmon habitat), the value of critical habitat for both the survival and recovery of SONCC Coho Salmon will not be appreciably diminished.

5.20 Eulachon, Southern DPS

Eulachon occur in the Klamath River watershed and, therefore, could be subjected to effects from seasonal operations of Lewiston Dam; there would be no effects from any other components of the proposed action. Adult Eulachon typically spawn at age 2-5 in the lower portions of rivers. As described in Chapter 2, Eulachon spawning generally occurs between December and June, with larvae being transported to the estuary and ocean by spring freshets.

Climate change is ranked as the highest threat to Eulachon, with dams and diversions the second most important threat to the Klamath River population of Eulachon. Operation of Trinity Reservoir, as well as associated changes in the Klamath River, have shifted the spring peak flow of the lower Klamath River from its historical peak in April to its current peak in March, one full month earlier (NRC 2004, as cited in Gustafson et al. 2010). Habitat–related effects to Eulachon as a result of the continued operations of Trinity Reservoir has the potential to affect Eulachon spawning behavior; egg viability; and larvae and juvenile growth, development, and survival. However, the principal habitat-related effects to Eulachon as a result of the continued operations of the dams are the hydrological effects on the estuary–plume environment, which is utilized by Eulachon larvae and juveniles for rearing and maturation. The April through July period coincides with Eulachon larval ocean entry and residence timing, and changes in flows during this period are likely to affect the chemical and physical processes of the estuary– plume environment (NMFS 2008a). Studies highlight the connection between river-derived nutrients, coastal upwelling, chemical and physical process in the estuary–plume environment, primary productivity, and the importance of the estuary–plume environment to Eulachon, especially Eulachon larvae and juveniles. However, there is no direct data on the link between decreases in freshwater inputs into the estuary-plume environment and effects on Eulachon larvae and juveniles to assess the significance of effects.

In general, Eulachon would spawn at low water levels before spring freshets (Lewis et al. 2002, as cited in Willson et al. 2006). In many rivers, the spawning reach is more or less limited to the part of the river that is influenced by tides (Lewis et al. 2002, as cited in Willson et al. 2006). However, Eulachon are reported to go as far as 80 km up the Susitna River (Barrett et al. 1984, Vincent-Lang and Queral 1984; as cited in Willson et al. 2006), possibly because of a low gradient (Lewis et al. 2002, Ref. 269). Eulachon once ascended more than 160 km in the Columbia River system. There is some evidence that water velocity greater than 0.4 m/s begins to limit upstream movements, at least for a segment of the Eulachon population (Lewis et al. 2002, as cited in Willson et al. 2006).

Entry into the spawning rivers appears to be related to water temperature and the occurrence of high tides (Ricker et al. 1954, Eulachon Research Council 2000, Prince Rupert Forest Region 1998, Bishop et al. 1989b, Lewis et al. 2002, WDFW/ODFW 2001, Spangler 2002; as cited in Willson et al. 2006).

Spawning is reported to occur at temperatures from 4° to 10°C; colder temperatures may stop migration (WDFW/ODFW 2001), at least in some rivers. run timing (as estimated from harvest rates) in the Fraser River tended to be earlier in years with somewhat warmer temperatures ($r = -0.47$; Ricker et al. 1954, as cited in Willson et al. 2006). Incubation is temperature-dependent, and so incubation times can differ among rivers and years. Egg survival is greatly influenced by salinity: exposure to salt water, especially salinity greater than 16 ppt, can be lethal (Farara 1996 cited in Lewis et al. 2002, as cited as cited in Willson et al. 2006). Major temperature changes also affect survival (e.g., a change from 5° to 11°C; Lewis et al. 2002, as cited in Willson et al. 2006). Peaks in larval outmigration are thought to occur during periods of relatively stable water temperatures and at low light intensities (Spangler 2002, as cited in Willson et al. 2006).

Thus, the proposed action could affect the transitions between adults and egg/larvae, and between egg/larvae and juveniles[1]. Seasonal operations of Lewiston Dam in winter and spring are of relevance for potential effects on Eulachon. Under WOA, based on observed data in the Klamath River from 1962-2003 and CalSim modeled results for WOA, Trinity River flow provides between 6% (September) to 19% (May) of the flow in the Klamath River (Figure 5.20-1). For the period from 1962–2003, under WOA, flow in the Trinity River at Lewiston as a percentage of observed flow in the Klamath River near Klamath has ranged from 0–15% in January to 11% to 47% in May (Table 5.20-1). Therefore, under WOA, flow from the Trinity River at Lewiston forms a small percentage (mean of 10%) of flow entering the lower Klamath River during December–April and a larger percentage in May and June (17%).

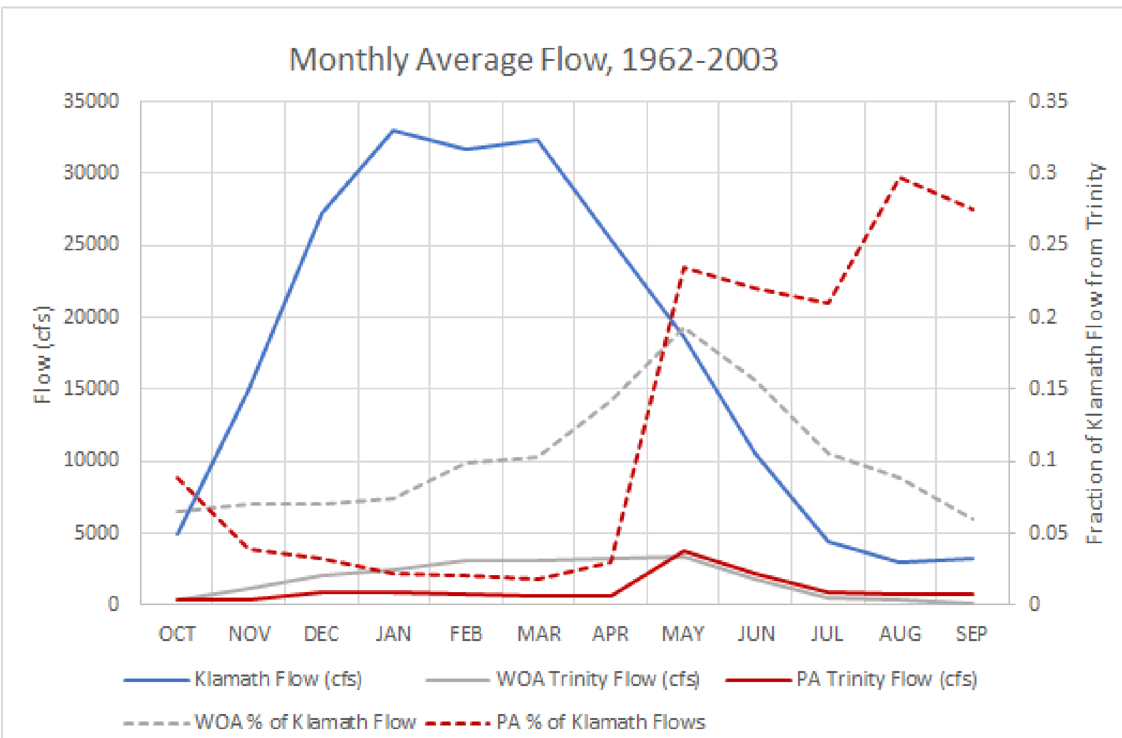


Figure 5.20-1. Monthly Average Klamath Flow (Observed) and Trinity Flow (Modeled).

Table 5.20-1. Modeled Flow in the Trinity River at Lewiston as a Percentage of Observed Flow in the Klamath River near Klamath, 1962-2003. (WOA/PA)

	DEC	JAN	FEB	MAR	APR	MAY	JUN
Max	0.18/0.18	0.15/0.07	0.2/0.11	0.26/0.09	0.34/0.11	0.43/0.47	0.41/0.5
95%	0.18/0.18	0.15/0.07	0.2/0.11	0.26/0.09	0.34/0.11	0.43/0.47	0.41/0.5
75%	0.08/0.04	0.1/0.03	0.14/0.02	0.12/0.02	0.19/0.04	0.22/0.3	0.21/0.32
50%	0.07/0.02	0.08/0.01	0.09/0.01	0.11/0.01	0.14/0.02	0.19/0.24	0.14/0.21
25%	0.05/0.01	0.06/0.01	0.07/0.01	0.08/0.01	0.11/0.01	0.17/0.16	0.12/0.14
5%	0.03/0.01	0.03/0	0.05/0.01	0.06/0.01	0.08/0.01	0.13/0.13	0.09/0.09
Min	0.01/0	0.01/0	0.04/0	0.05/0	0.07/0.01	0.12/0.11	0.07/0.05
Mean	0.07/0.03	0.07/0.02	0.1/0.02	0.1/0.02	0.14/0.03	0.19/0.23	0.16/0.22

For the December–June period of concern for Eulachon, CalSim modeling suggests that the proposed action scenario would reduce flows in December to April, but actually would increase flows in May and June. This pattern is essentially identical for the current operations COS scenario in relation to the WOA scenario. The patterns suggest that Trinity River flow changes would occur during the spawning migration period (December–April, with the main historical period being March–April; NRC 2004, p.275), with little or no effect to flow in the Trinity River expected during the later egg incubation and larval downstream migration period, which occurs around one month after spawning (NRC 2004, p.275). The extent to which the limited December-–April flows may negatively affect Eulachon is uncertain, given the lack of quantitative relationships between biological performance and flow. However, as discussed above, studies have shown effects on food in the estuary-plume environment, shifts in timing of spring freshets, and temperature affect Eulachon. Incubation is temperature-dependent, and major temperature changes affect survival (e.g., a change from 5° to 11°C; Lewis et al. 2002, as cited in Willson et al. 2006).

The most recent status review update noted that there have been catches of Eulachon in the Klamath River during surveys in recent years, whereas prior to that, runs were rare or sporadic for several decades (Gustafson 2016, p.13). The Klamath subpopulation appears to be much smaller than the Columbia, Fraser, and British Columbia subpopulations, some of which can number in the tens to hundreds of millions (NMFS 2017 Eulachon, p.73). See Figures 5.20-2 through 5.20-6.

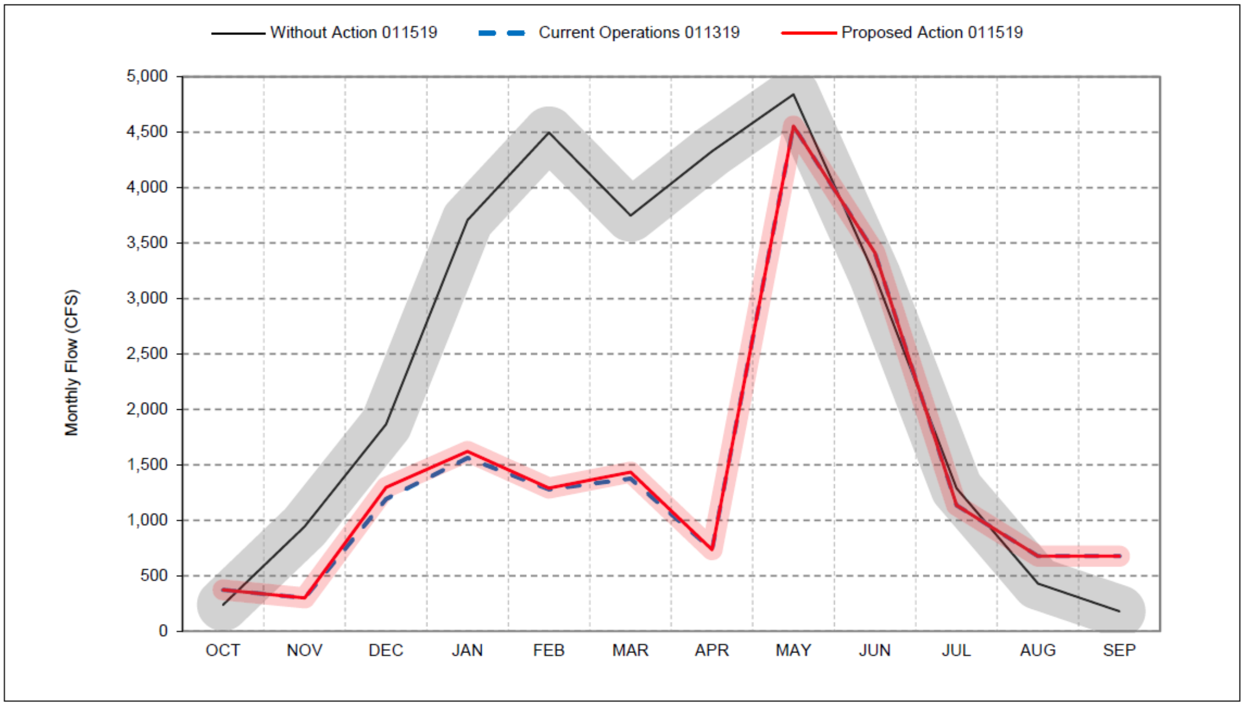


Figure 5.20-1. Mean Modeled Flow in the Trinity River Below Lewiston, Wet Years.

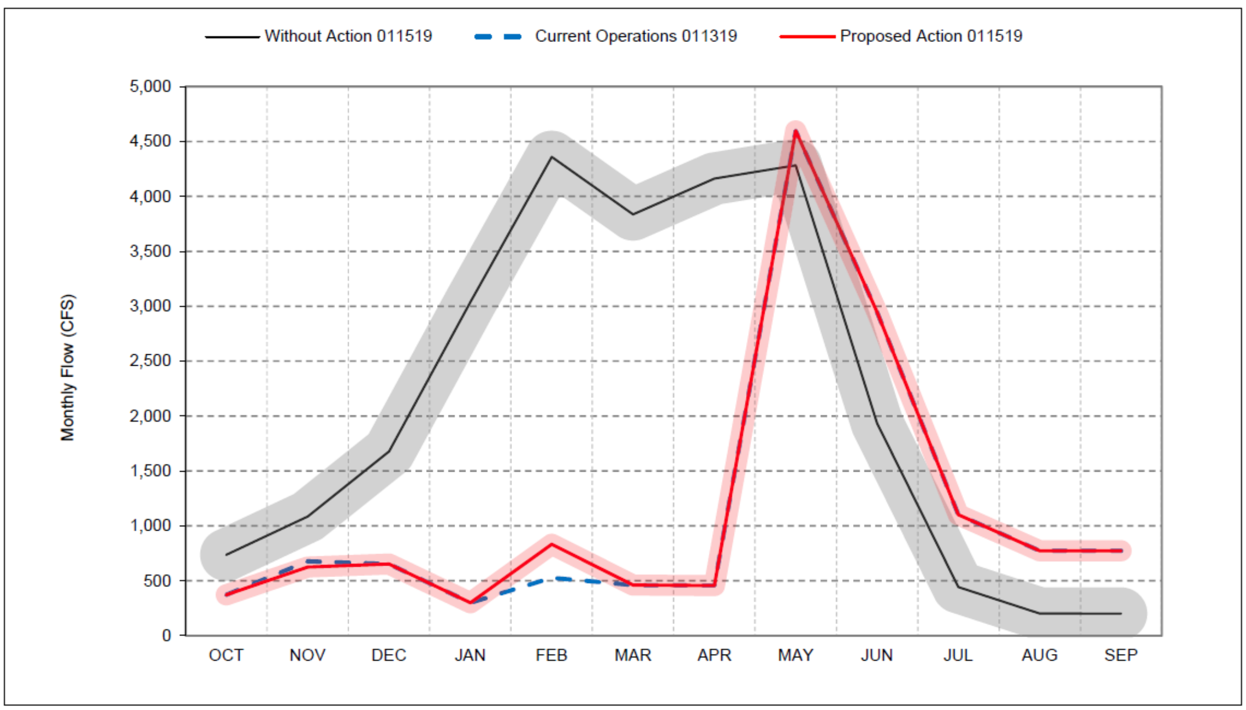


Figure 5.20-2. Mean Modeled Flow in the Trinity River Below Lewiston, Above Normal Years.

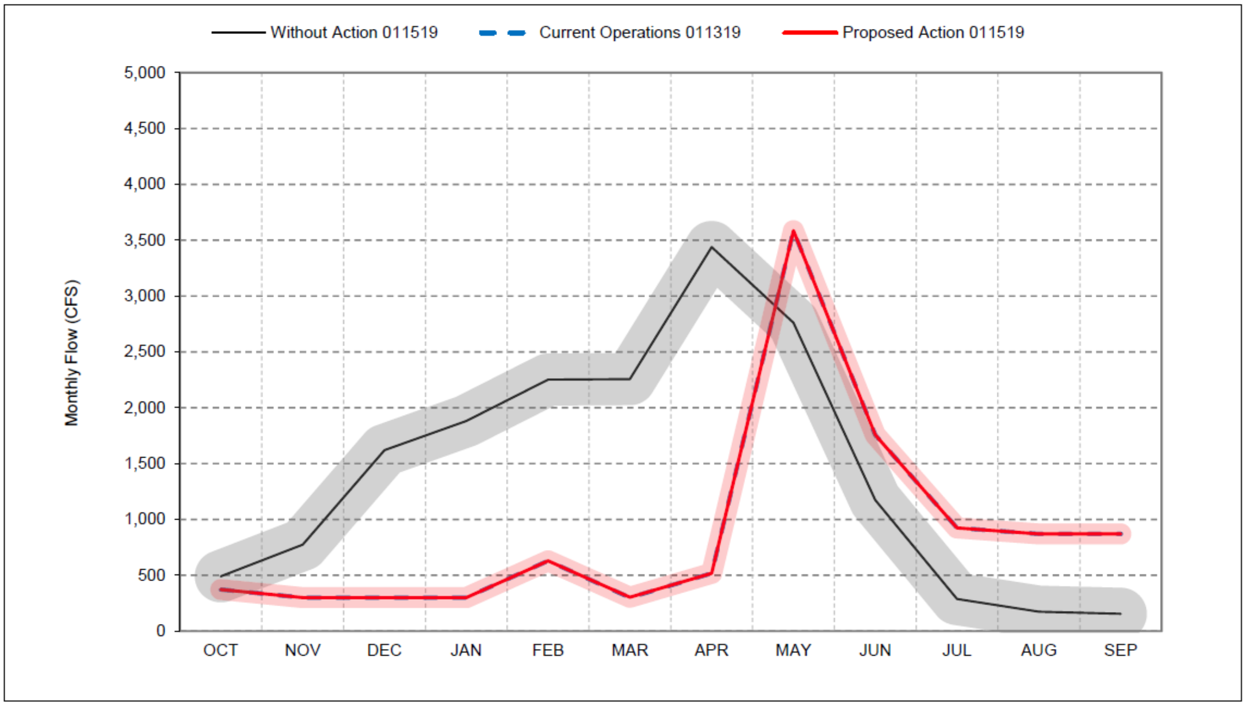


Figure 5.20-3. Mean Modeled Flow in the Trinity River Below Lewiston, Below Normal Years.

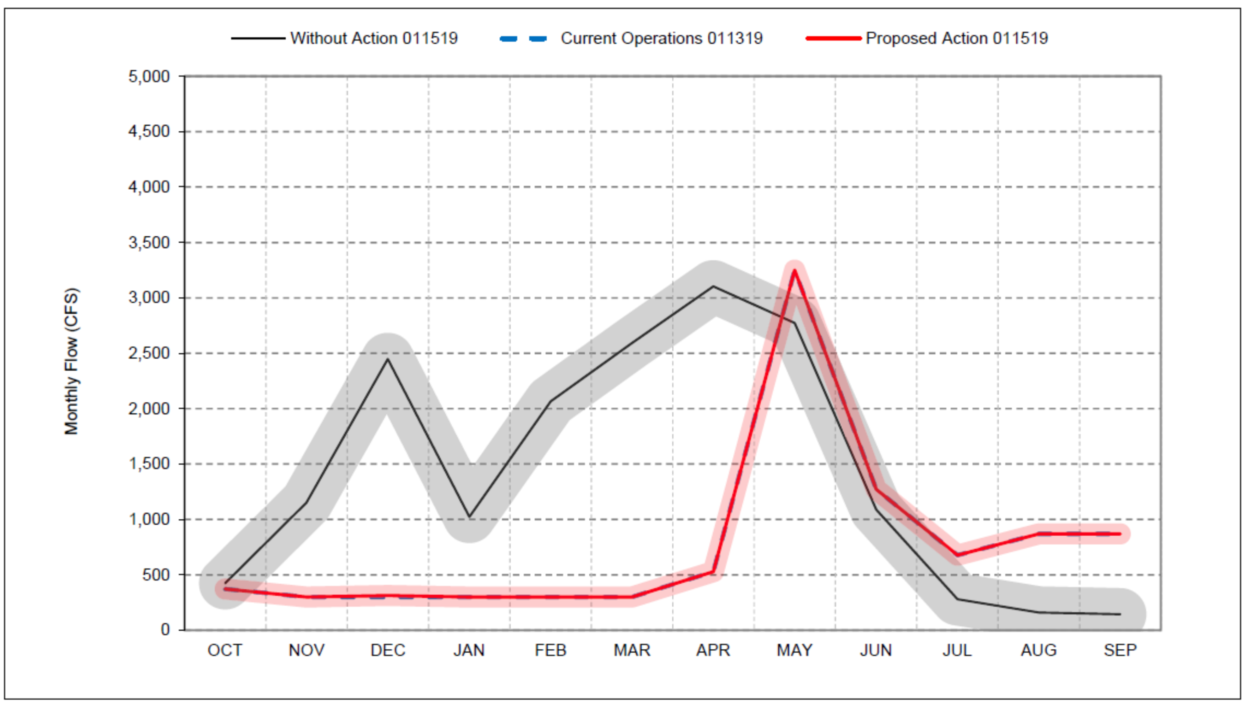


Figure 5.20-4. Mean Modeled Flow in the Trinity River Below Lewiston, Dry Years.

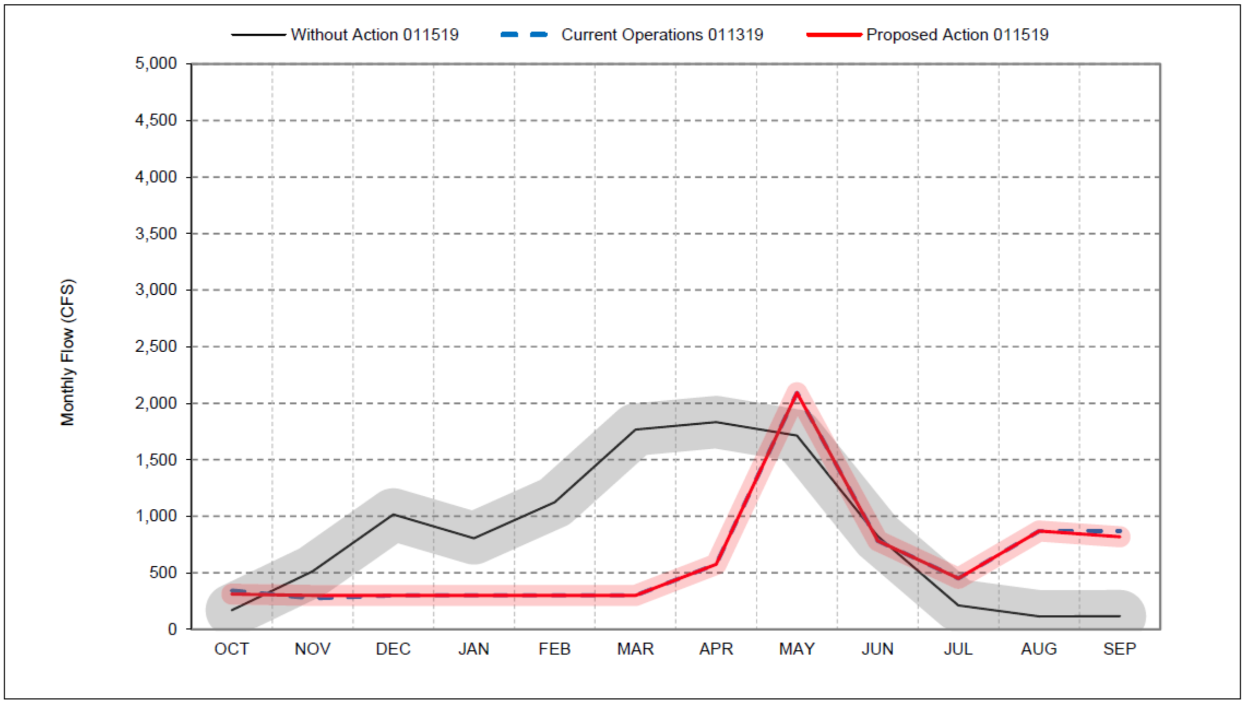


Figure 5.20-5. Mean Modeled Flow in the Trinity River Below Lewiston, Critically Dry Years.

Under the proposed action, Trinity River at Lewiston flows would contribute between 1,000 to 4,000 cfs less to flow entering the lower Klamath River than WOA during December-–April, reducing flows to approximately 300 cfs in most years. The timing coincides with Eulachon spawning and larvae being transported to the estuary and ocean. Under WOA, flows from the Trinity River provide, on average, 10% of the flow of the Klamath River, with the greatest percentage in May. Flows under the proposed action in the lower Klamath River could be reduced from 0% to nearly 23% compared to WOA in December - April of some years, with the average less than 10%. While the proposed action substantially reduces flow in December - April, and the proposed action slightly reduces flows in May of Wet water year types, the proposed action overall slightly increases flows from the Trinity River in May as compared to WOA, which is the month when the Trinity River provides the largest portion of the Klamath River flows. As previously noted, it is uncertain the extent to which there may be negative effects because of these differences, given the lack of quantitative relationships between biological performance and flow, but mechanisms include food transport and temperature.

Eulachon in the Klamath River generally spawn March–April (NRC 2004, p.275). Adult Eulachon require rapid changes in temperature of 6-8 C to experience mortality (Blahm and McConnell, 1971). Temperature modeling data for the proposed action are not available for the lower Klamath River where Eulachon spawn, but temperature averages in the Trinity River below Lewiston between December-April under the proposed action are not appreciably different than the WOA in the months of March and April (see Figure 5.20-7 and Figures 1-1 to 1-6 in the HEC-5Q modeling summary in Appendix D, *Modeling*), which, given that spawning sites for Eulachon have been found up to 52 F/11 C (see review by Willson et al. 2006), and the modest contribution of Trinity River water to the lower Klamath River (i.e., perhaps 20% under WOA; see discussion above) suggests that effects on spawning temperature would be limited.

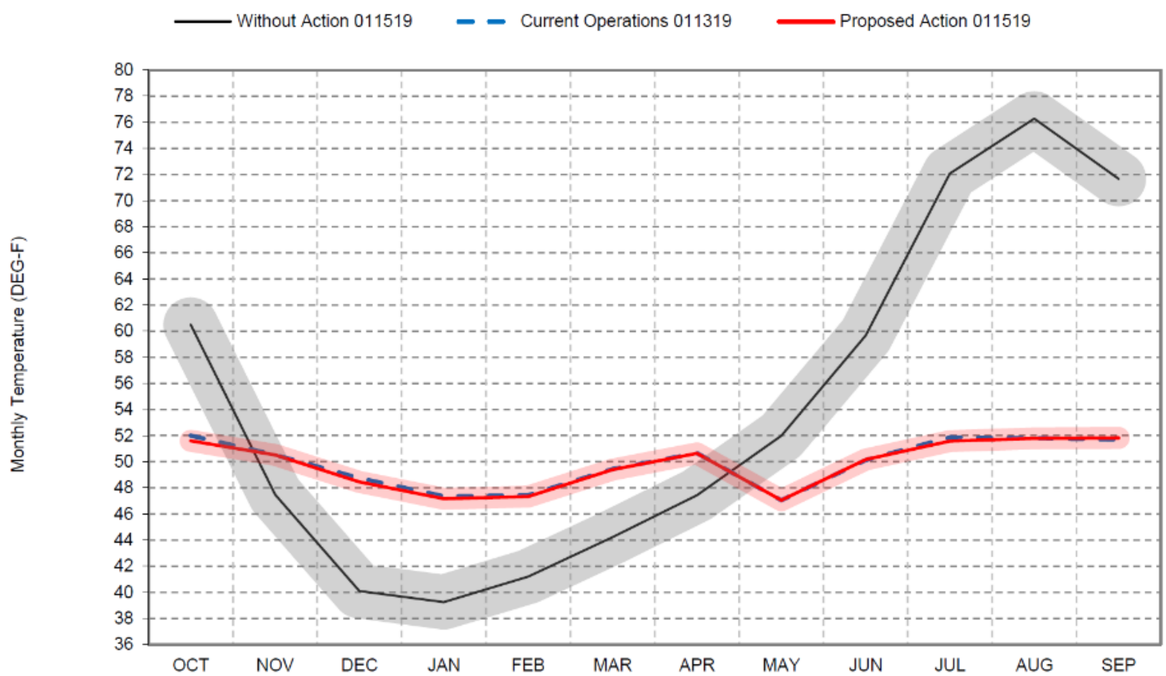


Figure 5.20-6. Mean Modeled Temperature in the Trinity River Below Lewiston

5.21 Eulachon, Southern DPS Critical Habitat

5.21.1 Freshwater Spawning and Incubation Sites

As described in the *Aquatic Status of the Species and Designated Critical Habitat* for *Eulachon, Southern DPS*, the physical or biological features (PBFs) include water flow, quality and water temperature conditions and substrate supporting spawning and incubation. As previously noted, flow during December-–April under the proposed action is lower than under the WOA scenario; Figures 5.20-2 through 5.20-6). As previously stated, there is a lack of quantitative relationships between flow and Eulachon biological performance.

5.21.2 Freshwater and Estuarine Migration Corridors

As described in the *Aquatic Status of the Species and Designated Critical Habitat* for *Eulachon*, *Southern DPS*, the PBFs include freshwater and estuarine migration corridors free of obstruction and with water flow, quality and water temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted. The proposed action does not physically obstruct migration corridors—Eulachon only occur in the lower 8 miles or so of the tidal Klamath River (NRC 2004, p.275)—but could reduce water flow during December-–April, which includes the main historical period of spawning migration (March–April; NRC 2004, p.275). As previously noted, larval downstream migration occurs around one month after spawning, and, therefore, their exposure to reduced flows would be limited.

5.21.3 Nearshore and Offshore Marine Foraging Habitat

The proposed action would not be expected to have negative effects on the nearshore and offshore marine foraging habitat PBFs of Eulachon critical habitat.

5.22 Analytical Approach – Terrestrial Species

This section analyzes potential effects from the proposed action on terrestrial listed species, including riparian brush rabbit, riparian woodrat, salt marsh harvest mouse, California Rigway's rail, least Bell's vireo, western yellow-billed cuckoo, giant garter snake, valley elderberry longhorn beetle, soft bird's-beak, Suisun thistle, vernal pool fairy shrimp, vernal pool tadpole shrimp, California tiger salamander, and California least tern. This section also analyzes effects of the proposed action on listed species' designated critical habitat.

5.22.1 Wildlife and Plant Species

5.22.1.1 Range Maps and Species Occurrences

To determine which project components could affect federally listed terrestrial species, reclamation reviewed species range maps to assess which project components overlap the species' ranges as depicted in Chapter 2 range map figures. All the range maps originated from the following data sources.

- California Department of Fish and Wildlife California Interagency Wildlife Task Group. 2016. California Tiger Salamander Range. Available: ftp://ftp.dfg.ca.gov/BDB/GIS/BIOS/Public_Datasets. Accessed: January 24, 2019.
- California Department of Fish and Wildlife California Interagency Wildlife Task Group. 2016. Clapper Rail Range. Available: ftp://ftp.dfg.ca.gov/BDB/GIS/BIOS/Public_Datasets. Accessed: January 2, 2019.
- California Department of Fish and Wildlife California Interagency Wildlife Task Group. 2016. Giant Garter Snake Range. Available: ftp://ftp.dfg.ca.gov/BDB/GIS/BIOS/Public_Datasets. Accessed: January 2, 2019.
- California Department of Fish and Wildlife California Interagency Wildlife Task Group. 2016. Least Tern Range. Available: ftp://ftp.dfg.ca.gov/BDB/GIS/BIOS/Public_Datasets. Accessed: January 24, 2019.
- California Department of Fish and Wildlife California Interagency Wildlife Task Group. 2016. Salt-Marsh Harvest Mouse Range. Available: ftp://ftp.dfg.ca.gov/BDB/GIS/BIOS/Public_Datasets. Accessed: January 2, 2019.
- California Department of Fish and Wildlife California Interagency Wildlife Task Group. 2016. Yellow-Billed Cuckoo Range. Available: ftp://ftp.dfg.ca.gov/BDB/GIS/BIOS/Public_Datasets. Accessed: January 2,2019.
- U.S. Geological Survey Gap Analysis Project. 2018. San Joaquin Valley Wood Rat Range. Available: https://gapanalysis.usgs.gov/species/data/download. Accessed: January 15, 2019.
- Carol W. Witham, Robert F. Holland and John Vollmar. 2014. Changes in the Distribution of Great Valley Vernal Pool Habitats from 2005 to 2012. Available: https://vernalpools.org/2012CVPIA/2012RemapVernalPoolsFINAL.zip. Accessed: August 27, 2017.

- U.S. Fish and Wildlife. 2005. Vernal Pool Core Areas.

Where the species' range overlaps the general area of effect for a proposed project component, Reclamation then assessed whether the species' current range includes the area. For all species except giant garter snake and California red-legged frog, Reclamation assumed the range maps reflect the current species' range for all except California red-legged frog and giant garter snake: for these species, the range maps include the historic range and Reclamation based species potential on more recent occurrences and information on locations where the species are believed to be extirpated.

5.22.1.2 Land Cover Data and Species Models

Reclamation used existing land cover data and, where available, species habitat models to assess which habitat components would affect federally listed species' habitat. Reclamation used the following data sources to make these determinations:

- Aerial Information Systems, Inc. 2011. Delta Vegetation and Land Use. Available: ftp://ftp.dfg.ca.gov/BDB/GIS/BIOS/Public_Datasets/200_299/ds292.zip. Accessed: December 10, 2018.
- U.S. Geological Survey. 2017. NHD Flowline. Available: http://prd-tnm.s3-website-us-west-2.amazonaws.com/?prefix=StagedProducts/Hydrography/NHD/State/HighResolution/GDB. Accessed: May 4, 2017.
- U.S. Geological Survey. 2017. NHD Area. Available: http://prd-tnm.s3-website-us-west-2.amazonaws.com/?prefix=StagedProducts/Hydrography/NHD/State/HighResolution/GDB. Accessed: May 4, 2017.
- Geographic Information Center, Chico Research Foundation. 2016. Vegetation - Great Valley Ecoregion. Available: ftp://ftp.dfg.ca.gov/BDB/GIS/BIOS/Public_Datasets/2600_2699/ds2632.zip. Accessed: November 11, 2017.
- Chico State University and California DWR. 2001. Legal Delta Boundary. Available: ftp://ftp.dfg.ca.gov/BDB/GIS/BIOS/Public_Datasets. Accessed: December 11, 2018. BDCP species models.

Table 5.23-1 lists each of the project components and indicates the federally listed species that may be affected by each, based on the analysis described above.

5.22.1.3 Avoidance and Minimization Measures, Effects Estimates

Reclamation developed avoidance and minimization measures with the first goal being to avoid effects on federally listed species, and the second goal being to minimize unavoidable effects. Reclamation analyzed each project component to determine whether it could fully avoid effects on federally listed species. If effects were determined to be unavoidable, or potentially unavoidable, Reclamation estimated the potential effects on each species.

The approach Reclamation used to estimate potential effects differed by project component, since the amount and source of information differed by project component. Project footprints were available for most of the spawning and rearing habitat restoration projects. For other habitat restoration projects, hypothetical footprints were used to estimate effects. These hypothetical footprints had been developed for BDCP, California WaterFix, and California Ecorestore. Reclamation also used information from existing environmental documents where available.

Precise, site-specific project information was unavailable for most of the project components. As such, the impact acres provided are intended to place upper limits on species effects to assist USFWS in making no-jeopardy determinations for each of the species.

5.22.2 Wildlife and Plant Critical Habitat

The analyses of potential effects on species' designated critical habitat follow the species analyses. Potential effects to primary constituent elements (PCEs)/physical and biological features (PBFs) of critical habitat are analyzed for western yellow-billed cuckoo and valley elderberry longhorn beetle. These analyses often draw on the foundation provided in the species analyses. Analysis of effects to critical habitat is guided by consideration of recent analyses by USFWS (2017a) and NMFS (2017), which included refined interpretation of critical habitat PCEs/PBFs relative to the original descriptions at the time critical habitat was designated.

In general, riparian vegetation would establish and grow more successfully during winter under the WOA scenario, but the low summer WOA flow could result in the loss of this vegetation. Therefore, the effect of the proposed action relative to the WOA on riparian habitat is uncertain.

5.23 Effects on Covered Wildlife and Plant Species

This section provides the results of the effects analysis for covered wildlife and plant species. Section 5.22, Analytical Approach, describes the methods used for this analysis. The project components that may affect each species are indicated in Table 5.23-1. The maximum allowable habitat loss for each species is provided in Table 5-Terrestrial.

Construction actions affecting terrestrial species are covered programmatically in this BA. As part of the subsequent site-specific consultation, Reclamation will provide a memo describing the action in detail, including where, when and how.

5.23.1 Riparian Brush Rabbit

The riparian brush rabbit occurs in the Stanislaus River and San Joaquin River watershed, and project components within these watersheds may affect this species as follows.

5.23.1.1 Stanislaus River Watershed

5.23.1.1.1 <u>Proposed Flow Changes</u>

For the purposes of the wildlife and plant species analyses, "proposed flow changes" constitute the expected effects of implementing the proposed action compared to WOA. Differences in flow management between the proposed action and WOA would have the potential to affect a covered wildlife or plant species if flow changes were to directly affect the species, directly alter habitat availability or quality, or result in vegetation changes that would alter habitat availability or quality. The great majority of stream channels within the action area are linear channels confined by levees or other engineered works that provide negligible habitat for covered wildlife or plant species. However, there is potential to affect such species at those sites where habitat has not been removed by channel alteration, or where habitat has been restored, or where habitat is expected to be restored during the proposed term of the proposed action. In the first two of these cases, existing habitat shows evidence of adaptation to anthropogenic modifications to the ecosystem that date back decades, and in many cases over a century.

These modifications include hydrologic changes associated with water manipulation; topographic changes associated with flood control, agriculture, restoration site construction, and other causes; and biological changes associated with the introduction of non-native species. Implementation of the proposed action generally results in higher flows in the fall and lower flows in the spring than WOA, and very minor potential changes relative to COS and are small relative to normal month-to-month and year-to-year variability in the system. Lower flows in the spring under the proposed action compared to WOA could potentially result in less riparian vegetation recruitment, such as cottonwood seed dispersal. However, flows under the proposed action would generally be more stable compared to WOA and would not alter the timing and magnitude of hydrologic vegetation and peak flow incidents such that erosion and potential loss of riparian vegetation occurs.

For example, CalSim results show average maximum flows in the Sacramento River below Keswick in April under the proposed action would be 30,893 cfs, compared to 56,209 cfs under WOA (see Appendix D, *Modeling*). With average maximum spring flows such as these the proposed action is more likely to negatively affect riparian vegetation recruitment compared to WOA. These maximum spring flows under WOA are not likely to destabilize the existing ecosystem or cause substantial disturbances to riparian vegetation as they are similar to average maximum flows during different times of the year compared to the proposed action and COS. Higher flows in the fall under the proposed action compared to WOA could result in reduced drought stress in riparian or wetland vegetation.

Table 5.23-1. Terrestrial: Terrestrial Project Components

Watershed	Title[1]	Riparian Brush Rabbit	Riparian Woodrat	Salt Marsh Harvest Mouse	CA Ridgway's Rail	Western Yellow-Billed Cuckoo	Least Bell's Vireo	Giant Garter Snake	Valley Elderberry Longhorn Beetle	Suisun Thistle	Soft Bird's-Beak	Vernal pool fairy shirmp	Vernal pool tadpole shrimp	California tiger salamander	California red-legged frog	California least tern
Upper Sacramento	Spawning and Rearing Habitat Restoration					X	X	X	X						X	
Upper Sacramento	Battle Creek Salmon and Steelhead Restoration Project								X							
Upper Sacramento	Colusa Basin Drain Food Web Routing					X	X	X	X							
Upper Sacramento	Seasonal Operations					X	X	X	X							
Feather River	FERC Flows					X			X							
American River	Spawning and Rearing Habitat Restoration					X			X							
American River	2017 FMS and “Planning Minimum”					X			X							
Bay-Delta	Delta Fishes Conservation Hatchery													X		

[1] Only project components with potential to affect federally listed terrestrial species are listed.

Watershed	Title[1]	Riparian Brush Rabbit	Riparian Woodrat	Salt Marsh Harvest Mouse	CA Ridgway's Rail	Western Yellow-Billed Cuckoo	Least Bell's Vireo	Giant Garter Snake	Valley Elderberry Longhorn Beetle	Suisun Thistle	Soft Bird's-Beak	Vernal pool fairy shirmp	Vernal pool tadpole shrimp	California tiger salamander	California red-legged frog	California least tern
Bay-Delta	Delta Cross Channel Improvements							X								
Bay-Delta	Tidal Habitat Restoration			X	X			X	X	X	X	X	X	X		X
Bay-Delta	Suisun Marsh Salinity Control Gates			X	X					X	X					
Bay-Delta	OMR Management			X	X			X	X	X	X					
Stanislaus	Spawning and Rearing Habitat Restoration					X	X		X							
Stanislaus	Stepped Release Plan	X	X			X	X		X							
San Joaquin River Lower	Spawning and Rearing Habitat Restoration	X	X			X	X		X							

5.23.1.1.1.1 Effects of Flow Changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the Stanislaus watershed, differences between the proposed action and COS are negligible, on the order of a few percent decrease in flow in February and a few percent increase in May and June. These changes are unlikely to produce any measurable change in quantity or quality of riparian brush rabbit habitat in the Stanislaus watershed, and there is no apparent mechanism by which these changes could result in harm to individual riparian brush rabbits. Conversely, differences between the proposed action and WOA are large, with substantial reductions in flows in Februrary, March, June and July, potentially causing drought stress in riparian or wetland vegetation, and increases in flows from August to October, which should allow for greater riparian growth than under WOA. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.1.1.1.2 Spawning and Rearing Habitat

Gravel will be placed in-stream, therefore will not result in loss or disturbance of riparian brush rabbit habitat. Access to the enhancement site by vehicles, workers, and equipment may disturb habitat or disrupt normal behavioral patterns of riparian brush rabbits in the vicinity of the activity, in the absence of avoidance and minimization measures. BOR will implement AMM-RBR/RWR to avoid adverse effects on riparian brush rabbit from spawning habitat restoration.

Enhancement of salmonid rearing habitat along the lower Stanislaus River may involve modification of river banks or creation of side channels in or near riparian habitat. This could result in loss of riparian brush rabbit habitat. In the absence of AMMs, this could also result in disruption of normal riparian brush rabbit behavioral patterns and injury or mortality of individuals through use of heavy equipment in occupied habitat. Reclamation will implement AMM-RBR/RWR however, to avoid occupied riparian brush rabbit habitat. Reclamation will remove no more than 10 acres of suitable but unoccupied riparian brush rabbit habitat.

5.23.1.2 Lower San Joaquin River Watershed

5.23.1.2.1 Proposed Flow Changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the lower San Joaquin watershed, differences between the proposed action and COS are almost nonexistent and have no potential to produce any change in quantity or quality of riparian brush rabbit habitat in the lower San Joaquin watershed. There is also no risk that these changes could result in harm to individual riparian brush rabbits. Conversely, differences between the proposed action and WOA are large, with flows in Februrary and May-June in particular much lower than under WOA. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.1.3 Lower San Joaquin Spawning and Rearing Habitat

5.23.1.3.1 <u>Habitat Loss or Conversion</u>

5.23.1.3.1.1 Permanent Habitat Loss

This proposed action component will involve a large-scale floodplain habitat restoration effort in the Lower San Joaquin River. Levee construction could result in removal or conversion of riparian brush rabbit habitat. Levee construction may result in the permanent removal of approximately 45 acres of riparian habitat and 25 acres of associated grassland habitat for the riparian brush rabbit along the lower San Joaquin River. Reclamation will ensure that riparian brush rabbit habitat permanently removed does not exceed the maximum allowable habitat loss for this species.

AMM-RBR/RWR requires avoidance of habitat occupied or assumed to be occupied by riparian brush rabbit.

5.23.1.3.1.2 Temporary Habitat Loss

Based on the hypothetical floodplain restoration footprint, the construction of setback levees to restore seasonally inundated floodplain is expected to temporarily remove up to 35 acres of suitable riparian habitat and 20 acres of adjacent grassland habitat. Temporarily disturbed areas will be restored as riparian and grassland habitat within 1 year following completion of construction activities. Although the effects are considered temporary, several years may be required for ecological succession to occur and for restored riparian habitat to functionally replace habitat that has been affected. Most of the riparian vegetation within the species' range is early- to midsuccessional, and this species prefers riparian scrub that is early successional; therefore, the replaced riparian vegetation is expected to meet habitat requirements for the riparian brush rabbit within the first few years after the initial restoration activities are complete.

5.23.1.3.1.3 Periodic Inundation

Existing levees will be breached for floodplain restoration and the newly constructed setback levees will allow inundation through seasonal flooding. The potentially inundated areas may consist of suitable riparian brush rabbit habitat. Based on a hypothetical footprint of floodplain restoration used for BDCP, floodplain restoration will result in periodic inundation of approximately 265 acres of riparian habitat and 425 acres of associated grassland habitat for the riparian brush rabbit ([to be developed]). Although they consist of small patches and narrow bands of riparian vegetation, many of the areas potentially affected are in proximity to, or contiguous with, habitat with recorded occurrences of riparian brush rabbits. The restored floodplain will include a range of elevations from low-lying areas that flood frequently (i.e., every 1 to 2 years) to high-elevation areas that flood infrequently (i.e., every 10 years or more). Seasonal flooding in restored floodplains can result in injury or mortality of individuals if riparian brush rabbits occupy these areas and cannot escape flood waters.

AMM-RBR/RWR requires avoidance of habitat occupied or assumed to be occupied by riparian brush rabbit. This includes avoiding flooding in areas known to be occupied by riparian brush rabbit. The adverse effects of periodic inundation on the riparian brush rabbit in suitable habitat that may become occupied in the future will be further minimized through construction and maintenance of flood refugia to allow riparian brush rabbits to escape flood conditionsthrough the creation of flood refugia mounds with thick cover vegetation and on the landward sides of the newly constructed levees (Kelly et al. 2011).

5.23.1.3.1.4 Construction-Related Effects

Construction-related effects on the riparian brush rabbit include construction-related injury or mortality and indirect noise and visual disturbance to habitat in the vicinity of construction. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the value of affected habitat or the specific nature of the effect.

5.23.1.3.1.5 Construction-Related Injury or Mortality

Reclamation will avoid disturbance of occupied riparian brush rabbit habitat and therefore will avoid construction-related injury or mortality of this species.

5.23.1.3.1.6 Construction-Related Effects on Adjacent Habitat

Construction of setback levees for floodplain restoration may result in noise and visual disturbance to the riparian brush rabbit. This effect will be avoided or minimized through establishment of nondisturbance buffers as described in AMM-RBR/RWR.

The use of mechanical equipment during construction might cause the accidental release of petroleum or other contaminants that will affect the riparian brush rabbit in adjacent habitat, if the species is present. The potential for this adverse effect will be avoided and minimized through best management practices (BMPs) under *AMM2 Construction Best Management Practices and Monitoring*.

5.23.2 Riparian Woodrat

The riparian woodrat occurs in the Stanislaus River and San Joaquin River watershed, and project components within these watersheds may affect this species as follows.

5.23.2.1 Stanislaus River Watershed

5.23.2.1.1 <u>Spawning Habitat Restoration</u>

Gravel will be placed in-stream, therefore will not result in loss or disturbance of riparian woodrat habitat. Access to the enhancement site by vehicles, workers, and equipment may, however, disturb habitat or disrupt normal behavioral patterns of riparian woodrats in the vicinity of the activity, in the absence of avoidance and minimization measures. Reclamation will implement AMM-RBR/RWR, to completely avoid adverse effects on riparian woodrat from spawning adaptive management.

5.23.2.1.2 <u>Rearing Habitat Restoration</u>

Enhancement of salmonid rearing habitat along the lower Stanislaus River may involve modification of river banks or creation of side channels in or near riparian habitat. This could result in loss of riparian woodrat habitat. In the absence of AMMs, this could also result in disruption of normal riparian woodrat behavioral patterns and injury or mortality of individuals through use of heavy equipment in occupied habitat. Reclamation will implement AMM-RBR/RWR, however, to avoid occupied riparian woodrat habitat. Reclamation will remove no more than 10 acres of suitable but unoccupied riparian woodrat habitat, and will offset this loss through restoration of suitable habitat or preservation of occupied habitat.

5.23.2.1.3 Proposed flow changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the Stanislaus watershed, differences between the proposed action and COS are negligible, on the order of a few percent increase in flow in February and a few percent decrease in May and June. These changes are unlikely to produce any measurable change in quantity or quality of riparian woodrat habitat in the Stanislaus watershed, and there is no apparent mechanism by which these changes could result in harm to individual riparian woodrats. Conversely, differences between the proposed action and WOA, with flows in Februrary, March, June and July much lower than flows under the WOA, and higher flows from August to October. However, existing vegetation has established in response to COS flows, and so while WOA would have increased riparian vegetation than today, the proposed action would not impact it as it does not exist. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.2.2 Lower San Joaquin River Watershed

5.23.2.2.1 Lower San Joaquin Spawning and Rearing Habitat (Steady Finance)

5.23.2.2.1.1 Habitat Loss or Conversion

5.23.2.2.1.1.1 Permanent Habitat Loss

This proposed action component will involve a large-scale floodplain habitat restoration effort in the Lower San Joaquin River. Levee construction could result in removal or conversion of riparian woodrat habitat. Based on a hypothetical footprint developed for BDCP, levee construction may result in the permanent removal of approximately 41 acres of riparian woodrat habitat along the lower San Joaquin River. Reclamation will ensure that riparian woodrat habitat permanently removed does not exceed the maximum allowable habitat loss for this species.

AMM-RBR-RWR requires avoidance of habitat occupied or assumed to be occupied by riparian woodrat.

5.23.2.2.1.1.2 Temporary Habitat Loss

Based on the hypothetical floodplain restoration footprint, the construction of setback levees to restore seasonally inundated floodplain is expected to temporarily remove up to 35 acres of suitable riparian woodrat habitat. Temporarily disturbed areas will be restored as riparian habitat within 1 year following completion of construction activities. Although the effects are considered temporary, several years (10 - 20) may be required for ecological succession to occur and for restored riparian habitat to functionally replace habitat that has been affected.

5.23.2.2.1.2 Periodic Inundation

Existing levees will be breached for floodplain restoration and the newly constructed setback levees will allow inundation through seasonal flooding. The potentially inundated areas may consist of suitable riparian woodrat habitat. Based on a hypothetical footprint of floodplain restoration used for BDCP, floodplain restoration will result in periodic inundation of approximately 200 acres of riparian woodrat habitat (Table 5-Terrestrial). The restored floodplain will include a range of elevations from low-lying areas that flood frequently (i.e., every 1 to 2 years) to high-elevation areas that flood infrequently (i.e., every 10 years or more). Seasonal flooding in restored floodplains can result in injury or mortality of individuals if riparian woodrats occupy these areas and cannot escape flood waters.

AMM-RBR/RWR requires avoidance of habitat occupied or assumed to be occupied by riparian woodrat. This includes avoiding flooding in areas known to be occupied by riparian woodrat. The adverse effects of periodic inundation on the riparian woodrat in suitable habitat that may become occupied in the future will be further minimized through construction and maintenance of flood refugia to allow riparian woodrats to escape flood conditions, with patches of riparian trees, as described in the Draft Habitat Assessment Guidelines & Survey Protocol for the Riparian Brush Rabbit and the Riparian Woodrat (USFWS, available at https://www.fws.gov/sacramento/es/Survey-Protocols-Guidelines/).

5.23.2.2.1.3 Construction-Related Effects

Construction-related effects on the riparian woodrat include construction-related injury or mortality and indirect noise and visual disturbance to habitat in the vicinity of construction. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the value of affected habitat or the specific nature of the effect.

5.23.2.2.1.3.1 Construction-Related Injury or Mortality

Reclamation will avoid disturbance of occupied riparian woodrat habitat and therefore will avoid construction-related injury or mortality of this species.

5.23.2.2.1.3.2 Construction-Related Effects on Adjacent Habitat

Construction of setback levees for floodplain restoration may result in noise and visual disturbance to the riparian woodrat. This effect will be avoided or minimized through establishment of nondisturbance buffers as described in AMM-RBR-RWR.

The use of mechanical equipment during construction might cause the accidental release of petroleum or other contaminants that will affect the riparian woodrat in adjacent habitat, if the species is present. The potential for this adverse effect will be avoided and minimized through best management practices (BMPs) under *AMM2 Construction Best Management Practices and Monitoring*.

5.23.2.2.2 Proposed Flow Changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the lower San Joaquin watershed, differences between the proposed action and COS are almost nonexistent and have no potential to produce any change in quantity or quality of riparian woodrat habitat in the lower San Joaquin watershed. There is also no risk that these changes could result in harm to individual riparian woodrats. Conversely, differences between the proposed action and WOA are large, with much lower flows in February and May-June than WOA, and higher flows in the fall than WOA. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.3 Salt Marsh Harvest Mouse

The salt marsh harvest mouse occurs in Suisun Marsh, and the components of the proposed action that may affect this species are in the Bay-Delta watershed only.

5.23.3.1 Bay-Delta Watershed

Project components within the Bay-Delta watershed that could affect salt marsh harvest mouse are those occurring in Suisun Marsh. These include Suisun Marsh salinity control gates and Chipps Island restoration. Potential effects of each of these components on the salt marsh harvest mouse and the measures to avoid, minimize, or offset these effects are described below.

5.23.3.1.1 Suisun Marsh Salinity Control Gates

Under the proposed action the Suisun Marsh Salinity Control Gates (SMSCG) will be operated between June and October for no more than 60 days in wet, above-normal and below-normal Sacramento Valley Index year types. The gates would be operated to minimize seawater intrusion into Montezuma Slough and decrease salinities overall to expand the extent of suitable habitat for Delta smelt. Other than this proposed change in SMSCG operations, gate operations would be unchanged from current conditions and salinities will not be substantially changed.

UnTRIM modeling of the proposed operation of the SMSCG found salinity decreases up to 2 PSU in Montezuma Slough in August and September in dry and below-normal water years (GEI 2018). Because of the limited temporal scale of the proposed action (60 days), the limited temporal overlap between the proposed action and the typical flooding regime for diked wetlands, the variability of existing salinities as well as the variability created between years when the proposed action is implemented and years when it is not; the salinity variability in the winter and spring (when there are no effects from the proposed action but when diked wetland flooding occurs), and the requirements to maintain adherence with RWQCB water quality requirements, the effects from SMSCG operations are presumed insignificant to the vegetation community. Thus, effects on the salt marsh harvest mouse are also considered insignificant. That is, effects to the vegetation community as a result of reduced salinities by no more than 2% in above-normal and below normal water years are not expected to affect salt marsh harvest mouse habitat to the extent that take would occur.

5.23.3.1.1.1 Tidal Habitat Restoration

The USFWS, in their 2008 biological opinion, required Reclamation to “to create or restore a minimum of 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh” to address adverse impacts on Delta smelt and its habitat. DWR has since been performing this action at a variety of restoration sites (Table 5.23-2). None of these projects has yet been certified by USFWS as meeting any portion of the 8,000 acre requirement, but the total acreage of the projects shown in Table 5-DSHR is 12,309 acres, and DWR staff, based on site-specific consultations with USFWS completed to date, consider it likely that completion of these restoration projects will provide mitigation acreages sufficient to fulfill the USFWS habitat creation requirement. As shown in Table 5.23-2, only a subset of these projects are included in the proposed action; the remainder have either completed ESA consultation and are being implemented pursuant to the terms and conditions of a project-specific biological opinion, or are being separately consulted under a lead agency other than Reclamation, and will be transferred to DWR ownership following completion of the restoration work.

Table 5.23-2. DWR Tidal Restoration Projects to secure Compliance with the 2008 USFWS Requirement for 8,000 Acres of Delta Smelt Habitat

Project	Status	Approx. Acres[d]	In Proposed Action
Decker Island	Done	140	No[a]
Lindsey Slough	Done	0	No[c]
Yolo Flyway Farms	Done	300	No[a]
Dutch Slough	In construction	660	Yes[f]
Tule Red	In construction	610	No[a]
Winter Island	2019 construction	553	Yes
Hill Slough	2019 construction	750	Yes[e]
Arnold Slough/Bradmoor Island	2019 construction	659	Yes
Chipps Island	2021 construction	807	Yes
Lookout Slough	2022 construction	3000	No[b]
Lower Yolo Ranch	Planning	1600	Yes
Prospect Island	2020 construction	1360	No[a]
Wings Landing	2020 construction	190	No[b]
Unnamed private project	2020 construction	1680	No[b]
TOTAL ACRES	--	12309	--
TOTAL ACRES UNDER proposed action	--	[waiting on Reclamation]	--

Sources for this table: EcoRestore fact sheets (DWR 2019), email from Gardner Jones (DWR), emails from Catherine McCalvin (DWR).

Notes

[a] A biological opinion has been issued for this project.

[b] This project is being undertaken by a private party, and lead agency is note Reclamation (DWR will assume ownership after site is constructed).

[c] Project presumably re ceived a biological opinion, but primarily restored freshwater and alkali wetlands, although it did include a tidal slough. Acreage of slough not stated in documentation at http://resources.ca.gov/docs/ecorestore/projects/Lindsey_Slough.pdf

[d] None of these projects have yet been certified by USFWS as counting towards the 8,000-acre requirement; acres shown are therefore approximate, representing a DWR estimate of what will be qualifying acreages.

[e] A biological assessment has been submitted but a biological opinion has not yet been received.

[f] Project is in construction, therefore ESA compliance is assumed, but not confirmed.

5.23.3.1.1.2 Habitat Conversion

The component projects and approach used in Tidal Habitat Restoration have been described previously. Tidal Habitat Restoration at sites named in Table 5.23-2 that are part of the proposed action could affect salt marsh harvest mouse via direct effects of construction, or through conversion of habitat, as described below. Take of salt marsh harvest mouse resulting from restoration at these sites will not be authorized through the biological opinion for this project, and will require separate consultation. Acreages of impact to modeled salt marsh harvest mouse habitat at these three sites are shown in Table 5.23-3. Models used to identify habitat for the salt marsh harvest mouse are described in the Draft BDCP (DWR and Reclamation 2013, Appendix 2.A).

Table 5.23-3. Expected Impacts on modeled Salt Marsh Harvest Mouse Habitat from Tidal Habitat Restoration

	Restoration Site (acres)			
Habitat Type	**Arnold Slough/ Bradmoor Island**	**Chipps Island**	**Hill Slough**	**Total**
Managed Wetland – Upland	3	0	15	18
Managed Wetland – Primary	68	41	98	207
Managed Wetland – Secondary	133	171	53	357
Tidal Brackish Emergent Wetland – Primary	25	123	524	672
Tidal Brackish Emergent Wetland – Secondary	26	307	14	346.49
Upland Secondary	24	0	141	165
TOTAL	276	642	830	1,748

The effects on habitat will include the conversion of primary mid- and high-marsh habitat types to secondary low-marsh types; the conversion of secondary, low-marsh habitat to subtidal habitat; and the conversion of upland refugia habitat to tidal habitat. While it is expected that primary and secondary salt marsh harvest mouse habitat will persist after restoration of tidal action, the extent of primary habitat types (mid- and high-marsh) is expected to decrease in the near-term. In the longer-term, and with the implementation of conservation measures , the extent of primary habitat is expected to expand. The extent of primary habitat may not expand to pre-restoration conditions, although the habitat will be more resilient to climate change because tidal habitat has potential to accrete sediment to keep up with sea level rise whereas diked wetlands do not. Sea level rise is one of the primary threats to the Suisun Marsh salt marsh harvest mouse (USFWS 2013b). Most occupied habitat in Suisun Marsh is diked and subsided and therefore vulnerable to catastrophic loss as a result of levee failure; and levees are more likely to fail as sea levels rise (USFWS 2013b). Consistent with the Suisun Marsh Plan Biological Opinion (USFWS 2013a), the creation of more resilient tidal wetland salt marsh harvest mouse habitat will compensate for the loss of diked wetland habitat.

5.23.3.1.1.3 Construction-Related Effects

Tidal Habitat Restoration may include excavation of levees, construction of tidal control gates, movement and staging of large construction equipment, piling and storage of soils, dredging, and filling and grading of vegetated areas. The operation of equipment for construction could result in injury or mortality of salt marsh harvest mice, if present. Only nonmechanized equipment will be used to remove vegetation in salt marsh harvest mouse habitat. Restrictions on the use of mechanized equipment, biological construction monitoring, and other measures will be implemented to ensure that salt marsh harvest mice occupying the construction area will be able to leave and escape to suitable adjacent habitat. Any vegetation removed will be done under supervision of a CDFW- and USFWS-approved biological monitor familiar with salt marsh harvest mouse. Temporary exclusion fences will be installed to ensure that mice do not reenter work areas during construction.

5.23.3.1.2 Proposed Flow Changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the Bay-Delta watershed, the methodology must be altered somewhat to reflect the complex effects of flow manipulation in the Delta and Suisun Marsh. In Suisun Marsh, the proposed action would maintain conditions similar to current, while under the WOA scenario DWR would cease operations of the Suisun Marsh Salinity Control Gates. The proposed action maintains a more constant salinity regime within the Marsh than would exist under WOA. Changes under the PA scenario would be negligible relative to COS, with little potential for the PA to modify habitat or otherwise harm the salt marsh harvest mouse.

In the Bay and in the lower Delta (the only portion of the Delta occupied by salt marsh harvest mouse), differences between proposed action and COS are negligible, on the order of a few percent change in flows at various times of the year. Changes at this scale are unlikely to produce any measurable change in quantity or quality of salt marsh harvest mouse habitat in the Delta, and there is no apparent mechanism by which these changes could result in harm to individual salt marsh harvest mice. Conversely, differences between the proposed action and WOA are large, with decreased flows in all months except September, and January through March flows under WOA exceeding flows in any month under PA or COS. The flow increases under WOA could result in flooding and erosion at any restoration sites or residual habitat for salt marsh harvest mice in the Bay-Delta, resulting in a substantial degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action would provide benefits as compared to the Without Action by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.4 California Ridgway’s Rail

The components of the proposed action that may affect this species are only in the Bay-Delta watershed.

5.23.4.1 Bay-Delta Watershed

Project components within the Bay-Delta watershed that could affect California Ridgway’s rail are those occurring in Suisun Marsh. These include Suisun Marsh salinity control gates, and potentially tidal restoration. Potential effects of each of these components on California Ridgway’s rail and the measures to avoid, minimize, or offset these effects are described below.

5.23.4.1.1 Suisun Marsh Salinity Control Gates

As described above for salt marsh harvest mouse, SMSCG operation is not expected to modify the vegetation communities in Suisun Marsh, therefore this project component is not expected to adversely affect California Ridgway's rail habitat to the extent that take would occur.

5.23.4.1.2 Tidal Habitat Restoration

The component projects and approach have been described previously. The sites named in Table 5.23-2 that are part of the proposed action are outside the range of California Ridgeway's rail, but it is near the range boundary for the species. Delta Smelt habitat could provide habitat where the species' range could expand, which would be a beneficial effect.

5.23.4.1.3 Proposed Flow Changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the Bay-Delta watershed, the methodology must be altered somewhat to reflect the complex effects of flow manipulation in the Delta and Suisun Marsh. In Suisun Marsh, the WOA scenario would cease operations of the Suisun Marsh Salinity Control Gates. This would lead to a more varied salinity regime within the Marsh, resulting in changes in marsh vegetation that would persist until the vegetation adapted to the new salinity and flow regime. This would likely render some areas of Ridgway's rail habitat unsuitable, while creating new areas of suitable habitat. To the extent that the Ridgway's rail could not migrate to accommodate these habitat changes, or was adversely affected by short-term losses in suitable habitat, mortality would result. Conversely, as described above in Section 5.24.3.1.1 *Suisun Marsh Salinity Control Gates*, changes under the PA scenario would be negligible relative to COS, with little potential for the PA to modify habitat or otherwise harm the Ridgway's rail.

In the Bay, differences between the proposed action and COS are negligible, on the order of a few percent change in flows at various times of the year. Changes at this sale are unlikely to produce any measurable change in quantity or quality of Ridgway's rail habitat in the Bay, and there is no apparent mechanism by which these changes could result in harm to individual Ridgway's rail. Conversely, differences between WOA and the PA are large, with increased flows in all months except September, and January through March exceeding flows in any month under PA or COS. The flow increases could result in flooding and erosion at any restoration sites or residual habitat for Ridgway's rail in the Bay, resulting in degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.5 Least Bell's Vireo

Watersheds with project components that may affect suitable least Bell's vireo habitat within the species' range include Upper Sacramento River watershed, Stanislaus River watershed, Lower San Joaquin River watershed, as well as Delta watershed with migratory stopover habitat. Applicable components are described below for each watershed.

5.23.5.1 Upper Sacramento River Watershed

The only Upper Sacramento River Watershed project components within the range of least Bell's vireo that may affect the species are *Colusa Basin Drain.* Effects of these components on least Bell's vireo are described below.

5.23.5.1.1 Colusa Basin Drain Food Web Routing

High water levels (flows of 200 to 500 cfs) are proposed to pass through the Yolo Bypass which is in a disjunct portion of the current range for this species. The proposed flows will not exceed local flooding levels. Flows are proposed in July, August and/or September for approximately 4 weeks, which would coincide with June through mid-September nesting although no adverse effects to individuals or habitat are anticipated.

5.23.5.1.2 Proposed flow changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the upper Sacramento watershed, differences between the proposed action and COS are negligible, on the order of a few percent decrease in flow in November and a few percent increase in May and June. These changes are unlikely to produce any measurable change in quantity or quality of least Bell's vireo habitat in the upper Sacramento watershed, and there is no apparent mechanism by which these changes could result in harm to individual least Bell's vireos. Conversely, differences between the proposed action and WOA are large, with flows in February and March in WOA exceeding flows in any month under PA or COS, and very low flows in WOA from July to September, which could very likely cause drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability. The flow increases could result in flooding and erosion at any restoration sites or residual habitat for least Bell's vireos in the upper Sacramento watershed, resulting in a substantial degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action does not have these impacts, and maintains current vegetation. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.5.2 Stanislaus River Watershed

Stanislaus River Watershed project components within the small disjunct mapped range of least Bell's vireo include Spawning and Rearing Habitat Named Projects, Spawning Habitat Restoration and Rearing Habitat Restoration. Although no current occurrences of this species are known in the watershed the effects of these components on least Bell's vireo are described below.

5.23.5.2.1 Spawning and Rearing Habitat

Gravel will be placed in-stream, therefore will not result in loss or disturbance of least Bell's vireo habitat. Access to the enhancement site by vehicles, workers, and equipment may, however, disturb habitat or disrupt normal behavioral patterns of least Bell's vireo in the vicinity of the activity, in the absence of project component specific avoidance and minimization measures. Reclamation will implement AMM-LBV to completely avoid adverse effects on least Bell's vireo from spawning and rearing habitat restoration. Rearing habitat creation will be outside the range of least Bell's vireo.

5.23.5.2.2 Proposed Flow Changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the Stanislaus watershed, differences between proposed action and COS are negligible, on the order of a few percent increase in flow in February and a few percent decrease in May and June. These changes are unlikely to produce any measurable change in quantity or quality of least Bell's vireo habitat in the Stanislaus watershed, and there is no apparent mechanism by which these changes could result in harm to individual least Bell's vireos. Conversely, differences between the proposed action and WOA are large, with flows in Februrary, March, June and July under WOA exceeding flows in any month under PA or COS, and very low flows from August to October, potentially causing drought stress in riparian or wetland vegetation. The flow increases could result in flooding and erosion at any restoration sites or residual habitat for least Bell's vireo in the Stanislaus watershed, resulting in a substantial degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action does not have these impacts, and maintains current vegetation. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.5.3 Lower San Joaquin River Watershed

Lower San Joaquin River Watershed project components within the small disjunct mapped range of least Bell's vireo include Lower San Joaquin Spawning and Rearing Habitat. Effects of this component on least Bell's vireo are described below.

5.23.5.3.1 Lower San Joaquin Spawning and Rearing Habitat

5.23.5.3.1.1 Habitat Loss or Conversion

Levee construction could result in removal or conversion of least Bell's vireo habitat. Based on a hypothetical footprint developed for BDCP, levee construction may result in the permanent removal of approximately 28 acres of least Bell's vireo habitat along the lower San Joaquin River. Although habitat consists primarily of small patches, these patches are in proximity to other habitat along the San Joaquin River. Although much of this component would occur north of San Joaquin River portion of mapped range of least Bell's vireo, the southern extent could be as close as 5 miles from least Bell's vireo breeding occurrences from 2005-2007. Reclamation will ensure that least Bell's vireo habitat permanently removed does not exceed the maximum allowable habitat loss for this species.

Under AMM-LBV, injury or mortality to nesting least Bell's vireos will be avoided through preconstruction surveys and establishment of 500-foot no-disturbance buffers around active nests.

5.23.5.3.1.2 Construction-Related Effects

Although least Bell's vireo nesting has not been observed in recent years in the disjunct San Joaquin River portion of mapped range, occurrences suggest that the reestablishment of a breeding population is a possibility in this area. If the least Bell's vireo nests where covered activities are to occur, equipment operation for construction activities could result in injury or mortality of individuals. Risk will be greatest to eggs and nestlings that could be injured or killed through crushing by heavy equipment, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is unlikely, as these individuals are expected to avoid contact with construction equipment. Under AMM-LBV, injury or mortality to nesting least Bell's vireos will be avoided through preconstruction surveys and establishment of 500-foot no-disturbance buffers around active nests, as described in AMM-LBV. Construction activities may create noise up to 60 dBA at no more than 1,200 feet from the edge of the noise generating activity. While 60 dBA is the standard noise threshold for birds (Dooling and Popper 2007), this standard is generally applied during the nesting season, when birds are more vulnerable to behavioral modifications that can cause nest failure. There is evidence, however, that migrating birds will avoid noisy areas during migration (McClure et al. 2013). To minimize this effect, BOR will reduce noise in the vicinity of least Bell's vireo habitat as described in AMM-LBV. This will include surveying for least Bell's vireos within the 60 dBA noise contour around the construction footprint, and if a least Bell's vireo is found, limiting noise to less than 60 dBA where the bird occurs until it has left the area.

Night lighting may also have the potential to affect least Bell's vireos. While there is no data on effects of night lighting on this species, studies show that other bird species are attracted to artificial lights and this may disrupt their behavioral patterns or cause collision-related fatalities (Gauthreaux and Belser 2006). To minimize this effect, BOR will screen all lights and direct them away from habitat as described in AMM-LBV. With this measure in effect, and given that least Bell's vireos are expected to occur in the vicinity of project activities seldom if at all, residual lighting effects on the species are expected to be negligible and is not expected to result in take of the species.

5.23.5.3.1.3 Inundation

Based on the hypothetical floodplain restoration footprint, the construction of setback levees to restore seasonally inundated floodplain is expected to inundate an estimated 148 acres of least Bell's vireo habitat. The floodplains will transition from areas that flood frequently (i.e., every 1 to 2 years) to areas that flood infrequently (i.e., every 10 years or more). Periodic inundation as a result of floodplain restoration is not expected to adversely affect the least Bell's vireo because flooding is unlikely to occur during the breeding season when the vireo could be present, and the potential effects of inundation on existing riparian vegetation are expected to be minimal. While frequent flooding in the lower elevation portions of the floodplain may result in scouring of riparian vegetation, this is expected to have a beneficial rather than an adverse effect on the species.

5.23.5.3.2 Proposed Flow Changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the lower San Joaquin watershed, differences between the proposed action and COS are almost nonexistent and have no potential to produce any change in quantity or quality of least Bell's vireo habitat in the lower San Joaquin watershed. There is also no risk that these changes could result in harm to individual least Bell's vireos. Conversely, differences between proposed action and WOA are large, with flows in February and May-June under WOA that exceed flows in any month under PA or COS. The flow increases could result in flooding and erosion at any restoration sites or residual habitat for least Bell's vireo in the lower San Joaquin watershed, resulting in a substantial degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action does not have these impacts, and maintains current vegetation. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.6 Western Yellow-Billed Cuckoo

Western yellow-billed cuckoo surveys, monitoring, and adaptive management conducted in accordance with Chapter 4, Section 4.10.1.5.2, *Conservation Measures*, will ensure project effects do not exceed those analyzed in this biological assessment and the programmatic biological opinion.

5.23.6.1 Upper Sacramento River Watershed

Upper Sacramento River Watershed project components within the mapped range of western yellow-billed cuckoo include Spawning and Rearing Named Projects and Colusa Basin Drain Food Web Routing. Implementation of AMM24 will result in minimization and avoidance of effects on western yellow-billed cuckoo. Effects from the project components are described below.

5.23.6.1.1 Spawning and Rearing Named Projects

5.23.6.1.1.1 Permanent Habitat Loss or Conversion

Creation of side channels will require removal of riparian habitat within the range of western yellow-billed cuckoo. The majority of the proposed projects are north of Red Bluff, California, where no occurrences of this species have been reported. However, the southernmost two proposed projects (La Barranca and Woodson Bridge Bank Rearing Improvement) are south of Red Bluff and overlap with a 2013 occurrence and 1988 occurrence, respectively. Although Reclamation will minimize removal of riparian habitat to the extent feasible through implementation of AMM22, up to 58 acres of western yellow-billed cuckoo habitat may be removed.

5.23.6.1.1.2 Construction-Related Effects

Although the majority of sites are far from known western yellow-billed cuckoo occurrences, the recent observation identified above suggest that western yellow-billed cuckoos may nest in the area. If the western yellow-billed cuckoo nests where covered activities are to occur, equipment operation for construction activities could result in injury or mortality of individuals. Risk will be greatest to eggs and nestlings that could be injured or killed through crushing by heavy equipment, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is unlikely, as these individuals are expected to avoid contact with construction equipment. Under AMM-WYBC, injury or mortality to nesting western yellow-billed cuckoos will be avoided through preconstruction surveys and establishment of a 500-foot no-disturbance buffers around active nests, as described in AMM-WYBC. Construction activities may create noise up to 60 dBA at no more than 1,200 feet from the edge of the noise generating activity. While 60 dBA is the standard noise threshold for birds (Dooling and Popper 2007), this standard is generally applied during the nesting season, when birds are more vulnerable to behavioral modifications that can cause nest failure. There is evidence, however, that migrating birds will avoid noisy areas during migration (McClure et al. 2013). To minimize this effect, Reclamation will reduce noise in the vicinity of western yellow-billed cuckoo habitat as described in AMM-WYBC. This will include surveying for western yellow-billed cuckoos within the 60 dBA noise contour around the construction footprint, and if a western yellow-billed cuckoo is found, limiting noise to less than 60 dBA where the bird occurs until it has left the area.

Night lighting may also have the potential to affect western yellow-billed cuckoos. While there is no data on effects of night lighting on this species, studies show that other bird species are attracted to artificial lights and this may disrupt their behavioral patterns or cause collision-related fatalities (Gauthreaux and Belser 2006). To minimize this effect, Reclamation will screen all lights and direct them away from habitat as described in AMM-WYBC. With this measure in effect, and given that western yellow-billed cuckoos are expected to occur in the vicinity of project activities seldom if at all, residual lighting effects on the species are expected to be negligible and is not expected to result in take of the species.

5.23.6.1.1.3 Colusa Basin Drain Food Web Routing

5.23.6.1.1.3.1 Inundation Effects

High water levels (flows of 200 to 500 cfs) are proposed to pass through the Yolo Bypass which includes a disjunct portion of the current range for this species. The proposed flows will not exceed local flooding levels and are unlikely to reach 3 feet above the ground where effects on cuckoo are possible. Flows are proposed in July, August and/or September for approximately 4 weeks, which would coincide with June through mid-September nesting although no adverse effects to individuals or habitat are anticipated.

5.23.6.2 Proposed Flow Changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the upper Sacramento watershed, differences between the proposed action and COS are negligible, on the order of a few percent decrease in flow in November and a few percent increase in May and June. These changes are unlikely to produce any measurable change in quantity or quality of western yellow-billed cuckoo habitat in the upper Sacramento watershed, and there is no apparent mechanism by which these changes could result in harm to individual western yellow-billed cuckoos. Conversely, differences between the proposed action and WOA are large, with flows in February and March under WOA exceeding flows in any month under PA or COS, and very low flows from July to September in WOA, which could very likely cause drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability. The flow increases could result in flooding and erosion at any restoration sites or residual habitat for western yellow-billed cuckoos in the upper Sacramento watershed, resulting in a substantial degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action does not have these impacts, as it has higher flows in the fall and maintains current vegetation. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.6.3 American River Watershed

Project components in the American River Watershed that may affect western yellow-billed cuckoo include Spawning and Rearing Habitat Restoration . Nimbus Hatchery Physical and Operational Improvements will avoid disturbance of western yellow-billed cuckoo habitat as described in AMM-WYBCC.

5.23.6.3.1 Spawning and Rearing Habitat

5.23.6.3.1.1 Permanent Habitat Loss or Conversion

Creation of spawning habitat will avoid disturbance of western yellow-billed cuckoo habitat, consistent with AMM-WYBC. Creation of side channels will require removal of riparian habitat within the range of western yellow-billed cuckoo. Although Reclamation will minimize removal of riparian habitat to the extent feasible through implementation of AMM-WBYC, up to four acres of riparian habitat may be removed.

5.23.6.3.1.2 Proposed Flow Changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the American River watershed, differences between the proposed action and COS are negligible, on the order of a few percent decrease in flow in December, February and March, a few percent increase in July and September. These changes are unlikely to produce any measurable change in quantity or quality of western yellow-billed cuckoo habitat in the American River watershed, and there is no apparent mechanism by which these changes could result in harm to individual western yellow-billed cuckoos. Conversely, differences between the proposed action and WOA are large, with flows in February, March, and April under WOA exceeding flows in any month under PA or COS, and very low flows from July to October under WOA, potentially causing drought stress in riparian or wetland vegetation. The flow increases could result in flooding and erosion at any restoration sites or residual habitat for western yellow-billed cuckoos in the American River watershed, resulting in a substantial degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action does not have these impacts, as it has higher flows in the fall and maintains current vegetation. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.6.4 Stanislaus River Watershed

5.23.6.4.1 Spawning and Rearing Habitat Named Projects

Creation of spawning habitat will avoid disturbance of western yellow-billed cuckoo habitat, consistent with AMM-WYBC. Creation of side channels will require removal of riparian habitat within the range of western yellow-billed cuckoo. Although Reclamation will minimize removal of riparian habitat to the extent feasible through implementation of AMM-WYBC, up to 43 acres of riparian habitat may be removed.

5.23.6.4.2 Proposed flow changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the Stanislaus watershed, differences between proposed action and COS are negligible, on the order of a few percent decrease in flow in February and a few percent increase in May and June. These changes are unlikely to produce any measurable change in quantity or quality of western yellow-billed cuckoo habitat in the Stanislaus watershed, and there is no apparent mechanism by which these changes could result in harm to individual western yellow-billed cuckoos. Conversely, differences between the proposed action and WOA are large, with flows in February, March, June and July under WOA exceeding flows in any month under PA or COS, and very low flows from August to October in WOA, potentially causing drought stress in riparian or wetland vegetation. The flow increases could result in flooding and erosion at any restoration sites or residual habitat for western yellow-billed cuckoo in the Stanislaus watershed, resulting in a substantial degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action does not have these impacts, as it has higher flows in the fall and maintains current vegetation. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.6.5 Lower San Joaquin River Watershed

Lower San Joaquin River Watershed project components within the range of western yellow-billed cuckoo include Lower San Joaquin Spawning and Rearing Habitat . Effects of this component on western yellow-billed cuckoo are described below.

5.23.6.5.1 Lower San Joaquin Spawning and Rearing Habitat

5.23.6.5.1.1 Habitat Loss or Conversion

Levee construction associated with floodplain restoration will result in the permanent removal of up to an estimated 11 acres of western yellow-billed cuckoo habitat. This habitat is of moderate value: although it consists primarily of small patches, these patches are in proximity to other habitat along the San Joaquin River, and some of the patches are adjacent to existing conservation lands. Because the estimates of habitat loss resulting from floodplain restoration are based on projections of where restoration may occur, actual habitat loss is expected to be lower because sites will be selected to minimize effects on western yellow-billed cuckoo habitat.

5.23.6.5.1.1.1 Construction-Related Effects

If the western yellow-billed cuckoo nests where covered activities are to occur, equipment operation for construction activities could result in injury or mortality of individuals. Risk will be greatest to eggs and nestlings that could be injured or killed through crushing by heavy equipment, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is unlikely, as these individuals are expected to avoid contact with construction equipment. Under AMM-WYBC, injury or mortality to nesting western yellow-billed cuckoos will be avoided.

5.23.6.5.1.2 Inundation

Based on a hypothetical floodplain restoration, this activity will periodically inundate an estimated 70 acres of habitat for the western yellow-billed cuckoo. The floodplains will transition from areas that flood frequently (i.e., every 1 to 2 years) to areas that flood infrequently (i.e., every 10 years or more). Periodic inundation as a result of Yolo Bypass operations and floodplain restoration is not expected to adversely affect the yellow-billed cuckoo because flooding is unlikely to occur during the breeding season when the cuckoo could be present, and the potential effects of inundation on existing riparian vegetation are expected to be minimal. While frequent flooding in the lower elevation portions of the floodplain may result in scouring of riparian vegetation, this is expected to have a beneficial rather than an adverse effect on the species.

5.23.6.5.2 Proposed Flow Changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the lower San Joaquin watershed, differences between the proposed action and COS are almost nonexistent and have no potential to produce any change in quantity or quality of western yellow-billed cuckoo habitat in the lower San Joaquin watershed. There is also no risk that these changes could result in harm to individual western yellow-billed cuckoos. Conversely, differences between the proposed action and WOA are large, with flows in February and May-June under WOA that exceed flows in any month under PA or COS. The flow increases could result in flooding and erosion at any restoration sites or residual habitat for western yellow-billed cuckoo in the lower San Joaquin watershed, resulting in degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action does not have these impacts, as it has lower flows in the spring and maintains current general flow regimes.

5.23.7 Giant Garter Snake

Based on the 2017 Recovery Plan (USFWS 2017) the current range of the giant garter snake encompasses nine separate populations associated with distinct watershed basins. Known giant garter snake populations and corresponding recovery units that overlap with proposed action components include the Butte Basin, Sutter Basin, Colusa Basin, Yolo Basin, and Delta Basin populations. Components of the proposed action that may affect this species are in the Upper Sacramento River watershed and the Bay-Delta watershed only.

5.23.7.1 Upper Sacramento River Watershed

Upper Sacramento River Watershed project components within the range of giant garter snake include Spawning and Rearing Named Projects, Colusa Basin Drain Food Web Routing. Projects within Sacramento River and on its banks, however, are not expected to affect giant garter snake habitat. This species does not typically occupy large rivers. Therefore, project components described below do not include Spawning and Rearing Named Projects or Sacramento Weir, as these components occur along the Sacramento River.

Effects from each of these components are described below.

5.23.7.1.1 Colusa Basin Drain Food Web Routing

5.23.7.1.1.1 Permanent Habitat Loss or Conversion

The diversion of approximately 24,000 AF of agricultural water over a 4-week period (during July, August, and/or September) from Colusa Basin into Yolo Bypass rather than outfalling into the Sacramento River would not result in adverse effects on giant garter snake because the Sacramento River does not support suitable aquatic habitat for this species. Increasing flows into the Yolo Bypass during late summer would be expected to increase surface water and improve habitat conditions for giant garter snake in the Yolo Bypass. Therefore, Food Web Routing would have a beneficial effect on giant garter snake.

5.23.7.1.2 Proposed flow changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the upper Sacramento watershed, differences between the proposed action and COS are negligible, on the order of a few percent increase in flow in November and a few percent decrease in May and June. These changes are unlikely to produce any measurable change in quantity or quality of giant garter snake habitat in the upper Sacramento watershed, and there is no apparent mechanism by which these changes could result in harm to individual giant garter snakes. Conversely, differences between WOA and the PA are large, with flows in February and March exceeding flows in any month under PA or COS, and very low flows from July to September, which could very likely cause drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability. The flow increases could result in flooding and erosion at any restoration sites or residual habitat for giant garter snakes in the upper Sacramento watershed, resulting in a substantial degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action does not have these impacts, as it has higher flows in the fall and maintains current vegetation. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.7.2 Bay-Delta Watershed

5.23.7.2.1 Delta Cross Channel Improvements

Delta Cross Channel Improvements involves modernizing Delta Cross Channel gates. Potentially suitable giant garter snake habitat is present in the vicinity of these gates. Assuming disturbance will occur within a 25-foot radius around the existing gates, Delta Cross Channel Improvements could result in loss of up to 0.2 acre of upland and .4 acre of aquatic habitat for giant garter snake.

5.23.7.2.2 Tidal Habitat Restoration

5.23.7.2.2.1 Habitat Conversion

The component projects and approach were described previously. Habitat Restoration at two of the sites named in Table 5-.23-2 that are part of the proposed action could affect giant garter snake via direct effects of construction, or through conversion of habitat, as described below. Take of giant garter snake resulting from restoration at these sites will not be authorized through the biological opinion for this project, and will require separate consultation. Acreages of impact to modeled giant garter snake habitat at these three sites are shown in Table 5-5.23-4. Models used to identify habitat for the giant garter snake are described in the Draft BDCP (DWR and Reclamation 2013, Appendix 2.A).

Table 5.23-4. Expected Impacts on Modeled Giant Garter Snake Habitat from Tidal Habitat Restoration

	Restoration Site (acres)		
Habitat Type	**Dutch Slough**	**Lower Yolo Ranch**	**Total**
Aquatic – Nontidal	37	8	45
Aquatic – Tidal	17	45	62
Upland	279	368	647
TOTAL	333	421	754

Tidal Habitat Restoration at each site would be achieved by conversion of currently leveed, cultivated land through breaching or setback of levees, thereby restoring tidal fluctuation to land parcels currently isolated behind those levees. Where appropriate, portions of restoration sites will be raised to elevations that will support tidal marsh vegetation following levee breaching. Depending on the degree of subsidence and location, lands may be elevated by grading higher elevations to fill subsided areas, importing clean dredged or fill material from other locations, or planting tules or other appropriate vegetation to raise elevations in shallowly subsided areas over time through organic material accumulation. Surface grading will create a shallow elevation gradient from the marsh plain to the upland transition habitat. Based on assessments of local hydrodynamic conditions, sediment transport, and topography, restoration activities may be designed and implemented in a manner that accelerates the development of tidal channels within restored marsh plains. Following reintroduction of tidal exchange, tidal marsh vegetation is expected to establish and maintain itself naturally at suitable elevations relative to the tidal range. Depending on site-specific conditions and monitoring results, patches of native emergent vegetation may be planted to accelerate the establishment of native marsh vegetation on restored marsh plain surfaces.

Permanent effects on giant garter snake aquatic habitat are likely to occur when agricultural ditches are modified and flooded as part of the tidal habitat restoration process, or as part of the channel margin restoration process in projects that entail levee setback. The conversion of rice to tidal habitat would be a permanent loss, however, rice is not common in the areas where tidal restoration and channel margin restoration would likely be sited. Other aquatic features that have potential to occur on restoration sites include natural channels and topographic depressions. Tidal aquatic edge habitat where open water meets the levee edge will also be permanently lost in those reaches where the levee is breached. Temporary effects on aquatic edge habitat are also likely to occur during the time of construction, though these effects would not be expected to last more than 2 years. Permanent effects on upland habitat will primarily occur where upland habitat is removed to create tidal connectivity.

5.23.7.2.2.2 **Construction Related Effects**

The operation of equipment for land clearing and restoration could result in injury or mortality of giant garter snakes. This risk is highest from late fall through early spring, when the snakes are dormant. Increased vehicular traffic associated with construction activities could contribute to a higher incidence of road kill. However, construction monitoring and other measures will be implemented to avoid and minimize injury or mortality of this species during construction, as described in AMM-GSS. Noise and visual disturbance outside the project footprint but within 200 feet of construction activities could temporarily affect the use adjacent habitat. These effects will be minimized by siting construction 200 feet away from the banks of giant garter snake aquatic habitat, where feasible, as described in AMM-GSS.

5.23.7.2.3 Proposed Flow Changes

See Section 5.24.1.1.3.1 *General Discussion of Flow Change Effects* for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the Bay-Delta watershed, the methodology must be altered somewhat to reflect the complex effects of flow manipulation in the Delta and Suisun Marsh. In Suisun Marsh, the WOA scenario would cease operations of the Suisun Marsh Salinity Control Gates. This would lead to a more varied salinity regime within the Marsh, resulting in changes in marsh vegetation that would persist until the vegetation adapted to the new salinity and flow regime. This would likely render some areas of giant garter snake habitat unsuitable, while creating new areas of suitable habitat. To the extent that the giant garter snake could not migrate to accommodate these habitat changes, or was adversely affected by short-term losses in suitable habitat, mortality would result, possibly with long-term effects on genetic diversity and population structure. Conversely, as described previously, changes under the proposed action scenario would be negligible relative to COS, with little potential for the proposed action to modify habitat or otherwise harm the giant garter snake.

In the Delta, differences between COS and the proposed action are negligible, on the order of a few percent change in flows at various times of the year. Changes at this sale are unlikely to produce any measurable change in quantity or quality of giant garter snake habitat in the Delta, and there is no apparent mechanism by which these changes could result in harm to individual giant garter snake . Conversely, differences between WOA and the PA are large, with increased flows in all months except September, and January through March exceeding flows in any month under the proposed action or COS. The flow increases could result in flooding and erosion at any restoration sites or residual habitat for giant garter snakes in the Delta, resulting in a substantial degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.8 Valley Elderberry Longhorn Beetle

5.23.8.1 Upper Sacramento River Watershed

All Upper Sacramento River watershed project components that result in habitat disturbance are within the range of valley elderberry longhorn beetle. Effects of the remaining components are described for each relevant component below.

5.23.8.1.1 Colusa Basin Drain Food Web Routing

High water levels (flows of 200 to 500 cubic cfs) are proposed to pass through the Yolo Bypass which is in a disjunct portion of the current range for this species. The proposed flows will not exceed local flooding levels. Flows are proposed in July, August and/or September for approximately 4 weeks, which would potentially adversely affect valley elderberry shrubs, although the extent to which these effects might occur is uncertain.

5.23.8.1.1.1 Spawning and Rearing Habitat Restoration

5.23.8.1.1.1.1 Permanent Habitat Loss or Conversion

During placement of gravel and other measures to enhance spawning habitat, Reclamation will avoid disturbance of elderberry shrubs consistent with AMM-VELB. Creation of side channels will require removal of riparian habitat within the range of valley elderberry longhorn beetle, and although Reclamation will minimize disturbance associated with this activity, they may remove up to an estimated 58 acres of riparian habitat that could include elderberry shrubs supporting valley elderberry longhorn beetle. Assuming an estimated average of 0.9 shrubs per acre (from BDCP, Appendix 6B), rearing habitat restoration could result in removal of up to 52 elderberry shrubs. Reclamation will offset adverse effects on elderberry shrubs through transplantation of affected shrubs and planting of new shrubs and associated riparian vegetation consistent with *Framework for Assessing Impacts to the Valley Elderberry Longhorn Beetle* (USFWS 2017).

5.23.8.1.1.1.2 Construction-Related Effects

Habitat restoration may include use of heavy equipment for ground clearing, grading, excavation, and placement of gravel or habitat structures. Construction related actions could injure or kill valley elderberry longhorn beetles if individuals are present in shrubs to be transplanted, but the potential for this effect will be minimized as described AMM-VELB.

The operation of equipment during construction in the vicinity of occupied elderberry shrubs could also result in injury or mortality of valley elderberry longhorn beetles if they are actively dispersing between shrubs, which is generally between March 15th to June 15th; or if occupied shrubs are inadvertently damaged by construction activities. These effects will be avoided and minimized as described in AMM-VELB.

Temporary construction-related ground disturbances could generate dust that could adversely affect adjacent valley elderberry longhorn beetle habitat. Dust is listed in the valley elderberry longhorn beetle recovery plan as a threat to the species (U.S. Fish and Wildlife Service 1984). However, one study indicated that dust deposition was not correlated with valley elderberry longhorn beetle presence (Talley et al. 2006), although dust was weakly correlated with elderberry stress symptoms (water stress, dead stems, smaller leaves). During times of drought, when elderberry shrubs are under stress, dust deposition could further stress the shrubs, potentially leading to their death. Such a loss of shrubs could adversely affect valley elderberry longhorn beetle (Talley and Hollyoak 2009). The potential effects of dust on valley elderberry longhorn beetle will be minimized by applying water during construction activities or by presoaking work areas that will occur within 100 feet of any potential elderberry shrub habitat.

Exhaust from construction and maintenance vehicles may result in deposition of particulates, heavy metals, and mineral nutrients that could influence the quality and quantity of elderberry shrubs and thereby affect beetle presence and abundance. The results of a study by Talley and Hollyoak (2009) showed no relationship, however, between the distance of the shrubs from highways and the presence or abundance of the beetle.

Temporary lighting from construction activities could adversely affect valley elderberry longhorn beetle. The effects of lighting on valley elderberry longhorn beetle are unknown, although insects are known to be subject to heavy predation when they are attracted to night lighting (Eisenbeis 2006). No restoration activity will occur during nighttime hours in the vicinity of habitat for federally listed species.

5.23.8.2 Proposed flow changes

See the previous discussion regarding flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. Differences between the proposed action and COS are negligible, on the order of a few percent decrease in flow in November and a few percent increase in May and June. These changes are unlikely to produce any measurable change in quantity or quality of valley elderberry longhorn beetle habitat in the upper Sacramento watershed, and there is no apparent mechanism by which these changes could result in harm to individual valley elderberry longhorn beetles. Conversely, differences between WOA and the PA are large, with flows in spring exceeding flows under PA or COS, and very low flows in the summer, which could very likely cause drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability. The flow increases could result in flooding and erosion at any restoration sites or residual habitat for valley elderberry longhorn beetles, resulting in a substantial degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.8.3 American River Watershed

All American River watershed project components that result in habitat disturbance are within the range of valley elderberry longhorn beetle. Effects from other components are described below.

5.23.8.3.1 Spawning and Rearing Habitat Restoration

5.23.8.3.1.1 Permanent Habitat Loss or Conversion

Creation of spawning habitat will avoid disturbance of valley elderberry longhorn beetle habitat, consistent with AMM-VELB. Creation of side channels will require removal of riparian habitat within the range of valley elderberry longhorn beetle. Although Reclamation will minimize removal of riparian habitat to the extent feasible through implementation of AMM-VELB, up to four acres of riparian habitat may be removed (approximately 3 to 4 elderberry shrubs). Reclamation will offset adverse effects on elderberry shrubs through transplantation of affected shrubs and planting of new shrubs and associated riparian vegetation consistent with *Framework for Assessing Impacts to the Valley Elderberry Longhorn Beetle* (USFWS 2017), or through mitigation.

5.23.8.3.1.2 Construction-Related Effects

Construction-related effects associated with Spawning and Rearing Named Projects in the American River Watershed are as described above for Spawning and Rearing Named Projects in the Upper Sacramento River Watershed.

5.23.8.4 Stanislaus River Watershed

5.23.8.4.1 Spawning and Rearing Habitat Named Projects

5.23.8.4.1.1 Permanent Habitat Loss or Conversion

Creation of spawning habitat will avoid disturbance of valley elderberry longhorn beetle habitat, consistent with AMM-VELB. Creation of side channels will require removal of riparian habitat within the range of valley elderberry longhorn beetle. Although Reclamation will minimize removal of riparian habitat to the extent feasible through implementation of AMM-VELB, up to 43 acres of riparian habitat may be removed. Reclamation will offset adverse effects on elderberry shrubs through transplantation of affected shrubs and planting of new shrubs and associated riparian vegetation, consistent with *Framework for Assessing Impacts to the Valley Elderberry Longhorn Beetle* (USFWS 2017), or through mitigation.

5.23.8.4.1.2 Construction-Related Effects

Construction-related effects associated with Spawning and Rearing Named Projects in the Stanislaus River Watershed are as described above for Spawning and Rearing Named Projects in the Upper Sacramento River Watershed.

5.23.8.5 Lower San Joaquin River Watershed

Lower San Joaquin River Watershed project components within the range of valley elderberry longhorn beetle include Lower San Joaquin Spawning and Rearing Habitat Restoration. Effects of this component on valley elderberry longhorn beetle are described below.

5.23.8.5.1 Lower San Joaquin Spawning and Rearing Habitat

5.23.8.5.1.1 Habitat Loss or Conversion

Levee construction associated with floodplain restoration will result in the permanent removal of up to an estimated 52 acres of valley elderberry longhorn beetle habitat (an estimated 47 shrubs). Reclamation will offset adverse effects on elderberry shrubs through transplantation of affected shrubs and planting of new shrubs and associated riparian vegetation consistent with *Framework for Assessing Impacts to the Valley Elderberry Longhorn Beetle* (USFWS 2017).

5.23.8.5.1.2 Construction-Related Effects

Construction-related effects associated with *Lower San Joaquin Rearing Habitat Restoration* are as described above for *Spawning and Rearing Habitat Restoration* in the Upper Sacramento River Watershed.

5.23.8.5.1.3 Inundation

Based on a hypothetical floodplain restoration, this activity will periodically inundate an estimated 226 acres of riparian habitat for the valley elderberry longhorn beetle. The area to be inundated will transition from areas that flood frequently (i.e., every 1 to 2 years) to areas that flood infrequently (i.e., every 10 years or more). While elderberry shrubs are not expected to be sustained in the lower elevation areas that frequently flood, the higher floodplain is expected to remain as high-value habitat for the species.

5.23.8.6 Bay-Delta Watershed

5.23.8.6.1 Tidal Habitat Restoration

5.23.8.6.1.1 Habitat Conversion

The component projects and approach used in Tidal Habitat Restoration have been described previously. Tidal Habitat Restoration at four of the sites named in Table 5.23-2 that are part of the proposed action could affect Valley elderberry longhorn beetle via direct effects of construction, or through conversion of habitat, as described below. Take of Valley elderberry longhorn beetle resulting from restoration at these sites will not be authorized through the biological opinion for this project, and will require separate consultation. Acreages of impact to modeled Valley elderberry longhorn beetle habitat at these three sites are shown in Table 5.23-5. Models used to identify habitat for the valley elderberry longhorn beetle are described in the Draft BDCP (DWR and Reclamation 2013, Appendix 2.A).

Table 5.23-5. Expected Impacts on Modeled Valley Elderberry Longhorn Beetle Habitat from Tidal Habitat Restoration

	Restoration Site				
Habitat Type	**Dutch Slough**	**Hill Slough**	**Lower Yolo Ranch**	**Winter Island**	**Total**
Habitat (acres)	29	0	56	3	88
Estimated number of shrubs	26	0	50	3	79

Levee breaches performed during tidal wetland restoration will require removal of riparian and contiguous grassland habitat within the range of valley elderberry longhorn beetle. The number of shrubs and stems that would be affected would be determined during preconstruction surveys in suitable habitat as outlined in AMM-VELB. Reclamation will offset adverse effects on elderberry shrubs through transplantation of affected shrubs and planting of new shrubs and associated riparian vegetation consistent with *Framework for Assessing Impacts to the Valley Elderberry Longhorn Beetle* (USFWS 2017c).

5.23.8.6.1.2 Construction Related Effects

Tidal Habitat Restoration may include use of heavy equipment for ground clearing, grading, excavation, and placement of large wood. Construction related actions could injure or kill valley elderberry longhorn beetles if individuals are present in shrubs to be transplanted, but the potential for this effect will be minimized as described in AMM-VELB.

The operation of equipment during construction in the vicinity of occupied elderberry shrubs could also result in injury or mortality of valley elderberry longhorn beetles if they are actively dispersing between shrubs, which is generally between March 15th and June 15th; or if occupied shrubs are inadvertently damaged by construction activities. These effects will be avoided and minimized as described in AMM-VELB.

Temporary construction-related ground disturbances could generate dust that could adversely affect adjacent valley elderberry longhorn beetle habitat. Dust is listed in the valley elderberry longhorn beetle recovery plan as a threat to the species (U.S. Fish and Wildlife Service 1984). Dust deposition is not correlated with valley elderberry longhorn beetle presence (Talley et al. 2006), but it is weakly correlated with signs of stress in elderberry plants (water stress, dead stems, smaller leaves). During times of drought, when elderberry shrubs are under stress, dust deposition could further stress the shrubs, potentially leading to their death. Such a loss of shrubs could adversely affect valley elderberry longhorn beetle (Talley and Hollyoak 2009). The potential effects of dust on valley elderberry longhorn beetle will be minimized by applying water during construction activities or by presoaking work areas within 100 feet of any potential elderberry shrub habitat.

Exhaust from construction and maintenance vehicles might deposit particulates, heavy metals, and mineral nutrients that could influence the quality and quantity of elderberry shrubs and thereby affect beetle presence and abundance. A study by Talley and Hollyoak (2009) showed no relationship, however, between the distance of the shrubs from highways and the presence or abundance of the beetle.

Temporary lighting from construction activities could adversely affect valley elderberry longhorn beetle. The effects of lighting on valley elderberry longhorn beetle are unknown, although insects are known to be subject to heavy predation when they are attracted to night lighting (Eisenbeis 2006). No restoration activity will occur during nighttime hours in the vicinity of habitat for federally listed species.

5.23.9 Soft Bird's-Beak and Suisun Thistle

5.23.9.1 Bay-Delta

5.23.9.1.1 Bay-Delta Watershed

Project components that could affect these species include Suisun Marsh salinity control gates and Chipps Island restoration. Potential effects of each of these components on soft bird's-beak and Suisun thistle and the measures to avoid, minimize, or offset these effects are described below.

5.23.9.1.2 Suisun Marsh Salinity Control Gates

Under the proposed action the Suisun Marsh Salinity Control Gates (SMSCG) will be operated between June and October for no more than 60 days in wet, above-normal and below-normal Sacramento Valley Index year types. The gates would be operated to minimize seawater intrusion into Montezuma Slough and decrease salinities overall to expand the extent of suitable habitat for Delta smelt. Other than this proposed change in SMSCG operations, gate operations would be unchanged from current conditions and salinities will not be substantially changed.

UnTRIM modeling of the proposed operation of the SMSCG found salinity decreases up to 2 PSU in Montezuma Slough in August and September in dry and below-normal water years (GEI 2018). Because of the limited temporal scale of the proposed action (60 days), the limited temporal overlap between the proposed action and the typical flooding regime for diked wetlands, the variability of existing salinities as well as the variability created between years when the proposed action is implemented and years when it is not; the salinity variability in the winter and spring (when there are no effects from the proposed action but when diked wetland flooding occurs), and the requirements to maintain adherence with RWQCB water quality requirements, the effects from SMSCG operations would reduce salinities by no more than 2% in above-normal and below normal water years. Because salinity levels of the habitat in which soft bird's-beak or Suisun thistle would not be substantially altered, the proposed operation of the SMSCG would not be likely to affect either species.

5.23.9.1.3 Tidal Habitat Restoration

The proposed action will convert the 450-acres of nontidal wetlands in the northern property to tidal action and may implement enhancement actions on the 250-acre southeastern parcel that is currently exposed to muted tidal action. Chipps Island occurs within the range of soft bird's-beak. However, neither soft bird's-beak nor Suisun thistle occur on Chipps Island. Therefore, habitat restoration at Chipps Island would not affect either soft bird's-beak or Suisun thistle. Restoration of tidal habitat at this site potentially could provide habitat where soft bird's-beak or Suisun thistle could be introduced, which would be a beneficial effect.

5.23.9.1.4 Bradmoor Island Habitat Restoration

The proposed action will restore tidal inundation to approximately 500 acres of managed wetlands and enhance and protect another 115 acres of existing tidal habitat. Bradmoor Island occurs within the range of soft bird's-beak. However, neither soft bird's-beak nor Suisun thistle occur on Bradmoor Island. Therefore, habitat restoration at Bradmoor Island would not affect either soft bird's-beak or Suisun thistle. Restoration of tidal habitat at this site potentially could provide habitat where soft bird's-beak or Suisun thistle could be introduced, which would be a beneficial effect.

5.23.9.1.5 Dutch Slough Habitat Restoration

The proposed action will restore 1,187 acres of Delta habitats on three leveed parcels adjacent to Dutch Slough. This area is outside of the ranges for Soft bird's-beak and Suisun thistle, and the proposed action would not affect either soft bird's-beak or Suisun thistle.

5.23.9.1.6 Hill Slough Habitat Restoration

The proposed action will restore tidal marsh on 750 acres of managed wetlands and enhance 200 acres of upland managed wildlife habitat. This area is within the range of both Soft bird's-beak and Suisun thistle, although neither species is known to occur within the action area. The proposed action is not likely to directly affect either species. However, restoration of tidal habitat at this site potentially could provide habitat into which soft bird's-beak or Suisun thistle could spread or where the species could be introduced, which would be a beneficial effect.

5.23.9.1.7 Lower Yolo Ranch Habitat Restoration

The proposed action will restore about 1,670 acres of tidal wetlands on a site which has historically been used for cattle grazing. This area is outside of the ranges for Soft bird’s-beak and Suisun thistle, and the proposed action would not affect either soft bird’s-beak or Suisun thistle.

5.23.9.1.8 Winter Island Habitat Restoration

The proposed action will restore tidal action on 589 acres of habitat on Winter Island. Winter Island occurs within the range of soft bird’s-beak. However, neither soft bird’s-beak nor Suisun thistle occur on Winter Island. Therefore, habitat restoration at Winter Island would not affect either soft bird’s-beak or Suisun thistle. Restoration of tidal habitat at this site potentially could provide habitat where soft bird’s-beak or Suisun thistle could be introduced, which would be a beneficial effect.

5.23.9.1.9 Proposed Flow Changes

See the previous discussion regarding flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In Suisun Marsh, the methodology must be altered somewhat to reflect the complex effects of flow manipulation in the Delta and Suisun Marsh. In Suisun Marsh, the WOA scenario would cease operations of the Suisun Marsh Salinity Control Gates. This would lead to a more varied salinity regime within the Marsh, resulting in changes in marsh vegetation that would persist until the vegetation adapted to the new salinity and flow regime. This would likely render some areas of soft bird’s-beak nor Suisun thistle habitat unsuitable, potentially extirpating occurrences of these plants, while also creating new areas of suitable habitat. To the extent that soft bird’s-beak or Suisun thistle could not disperse to accommodate these habitat changes, or were adversely affected by short-term losses in suitable habitat, mortality would result, possibly with long-term effects on genetic diversity and population structure. Conversely, as described above in Section 5.24.3.1.1 *Suisun Marsh Salinity Control Gates*, changes under the PA scenario would be negligible relative to COS, with little potential for the PA to modify habitat or otherwise harm soft bird’s-beak or Suisun thistle.

5.23.10 Vernal Pool Fairy Shrimp and Vernal Pool Tadpole Shrimp

Project components with the potential to affect vernal pool fairy shrimp and vernal pool tadpole shrimp are associated with *Tidal Habitat Restoration.* Reclamation will, however, avoid disturbance of vernal pools that are occupied or assumed to be occupied, including a 250-foot buffer of upland around the pools, for the restoration projects.

5.23.11 California Tiger Salamander

Project components with the potential to affect California tiger salamander are associated with Tidal Habitat Restoration and Conservation Fish Hatchery. Reclamation will, however, avoid disturbance of potentially occupied California tiger salamander habitat for this restoration.

5.23.12 California Least Tern

Project components with the potential to affect California least tern are associated with Tidal Habitat Restoration. Although most of the project components could affect aquatic areas that provide California least tern foraging habitat, these activities are not expected to adversely affect the species, since foraging habitat is readily available and the restoration and enhancement projects are expected to increase food supply. Proposed flow changes under the proposed action likewise have little potential to alter extent or quality of habitat available to the California least tern. Reclamation will avoid disturbance of any

California least tern nesting colony sites. The proposed action is therefore expected to have a net beneficial effect on the species.

5.23.13 California Red-Legged Frog

Project components with potential to affect California red-legged frog are associated with *Spawning and Rearing Named Projects* in the Upper Sacramento River Watershed. Although these components occur within the historic range of the species, there are no known populations within these areas and Reclamation has conducted surveys for California red-legged frog to support past spawning and rearing projects along the Sacramento River, south of Shasta Dam, and have not observed the species. Therefore, the likelihood of species occupancy of habitats along the Sacramento River downstream of Shasta Dam is discountable.

5.24 Effects on Terrestrial Species Critical Habitat

Federally listed species with critical habitat in the Action Area include western yellow-billed cuckoo, California red-legged frog, California tiger salamander, valley elderberry longhorn beetle, vernal pool fairy shrimp, vernal pool tadpole, soft bird’s-beak, and Suisun thistle. Effects on critical habitat will be avoided for all these species except western yellow-billed cuckoo. Effects are described below.

5.24.1 Western Yellow-Billed Cuckoo Proposed Critical Habitat

Western yellow-billed cuckoo proposed critical habitat is present in Tisdale Bypass and Sutter Bypass. However, Reclamation’s proposed action does not modify flows in the Tisdale or Sutter Bypasses. Changes in frequency of inundation in the Sacramento River would be minor, and within the current minimum and maximum flows. The proposed action could provide for some different riparian species that require year-round flows, as compared to WOA, where low flows in the fall would stress invasive plants and encourage drought tolerant native species to persist.

The average monthly flows under adjusted CP4A were similar (5% or less difference) to the proposed action in June-August. The average flows generally increase in September (by 44%) and November (by 30%) and decrease in December-May (by at most 19%) with a raised Shasta Dam (adjusted CP4A) compared to the proposed action model results. The operation of a Shasta Dam raise is not anticipated to change the minimum or maximum flows in the Sacramento River.

5.24.2 Valley Elderberry Longhorn Beetle

Critical habitat for valley elderberry longhorn beetle is present along the American River. However, Reclamation will avoid valley elderberry longhorn critical habitat. Therefore, there is no effect to valley elderberry longhorn beetle critical habitat.

5.24.3 Vernal Pool Fairy Shrimp and Vernal Pool Tadpole Shrimp

Critical habitat for vernal pool fairy shrimp and vernal pool tadpole shrimp is present in areas that Reclamation could potentially use for Tidal Habitat Restoration. Reclamation will, however, avoid areas that would affect the primary constituent habitat elements for these species in the critical habitat units. Therefore, the proposed action has no effect on critical habitat for these species.

5.24.4 California Tiger Salamander

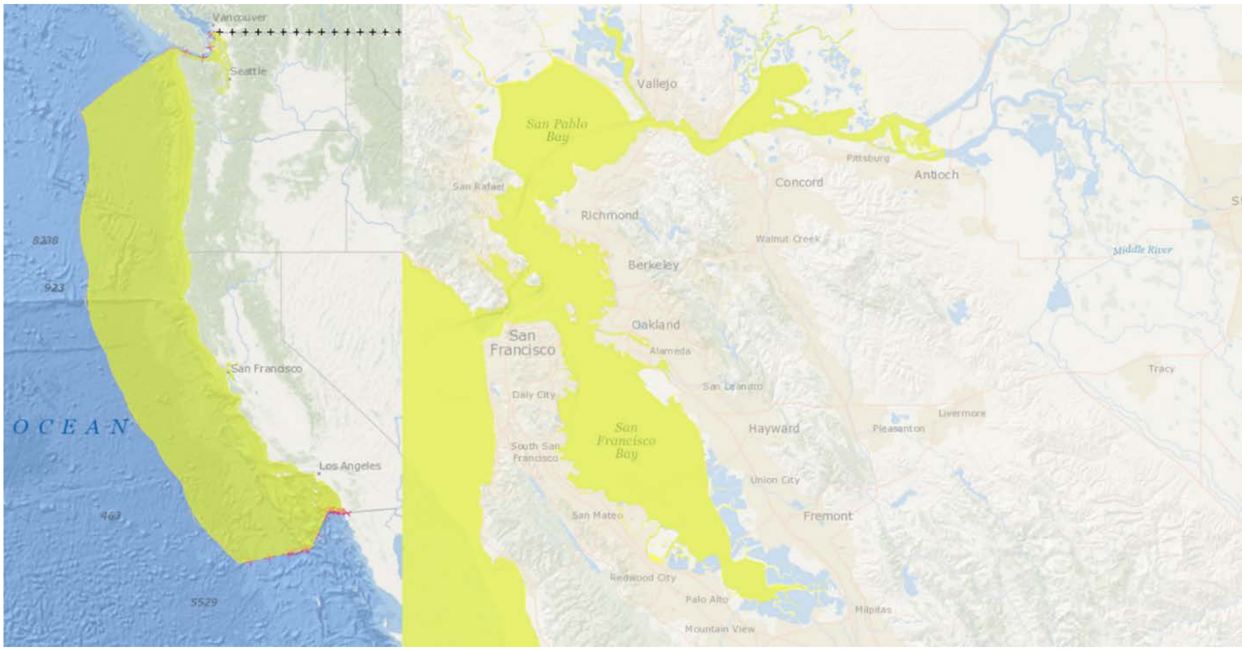
Critical habitat for California tiger salamander is present in areas that Reclamation could potentially use for Tidal Habitat Restoration. Reclamation will, however, avoid areas that would affect the primary constituent habitat elements for this species in the critical habitat units.

5.25 Essential Fish Habitat

The action area encompasses designated EFH for Pacific Coast Salmon (Figure 5.25-1), Coastal Pelagic Species (Figure 5.25-2), and Pacific Coast Groundfish (Figures 5.25-3 and 5.25-4). There is a number of species included in these groups that could be present in the action area (Table 5.25-1). The analyses below generally focus on species that are likely to be abundant (relative to other species within each group) in the main portion of the action area that could be affected by the proposed action, i.e., Pacific Coast Salmon: Sacramento River Winter-run Chinook Salmon, Central Valley Spring-run and Fall-run/Late Fall-run Chinook Salmon, Upper Klamath-Trinity Rivers Fall-run and Spring-run Chinook Salmon, Southern Oregon-Northern California Coastal Chinook Salmon, and Southern Oregon-Northern California Coast Coho Salmon; Coastal Pelagic Species: Northern Anchovy; and Pacific Coast Groundfish: Starry Flounder.

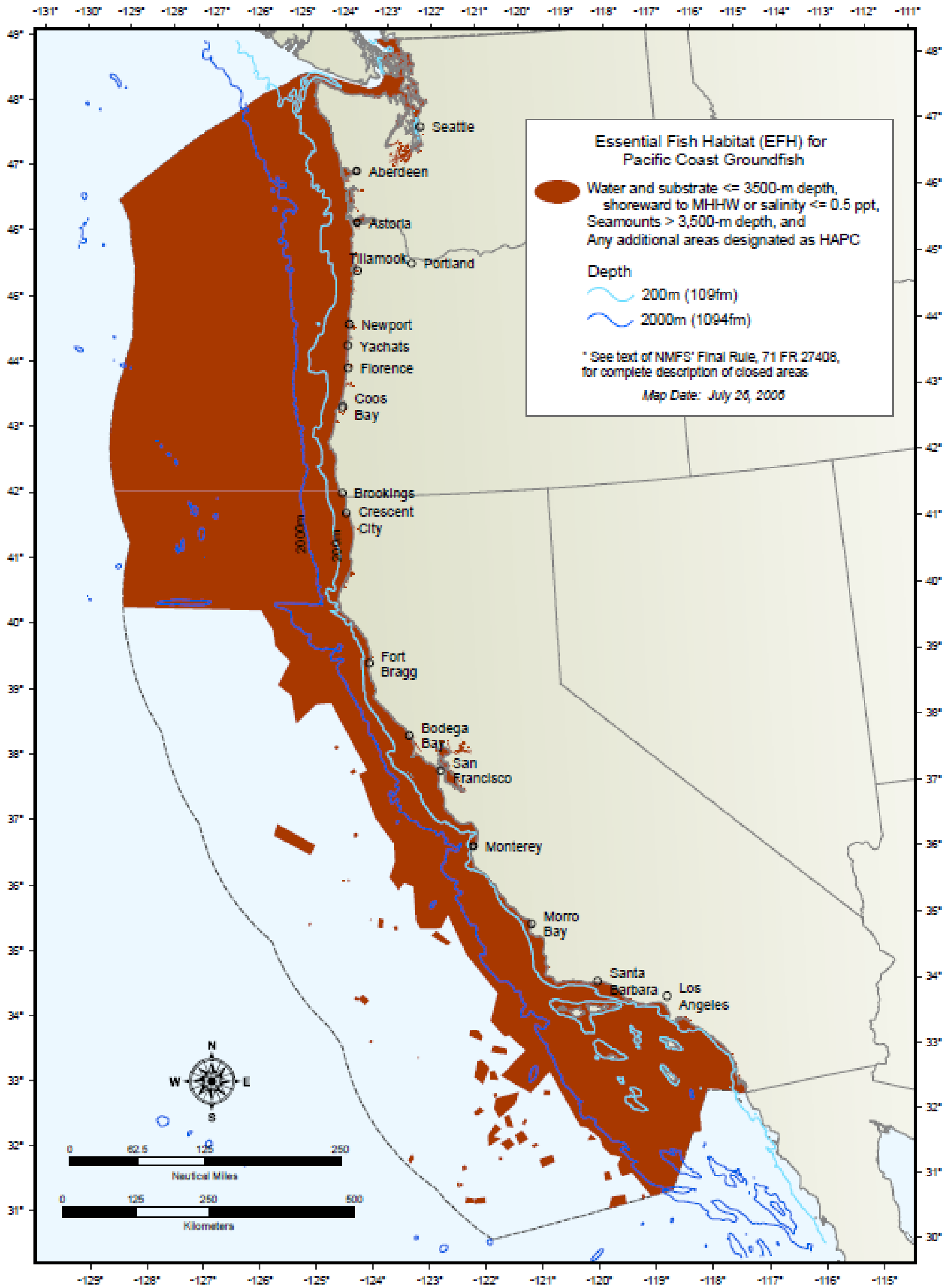
Source: https://www.westcoast.fisheries.noaa.gov/publications/habitat/essential_fish_habitat/west_coast_salmon_efh_2014__1_.pdf . Accessed: December 20, 2018.

Figure 5.25-1. Essential Fish Habitat for Pacific Coast Salmon



Source: https://www.habitat.noaa.gov/protection/efh/efhmapper/ Accessed: December 20, 2018. Note: Left map shows full extent of Coastal Pelagic Species EFH; right map includes main portion of EFH in the San Francisco Bay-Delta (there is no EFH in the Lower Klamath River, so that area is not included).

Figure 5.25-2. Essential Fish Habitat for Coastal Pelagic Species in the Vicinity of the Action Area



Source: https://www.westcoast.fisheries.noaa.gov/publications/gis_maps/maps/groundfish/map-gfish-efh.pdf Accessed: December 19, 2018.

Figure 5.25-3. Essential Fish Habitat for Pacific Coast Groundfish

Table 5.25-1. Essential Fish Habitat Species Potentially Present in the Action Area, with Focal Species in Bold

Species or FMP	**Common Name**	**Scientific Name**	**Comment**
Coastal Pelagic Species	Jack Mackerel	*Trachurus symmetricus*	Present; eggs & larvae
Coastal Pelagic Species	Northern Anchovy	*Engraulis mordax*	Abundant; eggs, larvae, juveniles & adults
Coastal Pelagic Species	Pacific Sardine	*Sardinops sagax*	Rare; juveniles & adults
Pacific Coast Groundfish FMP	Big Skate	*Raja binoculata*	Present; juveniles & adults
Pacific Coast Groundfish FMP	Bocaccio	*Sebastes paucispinis*	Rare; juveniles
Pacific Coast Groundfish FMP	Brown Rockfish	*Sebastes auriculatus*	Abundant; juveniles & adults
Pacific Coast Groundfish FMP	Cabezon	*Scorpaenichthys* spp.	Rare; juveniles & adults
Pacific Coast Groundfish FMP	Curlfin Sole	*Pleuronichthys decurrens*	Present; juveniles
Pacific Coast Groundfish FMP	English Sole	*Pleuronectes vetulus*	Abundant; juveniles & adults
Pacific Coast Groundfish FMP	Kelp Greenling	*Hexagrammos* spp.	Present; juveniles & adults
Pacific Coast Groundfish FMP	Leopard Shark	*Triakis semifasciata*	Present; juveniles & adults
Pacific Coast Groundfish FMP	Lingcod	*Ophiodon elongatus*	Present; juveniles & adults
Pacific Coast Groundfish FMP	Pacific Sanddab	*Citharichthys sordidus*	Present; eggs, larvae, juveniles & adults
Pacific Coast Groundfish FMP	Pacific Whiting (Hake)	*Merluccius productus*	Present; eggs & larvae
Pacific Coast Groundfish FMP	Sand Sole	*Psettichthys melanostictus*	Present; larvae, juveniles & adults
Pacific Coast Groundfish FMP	Soupfin Shark	*Galeorhinus zyopterus*	Present; juveniles & adults

Species or FMP	Common Name	Scientific Name	Comment
Pacific Coast Groundfish FMP	Spiny Dogfish	*Squalus acanthias*	Present; juveniles & adults
Pacific Coast Groundfish FMP	Starry Flounder	*Platichthys stellatus*	Abundant; eggs, larvae, juveniles & adults
Pacific Coast Salmon FMP	Chinook Salmon	*Oncorhynchus tshawytscha*	Abundant; eggs, larvae, juveniles & adults
Pacific Coast Salmon FMP	Coho Salmon	*Oncorhychus kisutch*	Present; eggs, larvae, juveniles & adults

Source: Adapted from NMFS (2017, p.1211).

5.25.1 Pacific Coast Salmon

Pacific Coast Salmon EFH includes the entire action area (Figure 5.25-1).

5.25.1.1 Effects of Operation

Operations of the proposed action have the potential to positively and negatively affect Pacific Coast Salmon EFH. Detailed analyses for *Flow-Dependent Actions* were previously described for Central Valley Chinook Salmon stocks, i.e., Winter-run, Spring-run, and Fall-run/Late Fall-run. Potential positive effects of the proposed action relative to the without action generally would occur as a result of reservoir storage allowing summer/fall releases to maintain favorable temperature conditions for early life stages, as exemplified for Winter-run Chinook Salmon in the Sacramento River below Keswick Dam (see Section 5.2.1.2.1 *Flow-Dependent Actions*). Potential negative effects of the Core Water Operation generally could occur during winter and spring, particularly the latter, which coincides with the main period of juvenile downstream migration and is when flow is often appreciably lower under the proposed action compared to the without action. These factors could affect juvenile salmon travel time and survival, for example.

Non-flow-dependent actions' operational effects generally would be expected to have positive effects on Chinook Salmon stocks from the Central Valley, although some negative effects are also possible, as discussed in species sections above.

5.25.1.2 Effects of Conservation Measures

As discussed in species sections above, the various proposed construction activities potentially could result in direct or indirect alteration in the quantity and quality of Pacific Coast Salmon EFH, but generally would provide beneficial long-term effects. Effects include temporary loss of aquatic and riparian habitat leading to increased predation and reduced food availability; degraded water quality from contaminant discharge by heavy equipment and soils, and increased discharges of suspended solids and turbidity, leading to direct toxicological impacts on fish health/performance, indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), loss of aquatic vegetation providing physical shelter, and reduced foraging ability caused by decreased visibility; impediments and delay in migration caused by elevated noise levels from machinery; and direct injury or mortality from in-water equipment strikes or isolation/stranding within dewatered cofferdams. These potential effects would be minimized through restriction of in-water work to windows limiting exposure by reducing potential for spatiotemporal overlap, and implementation of other AMMs to minimize the potential for effects when species do overlap with in-water work. In the long-term, the conservation measures proposed in this document should improve the extent and quality of EFH by increasing spawning and rearing habitat in the Sacrament, American, and Stanislaus Rivers.

5.25.1.3 Effects of Maintenance

Implementation of the species avoidance and take minimization steps described in Appendix C, *ROC Real Time Water Operations Charter* in section *Routine Operations and Maintenance on CVP Activities* would be anticipated to minimize potential negative effects to Pacific Coast Salmon EFH from maintenance activities.

5.25.1.4 Effects of Monitoring Activities

It is anticipated that there would be minimal negative effects of monitoring activities on Pacific Coast Salmon EFH, given the limited spatial extent of habitat that would be affected by activities such as trawling, seining, or operating video weirs, for example. Monitoring activities are summarized in Appendix C, *ROC Real Time Water Operations Charter* in section *Monitoring Program for Core CVP and SWP Operation*.

5.25.2 Coastal Pelagic Species

Coastal Pelagic Species EFH in the action area includes the action area upstream to the western Delta (lower Sacramento and San Joaquin Rivers), but not the Lower Klamath River (Figure 5.25-2).

5.25.2.1 Effects of Operation

Coastal Pelagic Species EFH could be subject to operational effects of the proposed action's Core Water Operation as it pertains to Delta outflow and its effect on the salinity field. However, the effects on salinity would be small relative to the salinity tolerance of Coastal Pelagic Species EFH such as Northern Anchovy (Baxter et al. 1999). Kimmerer et al. (2009) showed for Northern Anchovy that neither indices of habitat extent nor indices of abundance were related to X2, an index of Delta outflow and its effects. There is a large amount of Coastal Pegalic Species EFH relative to the action area (Figure 5.25-3).

5.25.2.2 Effects of Conservation Measures

Construction of proposed action components generally would be upstream of Coastal Pelagic Species EFH. Depending on the location of tidal marsh habitat restoration, there may be some construction effects from this component of the proposed action, for example if restoration sites border Suisun Bay or are on the lower Sacramento and San Joaquin Rivers. Depending on the specifics of the work, and as previously described for Pacific Coast Salmon, effects to Coastal Pelagic Species EFH could include factors such as temporary loss of aquatic habitat leading to increased predation and reduced food availability; degraded water quality from contaminant discharge by heavy equipment and soils; impediments and delay in migration caused by elevated noise levels from machinery; and direct injury or mortality from in-water equipment strikes or isolation/stranding within dewatered cofferdams. Implementation of AMMs (see Appendix E, *Avoidance and Minimization Measures*) would avoid and minimize potential effects to Coastal Pelagic Species EFH.

5.25.2.3 Effects of Maintenance

Implementation of the species avoidance and take minimization steps described in Appendix C, *ROC Real Time Water Operations Charter* in section *Routine Operations and Maintenance on CVP Activities* would be anticipated to minimize potential negative effects to Coastal Pelagic Species EFH from maintenance activities.

5.25.2.3.1 Effects of Monitoring Activities

It is anticipated that there would be minimal negative effects of monitoring activities on Coastal Pelagic Species EFH, given the limited spatial extent of habitat that would be affected by sampling in the Bay-Delta (in particular the Fall Midwater Trawl, 20-mm Survey, Spring Kodiak Trawl, Bay Study, Smelt Larva Survey, Summer Townet Survey, Chipps Island Trawl, Enhanced Delta Smelt Monitoring, and Environmental Monitoring Program; see Appendix E relative to the overall extent of EFH.

5.25.3 Pacific Coast Groundfish

Pacific Coast Groundfish EFH in the action area includes San Francisco Bay and Suisun Bay, but not the legal Delta (Figure 5.25-3).

5.25.3.1 Effects of Operation

As with Coastal Pelagic Species EFH, the proposed action's Core Water Operation could affect the Pacific Coast Groundfish EFH as it pertains to Delta outflow and its effect on the salinity field. However, the effects on salinity would be small relative to the salinity tolerance of Pacific Coast Groundfish EFH such as Starry Flounder (Baxter et al. 1999), and indices of habitat availability of Starry Flounder are not related to Delta outflow (expressed as X2; Kimmerer et al. 2009). Kimmerer et al. (2009) found a significant negative relationship between annual mean March–June X2 (an index of Delta outflow) and annual mean Starry Flounder bay otter trawl abundance indices, which they suggested could be related to an increase in residual circulation in the San Francisco Estuary with increasing Delta outflow; if such an increase translates to more rapid or more complete entrainment of Starry Flounder early life stages into the estuary, or more rapid transport to their rearing grounds, then presumably survival from hatching to settlement would be higher under high-flow conditions (Kimmerer et al. 2009: 385). Relative to the without action WOA scenario, the proposed action scenario has lower March–June Delta outflow and therefore higher X2 (Figure 5.25-4), potentially resulting in a negative effect to Pacific Coast Groundfish EFH as reflected by Starry Flounder abundance. There is appreciable uncertainty in this predictive relationship, however (ICF International 2016: p.5.E-34.

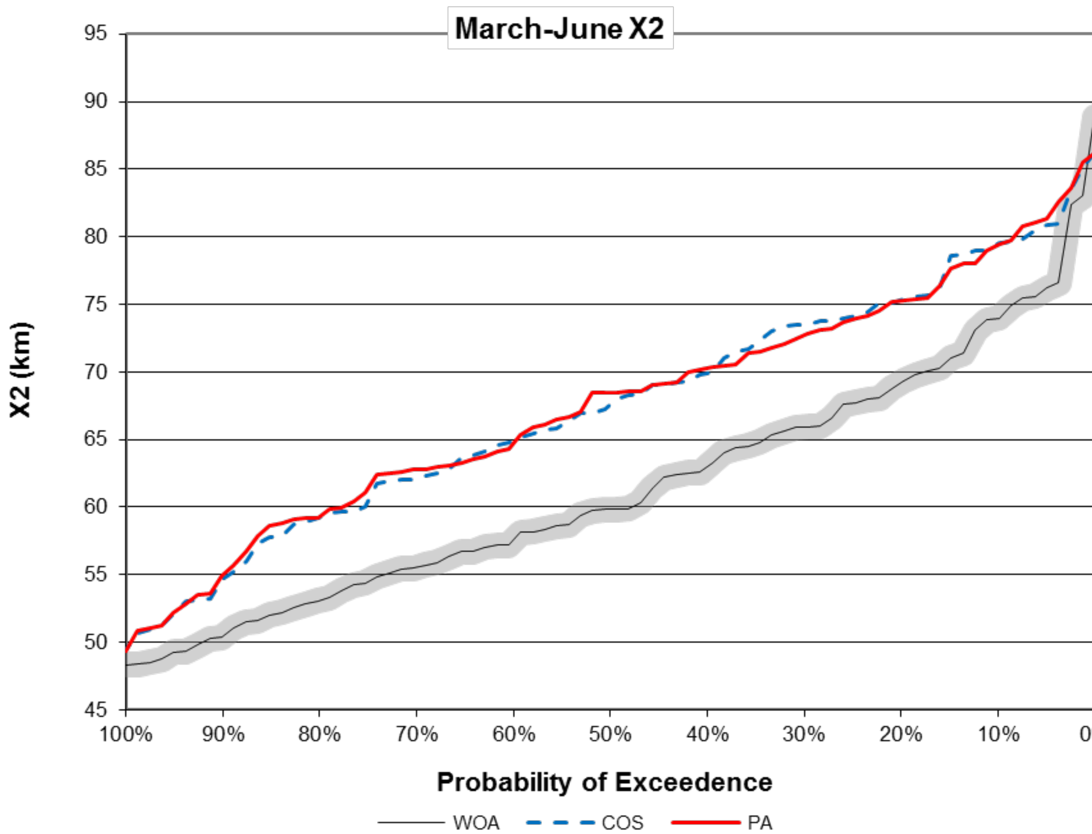


Figure 5.25-4. Mean Modeled X2, March–June

5.25.3.2 Effects of Conservation Measures

Construction of proposed action components generally would be upstream of Pacific Coast Groundfish EFH. As described for Coastal Pelagic Species EFH, there may be some construction effects from the tidal marsh habitat restoration component of the proposed action, for example if restoration sites border Suisun Bay. Depending on the specifics of the work, and as previously described for Pacific Coast Salmon, effects to Pacific Coast Groundfish EFH could include potential negative effects such as temporary loss of aquatic habitat leading to increased predation and reduced food availability; degraded water quality from contaminant discharge by heavy equipment and soils, and increased discharges of suspended solids and turbidity; impediments and delay in migration caused by elevated noise levels from machinery; and direct injury or mortality from in-water equipment strikes or isolation/stranding within dewatered cofferdams. Implementation of AMMs (see Appendix E, *Avoidance and Minimization Measures*) would avoid and minimize potential effects to Pacific Coast Groundfish EFH.

5.25.3.3 Effects of Maintenance

Implementation of the species avoidance and take minimization steps described in Appendix C, *ROC Real Time Water Operations Charter* in section *Routine Operations and Maintenance on CVP Activities* would be anticipated to minimize potential negative effects to Pacific Coast Groundfish EFH from maintenance activities.

5.25.3.4 Effects of Monitoring Activities

It is anticipated that there would be minimal negative effects of monitoring activities on Pacific Coast Groundfish EFH, given the limited spatial extent of habitat that would be affected by sampling in the Bay-Delta (in particular the Fall Midwater Trawl, 20-mm Survey, Spring Kodiak Trawl, Bay Study, Smelt Larva Survey, Summer Townet Survey, Chipps Island Trawl, Enhanced Delta Smelt Monitoring, and Environmental Monitoring Program; see Appendix C, *ROC Real Time Water Operations Charter* in section *Monitoring Program for Core CVP and SWP Operation*).

Chapter 6 Cumulative Effects

Cumulative effects, as defined by rule, are those effects of future State, tribal, local or private activities, not involving Federal activities, that are reasonably certain to occur within the Action Area of the Federal action subject to consultation (50 CFR 402.02) that USFWS and NMFS use in conducting a jeopardy analysis. For this biological assessment, these include unscreened water diversions, state or local levee maintenance, oil and gas production and powerplants, and the point and non-point source chemical contaminant discharges related to agricultural and urban land use. These actions typically result in habitat fragmentation and degradation of habitats that incrementally reduces the carrying capacity of the rearing and migratory corridors found within the action area. Cumulative effects also include the implementation of changes in state law. Several related and reasonably foreseeable future State or private projects and actions could result in impacts on Federally-listed aquatic and terrestrial biological resources considered in this biological assessment. The projects that are most likely to affect those resources are generally described below.

6.1 Unscreened Water Diversions

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the California Central Valley. Thousands of small and medium-size water diversions exist along the Sacramento River, San Joaquin River, their tributaries, and the Delta, and many of them remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions entrain and kill many life stages of aquatic species, including juvenile listed anadromous or osmeridae (smelt) species (Mussenet al. 2013, Mussen al.2014). For example, as of 1997, 98.5 percent of the 3,356 diversions included in a Central Valley database were either unscreened or screened insufficiently to prevent fish entrainment (Herren and Kawasaki 2001). This has improved due to the Anadromous Fish Screen Program (AFSP), part of CVPIA, as well as DWR’s fish screening program. While private irrigation diversions in the Delta are mostly unscreened, the total amount of water diverted onto Delta farms has remained stable for decades (Culberson et al. 2008).

6.2 Agricultural Practices

Agricultural practices may negatively affect riparian and wetland habitats through upland modifications that lead to increased siltation or reductions in water flow in stream channels flowing into the action area, including the Sacramento River, Stanislaus River, San Joaquin River, and Delta. Grazing activities from dairy and cattle operations can degrade or reduce suitable critical habitat for listed fish species by increasing erosion and sedimentation, as well as introducing nitrogen, ammonia, and other nutrients into the watershed, which then flow into receiving waters. Delta Smelt's exposure to contaminants are inherent in the Delta, ranging in the degree of effects. Sources of introduction vary from agricultural use pesticide runoff to urban wastewater treatment discharge, and other potential sources. Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may disrupt various physiological mechanisms and may negatively affect reproductive success and survival rates of listed anadromous fish (Scott and Sloman 2004). However, the State of California issues Waste Discharge Requirements (WDRs) to dischargers, including irrigators, dairy operations, and cattle operations, that require implementation of Best Management Practices (BMPs) designed to be protective of surface water quality, with benefits for listed fish species. Monitoring and reporting requirements associated with those WDRs ensure compliance with BMPs.

Agricultural practices introduce nitrogen, ammonium, and other nutrients into the watershed, which then flow into receiving waters, adding to other inputs such as wastewater treatment (Lehman et al. 2014). Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may negatively affect fish reproductive success and survival rates (Dubrovsky et al. 1998; Kuivila et al. 2004; Scholz et al. 2012). Discharges occurring outside the action area that flow into the action area also contribute to cumulative effects of contaminant exposure.

6.3 Wastewater Treatment Plants

The Sacramento Regional Wastewater Treatment Plan (SRWTP), in order to comply with Order no. R5-2013-0124, has begun implementing compliance measures to reduce ammonia discharges. Construction of treatment facilities for three of the major projects required for ammonia and nitrate reduction was initiated in March 2015 (Sacramento Regional County Sanitation District 2015). Order no. R5-2013-0124, which was modified on October 4, 2013, by the Central Valley Regional Water Quality Control Board imposed new interim and final effluent limitations, which must be met by May 11, 2021 (Central Valley Regional Water Quality Control Board 2013). By May 11, 2021, the SRWTP must meet effluent limits EPA published revised national recommended ambient water quality criteria for the protection of aquatic life from the toxic effects of ammonia in 2013. Few studies have been conducted to assess the effects of ammonia on listed fish species, although studies have been performed on surrogate non-listed fish species. Studies of ammonia effects on various fish species have shown numerous effects including membrane transport deficiencies, increases in energy consumption, immune system impairments, gill lamellae fusions deformities, liver hydropic degenerations, glomerular nephritis, and nervous and muscular system effects leading to mortality (Connon et al.2011). Additionally, a study of coho salmon and rainbow trout exposed to ammonia showed a decrease in swimming performance due to metabolic challenges and depolarization of white muscle (Wickset al.2002).

In addition to concerns about direct toxicity of ammonia to Delta Smelt, another important potential concern is that ammonium inputs have slowed diatom growth in the Delta and Suisun Bay, thereby reducing the productivity in the Delta Smelt food web (Wilkerson et al., 2006, Gilbert et al. 2011, Dugdale et al. 2016), in combination with other factors such as invasive clams.

6.4 Increased Urbanization

With a projected growth rate of 1.2% annually through 2030, California can expect to observe future increases in urbanization and housing developments (California Department of Finance 2012). Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. Increased growth will place additional burdens on resource allocations, including natural gas, electricity, and water, as well as on infrastructure such as wastewater sanitation plants, roads and highways, and public utilities.

Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. Increased growth will place additional burdens on resource allocations, including natural gas, electricity, and water, as well as on infrastructure such as wastewater sanitation plants, roads and highways, and public utilities. Some of these actions will not require Federal permits and thus will not undergo review through the Section 7 consultation process.

Adverse effects on listed fish species and their critical habitat may result from urbanization-induced point and non-point source chemical contaminant discharges within the action area. These contaminants include, but are not limited to, ammonia and free ammonium ion, numerous pesticides and herbicides, and oil and gasoline product discharges. Increased urbanization also is expected to result in increased recreational activities in the region.

6.5 Recreational Activities in the Region

Recreational boating is expected to increase in volume and frequency. Boating activities typically result in increased wave action and propeller wash in waterways. This potentially will degrade riparian and wetland habitat by eroding channel banks and mid-channel islands, thereby causing an increase in siltation and turbidity. Wakes and propeller wash also churn up benthic sediments thereby potentially resuspending contaminated sediments and degrading areas of submerged vegetation. This, in turn, would reduce habitat quality for the invertebrate forage base required for listed fish species. Increased recreational boat operation is anticipated to result in more contamination from the operation of gasoline and diesel powered engines on watercraft entering the associated water bodies.

6.6 Changes in Location, Volume, Timing, and Method of Delivery for Non-CVP/SWP Diversions

Changes in location, volume, timing, and method of delivery for non-CVP/SWP diversions may be implemented without Federal consultation. While not certain, changes may be expected to occur due to:

- Implementation of the California Sustainable Groundwater Management Act that requires development and implementation of Groundwater Sustainability Plans;
- Implementation of the California Senate Bill X7-7 provisions which require the state to achieve a 20% reduction in urban per capita water use by December 31, 2020;
- Implementation of the California 2009 Delta Reform Act (implementation of portions of the Delta Reform Act also is part of the California Water Action Plan);
- Implementation of the California Water Action Plan released by Governor Jerry Brown in January 2014, specifically, for provisions of the plan that would not necessarily require separate environmental documentation and consultation for related Federal actions.

Reduced reliance on groundwater under SGMA could result in increased surface water diversions in some cases, and associated impacts on listed species. Reduction of urban water use would be expected to have beneficial effects to listed species by reducing diversions.

6.7 Activities within the Nearshore Pacific Ocean

Future tribal, state, and local government actions will likely be in the form of legislation, administrative rules, policy initiatives, or fishing permits. Activities are primarily those conducted under state, and tribal management. These actions may include changes in ocean policy and increases and decreases in the types of activities that currently occur, including changes in the types of fishing activities, resource extraction, or designation of marine protected areas, any of which could impact listed fish species or their habitat.

6.8 Other Activities

Other future, non-Federal actions within the action area include: the dumping of domestic and industrial garbage that decreases water quality; oil and gas development and production that may affect aquatic habitat and may introduce pollutants into the water; infrastructure including roads, state and local dredging projects; and state or local levee maintenance that may also destroy or adversely affect habitat and interfere with natural, long term habitat-maintaining processes.

Power plant cooling system operations can also affect aquatic habitat. Contra Costa Power Plant, which was owned and operated by NRG Delta, LLC, was retired in 2013 and replaced with the new natural gas power plant, Marsh Landing Generating Station. The Pittsburg Generating Station (PGS) remains in operation and consisted of seven once-through cooling systems, two of which remain in operation. The once-through cooling system intake process can cause the impingement and entrainment of estuarine and marine animals, kill organisms from all levels of the food chain, and disrupt the normal processes of the ecosystem. On May 4, 2010, the SWRCB adopted a Statewide Policy on the Use of Coastal and Estuarine Water for Power Plant Cooling under Resolution No. 2010–0020, which required existing cooling water intake structures to reflect the best technology available for minimizing adverse environmental impacts (SWRCB 2010). The PGS chose to comply by retrofitting two of the existing units and retiring one unit. The retrofit and retirement of these units is underway (GenOn Delta LLC 2011). This is expected to have beneficial effects for listed species.

Chapter 7 Conclusion

The determination of effects for listed species and their designated critical habitat in this biological assessment considers direct and indirect effects of the proposed action together with the effect of other activities that are interrelated or dependent on the proposed action. This chapter presents a summary of the effects for listed species and their designated critical habitat.

This chapter also includes Reclamation's determinations under the Magnuson–Stevens Fishery Conservation and Management Act for EFH. The effects determination for EFH concludes whether or not adverse effects would occur, and whether or not the effects would be substantial.

7.1 Analytical Approach

Population and critical habitat analyses are included in this BA to assist the fishery agencies in making the determination of whether the proposed action would reasonably 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." 50 C.F.R. § 402.02; 16 U.S.C. § 1536(a)(2). Three possible determinations exist regarding a proposed action's effects on listed species:

- No effect - "No effect" is the appropriate conclusion when it is determined that the proposed action will not affect a listed species or designated critical habitat.
- "May affect, but is not likely to adversely affect" is the appropriate conclusion when effects to listed species or critical habitat are expected to be discountable (extremely unlikely to occur), insignificant (never resulting in take), or completely beneficial (positive effects without adverse effects)
- May affect, likely to adversely affect is the appropriate conclusion if any adverse effect may occur to listed species or critical habitat as a direct result of the proposed action, and the effect is not discountable, insignificant, or beneficial. If incidental take is anticipated to occur as a result of the proposed action, an "is likely to adversely affect" determination is made.

7.2 Aquatic Effects Determinations

The ongoing stressors associated with existing dams and other structures are part of the environmental baseline. Reclamation and DWR do not currently have the authority to remove these structures and alter these baseline conditions. The proposed action primarily includes coordinated long-term operation of the CVP and SWP to store, divert and convey water in accordance with existing water contracts and agreements, including water service and repayment contracts, settlement contracts, exchange contracts, and refuge deliveries, consistent with water rights and applicable laws and regulations. The proposed action also includes habitat restoration and other actions to benefit species.

In consideration of the foregoing effects assessments, incidental take could potentially occur as a result of the proposed action. A main objective in this consultation is incidental take coverage for the coordinated long-term operation of the CVP and SWP. Incidental take is 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. [50 CFR §402.02]. Take is to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect a listed species or attempt to engage in any such conduct. [ESA §3(19)] Harm means an act which actually kills or injures wildlife. Harm is further defined by USFWS to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering. Harass is defined by USFWS as actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. [50 CFR §17.3]

Although the effects analysis in Chapter 5 describes effects to listed species in a holistic, species-level manner throughout the action area, Reclamation and DWR also considered whether the effects analysis indicated effects to listed species at the individual level to determine whether incidental take coverage for the proposed action is necessary. Reclamation and DWR provide this biological assessment to help the USFWS and NMFS develop their biological opinions. The determination of jeopardy or adverse modification by USFWS and NMFS is based on the effects of the action on the continued existence of the entire population of the listed species or on a listed population, and/or the effect on critical habitat. An action that does not result in jeopardy or adverse modification can nevertheless result in incidental take. Reclamation and DWR have taken a precautionary approach to describing potential incidental take in the discussion that follows.

7.2.1 Sacramento Winter-Run Chinook Salmon ESU

The overall effects of the proposed action on Winter-Run Chinook Salmon in the Sacramento River upstream of the Delta are beneficial, and the proposed action would improve flows and water temperatures for spawning, rearing, and migration of Winter-Run Chinook Salmon compared to without action conditions. The modeling results illustrate that once the effects of the ongoing operation of the CVP and SWP are isolated from baseline conditions that include construction of the CVP and SWP facilities and other stressors, the operation of the CVP and SWP provides the necessary cold water to ensure adequate pre-spawning, spawning, and incubation conditions for Winter-Run Chinook Salmon. These improvements in water temperature management under the proposed action, including operation of the Shasta TCD, provide for cold water to maintain egg incubation and avoid temperature dependent mortality. The impacts of increased summer and fall flows under the proposed action would be beneficial for egg and alevin survival. Under without action conditions, it is likely Winter-Run Chinook Salmon would not exist in the mainstem upper Sacramento River.

The proposed action provides substantial beneficial conditions, including water temperatures that allow Winter-Run Chinook Salmon to persist despite the existence of dams and other stressors. The benefits of the lower summer and fall water temperatures under the proposed action outweigh potential adverse effects of higher winter water temperatures because the summer and fall temperatures are often near critical temperature thresholds and, therefore, more of a limiting factor. Also, the juveniles are at their youngest and therefore most vulnerable during summer and fall. These results indicate that water temperatures under the proposed action provide benefits to rearing juvenile Winter-Run Chinook Salmon in the upper Sacramento River.

The proposed action would have higher flows during summer, when flow is generally low and potentially limiting Winter-Run Chinook Salmon holding and spawning success. Additionally, the proposed action would allow for higher fall flows, leading to less dewatering, more food, rearing habitat, and cover. Spring pulse flows under the proposed action would trigger outmigrating juveniles and adults migrating upstream in late spring and provide benefits to multiple life stages.

The higher than ideal May water temperatures in the middle Sacramento River under the proposed action would be likely to negatively impact Winter-run Chinook Salmon adults migrating at that time in the middle Sacramento River, even though the proposed action would improve water temperatures over baseline conditions.

Incidental take of individual members of the species associated with the proposed action result from entrainment, impingement, and predation at the Delta pumps and other diversions, and changes in flows that may affect migratory success. Operation of the DCC gates would entrain juvenile Winter-Run Chinook Salmon into the central and south Delta. Analysis shows entrainment loss rates for Winter-Run Chinook Salmon would be low. The measures included in the proposed action provide for Delta operations to minimize salvage and other effects related to exports.

Conservation measures, such as rice decomposition smoothing, spring management of spawning locations, intakes at Wilkins Slough, Shasta Temperature Control Device Improvements, habitat restoration projects, trap and haul, predator hot spot removal, DCC improvements, Tracy and Skinner improvements, and small screen improvements would be beneficial to Winter-Run Chinook Salmon.

Winter-Run Chinook Salmon adults, eggs, and alevins would be temporarily subject to potential adverse effects from proposed spawning and rearing habitat restoration projects in the upper Sacramento River associated with the proposed action. Construction activities could result in mortality of eggs and alevins by crushing if heavy equipment enters the stream channel or otherwise disturbs existing redds during in-water activities. Eggs and alevins could also be negatively impacted by increases in suspended sediment, turbidity, and contaminant exposure risk, leading to indirect impacts on individuals from reductions in habitat quality in the redd or direct impacts from sublethal and lethal exposures to contaminants. Although these potential effects may be unavoidable, exposure to construction effects would be low based on the limited extent of proposed restoration relative to the overall distribution of spawning adults and the implementation of other AMMs. These projects would be implemented for the benefit of salmonids, including Winter-Run Chinook Salmon, and these effects would be temporary and minimized through AMMs.

In summary, there may be incidental take associated with the proposed action through:

- Redd dewatering and temperature dependent mortality based on in-season adjustments to operations.
- Spawning and rearing habitat restoration projects in Shasta and Tehama counties.
- Clifton Court aquatic mechanical weed removal and predator management.
- Capture and harassment of fish at the Tracy Fish Collection Facility and Skinner Fish Protective Facility.
- Juveniles exposed to screened diversions on the Sacramento River to the Delta, which could result in harassment, injury or mortality.
- Cumulative direct and indirect loss associated with export operations including loss in south Delta interior, loss at export facilities, altered hydrodynamics, and operation of the DCC. Loss from entrainment, impingement, and predation at the Delta pumps, could occur and migration success may be affected by changes in flows.
- Diversion of water through the Rock Slough Intake up to the maximum capacity of the intake (350 cfs) for the maximum annual diversion of 195 TAF.
- Monitoring activities supporting the proposed action may result in harassment or mortality.

Therefore, while the proposed action is likely to have overall beneficial effects, it is also likely to adversely affect individual salmon in the Sacramento River Winter-Run Chinook Salmon ESU.

7.2.2 Sacramento Winter-Run Chinook Salmon Critical Habitat

The proposed action would have no adverse water temperature-related effect on access to spawning areas (PBF1) in Winter-Run Chinook Salmon critical habitat. The effect of the proposed action on the availability of clean gravel for spawning substrate (PBF2) is uncertain. Natural pulse flows would be larger and less frequent under the proposed action which could result in less flushing flows. However, if flows are too large they could lead to transport of gravel without recruitment. The effects of the proposed action on PBF3 are uncertain. The proposed action is expected to substantially benefit river flows for successful spawning, incubation, and emergence; however, would reduce downstream transport and environmental cues for emigrating juveniles (PBF3). The proposed action would have benefits related to water temperatures for spawning, incubation, and development (PBF4). Riparian vegetation would establish (PBF6) less during winter under the proposed action. The proposed action would provide less favorable conditions for emigrating juveniles during winter and early spring (PBF7), because proposed action flows would be lower, but would provide more favorable conditions in the summer months because proposed action flows would be higher. The proposed action is not expected to negatively impact downstream access in critical habitat for juvenile Winter-Run Chinook Salmon emigrating down river.

Spawning and rearing habitat restoration projects in the upper Sacramento River may cause temporary localized adverse effects but are expected to result in long-term beneficial effects to critical habitat for Winter-Run Chinook Salmon.

The proposed action would have beneficial or no adverse effect on numerous PBFs Winter-Run Chinook Salmon critical habitat relative to without action conditions. Beneficial effects include flows and water temperatures important for several PBFs. However, effects to some PBFs remain uncertain. The proposed action could reduce riparian vegetation establishment (PBF6) and provides less flows for emigrating juveniles during winter and early spring (PBF7). Overall the proposed action provides benefits to Sacramento River Winter-Run Chinook Salmon critical habitat.

7.2.3 Sacramento Winter-Run Chinook Salmon Incidental Take Considerations

Conservation measures and other beneficial actions provided in this biological assessment for NMFS to consider when developing an Incidental Take Statement include:

- Number of Winter-Run Chinook Salmon redds below the Clear Creek Confluence and proposed action measures to optimize the use of the available cold water pool under the different “Tiers” to protect the majority of redds, target critical life stages, and avoid releases for water temperatures outside of the spawning areas when cold water is limited.
- Operation of fish screens at Red Bluff Pumping Plant and the Rock Slough Diversion.
- Operation of the DCC based on near real-time monitoring of juvenile presence.
- Management of OMR reverse flows based on near real-time monitoring, fish behavioral cues, predictive tools, and salvage.
- Operation of the Tracy and Skinner salvage facilities.
- Increased production in drought years at the Livingston-Stone National Fish Hatchery.

Reclamation anticipates continued collaboration in a science enterprise to implement and evolve the SAIL monitoring program as well as ongoing restoration and recovery actions developed in collaborative forums using Structured Decision Making. Reclamation and DWR-led efforts welcome NMFS participation, and would include progress reports in annual reporting under the ITS.

7.2.4 Chinook Salmon, Central Valley Spring-Run ESU

Overall effects of the proposed action on Central Valley Spring-Run Chinook Salmon upstream of the Delta are beneficial. The proposed action provides substantial beneficial conditions, including water temperatures that allow Spring-run Chinook Salmon to persist despite the existence of dams and other stressors. The proposed action would improve flows and water temperatures for spawning and incubation compared to without action conditions in the upper and middle Sacramento and Feather Rivers along with Clear Creek. The proposed action also provides adequate flows for rearing and migration of juveniles in the middle Sacramento and lower American rivers from the Central Valley out to the ocean. Higher flows in some years under the proposed action benefit adult Spring-Run Chinook Salmon migrating in the middle Sacramento River and holding in the upper river by enhancing water quality and upstream passage, and reducing stranding, straying, poaching, and disease risks. The modeling results illustrate that once the ongoing operation of the CVP and SWP are isolated from baseline conditions that include construction of the CVP and SWP facilities and other stressors, the CVP and SWP provide necessary cold water and flow to ensure adequate conditions for Spring-Run Chinook Salmon. Under without action conditions, it is likely Spring-Run Chinook Salmon would not exist in the mainstem upper Sacramento River.

The proposed action includes many beneficial aspects that are aimed at improving the status of Spring-Run Chinook Salmon. These conservation measures include habitat restoration projects, predator hot spot removal, DCC improvements, Tracy and Skinner improvements and small screen improvements. Conservation measures may expose individuals to detrimental effects; however, these actions would provide benefits to Chinook salmon and would offset the adverse effects from operations in the Delta.

Spring-Run Chinook Salmon adults, eggs, and alevins would be temporarily subject to potential adverse effects from proposed spawning and rearing habitat restoration projects in the upper Sacramento River associated with the proposed action. Construction activities could result in mortality of eggs and alevins by crushing if heavy equipment enters the stream channel or otherwise disturbs existing redds during in-water activities. Eggs and alevins could also be negatively impacted by increases in suspended sediment, turbidity, and contaminant exposure risk, leading to indirect impacts on individuals from reductions in habitat quality in the redd or direct impacts from sublethal and lethal exposures to contaminants. Although these potential effects may be unavoidable, exposure to construction effects would be low based on the limited extent of proposed restoration relative to the overall distribution of spawning adults and the implementation of other AMMs. These projects would be implemented for the benefit of salmonids, including Spring-Run Chinook Salmon, and potential adverse effects would be temporary and minimized through AMMs.

In summary, there may be incidental take associated with the proposed action through:

- Redd dewatering and temperature dependent mortality based on in-season adjustments to operations.
- Spawning and rearing habitat restoration projects in Shasta and Tehama counties.
- Clifton Court aquatic mechanical weed removal and predator management

- Capture and harassment of fish at the Tracy Fish Collection Facility and Skinner Fish Protective Facility.
- Juveniles exposed to screened diversions on the Sacramento River to the Delta, which could result in harassment, injury or mortality.
- Cumulative direct and indirect loss associated with export operations including loss in south Delta interior, loss at export facilities, altered hydrodynamics, and operation of the DCC. Loss from entrainment, impingement, and predation at the delta pumps, could occur and migration success may be affected by changes in flows.
- Diversion of water through the Rock Slough Intake up to the maximum capacity of the intake (350 cfs) for the maximum annual diversion of 195 TAF.
- Monitoring activities supporting the proposed action may result in harassment or mortality.

Therefore, while the overall effects of the proposed action are beneficial, the proposed action is likely to adversely affect individual salmon in Central Valley Spring-Run Chinook Salmon ESU.

7.2.5 Chinook Salmon, Central Valley Spring-Run ESU Critical Habitat

Critical habitat for Spring-Run Chinook Salmon is defined as specific areas that contain the PBFs and physical habitat elements essential to the conservation of the species. Within the range of the Spring-Run Chinook Salmon ESU, biological features of the designated critical habitat that are considered vital for Spring-Run Chinook Salmon include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine areas, and nearshore marine areas. Nearshore marine areas are not discussed further since the habitat is not affected by the proposed action. There are likely to be adverse effects to certain PBFs of Spring-Run Chinook Salmon designated critical habitat resulting from the proposed action. However, those effects are uncertain. These include effects to freshwater rearing habitat and estuarine habitat. However, once the ongoing operation of the CVP and SWP are isolated from baseline conditions that include construction of the CVP and SWP facilities and other stressors, the proposed action is expected to benefit spawning habitat allowing the species to persist to other life stages and habitats. The proposed action also includes additional beneficial actions that would improve habitat conditions, such as geomorphic flows and gravel augmentation. Therefore, Reclamation has determined that the proposed action would have overall long term beneficial effects on the designated critical habitat. Core and programmatic actions, such as habitat restoration and facility construction, may cause temporary localized adverse effects but are expected to result in long-term beneficial effects to PBFs for Central Valley Spring-Run Chinook Salmon critical habitat.

7.2.6 Central Valley Spring-Run Chinook Salmon Incidental Take Considerations

Conservation measures and other beneficial actions provided in this biological assessment for NMFS to consider when developing an Incidental Take Statement for Spring-Run Chinook Salmon include:

- Operation of fish screens at Red Bluff Pumping Plant and the Rock Slough Diversion.
- Management of OMR reverse flows based on near real-time monitoring, fish behavioral cues, predictive tools, and salvage.
- Operation of the Tracy and Skinner salvage facilities.
- Spring Pulse Flows for Spring-Run Chinook Salmon.

Reclamation anticipates continued collaboration in a science enterprise to implement and evolve the SAIL monitoring program as well as ongoing restoration and recovery actions developed in collaborative forums using Structured Decision Making. Watershed specific programs include the Clear Creek Restoration Program and San Joaquin River Restoration Program. Reclamation and DWR-led efforts welcome NMFS participation, and would include progress reports in annual reporting under the ITS.

7.2.7 Steelhead, Central Valley DPS

Overall effects of the proposed action on Central Valley Steelhead are beneficial. The modeling results illustrate that once the ongoing operation of the CVP and SWP are isolated from baseline conditions that include construction of the CVP and SWP facilities and other stressors, the CVP and SWP provide necessary cold water and flow to ensure adequate conditions for CV Steelhead. The proposed action will improve flows and water temperatures for spawning and incubation in the American River, upper and middle Sacramento and Feather Rivers along with Clear Creek.

The proposed action provides substantial beneficial conditions, including water temperatures that allow CV Steelhead to persist despite the existence of dams and other stressors throughout the year. Operating the temperature control devices on Shasta and Folsom dams would have beneficial effects under the proposed action. With higher reservoir storage and water temperature management actions, suitable water temperatures would be maintained through the primary CV Steelhead spawning and incubation period (January through April). Lower water temperatures under the proposed action would extend the period of suitable incubation temperatures into April. Based on the CV Steelhead spawning WUA curves for the upper Sacramento River, lower winter and spring flows under the proposed action are expected to increase spawning habitat suitability (velocity) relative to without action conditions in the mainstem Sacramento River; however, CV Steelhead do not usually spawn in the mainstem Sacramento River, but rather spawn in its tributaries.

The proposed action would result in reduced spring flows when compared to without action conditions, which are likely to affect rearing and migrating CV Steelhead and their habitat. Effects include a decrease in floodplain and side-channel habitat, reduced foraging conditions, increased competition and predation, higher water temperatures and lower DO, and reduced emigration flows. Under without action conditions, CV Steelhead completing their lifecycle in the American River, upper and middle Sacramento River, Stanislaus and Feather Rivers along with Clear Creek would not likely survive the high summer water temperatures compared to the proposed action. Several conservation measures proposed would reduce impacts of reduced spring flows on CV Steelhead juveniles. These include pulse flows from Shasta and Folsom Reservoirs, spawning and rearing habitat enhancement on the Sacramento, American, and Stanislaus rivers, cold water pool management tools and infrastructure, predator hot spot removal and the small screen program. OMR management establishes generally protective criteria to avoid entrainment.

Potential short-term adverse effects could occur from some of these beneficial conservation measures, which many are programmatic and adaptive. Adverse effects from proposed spawning and rearing habitat restoration projects resulting from construction activities could result in injuring or mortality of during in-water activities, but these effects would be temporary and minimized through AMMs.

In summary, there may be incidental take associated with the proposed action through:

- Redd dewatering and temperature dependent mortality based on in-season adjustments to operations.
- Clifton Court aquatic weed removal and predator management.

- Capture and harassment of fish at the Tracy Fish Collection Facility and Skinner Fish Protective Facility.
- Juveniles exposed to screened CVP diversions, which could result in harassment, injury or mortality.
- Cumulative direct and indirect loss associated with export operations including the operation of the DCC (loss in south Delta interior, loss at export facilities, and altered hydrodynamics). Loss from entrainment, impingement, and predation at the Delta pumps, could occur and migration success may be affected by changes in flows.
- Diversion of water through the Rock Slough Intake up to the maximum capacity of the intake (350 cfs) for the maximum annual diversion of 195 TAF.
- Temporary construction activities associated with habitat restoration and facility improvements.
- Monitoring activities supporting the proposed action may result in harassment or mortality.

The conservation measures included in the proposed action provide additional opportunities for adjustments to Delta operations to minimize salvage and other effects related to exports.

Therefore, while the overall effects of the proposed action are beneficial to the population of Central Valley Steelhead DPS, the proposed action is likely to adversely affect individuals.

7.2.8 Steelhead, Central Valley DPS Critical Habitat

Critical habitat for CV Steelhead is defined as specific areas that contain the PBFs and physical habitat elements essential to the conservation of the species. Within the range of the Central Valley Steelhead DPS, biological features of the designated critical habitat that are considered vital for CV Steelhead include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas. There are likely to be adverse impacts to certain PBFs of CV Steelhead designated critical habitat resulting from the proposed action. These include effects to freshwater migration corridors and estuarine areas. The proposed action relative to without action conditions could reduce riparian vegetation establishment and less flows for emigrating juveniles during winter and early spring.

The proposed action would have both positive and negative effects on the PBFs of freshwater migration habitat for adult and juvenile CV Steelhead. Lower flows during the winter and early spring would have negative effects on migratory habitat for juvenile Steelhead relative to without action conditions. However, higher flows and lower water temperatures under the proposed action during the late spring and summer would have beneficial effects on migratory habitat of juveniles and adults, especially in dry and critically dry years.

The proposed action includes spawning, rearing, and tidal and channel margin restoration activities that could affect estuarine and freshwater critical habitat for CV Steelhead. These construction-related effects are temporary and localized in nature, and minimized through proposed implementation of AMMs. Restoration projects under the proposed action are expected to result in long-term beneficial effects to critical habitat for CV Steelhead.

Once the ongoing operation of the CVP and SWP are isolated from baseline conditions that include construction of the CVP and SWP facilities and other stressors, the proposed action is expected to result in benefits to CV Steelhead critical habitat. Based on relationships between flow and spawning WUA for CV Steelhead in the upper Sacramento River (USFWS 2003), lower flows under the proposed action would substantially increase the number of years in which flows would be within the optimum weighted usable area range during the primary spawning period (January through March). However, few CV Steelhead are expected to spawn in the mainstem Upper Sacramento River. The proposed action is also expected to increase the availability of freshwater rearing habitat. Benefits of higher flows under the proposed action during the summer compared to without action conditions include increased downstream extent of suitable rearing water temperatures, improved access to riparian and off-channel habitat, reduced crowding and competition, and increased prey. Therefore, Reclamation has determined that the proposed action would have overall long term beneficial effects on CV Steelhead designated critical habitat.

7.2.9 Steelhead, Central Valley DPS, Incidental Take Considerations

Conservation measures and other beneficial actions provided in this biological assessment for NMFS to consider when developing an Incidental Take Statement for Central Valley Steelhead include:

- Implementation of the 2017 Flow Management Standard and “planning minimum” on the American River.
- Operation of fish screens at Red Bluff Pumping Plant and the Rock Slough Diversion.
- Management of OMR reverse flows based on near real-time monitoring, fish behavioral cues, predictive tools, and salvage.
- Operation of the Tracy and Skinner salvage facilities.

Reclamation anticipates continued collaboration in a science enterprise to implement and evolve the SAIL monitoring program as well as ongoing restoration and recovery actions developed in collaborative forums using Structured Decision Making. Reclamation and DWR-led efforts welcome NMFS participation and would include progress reports in annual reporting under the ITS.

7.2.10 Coho Salmon, Southern Oregon/Northern California Coastal ESU

Overall effects of the proposed action on the Southern Oregon/Northern California Coastal ESU are beneficial. The modeling results illustrate that once the ongoing operation of the CVP and SWP are isolated from baseline conditions that include construction of the CVP and SWP facilities and other stressors, the CVP and SWP operation provide necessary cold water and flow to ensure adequate conditions for Coho Salmon. The proposed action will improve flows and water temperatures for adult migration, holding, and spawning in the Trinity River compared to a scenario without the operation of Trinity Reservoir.

The proposed action provides beneficial conditions, including water temperatures that allow Coho Salmon to persist despite the existence of dams and other stressors. Reclamation would continue to implement the 2000 ROD flows and the Trinity River Restoration Program to reduce the effects of operation of the Trinity River Division of the CVP. The long term plan to protect salmon in the Lower Klamath River ameliorates the chances of fish die off and provides flows for Coho Salmon spawning and rearing on Grass Valley Creek under the proposed action.

Despite the beneficial components of the proposed action, the inter-basin transfer of water to the Sacramento River likely will continue to affect Coho Salmon, primarily the upper and lower Trinity River populations, through changes in habitat that affect their ability to spawn and rear in the mainstem of the Trinity River. There may be incidental take associated with the proposed action through reductions in floodplain and rearing habitat in the spring.

Therefore, while the overall effects of the proposed action are beneficial, the proposed action is likely to adversely affect individual Southern Oregon/Northern California Coastal Coho Salmon ESU.

7.2.11 Coho Salmon, Southern Oregon/Northern California Coastal ESU Critical Habitat

Critical habitat for Coho Salmon is defined as specific areas that contain the PBFs and physical habitat elements essential to the conservation of the species. Within the range of the Southern Oregon/Northern California Coastal Coho Salmon ESU, biological features of the designated critical habitat that are considered vital for Coho Salmon include: substrate, water quality, water quantity, water temperature, water velocity, cover and shelter, food, riparian vegetation, space, and safe passage conditions.

Under the proposed action, the TRRP is expected to continue to result in increases in Coho Salmon populations, through improving fish habitat conditions, such as Coho Salmon critical habitat and associated biological features.

Although there may be adverse effects to the rearing and floodplain habitat PBFs of Coho Salmon designated critical habitat resulting from the proposed action, the ongoing TRRP, lower Klamath augmentation flows, and Grass Valley Creek flows will address these effects. Therefore, Reclamation has determined that considering the continued implementation of ongoing actions, the proposed action would have overall long term beneficial effects on the Coho Salmon designated critical habitat.

7.2.12 North American Green Sturgeon, Southern DPS

Overall, effects of the proposed action on the Southern DPS of Green Sturgeon in the Sacramento River, Bay-Delta, and Feather River are beneficial. The proposed action would also improve flows and water temperatures for spawning, rearing, and migration of Green Sturgeon. The modeling results illustrate that once the effects of the ongoing operation of the CVP and SWP are isolated from baseline conditions that include construction of CVP and SWP facilities and other stressors, the operation of the CVP and SWP generally provides better cold water and flow conditions to ensure adequate pre-spawning, spawning, and incubation survival conditions for Green Sturgeon.

Improvements in water temperature management under the proposed action, including operation of the Shasta Dam TCD, provide for cold water to maintain egg incubation and reduce temperature dependent mortality compared to without action conditions. The impacts of increased summer and fall flows under the proposed action would be beneficial for egg and larvae survival, although the proposed action reduces temperatures below the optimal growth temperature for Green Sturgeon juveniles in some months.

In the Sacramento River, spawning and rearing Green Sturgeon would benefit from the proposed action flows that are higher than without action conditions during years with dry hydrology during the months of May to October. Improved spawning and egg incubation would occur due to higher flows during June through October. The proposed action flows would increase transport of juvenile Green Sturgeon to favorable habitat, while also increasing larval rearing habitats and an increased dispersion of larvae to rearing habitats. While there are negative effects of lower flows in April during Green Sturgeon spawning and egg incubation, these reductions in flow and increases in temperature are offset by the increased flows and improved temperatures for Green Sturgeon spawning and egg incubation under the proposed action in summer and May in drier years. In addition to benefits for spawning and egg incubation, water temperatures in the summer are generally cooler under the proposed action, benefiting larvae Green Sturgeon.

In the Feather River, higher summer flows under the proposed action minimize the potential exposure to low flows for egg and larvae incubation under conditions that do not include operation of the SWP. The proposed action would also improve temperature objectives at the lower FERC boundary on the Feather River, during the months of April to July, achieving optimal range temperatures for Green Sturgeon egg and larval survival. The proposed action flows would benefit the peak period of abundance for larvae and juvenile Green Sturgeon on the Feather River. Increased flows under the proposed action during July to August are also anticipated to benefit post-spawning Green Sturgeon adults. Lower flows under the proposed action from January to June in the Feather River could negatively impact juvenile Green Sturgeon migration cues and conditions, such as foraging conditions, DO, toxicity, and habitat impacts, but these impacts are anticipated to be minimal since proposed action flows are well in excess of flows believed to be protective of Green Sturgeon juveniles.

Conservation measures, such as habitat restoration projects, predator hot spot removal, and small screen improvements would be beneficial to Green Sturgeon through increased food availability and quality and refuge habitat from predators. Some conservation measures may expose individuals to direct detrimental effects, such as adult fish rescue and juvenile trap and haul; however, these actions could provide benefits to survival and escapement and would potentially offset the adverse effects. Other conservation measures that require construction could lead to negative effects due to temporary loss of habitat leading to predation, degraded water quality, noise-related delay in migration, and direct effects from contact with construction equipment. Although these potential effects may be unavoidable, exposure to construction effects would be low based on the limited extent of proposed restoration relative to the overall distribution of Green Sturgeon adults and juveniles, and the implementation of avoidance and minimization measures.

The proposed action provides substantial beneficial conditions to the species; however, there will be incidental take of individual members of the species resulting from:

- Temperature dependent mortality based on in-season adjustments to operations.
- Entrainment, impingement, and predation at the Delta pumps and other diversions.
- Changes in flows that may affect migratory success in the Feather River.
- Juveniles exposed to CVP screened diversions on the Sacramento River to the Delta, which could result in harassment, injury or mortality.
- Cumulative direct and indirect loss associated with export operations including loss in south Delta interior, loss at export facilities, altered hydrodynamics, and operation of the DCC. Loss from entrainment, impingement, and predation at the delta pumps could occur and migration success may be affected by changes in flows.
- Diversion of water through the Rock Slough Intake up to the maximum capacity of the intake (350 cfs) for the maximum annual diversion of 195 TAF.

Therefore, while the proposed action is likely to have overall beneficial effects, the proposed action is likely to adversely affect individual North American Green Sturgeon southern DPS. The measures included in the proposed action provide additional opportunities for adjustments to Delta operations to minimize salvage and other effects on Green Sturgeon.

7.2.13 North American Green Sturgeon, Southern DPS Critical Habitat

Critical habitat for Green Sturgeon is defined as specific areas that contain the PBFs and physical habitat elements that are essential to the conservation of the species. Within the range of the southern DPS of North American Green Sturgeon, biological features of the designated critical habitat that are considered vital for Green Sturgeon in estuarine habitat are: food resources, water flow, water quality, migratory corridor, water depth, and sediment quality. These biological features are also considered vital for Green Sturgeon in freshwater habitat, with the addition of substrate type or size.

In Estuarine habitats, increased flow under the proposed action, particularly during July and August of all but the wettest years, may result in greater depths, or greater diversity in habitats, which, in turn, potentially increase productivity and diversity of food resources for Green Sturgeon. Increased flows during the summer and early fall in the Sacramento River, when Green Sturgeon spawn, may adversely impact and deepen scour holes used for spawning, but would also effectively flush out contaminants.

Reduced flows under the proposed action during winter and early spring have the potential to impact immigrating adults, but the flows will be high enough to prevent passage problems in the Sacramento River. In addition, higher proposed flows during late spring, summer, and early fall have the potential to benefit spawning, eggs, and larvae life stages, such as moving larvae and juvenile Green Sturgeon quickly to rearing habitats in the middle Sacramento, although they also may result in water temperatures too cold for effective Green Sturgeon juvenile rearing.

The proposed action has the potential to reduce sediment supply and turbidity due to reduced winter-spring inflow; however, the higher spring, summer, and fall flows under the proposed action would dilute contaminants present in Green Sturgeon critical habitat. The proposed action would adversely impact Green Sturgeon substrate type and size for Green Sturgeon spawning habitat during winter and early spring months in wet years due to high flows scouring gravels suitable for spawning. However, during the late spring and summer months, when Green Sturgeon spawn, flows under the proposed action benefit the suitability of gravel substrates by removing sediments for incubating embryos. The proposed action may reduce fine sediment habitat for Green Sturgeon prey, but may also improve fine sediment conditions in spawning habitat.

Therefore, Reclamation has determined that the proposed action may adversely affect components of Green Sturgeon critical habitat while also resulting in benefits to Green Sturgeon critical habitat.

7.2.14 Delta Smelt

The modeling results illustrate that once the effects of the ongoing operation of the CVP and SWP are isolated from baseline conditions that include construction of the CVP and SWP facilities and other stressors, the operation of the CVP and SWP under the proposed action results in negative effects to Delta Smelt, including adult and larval/early juvenile entrainment at the south Delta and other water diversion facilities; extent of low salinity rearing habitat through less Delta outflow or south Delta export effects in certain year types and seasons; and the diversion of water through the Rock Slough Intake. Positive effects include improved low salinity rearing habitat in drier year types and seasons (e.g. summer) and actions to address the effects of degraded habitat and invasive species on the food web. OMR management would reduce entrainment risk. The extent of the other potential adverse effects are generally uncertain.

Additional adverse effects under the proposed action would occur from proposed construction, maintenance, and monitoring activities. These effects might include potentially scoured and eroded habitat within waterways adjacent to restored areas following levee breaching; disturbance of Delta Smelt within some distance (e.g., ~100 feet, depending on tidal currents) of levee breach locations as a result of sediment plumes, noises, and vibrations; changing hydraulics because of breaching which could lead to exposure to residual (historically used) agricultural pesticides and other contaminants; and direct effects from excavation (physical injury or death), or indirect effects through disruption of normal behavior resulting in increased predation.

Effects to Delta Smelt could include temporary or permanent loss of habitat; exposure to increased suspended sediment and turbidity leading to changes in habitat quality and foraging ability; potential harm from accidental release of construction-related hazardous materials, chemicals, and waste; and effects from inadvertent spread of invasive or nuisance species. The magnitude of these effects is low. Construction and maintenance effects would be limited through avoidance and minimization measures, with minor effects also expected from monitoring.

The proposed action would also provide beneficial effects to Delta Smelt, primarily through operations of SMSCG for 60 days in June–September of above normal and below normal years, which would increase juvenile and subadult Delta Smelt access to relatively food-rich habitat. Several conservation measures are included to avoid and minimize or compensate for effects of the proposed action, including continuing tidal habitat restoration (8,000 acres) in the Delta; Tracy and Skinner Fish Facility improvements; and construction and operation of a Delta Fish Species Conservation Hatchery. A suite of programmatic actions to improve habitat and facilities are also part of the proposed action. Among the actions potentially benefiting Delta Smelt are reconnection of the Sacramento Deepwater Ship Channel with the Sacramento River, which together with nutrient addition could increase food availability for Delta Smelt in the north Delta; introduction of dredge material to increase turbidity; a Central Valley-wide and Delta small diversion screening program; Skinner and Tracy fish facility improvements; and provision of lower San Joaquin River spawning and rearing habitat and Putah Creek Yolo Bypass realignment restoration, which could export food from floodplains to Delta Smelt habitat.

In summary, there may be incidental take associated with the proposed action through:

- Cumulative direct and indirect loss associated with export operations including loss in south Delta interior, loss at export facilities, altered hydrodynamics, and operation of the DCC. Loss from adult and larval/early juvenile entrainment, impingement, and predation at the Delta pumps and other water diversion facilities.
- Reduction in the extent of low salinity rearing habitat through less Delta outflow or south Delta export effects
- Temporary and permanent loss of habitat
- Exposure to increased suspended sediment and turbidity leading to changes in habitat quality and foraging ability
- Potential harm from accidental release of construction-related hazardous materials, chemicals and waste
- Effects from inadvertent spread of invasive or nuisance species.
- Clifton Court aquatic mechanical weed removal and predator management.
- Diversion of water through the Rock Slough Intake up to the maximum capacity of the intake (350 cfs) for the maximum annual diversion of 195 TAF.
- Monitoring activities supporting the proposed action may result in harassment or mortality.

Therefore, while the proposed action is likely to have some beneficial effects, it is likely to adversely affect Delta Smelt.

7.2.15 Delta Smelt Incidental Take Considerations

Conservation measures and other beneficial actions provided in this biological assessment for USFWS to consider when developing an Incidental Take Statement include:

- Management of OMR reverse flows based on near real-time monitoring, fish behavioral cues, predictive tools, and salvage.
- Management of habitat acreage, creation of low salinity zone habitat in Suisun Marsh, food subsidies, and restoration.
- Operation of the Fish Conservation and Culture Lab to supplement wild populations and support development of a Delta Fish Species Conservation Hatchery.
- Operation of the Tracy and Skinner salvage facilities.

Reclamation anticipates continued collaboration in a science enterprise to implement and evolve the EDSM program as well as ongoing restoration and recovery actions developed in collaborative forums using Structured Decision Making. Reclamation and DWR-led efforts welcome USFWS participation and would include progress reports in annual reporting under the ITS.

7.2.16 Delta Smelt Critical Habitat

Within critical habitat for Delta Smelt, PBFs are considered essential to the conservation of the species. Once the effects of the ongoing operation of the CVP and SWP are isolated from baseline conditions, the proposed action would result in adverse effects to the physical habitat PBF (through reduction of spawning substrate), the water quality PBF (through reductions in food availability and turbidity), the river flow PBF (through entrainment risk), and the salinity PBF (through changes in location and reduction in extent of low salinity zone habitat) in certain years and seasons. The proposed action would result in beneficial effects to the salinity PBF (through chances in location and increase in extent of low salinity zone habitat) in certain years and seasons. Adverse effects to Delta Smelt critical habitat would also occur from construction of conservation measures and maintenance. Construction and maintenance effects would be temporary and limited through avoidance and minimization measures.

Beneficial effects to Delta Smelt critical habitat from the proposed action include reduced salinity in Suisun Marsh through operation of the SMSCG for 60 days in June through September of above normal and below normal years, increasing habitat suitability in a food-rich environment, as well as food subsidies from the Sacramento Deepwater Ship Channel, and Colusa Basin Drain. The water quality and physical habitat PCE would continue to be positively affected by the 8,000 acres of tidal habitat restoration in the Delta associated with the proposed action, which would increase food availability and extent of spawning substrate. The programmatic actions described previously could also contribute beneficial effects to the various PCEs of Delta Smelt critical habitat and reduce the extent of the adverse effects of the proposed action on Delta Smelt critical habitat.

Therefore, the proposed action results in both beneficial and adverse effects to Delta Smelt critical habitat.

7.2.17 Eulachon, Southern DPS

Under the proposed action, Trinity River at Lewiston flows would contribute less to flow entering the lower Klamath River during December–April. The timing coincides with Eulachon spawning in the Klamath River and larvae being transported to the estuary and ocean. The proposed action overall slightly increases flows from the Trinity River in May, which is the month when the Trinity River provides the largest portion of the Klamath River flows. It is uncertain the extent to which there may be negative effects because of these differences, given the lack of quantitative relationships between biological performance and flow, but mechanisms include food transport and water temperature. Flows under the proposed action would not be appreciably lower in the lower Klamath River. Flow from the Trinity River under the proposed action during December–April generally aligns with the preferred water temperatures for spawning Eulachon. Flows and water temperature differences under the proposed action are insignificant and, therefore, are not likely to adversely affect Eulachon spawning temperatures in the lower Klamath River.

The proposed action may affect, but is not likely to adversely affect Eulachon.

7.2.18 Eulachon, Southern DPS Critical Habitat

Eulachon critical habitat PBFs include water flow, quality, and temperature conditions, and substrate supporting spawning and incubation. Under the proposed action, Trinity River flows would be less during December–April, a time when Trinity River flows form a small percentage of flow entering the lower Klamath. Flows from Trinity River would be similar under the proposed action during May, a time when Trinity River flows form a larger percentage of Klamath River flows. The proposed action does not physically obstruct migration corridors or freshwater spawning and incubation sites in the lower tidal Klamath River but could reduce water flow and quality during the main historical period of spawning migration.

The proposed action may affect, but is not likely to adversely affect Eulachon critical habitat.

7.2.19 Southern Resident Killer Whale

Effects of the proposed action to SRKW are examined within the context of changes in the availability of its preferred prey, Chinook salmon. As stated above in the effects analysis for each Chinook salmon run, the proposed action will have negative impacts to individual Chinook salmon from both the Core Water Operation and construction of conservation measures. Despite these negative effects to Chinook salmon individuals, the proposed action results in an overall beneficial effect to the different Chinook salmon populations in the Central Valley. Beneficial effects include summer/fall water temperatures favorable for rearing of early Chinook salmon life stages; provision of gravel for spawning habitat in the upper Sacramento River; restoration of rearing habitat between Keswick and Red Bluff; trap and haul for salmonid juveniles from the upper Sacramento River to downstream of the Delta in drought years; increased Winter-Run Chinook Salmon hatchery production in drought years; implementation of spawning and rearing habitat projects in the American River; continued maintenance at restoration sites in the American River; drought temperature management in the American River; 8,000 acres of habitat restoration in the Delta and Tracy; and Skinner fish facility improvements, among others. A suite of programmatic actions to improve habitat and facilities are also proposed. Among those potentially benefiting Chinook salmon are a Central Valley-wide small diversion screening program, DCC improvements, Skinner and Tracy fish facility improvements, spawning and rearing habitat restoration, and improvements to the Shasta Dam TCD.

When combined with lack of effects to hatchery production, the proposed action is not likely to reduce prey availability for SRKW. Therefore, the proposed action may affect, but is not likely to adversely affect SRKW.

7.2.20 Southern Resident Killer Whale Critical Habitat

Critical Habitat for SRKW is located outside of the action area. Therefore, the designated critical habitat will not be affected by the proposed action.

7.3 Terrestrial Effects Determinations

The procedure for analyzing effects on terrestrial species is described in Section 13. As there described, various data sources were used to identify potentially affected acreages of suitable habitat for each species; in most cases suitable habitat was identified using either a USFWS species range map or a pre-existing habitat model for the species. Table 5.23-1 identifies which components of the PA have the potential to affect each terrestrial species, in which watersheds those effects may occur, and whether each component was evaluated at the specific or programmatic level; in this context “specific” indicates that this biological assessment is intended to support a request for concurrence or incidental take authorization by USFWS, while “programmatic” indicates that this biological assessment is intended to support a jeopardy or adverse modification determination by USFWS. Table 7.3-1 summarizes the acreage of suitable habitat affected for each species, and whether the affected acreage is linked to specific or programmatic components of the PA. The effects determinations for each federally listed terrestrial species and any designated critical habitat that may be affected by the proposed action are provided below.

Table 7.3-1. Affected Areas and Mitigation

Component	Amount Affected (Acres Unless Otherwise Specified)
American River Watershed, Western Yellow-Billed Cuckoo	40
American River Watershed, Valley Elderberry Longhorn Beetle	40 acres or 36 shrubs
Bay-Delta Region, Salt Marsh Harvest Mouse	1,748
Bay-Delta Region, Valley Elderberry Longhorn Beetle	88 acres or 79 shrubs
Bay-Delta Region, Giant Garter Snake	755
Feather River Watershed, Western Yellow-Billed Cuckoo	89
Feather River Watershed, Valley Elderberry Longhorn Beetle	23 shrubs
San Joaquin River Watershed, Riparian brush rabbit	345 riparian and 470 grassland
San Joaquin River Watershed, Riparian Woodrat	76 plus 200 inundation consistent with AMM-RBR/RWR

Component	Amount Affected (Acres Unless Otherwise Specified)
San Joaquin River Watershed, Least Bell's Vireo	28
San Joaquin River Watershed, Western Yellow-billed Cuckoo	11
San Joaquin River Watershed, Valley Elderberry Longhorn Beetle	278 (250 shrubs)
Stanislaus River Watershed, Least Bell's Vireo	30
Stanislaus River Watershed, Riparian Brush Rabbit	10 riparian
Stanislaus River Watershed, Riparian Brush Woodrat	10
Stanislaus River Watershed, Western Yellow-billed Cuckoo	73
Stanislaus River Watershed, Valley Elderberry Longhorn Beetle	44 shrubs
Upper Sacramento River Watershed, Giant Garter Snake	34 acres aquatic and 266 acres upland
Upper Sacramento River Watershed, Least Bell's Vireo	10
Upper Sacramento River Watershed, Western Yellow-billed Cuckoo	67
Upper Sacramento River Watershed, Valley Elderberry Longhorn Beetle	60 shrubs
Total Across Watersheds	
All Watersheds, Riparian Brush Rabbit	355 riparian and 470 grassland
All Watersheds, Riparian Woodrat	86 plus 200 inundation consistent with AMM-RBR/RWR
All Watersheds, Salt Marsh Harvest Mouse	1,748
All Watersheds, Western Yellow-billed Cuckoo	280
All Watersheds, Least Bell's Vireo	68
All Watersheds, Giant Garter Snake	1,055

Component	Amount Affected (Acres Unless Otherwise Specified)
All Watersheds, Valley Elderberry Longhorn Beetle	492 shrubs
All other terrestrial species	0

7.3.1 Riparian Brush Rabbit

The proposed action may result in loss of up to 90 acres of suitable but unoccupied riparian habitat for the species (permanent and temporary habitat loss are treated together because of the relatively long time required for riparian habitat to recover). The proposed action may also result in permanent loss of up to 25 acres and temporary loss of up to 20 acres of suitable but unoccupied adjacent grasslands. Floodplain restoration along the San Joaquin River may result in periodic flooding of up to 265 acres of suitable but unoccupied riparian and 425 acres of suitable but unoccupied adjacent grasslands for riparian brush rabbit. Reclamation will discuss appropriate mitigation ratios with USFWS. Reclamation will offset effects of periodic flooding by constructing refugia for riparian brush rabbits to use during flood events.

The proposed action may affect, is likely to adversely affect, riparian brush rabbit.

7.3.2 Riparian Woodrat

The proposed action may result in loss of up to 86 acres of suitable but unoccupied riparian habitat for the species (permanent and temporary habitat loss are treated together because of the relatively long time required for riparian habitat to recover). Floodplain restoration may result in periodic flooding of up to 200 acres of suitable but unoccupied riparian habitat for riparian woodrat. Reclamation will discuss appropriate mitigation ratios with USFWS, and will offset effects of periodic flooding by constructing refugia for riparian woodrats to use during flood events.

The proposed action may affect, is likely to adversely affect, riparian woodrat.

7.3.3 Salt Marsh Harvest Mouse

Adverse effects from Tidal Habitat Restoration would involve temporary loss of up to 1,748 acres. Over time, the restored and enhanced area is expected to be suitable for salt marsh harvest mouse and of higher long-term value for the species because it will be less vulnerable to sea level rise. Thus, the proposed action is expected to have a net beneficial effect on the species.

The proposed action may affect, is likely to adversely affect, salt marsh harvest mouse.

7.3.4 California Ridgeway’s Rail

The restoration projects are outside the current range of the species. Over time, the restored and enhanced area is expected to be suitable for California Ridgeway’s rail and of higher long-term value for the species because it will be less vulnerable to sea level rise by including gradual slopes up from the current tidal region, potentially allowing introduction of the species into the restored areas. Thus, the proposed action is expected to have a wholly beneficial effect on the species.

The proposed action may affect, and is not likely to adversely affect, California Ridgeway's rail.

7.3.5 Least Bell's Vireo

The proposed action may result in loss of up to 216 acres of suitable habitat within the species' range. Reclamation will avoid disturbance of occupied habitat and will avoid injury or mortality of least Bell's vireo. Reclamation will discuss appropriate mitigation ratios with USFWS.

The proposed action may affect, is likely to adversely affect, least Bell's vireo.

7.3.6 Western Yellow-Billed Cuckoo

The proposed action may result in loss of up to 221 acres of suitable habitat within the species' range. Reclamation will avoid disturbance of occupied habitat and will avoid injury or mortality of western yellow-billed cuckoo. Reclamation will discuss appropriate mitigation ratios with USFWS. The proposed action may affect, and is likely to adversely affect, western yellow-billed cuckoo.

7.3.7 Western Yellow-Billed Cuckoo Critical Habitat

Reclamation will avoid modification of habitat for this species within designated critical habitat units by avoiding disturbance of suitable habitat in these areas. The proposed action could provide for some different riparian species that require year-round flows, benefiting Western Yellow-Billed Cuckoo critical habitat.

The proposed action may affect, but is not likely to adversely affect western yellow-billed cuckoo critical habitat.

7.3.8 Giant Garter Snake

The proposed action may result in loss of up to 1,049 acres of giant garter snake aquatic and upland habitat. Reclamation will discuss appropriate mitigation ratios with USFWS.

The proposed action may affect, is likely to adversely affect, giant garter snake.

7.3.9 Valley Elderberry Longhorn Beetle

Adverse effects from the project components may involve removal of up to 440 elderberry shrubs. Reclamation will offset habitat loss through transplanting elderberry shrubs and planting new elderberry and associated plants consistent with USFWS guidelines.

The proposed action may affect, is likely to adversely affect, valley elderberry longhorn beetle.

7.3.10 Soft Bird's-Beak

Tidal habitat restoration will occur in areas where habitat is not currently suitable for soft bird's-beak, and no negative effects would be expected from restoration activities. Over time, the restored and enhanced area is expected to be suitable and of higher long-term value for the species because it will be less vulnerable to sea level rise by including gradual slopes up from the current tidal region, potentially allowing introduction of the species into the restored areas. Thus, the proposed action is expected to have a wholly beneficial effect on the species.

The proposed action may affect, but is not likely to adversely affect, soft bird's-beak.

7.3.11 Suisun Thistle

Tidal habitat restoration will occur in areas where habitat is not currently suitable for Suisun thistle, and no negative effects would be expected from restoration activities. Over time, the restored and enhanced area is expected to be suitable for the species and of higher long-term value for the species because it will be less vulnerable to sea level rise by including gradual slopes up from the current tidal region, potentially allowing introduction of the species into the restored areas. Thus, the proposed action is expected to have a wholly beneficial effect on the species.

The proposed action may affect, but is not likely to adversely affect, Suisun thistle.

7.3.12 Vernal Pool Tadpole Shrimp and Vernal Pool Fairy Shrimp

Although Tidal Habitat Restoration under the proposed action has the potential to occur where these species occur, Reclamation will avoid habitat that is occupied or assumed to be occupied by conducting surveys in potential habitat areas.

The proposed action may affect, but is not likely to adversely affect, vernal pool tadpole shrimp and vernal pool fairy shrimp.

7.3.13 California Tiger Salamander

Although Tidal Habitat Restoration under the proposed action has the potential to occur where this species occurs, Reclamation will avoid habitat that is occupied or assumed to be occupied by conducting surveys in potential habitat areas.

The proposed action may affect, but is not likely to adversely affect, California tiger salamander.

7.3.14 California Tiger Salamander Critical Habitat

Although Tidal Habitat Restoration under the proposed action has the potential to occur within a designated critical habitat unit for this species, Reclamation will avoid effects on any of the primary constituent elements of its habitat by conducting surveys in potential habitat areas.

The proposed action is not likely to adversely affect critical habitat for California tiger salamander.

7.3.15 California Least Tern

Although proposed action components occur where California least terns are potentially present, Reclamation will avoid nesting colony sites through surveys and monitoring. The restoration projects are expected to have a net benefit on the species by increasing food production.

The proposed action may affect, but is not likely to adversely affect California least tern.

7.3.16 California Red-Legged Frog

Although proposed action components occur where California red-legged frogs may have historically been present, the likelihood of occupancy of habitats along the Sacramento River downstream of Shasta

Dam is discountable as they have not been observed along the Sacramento River corridor downstream of Shasta Dam.

The proposed action may affect, but is not likely to adversely affect California red-legged frog.

7.4 Essential Fish Habitat

7.4.1 Pacific Coast Salmon

The proposed action would adversely affect Pacific Coast Salmon EFH, although the adverse effects would not be substantial. Adverse effects primarily would occur as a result of the proposed action reducing flow during winter/spring relative to without action conditions, which could affect EFH for juvenile Chinook Salmon in particular, for example by increasing travel time and predation risk. Other adverse effects could arise from construction and maintenance activities.

A number of factors would contribute to the proposed action not having a substantial effect on Pacific Coast Salmon EFH. Construction and maintenance effects under the proposed action would be limited through avoidance and minimization measure. Exposure would be limited relative to the overall extent of Pacific Coast Salmon EFH. Reservoir storage under the proposed action would allow summer/fall water temperatures to be favorable for rearing of early Chinook Salmon life stages. A number of conservation measures are included to avoid and minimize or compensate for effects of the proposed action, including provision of gravel for spawning habitat in the upper Sacramento River; restoration of rearing habitat between Keswick Dam and Red Bluff; implementation of spawning and rearing habitat projects in the lower American River; continued maintenance at restoration sites in the lower American River; drought temperature management in the lower American River; and continued implementation of 8,000 acres of habitat restoration in the Delta. A suite of programmatic actions to improve habitat are also proposed. Among those potentially benefiting Chinook Salmon are a Central Valley-wide small diversion screening program; Delta Cross Channel improvements; lower San Joaquin River spawning and rearing habitat restoration; and improvements to Shasta TCD.

7.4.2 Coastal Pelagic Species

The proposed action is not likely to adversely affect Coastal Pelagic Species EFH. Limited construction effects could occur for proposed action activities bordering EFH (e.g., Delta habitat restoration). AMMs would minimize effects. Operational effects of the proposed action on the salinity field in the Bay-Delta would be small relative to the salinity tolerance of Northern Anchovy. Overall effects to Coastal Pelagic Species EFH would be small relative to the overall extent of Coastal Pelagic Species EFH.

7.4.3 Pacific Coast Groundfish

The proposed action would adversely affect Pacific Coast Groundfish EFH, although the adverse effects would not be substantial. Limited construction effects could occur for proposed action activities bordering EFH (e.g., Delta restoration). Core Water Operation effects on the salinity field in the Bay-Delta would be small relative to the salinity tolerance of Starry Flounder, although reductions in spring Delta outflow relative to without action conditions could negatively affect abundance of Starry Flounder through effects on rearing habitat. Overall effects to Pacific Coast Groundfish EFH would be small relative to the overall extent of Pacific Coast Groundfish EFH.

Chapter 8 Literature Cited

8.1 Published References

Adams, P. B., C. B. Grimes, J. E. Hightower, S. T. Lindley, and M. L. Moser. 2002. Status Review for North American Green Sturgeon, Acipenser meditostris. National Marine Fisheries Service, Northwest Fisheries Science Center and United States Geological Survey, North Carolina Cooperative Fish and Wildlife Research Unit. Available: <http://www.nmfs.noaa.gov/pr/pdfs/statusreviews/greensturgeon.pdf.

Adams, P. B., C. B. Grimes, J. E. Hightower, S. T. Lindley, M. L. Moser and M. J. Parsley. 2007. Population status of North American green sturgeon, Acipenser medirostris. Environmental Biology of Fishes 79:339–356.

Ahearn, D. S., J. H. Viers, J. F. Mount, and R. A. Dahlgren. 2006. Priming the Productivity Pump: Flood Pulse Driven Trends in Suspended Algal Biomass Distribution Across a Restored Floodplain. Freshwater Biology 51:1417–1433.

Ahul, J. S. B. 1991. Factors Affecting Contributions of the Tadpole Shrimp, Lepidurus Packardi, to Its Oversummering Egg Reserves. Hydrobiologia 212:137–143.

Albertson J. D., J. G. Evens. 2000. California clapper rail. In: Olofson PR (ed) Baylands Ecosystem Species and Community Profiles: Life Histories and Environmental Requirements of Key Plants, Fish and Wildlife. San Francisco Bay Area Wetland Ecosystem Goals Project. San Francisco Bay Regional Water Quality Control Board, Oakland, CA, pp 332-341.

Albertson, J. D. 1995. Ecology of the California Clapper Rail in South San Francisco Bay. Thesis. San Francisco State University, San Francisco, California, U.S.A.

Alpine A. and J. Cloern. 1992. Trophic interactions and direct physical effects control phytoplankton biomass and production in an estuary. American Society Limnology and Oceanography. pp 946 – 955.

Amweg, E. L., D. P. Weston, J. You, M. J. Lydy. 2006. Pyrethroid Insecticides and Sediment Toxicity in Urban Creeks from California and Tennessee, 40 ENVTL. SCI. TECH. 1700, 1700–06 (2006).

Anchor QEA. 2018. Evaluation of the Effects of Summer Operation of the Suisun Marsh Salinity Control Gates. Prepared for the California Department of Water Resources. May.

Anderson, P. R. 1968. The reproductive and developmental history of the California tiger salamander. Masters of Arts thesis, Fresno State College, Fresno, California.

Anderson, C. and M. Rigney. 1980. California Least Tern Breeding Survey, South San Francisco Bay – 1981. U.S. Department of the Interior, Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Special Report.

Anderson, J. 2018. Using river temperature to optimize fish incubation metabolism and survival: a case for mechanistic models. Researchgate Preprint. 10.1101/257154.

Anderson J. J., E. Gurariea and R. Zabelb. 2005. Mean free-path length theory of predator–prey interactions: Application to juvenile salmon migration. Ecological Modelling (186)196–211.

Anderson, J. T., C. B. Watry, and A. Gray. 2007. Upstream Fish Passage at a Resistance Board Weir Using Infrared and Digital Technology in the Lower Stanislaus River, California: 2006-2007 Annual Data Report.

Anderson, L. E. and M. Plummer. 2017. Recreational demand for shellfish harvesting under environmental closures. Marine Resource Economics, 32(1):43-57.

Andrews, S.W., E.S. Gross, and P.H. Hutton. 2017. Modeling salt intrusion in the San Francisco Estuary prior to anthropogenic influence. Continental Shelf Research 146:58-81. http://dx.doi.org/10.1016/j.csr.2017.07.010

Arthur, J. F., M. D. Ball, and S. Y. Baughman. 1996. Summary of Federal and State Water Project Environmental Impacts in the San Francisco Bay–Delta Estuary, California. In: J. T. Hollibaugh (ed.). San Francisco Bay: The Ecosystem. San Francisco, CA: Pacific Division, American Association for the Advancement of Science. Pages 445–495.

Atwater B. F., S. G. Conrad, J. N. Dowden, C. W. Hedel, R. L. MacDonald, and W. Savage. 1979. History, Landforms, and Vegetation of the Estuary's Tidal Marshes. In: Conomos TJ, editor. San Francisco Bay: The Urbanized Estuary. San Francisco, CA: Pacific Division, American Association for the Advancement of Science. p 347-385.

Austin, C. C., and H. B. Shaffer. 1992. Short, Medium, and Long-Term Repeatability of Locomotor Performance in the Tiger Salamander, Ambystoma californiense. Functional Ecology 6:145–153.

Azat, J. 2018. GrandTab 2018.04.09. California Central Valley Chinook Population Database Report. California Department of Fish and Wildlife. Available from http://www.calfish.org/ProgramsData/Species/CDFWAnadromousResourceAssessment.aspx

Bain, D. 1990. Examining the Validity of Inferences Drawn from Photo-Identification Data, with Special Reference to Studies of the Killer Whale (*Orcinus orca*) in British Columbia. In Individual recognition of cetaceans: Use of photo-identification and other techniques to estimate population parameters, edited by Hammond, P. S., S. A. Mizroch, and G. P. Donovan. Report of the International Whaling Commission, Special Issues 12:93-100.

Baird R.W. and H. Whitehead. 2000. Social organization of mammal-eating killer whales: group stability and dispersal patterns. Canadian Journal of Zoology. 78: 2096-2105.

Balcomb, K.C. III. 2006. Winter distribution of southern resident killer whales, 2003-2006. In: Proceedings of the 2006 Symposium on Southern Resident Killer Whales, 3-5 April, 2006. NOAA Western Regional Center Auditorium, Seattle, WA.

Balcomb, K. C., J. R. Boran, and S. L. Heimlich. 1982. Killer whales in greater Puget Sound. In: Thirty-Second Report of the International Whaling Commission. Reports for the International Whaling Commission 32:681–685.

Baldwin, D. H., J. A. Spromberg, T. K. Collier, and N. L. Scholz. 2009. A Fish of Many Scales: Extrapolating Sublethal Pesticide Exposures to the Productivity of Wild Salmon Populations. Ecological Applications 19(8): 2004-2015.

Barnett-Johnson, R., C. B. Grimes, C. F. Royer, and C. J. Donohoe. 2007. Identifying the contribution of wild and hatchery Chinook salmon (*Oncorhynchus tshawytscha*) to the ocean fishery using otolith microstructure as natural tags. Canadian Journal of Fisheries and Aquatic Sciences 64(12):1683-1692.

Barnhart, R. A. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest), steelhead. U.S. Fish and Wildlife Service, Biological Report 82 (11.60). 21 pp.

Barr, C. B. 1991. The distribution, habitat and status of the Valley elderberry longhorn beetle Desmocerus californicus dimorphus fisher (Insecta: Coleoptera: Cerambycidae). Report to US Fish and Wildlife Service, Sacramento.

Barraclough, W. E. 1964. Contribution to the marine life history of the eulachon Thaleichthys pacificus. Journal of the Fisheries Research Board of Canada 21(5):1333-1337.

Barry, S. J., and G. M. Fellers. 2013. History and Status of the California red-legged frog (Rana draytonii) in the Sierra Nevada, California, USA in Herpetological Conservation and Biology 8(2):456−502. Submitted: 7 May 2012; Accepted: 7 May 2013; Published: 15 September 2013.

Barry, S. J., and H. B. Shaffer. 1994. The Status of the California Tiger Salamander (Ambystoma californiense) at Lagunita: A 50-Year Update. Journal of Herpetology 28:159–164.

Bartholow, J. M. 2000. Estimating Cumulative Effects of Clearcutting on Stream Temperatures. Rivers. 7.

Baskerville-Bridges, B., J. C. Lindberg, and S. I. Doroshov. 2004. The Effect of Light Intensity, Alga Concentration, and Prey Density on the Feeding Behavior of Delta Smelt Larvae. American Fisheries Society Symposium 39: 219–227.

Baumgartner L. J., N. K. Reynoldson, L. Cameron, J. G. Stanger. 2009, Effects of irrigation pumps on riverine fish. Fish Manag Ecol 16: 429–437.

Baxter et al. 1999. Summary of Biological Information on the Northern Anchovy (Engraulis Mordax Girard). California Cooperative Oceanic Fisheries Investigations. Reports Volume XI, July 1 1963 to June 30 1966.

Baxter, R., K. Hieb, S. DeLeón, K. Fleming, and J. Orsi. 1999. Report on the 1980-1995 fish, shrimp, and crab sampling in the San Francisco Estuary, California. Interagency Ecological Program for the Sacramento-San Joaquin Estuary, Technical Report 63, California Department of Fish and Game, Stockton, CA, 503 p.

Baye, P. R. 2008. Vegetation management in terrestrial edges of tidal marshes, western San Francisco Estuary, California. Prepared for Marin Audubon Society, Mill Valley, CA.

Beamesderfer, R., M. Simpson, G. Kopp, J. Inman, A. Fuller, and D. Demko. 2004. Historical and current information on Green Sturgeon occurrence in the Sacramento and San Joaquin rivers and tributaries. Prepared for State Water Contractors by S.P. Cramer and Associates, Inc., Gresham, Oregon. 46 pages.

Bell, M. C. 1991. Fisheries handbook of engineering requirements and biological criteria. Third edition. U.S. Army Corps of Engineers, Office of the Chief of Engineers, Fish Passage Development and Evaluation Program, North Pacific Division, Portland, Oregon.

Bellinger M. R. , Banks M. A., Bates S. J., Crandall E. D., Garza J. C., Sylvia G., Lawson P. W. 2015. Geo-referenced, abundance calibrated ocean distribution of Chinook salmon (Oncorhynchus tshawytscha) stocks across the West coast of North America. PLoS ONE , 10: e0131276-25.

Bennett, W. A. 2005. Critical Assessment of the Delta Smelt Population in the San Francisco Estuary, California. San Francisco Estuary and Watershed Science 3(2). Available at: http://repositories.cdlib.org/jmie/sfews/vol3/iss2/art1/.

Bennett, W. A. and J. R. Burau. 2015. Riders on the storm: selective tidal movements facilitate the spawning migration of threatened Delta Smelt in the San Francisco Estuary. Estuaries and Coasts 38(3):826-835. doi: http://dx.doi.org/10.1007/s12237-014-9877-3.

Bensen, R. L., S. Turo, and B. W. McCovey, Jr. 2007. Migration and Movement Patterns of Green Sturgeon (Acipenser medirostris) in the Klamath and Trinity Rivers, California, USA. Environmental Biology of Fishes 79:269–279.

Bergman, P. B., G. Schumer, S. Blankenship, E. Campbell. 2016. Detection of Adult Green Sturgeon using Environmental DNA Analysis. PLoS ONE 11(4): e0153500. doi:10.1371/journal.pone.0153500

Bever, A. J., M. L. MacWilliams, and D. K. Fullerton. Estuaries and Coasts. 2018. 41: 1943. https://doi.org/10.1007/s12237-018-0403.

Bever, A. J., M. L. MacWilliams, B. Herbold, L. R. Brown and F. V. Feyrer. 2016. Linking hydrodynamic complexity to delta smelt (*Hypomesus transpacificus*) distribution in the San Francisco Estuary, USA. San Francisco Estuary and Watershed Science 14(1). doi: http://dx.doi.org/10.15447/sfews.2016v14iss1art3

Bigg, M. A., P. F. Olesiuk, G. M. Ellis, J. K. B. Ford, and K. C. Balcomb III. 1990. Social organization and genealogy of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. In Individual recognition of cetaceans: Use of photo-identification and other techniques to estimate population parameters, edited by Hammond, P. S., S. A. Mizroch, and G. P. Donovan. Report of the International Whaling Commission Special Issue 12:383-406.

Bigg, M. A. 1982. An assessment of killer whale (*Orcinus orca*) stocks off Vancouver Island, British Columbia. Rep. Int. Whal. Comm., 32:655-666.

Bishop, D. M., R. L. Carstensen, and G. H. Bishop. 1989b. Report on environmental studies concerning the proposed Haines airport reconstruction: [Revision of Section A, Hydrology], second phase. ENVIRONAID consultants report to Alaska Department of Transportation and Public Facilities. Juneau.

Bisson et al, 1987. Large woody debris in forested streams in the Pacific Northwest: Past, present and future. Contribution No. 57. Pages 143-190 in: E. Saloand T. Cundy, editors. Proceeding of a symposium on s~eamside management: Forestryand fisht~ries interactions. University of Washington, Seattle, Washington, USA.

Bjorkstedt, E. P., B. C. Spence, J. C. Garza, D. G. Hankin, D. Fuller, W. E. Jones, J. J. Smith, and R. Macedo. 2005. An analysis of historical population structure for evolutionarily significant units of Chinook salmon, coho salmon, and steelhead in the north-central California coast recovery domain. U.S. Department of Commerce. NOAA Technical Memorandum. NMFS-SWFSC-382.

Blahm, T. H., and McConnell, R. J. 1971. Mortality of adult eulachon (Thaleichthys pacificus) subjected to sudden increases in water temperature. Northwest Science 45(3):178-82.

Bobzien, S., and J. E. DiDonato. 2007. The Status of the California Tiger Salamander (Ambystoma californiense), California Red-Legged Frog (Rana draytonii), and Foothill Yellow-Legged Frog (Rana boylii), and Other Herpetofauna in the East Bay Regional Park District, California. East Bay Regional Park District.

Boles, G. L., S. M. Turek, C. C. Maxwell, and D. M. McGill. 1988. Water Temperature Effects on Chinook Salmon (Oncorhynchus tshawytscha) with Emphasis on the Sacramento River: A Literature Review. California Department of Water Resources. 42 p.

Bouley, P., and W. J. Kimmerer. 2006. Ecology of a highly abundant, introduced cyclopoid copepod in a temperate estuary. Marine Ecology Progress Series 324: 219–228.

Brander, S. M. 2013. From ‘Omics to Otoliths: Responses of an Estuarine Fish to Endocrine Disrupting Compounds across Biological Scales. PLoS One. 2013; 8(9).

Brandes, P. L., and J. S. McLain. 2001. Juvenile Chinook salmon abundance, distribution, and survival in the Sacramento-San Joaquin Estuary. Contributions to the Biology of the Central Valley Salmonids, Fish Bulletin 179: Volume 2. Sacramento (CA): California Department of Fish and Game. p 39-136.

Bratovich, P. M., G. W. Link, P. B. J. Ellrott, and J. A. Piñero. 2004. Impacts on Lower American River salmonids and recommendations associated with Folsom Reservoir Operations to meet Delta water quality objectives and demands. 24 p. http://www.waterforum.org/wp-content/uploads/2015/09/Impacts-to-LAR-Resources-Report-2004.pdf

Brett, J. R., W. Clarke, J. E. Shelbourn. 1982. Experiments on thermal requirements for growth and food conversion efficiency of juvenile chinook salmon, Oncorhynchus tshawytscha. Canadian technical Reports in Fisheries and Aquatic Science. 1127. 1-29.

Brooks, M., E. Fleishman, L. Brown, P. Lehman, I. Werner, N. Scholz, C. Mitchelmore, J. Lovvorn, M. Johnson, D. Schlenk, S. van Drunick, J. Drever, D. Stoms, A. Parker, and R. Dugdale. 2012. Life Histories, Salinity Zones, and Sublethal Contributions of Contaminants to Pelagic Fish Declines Illustrated with a Case Study of San Francisco Estuary, California, USA. Estuaries and Coasts 35(2):603-621. doi: http://dx.doi.org/10.1007/s12237-011-9459-6

Brown L. R., L. M. Komoroske, R. W. Wagner, T. Morgan–King, J. T. May, R. E. Connon, N. A. Fangue. 2016. Coupled downscaled climate models and ecophysiological metrics forecast habitat compression for an endangered estuarine fish: PloS ONE 11(1): e0146724. doi: http://dx.doi.org/10.1371/journal.pone.0146724

Brown, L. R., R. Baxter, G. Castillo, L. Conrad, S. Culberson, G. Erickson, F. Feyrer, S. Fong, K. Gehrts, L. Grimaldo, B. Herbold, J. Kirsch, A. Mueller-Solger, S. Slater, K. Souza, and E. Van Nieuwenhuyse. 2014. Synthesis of studies in the fall low-salinity zone of the San Francisco Estuary, September–December 2011: U.S. Geological Survey Scientific Investigations Report 2014–5041. U.S. Geological Survey, Reston, VA.

Brown, L. R., W. A. Bennett, R. W. Wagner, T. Morgan-King, N. Knowles, F. Feyrer, D. H. Schoelhamer, M.T. Stacey, and M. Dettinger. 2013. Implications for future survival of delta smelt from four climate change scenarios for the Sacramento-San Joquin Delta, California. Estuaries and Coasts. DOI 10.1007/s12237-013-9585-4. Available on the internet at < http://link.springer.com/article/10.1007%2Fs12237-013-9585-4#>.

Buchanan, R. 2013. OCAP 2011 Steelhead Tagging Study: Statistical Methods and Results. Prepared for Bureau of Reclamation, Bay Delta Office, Sacramento CA. August 9, 2013. 110 p.

Buchanan, R. A. 2018a. 2014 Six-Year Acoustic Telemetry Steelhead Study: Statistical Methods and Results. Seattle: Columbia Basin Research, School of Aquatic & Fishery Sciences, University of Washington; 2018. Available from: sites/default/files/papers/UW 6yr steelhead report 2014 FINAL.PDF

Buchanan, R. A. 2018b. 2015 Six-Year Acoustic Telemetry Steelhead Study: Statistical Methods and Results. Seattle: Columbia Basin Research, School of Aquatic and Fishery Sciences, University of Washington; 2018. Available from: sites/default/files/papers/UW 6yr steelhead report 2015 FINAL.pdf

Buchanan, R. A. 2018c. 2016 Six-Year Acoustic Telemetry Steelhead Study: Statistical Methods and Results. Seattle: Columbia Basin Research, School of Aquatic and Fishery Sciences, University of Washington; 2018. Available from: sites/default/files/papers/UW 6yr steelhead report 2016 FINAL.pdf

Buchanan, R. A., J. R. Skalski, P. L. Brandes, and A. Fuller. 2013. Route use and survival of juvenile Chinook salmon through the San Joaquin River Delta. *North American Journal of Fisheries Management* 33(1):216–229.

Buchanan R. A., P. L. Brandes, and J. R. Skalski. 2018. Survival of Juvenile Fall-Run Chinook Salmon through the San Joaquin River Delta, California, 2010–2015. North American Journal of Fisheries Management. 38 (3): 663-679. Availalble at: https://doi.org/10.1002/nafm.10063.

Busby, P. J., T. C. Wainwright, G. J. Bryant, L. J. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Largomarsino. 1996. Status review of West Coast steelhead from Washington, Idaho, Oregon, and California. National Marine Fisheries Service, Northwest Fisheries Sceince Center and Southwest Region Protected Resources Division, NOAA Technical Memorandum, NMFS-NWFSC-27

Bush, E. E. 2017. Migratory Life Histories and Early Growth of the Endangered Estuarine Delta Smelt (*Hypomesus transpacificus*). M.S. Thesis. University of California, Davis, Davis, CA.

Cal Fish. 2018. Lower Sacramento River Green Sturgeon Telemetry Monitoring. https://www.calfish.org/ProgramsData/ConservationandManagement/CentralValleyMonitoring/LowerSacramentoRiverGreenSturgeonTelemetryMonitoring.aspx

CALFED. 2000. North of the Delta Offstream Storage Investigations. Integrated Storage Investigations. CALFED Bay-Delta Program.

California Advisory Committee on Salmon and Steelhead Trout. 1988. California Advisory Committee Restoring the balance. 1988 annual report. 84 p.

California Coastal Chinook Salmon ESU Central California Coast Coho Salmon ESU. National Marine Fisheries Service. Southwest Region, Long Beach, CA. 54 pp.

California Cyanobacteria and Harmful Algal Blooms Network. 2010. Cyanobacteria in California Recreational Waterbodies: Providing Voluntary Guidance about Harmful Algal Blooms, Their Monitoring, and Public Notification. Viewed online at: http://www.mywaterquality.ca.gov/monitoring_council/cyanohab_network/docs/2010_guidance.pdf. Accessed: Oct. 29, 2018. Last updated: Sept. 2008.

California Department of Finance. 2012. Available at: http://www.dof.ca.gov/Forecasting/Demographics/projections/.

California Department of Fish and Game (CDFG). 1929. Sacramento-San Joaquin Salmon (Oncorhynchus tschawytscha) Fishery of California. By G. H. Clark. 1929; 73 p., 32 figs.

California Department of Fish and Game (CDFG). 1929. The Commercial Fish Catch of California for the Years 1926 and 1927. By the Bureau of Commercial Fisheries. 1929; 93 p., 52 figs.

California Department of Fish and Game (CDFG). 1965. California fish and wildlife plan. Volume III supporting data: Part B, inventory salmon-steelhead and marine resources, available from California Department of Fish and Game, 1416 Ninth St., Sacramento, CA 95814.

California Department of Fish and Game (CDFG). 1994. California Endangered Species Act Memorandum of Understanding by and between Contra Costa Water District and California Department of Fish and Game Regarding the Los Vaqueros Project (Ref. No. 9339). January 24, 1994.

California Department of Fish and Game (CDFG). 1996. Steelhead Restoration and Management Plan for California. Inland Fisheries Division, California Department of Fish and Game, Sacramento, California.

California Department of Fish and Game (CDFG). 1997–2012. Unpublished data. Suisun Marsh Unit, Stockton, CA.

California Department of Fish and Game (CDFG). 1998. Report to the Fish and Game Commission: Report to the Fish and Game Commission: A Status Review of the Spring-Run Chinook Salmon (Oncorhynchus tshawytscha) in the Sacramento River Drainage. Candidate Species Status Report 98-01. Sacramento, CA: Department of Fish and Game.

California Department of Fish and Game (CDFG). 2002. Unpublished data from 1994-1996. Entrainment of Listed Fish Species at Pumping Plant #1 of the Contra Costa Canal and the Headworks at the

Rock Slough Intake. Monitoring required for the NMFS 1993 Los Vaqueros Reservoir biological opinion.

California Department of Fish and Game (CDFG). 2004. Sacramento River Winter-run Chinook Salmon. Biennial Report 2002 – 2003. Prepared for the Fish and Game Commission. June 2004

California Department of Fish and Game (CDFG). 2009. California Endangered Species Act Incidental Take Permit No. 2081-2009-001-03. Department of Water Resources California State Water Project Delta Facilities and Operations. Yountville, CA: California Department of Fish and Game, Bay Delta Region.

California Department of Fish and Game (CDFG). 2009. California Endangered Species Act Incidental Take Permit No. 2081-2009-013-03. Contra Costa Water District Maintenance and Operation of the Los Vaqueros Project and Alternative Intake Project. Signed November 9, 2009.

California Department of Fish and Game (CDFG). 2010. Report to the Fish and Game Commission: A status review of the California tiger salamander (Ambystoma californiense). Nongame Wildlife Program Report 2010-4. January 11, 2010.

California Department of Fish and Game (CDFG). 2011. East Marin County San Francisco Bay Stream Habitat Assessment Reports, Miller Creek. Surveyed 2009, Report Completed Feb, 2011.

California Department of Fish and Wildlife (CDFW). Undated. Drought Stressor Monitoring Case Study: Dissolved Oxygen Monitoring in the San Joaquin and Stanislaus Rivers. Available from: https://www.wildlife.ca.gov/Drought/Projects/San-Joaquin. Accessed on October 29, 2018.

California Department of Fish and Wildlife (CDFW). 2013. California Natural Diversity Database, RareFind 3, Version 3.1.0. June.

California Department of Fish and Wildlife (CDFW). 2015. Aquatic Invasive Species Monitoring at CDFW Hatcheries. October. Available: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=59228 Accessed: December 4, 2018.

California Department of Fish and Wildlife (CDFW). 2015. Aquatic Plant Risk Assessment: Curlyleaf Pondweed, Potamogeton crispus L. Available online at: https://dbw.parks.ca.gov/pages/28702/files/Curlyleaf%20pondweed%20Risk%20Assessment.pdf Accessed: Dec. 13, 2018.

California Department of Fish and Wildlife (CDFW). 2016. 2016 California Ocean Salmon Fisheries. Ocean Salmon Project.

California Department of Fish and Wildlife (CDFW). 2018. Drought Stressor Monitoring Case Study: Dissolved Oxygen Monitoring in the San Joaquin and Stanislaus Rivers. Available at: Drought Stressor Monitoring Case Study: Dissolved Oxygen Monitoring in the San Joaquin and Stanislaus Rivers.

California Department of Fish and Wildlife (CDFW). 2018. California Natural Diversity Database (CNDDB), RareFind 5, Version 5.2.14. Available: https://www.wildlife.ca.gov/Data/CNDDB/Maps-and-Data. Accessed: December 6, 2018.

California Department of Fish and Wildlife (CDFW). 2018. Historical Anadromous Fish Releases from CDFW Hatcheries. Available: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=156895 Accessed: December 19, 2018.

California Departmnet of Fish and Wildlife (CDFW). 2018a. Monthly Abundance Indices. http://www.dfg.ca.gov/delta/data/fmwt/indices.asp

California Department of Fish and Wildlife (CDFW). 2018b. Grand Tab 2018.04.09. California Central Valley Chinook Population Database Report. Compiled 9 April 2018. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=84381

California Department of Fish and Wildlife (CDFW). 2018. Lower Sacramento River Green Sturgeon Telemetry Monitoring. https://www.calfish.org/ProgramsData/ConservationandManagement/CentralValleyMonitoring/L

California Department of Fish and Wildlife. 2019. California Natural Diversity Database. RareFind 5. Version 5.2.14. January.

California Department of Fish and Wildlife and U.S. Bureau of Reclamation (CDFW and Reclamation). 2017. Hatchery and Genetics Management Plan for Trinity River Hatchery Coho Salmon. December.

California Department of Parks and Recreation (CDPR). 2018. Submersed Aquatic Vegetation Control Program: 2017 Annual Monitoring Report. Viewed online at: http://dbw.parks.ca.gov/pages/28702/files/2017%20SAV%20Annual%20Report%20B.pdf. Accessed: Dec. 13, 2018.

California Department of Parks and Recreation (CDPR). 2018b. Folsom Powerhouse State Historic Park. https://www.parks.ca.gov/pages/501/files/FolsomPowerhouse.pdf

California Department of Water Resources (DWR). 2007. Morrow Island Distribution System fish entrainment study. Interim data summary report, Division of Environmental Services, Sacramento, CA.

California Department of Water Resources (DWR). 2012. 2011 Georgiana Slough Non-Physical Barrier Performance Evaluation Project Report. California Department of Water Resources, Sacramento, CA. 9

California Department of Water Resources (DWR). 2016. 2014 Georgiana Slough Floating Fish Guidance Structure Performance Evaluation Project Report. California Department of Water Resources, Sacramento, CA.

California Department of Water Resources (DWR). 2015. An Evaluation of Juvenile Salmonid Routing and Barrier Effectiveness, Predation, and Predatory Fishes at the Head of Old River, 2009–2012. Prepared by AECOM, ICF International, and Turnpenny Horsfield Associates. April. California Department of Water Resources, Sacramento, CA.

California Department of Water Resources (DWR). 2015. Aquatic Plant Risk Assessment: Curlyleaf Pondweed, Potamogeton crispus L. Viewed online at:

http://dbw.parks.ca.gov/pages/28702/files/Curlyleaf%20pondweed%20Risk%20Assessment.pdf. Accessed: Dec. 13, 2018.

California Department of Water Resources (DWR). 2015. Biological Assessment for the West False River Emergency Drought Barrier Project. Prepared by AECOM, July 2015. 36 pp. plus appendixes.

California Department of Water Resources (DWR). 2016. 2014 Georgiana Slough Floating Fish Guidance Structure Performance Evaluation Project Report. California Department of Water Resources, Sacramento, CA.

California Department of Water Resources (DWR). 2017. Yolo Bypass Salmonid Habitat Restoration and Fish Passage. Draft Environmental Impact Statement/Environmental Impact Report. December.

California Department of Water Resources (DWR). 2018. Effect of the south Delta agricultural barriers on emigrating juvenile salmonids. Prepared by Environmental Science Associates and AECOM Technical Services, Sacramento, CA.

California Department of Water Resources (DWR). 2019. California EcoRestore Projects. http://resources.ca.gov/ecorestore/california-ecorestore-projects/, accessed January 23, 2019.

California Department of Water Resources and U.S. Bureau of Reclamation (DWR and Reclamation). 2016. Final Environmental Impact Report/Environmental Impact Statement for the Bay Delta Conservation Plan/California WaterFix—Volume I. Final EIR/EIS for the BDCP/California WaterFix. December. (DOE/EIS-0515.) (ICF 00139.14.) Prepared by ICF International, Sacramento, CA.

California Department of Water Resources and U.S. Bureau of Reclamation (DWR and Reclamation). 2017. Yolo Bypass Salmonid Habitat Restoration and Fish Passage. Draft Environmental Impact Statement/Environmental Impact Report. December.

Central California Irrigation District. 2011. Major Renovations Planned for Mendota Dam. Issue Three. http://www.ccidwater.org/CCID_Newsletter_2011_issue_3.pdf

California Native Plant Society (CNPS). 2018. Rare Plant Program. Inventory of Rare and Endangered Plants of California (online edition, v8-03 0.30). Available from http://www.rareplants.cnps.org. Accessed: February 6, 2019.

California Natural Resources Agency (CNRA). 2010. State of the state's wetlands. June 2010. State of California. 42p. Retrieved on September 14, 2015, from: http://www.resources.ca.gov/docs/SOSW_report_with_cover_memo_10182010.pdf

California Natural Resources Agency (CNRA). 2016. Delta Smelt Resiliency Strategy. Available from: http://resources.ca.gov/docs/Delta-Smelt-Resiliency-Strategy-FINAL070816.pdf Accessed: December 3, 2018.

California Natural Resources Agency (CNRA). 2017. Delta Smelt Resiliency Strategy Progress Report. Available: http://resources.ca.gov/docs/Delta-Smelt-Resiliency-Strategy-Update.pdf Accessed: January 2, 2019.

California Regional Water Quality Control Board, Central Valley Region. 2013. Order R5-2013-0124. Amending Wast Discharge Requirements Order R5-2010-0114-01 (PDES Permit No. CA0077682) and Time Schedule Order R5-2010-0115-01. Sacramento Regional County Sanitation District. Sacramento Regional Wastewater Treatment Plant. Sacrameto, California. Available at: https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/sacramento/r5-2013-0124.pdf.

California State Coastal Conservancy, Ocean Protection Council, National Marine Fisheries Service, San Francisco Bay Conservation and Development Commission, and San Francisco Estuary Partnership. 2010. San Francisco Bay subtidal habitat goals report; Conservation planning for the submerged areas of the Bay; 50-Year Conservation Plan. California Wetlands Monitoring Workgroup (CWMW). EcoAtlas. http://www.ecoatlas.org/regions/ecoregion/bay-delta/projects

Calkins, R.D., W.F. Durand, and W.H. Rich. 1940. Report ofthe board ofconsultants on the fish problem ofthe upper Sacramento River. Stanford U niv., 34 p. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon St., Suite 500, Portland, OR 97232.)

Carlson A., F. Rahel. 2007. A Basinwide Perspective on Entrainment of Fish in Irrigation Canals. Transactions of the American Fisheries Society 136:1335–1343, 2007.

Castillo, G., J. Morinaka, J. Lindberg, R. Fujimura, B. Baskerville-Bridges, J. Hobbs, G. Tigan, and L. Ellison. 2012. Pre-Screen Loss and Fish Facility Efficiency for Delta Smelt at the South Delta's State Water Project, California. San Francisco Estuary and Watershed Science 10(4).

Cavallo, B., J. Merz, J. Setka. 2012. Effects of predator and flow manipulation on Chinook Salmon (Oncorhynchus tshawytscha) survival in an imperiled estuary. Environmental Biology of Fish. Published online April 2012. DOI 10.1007/s10641-012-9993-5.

Cavallo, B., P. Gaskill, J. Melgo, and S. Zeug. 2015. Predicting juvenile Chinook routing in riverine and tidal channels of a freshwater estuary. Environmental Biology of Fishes 98(6):1571-1582.

Cavallo, B. 2016. Information to support DOSS entrainment risk evaluation. Memorandum to Delta Operations for Salmonids and Sturgeon group.

Cayan D. R., M. Tyree, M. D. Dettinger, H. Hidalgo, T. Das, E. Maurer, P. D. Bromirski, N. Graham, and R. E. Flick. 2009. Climate change scenarios and sea level rise estimates for California - 2008 Climate Change Scenarios Assessment - Final Report. California Energy Commission, PIER Report CEC500-2009-014-F.

Center for Whale Research. 2018. Available at: https://www.whaleresearch.com/. Accessed December 28, 2018.

Center for Whale Research. 2013. Southern Resident Killer Whales. Available At: http://www.whaleresearch.com/#!orcas/cto2

Central Valley Regional Water Quality Control Board. 2013. *Amending Waste Discharge Requirements Order R5-2010-0114-01 (NPDES Permit No. Ca0077682) and Time Schedule Order R5-2010-0115-01.* Sacramento Regional County Sanitation District, Sacramento Regional

Wastewater Treatment Plant, Sacramento County. Sacramento, Ca. Available: http://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/sacramento/r5-2013-0124.pdf.

Chesser T. R., R. C. Banks, C. Cicero, J. L. Dunn, A. W. Kratter, I. J. Lovette, A. G. NavarroSigüenza, P. C. Rasmussen, J. V. Remsen, Jr., J. D. Rising, D. F. Stotz, and K. Winker. 2014. Fifty-Fifth Supplement to the American Ornithologists' Union Check-list of North American Birds. The Auk: October 2014, Vol. 131, No. 4

Christensen, I. 1984. Growth and reproduction of killer whales, *Orcinus orca*, in Norwegian coastal waters. In: Reproduction in Whales, Dolphins and Porpoises: Proceedings of the Conference Cetacean Reproduction: Estimating Parameters for Stock Assessment and Management, W. F. Perrin, R. L. Brownell, Jr, D. P. DeMaster (eds.). Reports for the International Whaling Commission Special Issue. 6:253-258

Clear Creek Technical Team. 2018. Annual Report for the Coordinated Long-Term Operations Biological Opinion.

Cloern, J. E., A. Alpine, B. Cole, R. Wong, J. Arthur, and M. Ball. 1983. River discharge controls phytoplankton dynamics in Northern San Francisco Bay Estuary. Estuarine, Coastal and Shelf Science. 16. 415-429. 10.1016/0272-7714(83)90103-8.

Cloern, J. E. and A. D. Jassby. 2012. Drivers of change in estuarine-coastal ecosystems: Discoveries from four decades of study in San Francisco Bay. Reviews of Geophysics 50, RG4001, 33 pp.

Cloern, J. E., Morinaka, N. Brown, R. L., Cayan, D., Dettinger, M.D., Morgan, T. L., Schoellhammer, D. H., Stacey, M. T., van der Wegen, M., Wagner, R. W., and A.D. Jassby. 2011. Projected evolution of California’s San Francisco Bay-Delta-River system in a century of climate change. PLoS ONE 6(9): e24465. DOI: 10.371/journal.pone.0024465.

Clothier, W. D. 1953. Fish loss and movement in irrigation diversions from the West Gallatin River, Montana. Journal of Wildlife Management 17: 144-158. Cohen, A. N., and Carlton, J.T.. 1995. Nonindigenous Aquatic Species in a United States Estuary: A Case Study of the Biological Invasion of the San Francisco Bay and Delta. U.S. Fish and Wildlife Service, Washington DC.

Cohen, A. N. and J. T. Carlton. 1998. Accelerating Invasion Rate in a High Invaded Estuary. Science 279:555-558.

Cole, B. E. and J. E. Cloern. 1984. Significance of biomass and light availability to phytoplankton productivity in San Francisco Bay. Marine Ecology Progress Series. 17: 15-24.Collinge, S.K., M. Holyoak, C.B. Barr, and J.T. Marty. 2001. Riparian habitat fragmentation and population persistence of the threatened valley elderberry longhorn beetle in Central California. Biological Conservation 100:103-113.

Connon, R. E., Deanovic, L. A., Fritsch, E. B., D'Abronzo, L. and I Werner. 2011. Sublethal responses to ammonia exposure in the endangered delta smelt; Hypomesus transpacificus (Fam. Osmeridae). Aquatic Toxicology. (105): 369-377.

Conrad L., A. J. Bibian, K. Weinersmith, D. DeCarion, M. Young, P. Crain, E. Hestire, M. Santose, A. Sih. 2016. Novel species interactions in a highly modified estuary: association of Largemouth

Bass with Brazilian Waterweed Egeria densa. Trans Am Fish Soc 145:249- 263 doi: http://dx.doi.org/10.1080/00028487.2015.111 4521

Cook, D. G., Trenham, P. C., and Northern, P. T. 2006. Demography and Breeding Phenology of the California Tiger Salamander (Ambystoma Californiense) in an Urban Landscape. Northwestern Naturalist 87: 215–224.

Cook, R. R. 1992. An inventory of the mammals of Caswell Memorial State Park. California Dept. Parks and Recreation, Lodi, Final Rep., 30 pp.

Cordoleani, F., C. Michel, J. Notch, M. Daniels, H. Brown, M. Johnson, J. Israel, and E. Buttermore. 2019. Sacramento River spring pulse flow proposal to increase Central Valley Spring and Fall-run Chinook Salmon out-migration. Draft Proposal. January 2, 2019. 24p.

Cosco Busan Oil Spill Trustees. 2012. Cosco Busan *Oil Spill Final Damage Assessment and Restoration Plan/Environmental Assessment.* Prepared by California Department of Fish and Game, California State Lands Commission, National Oceanic and Atmospheric Administration, United States Fish and Wildlife Service, National Park Service, Bureau of Land Management.

Cramer Fish Sciences. 2006a. Stanislaus River Weir Update—November 20 through December 3, 2006. Stanislaus River Weir Email Summary dated December 6, 2006. Available from: http://fishsciences.net/postcards/postcard6.htm.

Cramer Fish Sciences. 2006b. Stanislaus River Weir Update—October 9 through October 22, 2006. Stanislaus River Weir Email Summary dated October 23, 2006. Available from: http://fishsciences.net/postcards/postcard3.htm.

Cramer Fish Sciences. 2006c. Stanislaus River Weir Update—September 25 through October 8, 2006. Stanislaus River Weir Email Summary dated October 10, 2006. Available from: http://fishsciences.net/postcards/postcard2.htm.

Cramer Fish Sciences. 2006d. Stanislaus River Weir Update—September 6 through September 24, 2006. Stanislaus River Weir Email Summary dated September 27, 2006. Available from: http://fishsciences.net/postcards/postcard1.htm.

Culberson, S., L. Bottorff, M. Roberson, and E. Soderstrom. 2008. Geophysical Setting and Consequences of Management in the Bay-Delta. Pages 37-54 in M.C. Healey, M.D. Dettinger, and R.B. Norgaard, eds. The State of Bay-Delta Science, 2008. Sacramento, CA: CALFED Science Program.

Culberson, S. D. 2001. The interaction of physical and biological determinants producing vegetation zonation in tidal marshes of the San Francisco Bay Estuary, California. Ph.D. Dissertation, University of California, Davis, CA.

Damon, L.J., S.B. Slater, R.D. Baxter, and R.W. Fujimura. 2016. Fecundity and reproductive potential of wild female delta smelt in the upper San Francisco Estuary, California. California Fish and Game 102(4): 188-210. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=141865&inline

Damon, L. J., S. B. Slater, R. D. Baxter, and R. W. Fujimura. 2016. Fecundity and reproductive potential of wild female delta smelt in the upper San Francisco Estuary, California. California Fish and Game 102(4): 188-210. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=141865&inline

Davidson, C., H. B. Shaffer, and M. R. Jennings. 2002. Spatial Tests of the Pesticide Drift, Habitat Destruction, UV-B and Climate Change Hypotheses for California Amphibian Declines. Conservation Biology 16:1588–1601.

Davis, J. A., D. Yee, J. N. Collins, S. E. Schwarzbach, S. N. Luoma. 2003. Potential for increased mercury accumulation in the estuary food web. San Francisco Estuary and Watershed Science [online serial]. VOL 1, Issue 1 (October 2003), Article 2.

Davis, M. 1974. Experiments in Nesting Behavior of the Least Tern Sterna Albifrons Browni. Proceedings of the Linnaean Society. New York 72:25-43. As cited in Rigney, M. and S. Granholm. 2005. Life History Account for Least Tern. California Wildlife Habitat Relationships System, California Department of Fish and Wildlife, California Interagency Wildlife Task Group. Available: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=1817.

De la Fuente, J., T. Lauent, D. Elder, R. VendeWater, A. Olsen. 2000. Watershed condition assessment beta-test results of northern province forests. U.S. Forest Service, Pacific Southwest Region.

Dege, M. and L. R. Brown. 2004. Effect of outflow on spring and summertime distribution and abundance of larval and juvenile fishes in the upper San Francisco Estuary. American Fisheries Society Symposium 39: 49-65.

DeGroot, D. S. 1927. The California clapper rail: its nesting habits, enemies, and habitat. Condor 29: 259-270.

Del Rio, A., B. Davis, N. Fangue, and A. Todgham. In press. Combined effects of warming and hypoxia on early life stage Chinook salmon physiology and development. Conservation Physiology

del Rosario, R. B., Y. J. Redler, K. Newman, P. L. Brandes, T. Sommer, K. Reece, and R. Vincik. 2013. Migration Patterns of Juvenile Winter-Run-Sized Chinook Salmon (Oncorhynchus tshawytscha) through the Sacramento–San Joaquin Delta. San Francisco Estuary and Watershed Science 11(1).

Delta Modeling Associates, Inc. (DMA). 2014. Low Salinity Zone Flip Book, Version 2.0. December 31.

Delta Operations for Salmonids and Sturgeon (DOSS). 2018. Annual Report of Activities October 1, 2017, to September 30, 2018.

Demko, D., C. Gemperle, A. Phillips, & S. Cramer. 2000. Outmigrant trapping of juvenile salmonids in the lower Stanislaus River Caswell State Park site 1999. Gresham (OR): SP Cramer & Associates, Inc. 135 p.

Deng, X., J. P. Van Eenennaam, and S. I. Doroshov. 2002. Comparison of Early Life Stages and Growth of Green and White Sturgeon. Transactions of the American Fisheries Society 28:237–248.

Dettinger, M., B. Udall and A. Georgakakos. 2015. Western water and climate change. Ecological Applications 25(8): 2069-2093. doi: http://dx.doi.org/10.1890/15-0938.1

Dettinger, M. D. 2005. From climate-change spaghetti to climate-change distributions for 21st Century California. San Francisco Estuary and Watershed Science Available on the internet at <http://repositories.cdlib.org/jmie/sfews/vol3/iss1/art4>.

Dettling, M. D., and C. A. Howell. 2011. Status of the Yellow-billed Cuckoo along the Sacramento River in 2010. Report to California Department of Fish and Game. PRBO Contribution #1794.

Dettman, D. H., D. W. Kelley, and W. T. Mitchell. 1987. The influence of flow on Central Valley salmon. Report prepared for the California Department of Water Resources. July 1987.

Dooling R. J. and A. N. Popper. 2007. The Effects of Highway Noise on Birds. Prepared for the California Department of Transporation, Division of Environmental Analysis. Available at: http://www.dot.ca.gov/hq/env/bio/files/caltrans_birds_10-7-2007b.pdf.Drinkwater KF, Frank KT. (1994) Effects of river regulation and diversion on marine fish and invertebrates. Aquat Conserv Mar Freshw Ecosyst 4: 135–151.

Dubrovsky N. M. Kratzer, C. R., Brown, L. R., Gronberg J. M., and K. R. Burow. 1998. Water quality in the San Joaquin-Tulare Basins, California, 1992-95. Circular 1159. U. S. Geological Survey.

Dugdale, R. C., F. P. Wilkerson, A. E. Parker, A. Marchi and K. Taberski. 2012. River Flow and Ammonium Discharge Determine Spring Phytoplankton Blooms in an Urbanized Estuary. Estuarine Coastal and Shelf Science 115:187-199.

Dugdale, R. C., F. P. Wilkerson and A. E. Parker. 2016. The effect of clam grazing on phytoplankton spring blooms in the low-salinity zone of the San Francisco Estuary: A modelling approach. Ecological Modelling 340:1-16. doi: http://dx.doi.org/10.1016/j.ecolmodel.2016.08.018

Dugdale, R. C., F. P. Wilkerson, V. E. Hogue and A. Marchi. 2007. The role of ammonium and nitrate in spring bloom development in San Francisco Bay. Estuarine, Coastal, and Shelf Science 73:17-29.

Alpine, E. and Cloern, J. 1992. Trophic interactions and direct physical effects control phytoplankton biomass and production in an. Limnology & Oceanography. 37.

Earley, J. T., D. J. Colby, and M. R. Brown. 2013. Juvenile salmonid monitoring in Sacramento River tributaries, California, from October 2009 through September 2010. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.

East Contra Costa County Habitat Conservancy. 2006. East Contra Costa County Habitat Conservation Plan and Natural Community Conservation Plan. Available: <http://www.co.contra-costa.ca.us/depart/cd/water/HCP/archive/final-hcp-rev/pdfs/hcptitleverso_9-27-06.pdf>.

Eddleman, W. R., F. L. Knopf, B. Meanley, F. A. Reid, and R. Zembal. 1988. Conservation of North American rallids. Wilson Bulletin 100:458-475.

Eliott J. M. 1981. Some aspects of thermal stress on freshwater teleosts. Stress and Fish. A.D. Pickering (ed). p 209-245.Eisenbeis, Gerhard. "Artificial night lighting and insects: attraction of insects to streetlamps in a rural setting in Germany." Ecological consequences of artificial night lighting 2 (2006): 191-198.

Enos, C., J. Sutherland, and M. L. Nobriga. 2007. Results of a Two Year Fish Entrainment Study at Morrow Island Distribution System in Suisun Marsh. IEP Newsletter 20(1):10-19.

Ensminger M. P., R. Budd, K. C. Kelley, K. S. Goh. 2013. Pesticide occurrence and aquatic benchmark exceedances in urban surface waters and sediments in three urban areas of California, USA, 2008–2011. Environ Monit. Assess 185:3697–710. doi: http://link.springer.com/article/10.1007/s10661-012-2821-8

Eulachon Research Council. 2000. Notes summarizing meetings in Terrace, B.C. (May 4), New Westminster, and Bella Coola, B.C. (May 9). Informal joint report prepared jointly by B.C. Forests, Department of Fisheries and Oceans-Canada.

Erickson, D. and A. H. Webb. 2007. Spawning Periodicity, Spawning Migration, and Size at Maturity of Green Sturgeon, Acipenser medirostris , in the Rogue River, Oregon. Environmental Biology of Fishes. 79. 255-268. 10.1007/s10641-006-9072-x.

Eriksen, C. and D. Belk. 1999. *Fairy Shrimps of California's Pools, Puddles, and Playas*. Eureka, CA: Mad River Press.

ESA PWA. 2012. Attachment 5E.A: BDCP South Delta Habitat And Flood Corridor Planning Corridor Description And Assessment Document. Attachment to Appendix 5.E: Habitat Restoration. Revised Administrative Draft. Bay Delta Conservation Plan. March. Sacramento, CA. Prepared for: California Department of Water Resources, Sacramento, CA.

Evens, J., and G. W. Page. 1983. The ecology of rail populations at Corte Madera Ecological Reserve: with recommendations for management. Report by the Point Reyes Bird Observatory. Stinson Beach, CA. 62 pp.

Evens, J., and G. W. Page. 1986. Predation on black rails during high tides in salt marshes. The Condor 88:107-109.

Everest, F. H. 1969. Habitat selection and spatial interaction of juvenile Chinook salmon and steelhead in two Idaho streams. PhD. Dissertation, University of Idaho, Moscow, ID. 77 pp

Everest, F. H., R.L. Beschta, J.C. Scrivener, K.V. Koski, J.R. Sedell, and C.J. Cederholm. 1987. Fine sediment and salmonid production: a paradox.

Federal Energy Regulatory Commission (FERC). 2011. Final Environmental Impact Statement for Hydropower License. McCloud-Pit Hydroelectric Project FERC Project No. 2106, California. Available at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/docs/mccloud_ferc2106/mccloudpit2106_feis2011.pdf

Feist, B. E., E. Buhle, P. Arnold, J. W. Davis, N. L. Scholz. 2011. Landscape ecotoxicology of coho salmon spawner mortality in urban streams. PLoS ONE, 6(8):e23424.

Felleman, F. L., J. R. Heimlich-Boran, and R. W. Osborne. 1991. The feeding ecology of killer whales (*Orcinus orca*) in the Pacific Northwest. Pp. 113–147 in Dolphin Societies: Discoveries and Puzzles, edited by Karen Pryor and K.S. Norris. Berkeley: University of California Press

Fera, S. A., M. D. Rennie, and E. S. Dunlop. 2017. Broad shifts in the resource use of a commercially harvested fish following the invasion of dreissenid mussels. Ecology 98(6):1681-1692.

Ferrari, M. C. O., L. Ranåker, K. L. Weinersmith, M. J. Young, A. Sih, and J. L. Conrad. 2014. Effects of turbidity and an invasive waterweed on predation by introduced largemouth bass. Environmental Biology of Fishes 97(1):79-90.

Feyrer F., B. Herbold, S. Matern, and P. Moyle. 2003. Dietary shifts in a stressed fish assemblage: Consequences of a bivalve invasion in the San Francisco Estuary. Environmental Biology of Fishes. 67 (3): 277-288.

Feyrer, F., K. Newman, M.L. Nobriga and T.R. Sommer. 2011. Modeling the effects of future outflow on the abiotic habitat of an imperiled estuarine fish. Estuaries and Coasts: 34(1):120-128. DOI 10.1007/s12237-010-9343-9.

Feyrer, F., M. L. Nobriga and T. R. Sommer. 2007. Multi-decadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, USA. Canadian Journal of Fisheries and Aquatic Sciences 64:723-734.

Fiedler, P. L., M. E. Keever, B. J. Grewell, and D. J. Partridge. 2007. Rare plants in the Golden Gate Estuary (California): the relationship between scale and understanding. Australian Journey of Botany 55: 206–220.

FishBIO. 2012. California Central Valley Steelhead. Available at https://fishbio.com/field-notes/fish-biology-behavoir/california-central-valley-steelhead.

FishBIO. 2015. Adult Chinook Salmon Adults Observed in the Video Weir and Provided in Excel Tables During the Spring on the Stanislaus River, Unpublished Data.

Fisher, F. W. 1994. Past and Present Status of Central Valley Chinook Salmon. Conservation Biology Volume 8: 870-873.

Fisher, R. N., and H. B. Shaffer. 1996. The decline of amphibians in California's Great Central Valley. Conservation Biology 10:1387–1397.

Fisler, G. F. 1965. Adaptations and speciation in harvest mice of the marshes of the San Francisco Bay. University of California Publications in Zoology 77: 1–108.

Fitzpatrick, B. M., and H. B. Shaffer. 2004. Environment-Dependent Admixture Dynamics in a Tiger Salamander Hybrid Zone. Evolution 58:1282–1293.

Fitzpatrick, B. M., J. R. Johnson, D. K. Kump, H. B. Shaffer, J. J. Smith, and S. R. Voss. 2009. Rapid Fixation of Non-Native Alleles Revealed by Genome-Wide SNP Analysis of Hybrid Tiger Salamanders. BMC Evolutionary Biology 9:176.

Foerster, K. S., J. E. Takekawa, and J. D. Albertson. 1990. Breeding density, nesting habitat, and predators of the California clapper rail. Unpubl. Rpt. No. SFBNWR-116400-90-1, prep. for San Francisco Bay NWR, Newark, CA. 46 pp.

Fong, S., S. Louie, I. Werner. 2016. Contaminant Effects on California Bay-Delta Species and Human Health. San Francisco Estuary and Watershed Science, 14(4). https://escholarship.org/uc/item/52m780xjFoote, A. D. R. W. Osborne, A. R. Hoelzel. 2004. Whale-call response to masking boat noise. Nature. 418: 910.

Ford M. J., H. Fuss, B. Boelts, E. LaHood, J. J. Hard. 2006. Changes in run timing and natural smolt production in a naturally spawning coho salmon (Oncorhynchus kisutch) stream after 60 years of intensive hatchery supplementation. Canadian Journal of Fisheries and Aquatic Sciences. 2006;63:2343–2355

Ford, J. K. B., and G. M. Ellis. 2005. Prey selection and food sharing by fish-eating 'resident' killer whales (*Orcinus orca*) in British Columbia. Canadian Science Advisory Secretariat Research Document 2005/041

Ford, J. K. B., G. M. Ellis, and P. F. Olesiuk. 2005. Linking prey and population dynamics: did food limitation cause recent declines of "resident" killer whales (*Orcinus orca*) in British Columbia. Canadian Science Advisory Secretariat Research Document 2005/042

Ford, J. K. B., G. M. Ellis, L. G. Barrett-Lennard, A. B. Morton, R. S. Palm, and K. C. Balcomb III. 1998. Dietary specialization in two sympatric populations of killer whales (*Orcinus orca*) in coastal British Columbia and adjacent waters. Canadian Journal of Zoology 76:14566–1471

Ford, J. K. B., and G. M. Ellis. 2005. Prey selection and food sharing by fish-eating 'resident' killer whales (Orcinus orca) in British Columbia. Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, 2005/041.

Ford, J. K. B., G. M. Ellis, and K. C. Balcomb. 2000. Killer whales: the natural history and genealogy of Orcinus orca in B.C. and Washington State. University of British Columbia, Vancouver, B.C.

Ford, J. K. B., G. M. Ellis, L. G. Barrett-Lennard, A.B. Morton, R.S. Palm, and K.C. Balcomb III. 1998. Dietary specialization in two sympatric populations of killer whales (Orcinus orca) in coastal B.C. and adjacent waters. Canadian Journal of Zoology 76:1456-1471.

Ford, J. 2006. An assessment of critical habitats of resident killer whales in waters on the Pacific coast of Canada. Can. Sci. Advis. Sec. Res. Doc. 72. 1-34.

Franks, S. 2014. Possibility of Natural Producing Spring-run Chinook Salmon in the Stanislaus and Tuolumne Rivers. National Oceanic Atmospheric Administration.

Frantzich, J., T. Sommer, and B. Schreier. 2018. Physical and Biological Responses to Flow in a Tidal Freshwater Slough Complex. San Francisco Estuary and Watershed Science 16(1).

Frost, N. 2015. California least tern breeding survey, 2014 season. California Department of Fish and Wildlife, Wildlife Branch, Nongame Wildlife Program Report, 2015-01. Sacramento, CA. 23 pp.

Frost, N. 2016. California least tern breeding survey, 2015 season. California Department of Fish and Wildlife, Wildlife Branch, Nongame Wildlife Program Report, 2016-01. Sacramento, CA. 24 pp.

Frost, N. 2017. California least tern breeding survey, 2016 season. California Department of Fish and Wildlife, Wildlife Branch, Nongame Wildlife Program Report, 2017-03. Sacramento, CA. 20 pp.

Fry, D. H., Jr. 1961. King Salmon Spawning Stocks of the California Central Valley, 1940–1959. California Fish and Game 47(1):55–71.

Gaines, D., and Laymon, S.A. 1984. Decline, status and preservation of the Yellowbilled Cuckoo in California. W. Birds 15:49-80.

Garrett, K., and J. Dunn. 1981. Birds of Southern California. Los Angeles Audubon Society.

Gauthreaux, S. and C. Belser. 2006. Effects of artificial night lighting on migrating birds. Ecological Consequences of Artificial Night Lighting. pp. 67-93. GEI Consultants. 2018. 2018 Suisun Marsh Salinity Gates Pilot Study. Delta Smelt Effects Analysis. Prepared for the California Department of Water Resources.

Geist, D. R., C. S. Abernethy, K. D. Hand, V. I. Cullinan, J. A. Chandler, P. A. Groves. 2006. Survival, Development, and Growth of Fall Chinook Salmon, Embryos, Alevins, and Fry Exposed to Variable Thermal and Dissolved Oxygen Regimes. Trans. Am. Fish. Soc. 135:1462-1477.

GenOn Delta LLC. 2011. Contra Costa Generating Station Implementation Plan for the Statewide Water Quality Contol Policy on the use of Coastal and Estuarine Waters for Power Plant Cooling. Available at: https://www.waterboards.ca.gov/water_issues/programs/ocean/cwa316/powerplants/contra_costa/docs/cc_ip2011.pdf.Gewant, D. and S.M. Bollens. 2012. Fish assemblages of interior tidal marsh channels in relation to environmental variables in the upper San Francisco Estuary. Environmental biology of fishes 94(2):483-499. doi: http://dx.doi.org/10.1007/s10641-011-9963-3

Glibert, P. M., 2010. Long-Term Changes in Nutrient Loading and Stoichiometry and Their Relationships with Changes in the Food Web and Dominant Pelagic Fish Species in the San Francisco Estuary, California, Reviews in Fisheries Science, 18:2, 211-232, DOI: 10.1080/10641262.2010.492059

Gill, R., Jr. 1972. South San Francisco Bay breeding bird survey, 1971. Calif. Dept. Fish and Game, Wildlife Management Branch Administrative Report 72-6. Sacramento, CA. 69 pp.

Giovannetti, S. L., RJ Bottaro, and M. R. Brown. 2013. Adult steelhead and late-fall Chinook salmon Monitoring on Clear Creek, California: 2011 Annual report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.

Gisbert, E., J. J. Cech, and S. I. Doroshov. 2001. Routine metabolism of larval green sturgeon (Acipenser medirostris). Fish Physiology and Biochemistry 25:195-200

Glibert, P. M., D. Fullerton, J. M. Burkholder, J. C. Cornwell, and T. M. Kana. 2011. Ecological stoichiometry, biogeochemical cycling, invasive species, and aquatic food webs: San Francisco Bay and comparative systems. Reviews in Fisheries Science 19: 358–417.

Good, T. P., R. S. Waples, and P. B. Adams. 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Department of Commerce. NOAA Technical Memorandum. NMFS-NWFSC-66.

Gore, J. A., B. P. Kennedy, R. R. Kneib, N. E. Monsen, J. Van Sickle, D. D. Tullos. 2018. Independent Review Panel (IRP) Report for the 2017 Long-term Operations Biological Opinions (LOBO) Biennial Science Review: Report to the Delta Science Program. Delta Stewardship Council and Delta Independent Science Program.

Grant, S. C. H., and P. S. Ross. 2002. Southern resident killer whales and risk: toxic chemicals in the British Columbia and Washington environment. Canadian Technical report of Fisheries and Aquatic Sciences 2412. Institute of Ocean Sciences. Fisheries and Oceans Canada, Sidney, BC

Greenwood, M. 2018. Potential Effects on Zooplankton From California WaterFix Operations. Technical Memorandum to California Department of Water Resources. July 2. Available: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/docs/petitioners_exhibit/dwr/part2_rebuttal/dwr_1349.pdf Accessed: November 30, 2018.

Gregory, R. S. and C. D. Levings. 1998. Turbidity reduces predation on migrating juvenile Pacific Salmon. Transactions of the American Fisheries Society. 127(2).

Grewell, B. J, M. A. DaPrato, P. R. Hyde, and E. Rejmánková. 2003. Experimental reintroduction of endangered soft bird's beak to restored habitat in Suisun Marsh. Final report. Report for CALFED Ecosystem Restoration Project 99-N05.

Grewell, B. J. 2005. Population census and status of the endangered soft bird's-beak (*Cordylanthus mollis* ssp. *mollis*) at Benicia State Recreation Area and Rush Ranch in Solano County, California. Report for Solano County Water Agency.

Grewell, B. J., J. C. Callaway, and W. R. Ferren, Jr. 2007. Estuarine wetlands. Pp. 124–154 in M. G. Barbour, T. Keeler-Wolf, and A. A. Schoenherr (eds.), Terrestrial Vegetation of California. University of California Press, Berkeley, CA.

Grimaldo, L. F., W. E. Smith, and M. L. Nobriga. 2017. After the storm: Re-examining factors that affect Delta smelt (Hypomesus transpacificus) entrainment in the Sacramento and San Joaquin Delta. Collaborative Adaptive Management Team Report. But I think more appropriate is: Grimaldo, L.F., W.E. Smith, and M.L. Nobriga. 2017. After the storm: Re-examining factors that affect Delta smelt (Hypomesus transpacificus) entrainment in the Sacramento and San Joaquin Delta. Unpublished manuscript.

Grimaldo, L. F., T. Sommer, N. Van Ark, G. Jones, E. Holland, P. B. Moyle, P. Smith and B. Herbold. 2009. Factors affecting fish entrainment into massive water diversions in a freshwater tidal estuary: can fish losses be managed? North American Journal of Fisheries Management 29(5) 1253-1270. First published online on: 09 January 2011 (iFirst).

Grinnell, J. and A. H. Miller. 1944. The distribution of the birds of California. Pacific Coast Avifauna 27:1-608.

Grossman, G. D., T. Essington, B. Johnson, J. Miller, N. Monsen, and T. N. Pearsons. 2013. Effects of fish predation on salmonids in the Sacramento River-San Joaquin Delta and associated ecosystems. Panel Report for State of the Science Workshop on Fish Predation on Central Valley Salmonids in the Bay-Delta Watershed. 25 September.

Gustafson, R. G., M. J. Ford, D. Teel, and J. S. Drake. 2010. Status review of eulachon (Thaleichthys pacificus) in Washington, Oregon, and California. US Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-105. Online at: http://www.nwfsc.noaa.gov/assets/25/7092_06162010_142619_EulachonTM105WebFinal.pdf.

Gustafson, R. G., M. J. Ford, P. B. Adams, J. S. Drake, R. L. Emmett, K. L. Fresh, M. Rowse, E. A. K. Spangler, R. E. Spangler, D. J. Teel, and M. T. Wilson. 2012. Conservation status of eulachon in the California Current. Fish and Fisheries 13: 121–138.

Gustafson, R.G. (Editor). 2016. Status Review Update of Eulachon (Thaleichthys pacificus) Listed under the Endangered Species Act: Southern Distinct Population Segment. 25 March. Seattle, WA: Northwest Fisheries Science Center, National Marine Fisheries Service.

H. T. Harvey & Associates. 1990a. San Jose permit assistance program California clapper rail 1990 breeding surveys. Prepared for CH2MHill, Emeryville, CA.

H. T. Harvey & Associates. 1990b. San Jose permit assistance program salt marsh harvest mouse trapping surveys, August to October 1990. Prepared for CH2MHill, Emeryville, CA. H.T.

H.T. Harvey and Associates, 1991. San Jose permit assistance program salt marsh harvest mouse trapping surveys. Prepared for CH2M Hill. Report number 477-11. 57 p.

H.T. Harvey and Associates. 1989. California Clapper Rail breeding survey, South San Francisco Bay. Alviso, CA. Prepared for CH2M Hill.

H.T. Harvey and Associates. 1997. Marsh plant associations of South San Francisco Bay: 1996 comparative study including Alviso Slough. Unpubl. report, 22 January, 1997. Project No. 477-18. Prepared for the City of San Jose, CA: 117.

Hadaway. H. C. and J. R. Newman. 1971. Differential responses of five species of salt marsh mammals to inundation. Journal of Mammalogy, 52: 818–820.

Hallock, R. J., and W. F. Van Woert. 1959. A Survey of Anadromous Fish Losses in Irrigation Diversions from the Sacramento and San Joaquin Rivers. California Fish and Game 45(4):227–296.

Hallock, R. J., W. F. Van Woert, and L. Shapovalov. 1961. An Evaluation of Stocking Hatchery- Reared Steelhead Rainbow Trout (*Salmo gairdnerii gairdnerii*) in the Sacramento River system. Fish Bulletin No. 114. Sacramento, CA: Department of Fish and Game.

Halstead B. J., P. Valcarcel, G. D. Wylie, P. S. Coates, M. L. Casazza, and D. K. Rosenberg. 2016. Active season microhabitat and vegetation selection by giant gartersnakes associated with a restored marsh in California. Journal of Fish and Wildlife Management 7(2):397–407; e1944-687X. doi: 10.3996/042016-JFWM-029

Halstead, B. J., S. M. Skalos, G. D. Wylie, M. L. Casazza. 2015. Terrestrial Ecology of Semi-Aquatic Giant Gartersnakes (Thamnophis gigas). Herpetological Conservation and Biology 10(2):633-644.

Hamilton, S. A., and D. D. Murphy. 2018. Analysis of limiting factors across the life cycle of delta smelt (*Hypomesus transpacificus*). Environmental Management https://doi.org/10.1007/s00267-018-1014-9.

Hammock, B. G., S. B. Slater, R. D. Baxter, N. A. Fangue, D. Cocherell, A. Hennessy, T. Kurobe, C. Y. Tai, and S. J. 2017. Foraging and metabolic consequences of semi-anadromy for an endangered estuarine fish. PloS one 12, no. 3 (2017): e0173497.

Hammock, B. G., J. A. Hobbs, S. B. Slater, S. Acuña and S. J. Teh. 2015. Contaminant and food limitation stress in an endangered estuarine fish. Science of the Total Environment 532:316-326. doi: http://dx.doi.org/10.1016/j.scitotenv.2015.06.018

Hanak, E., J. Lund, A. Dinar, B. Gray, R. Howitt, J. Mount, P. Moyle, and B. Thompson. 2011. Managing California's Water: From Conflict to Reconciliation. San Francisco: Public Policy Institute of California.Hannah, R., and S. Jones. 2009. 20th annual pink shrimp review. Oregon Dept. Fish Wildlife, Marine Resources Program, Newport. Online at http://www.dfw.state.or.us/MRP/publications/shrimp _newsletter2009.pdf

Hannon, J. and B. Deason. 2008. American River Steelhead (Oncorhynchus Mykiss) Spawning 2001 – 2007. U.S. Department of the Interior, Bureau of Reclamation, Mid-Pacific Region.

Hannon, J., M. Healey, and B. Deason. 2003. American River Steelhead (Oncorhynchus Mykiss) Spawning 2001 – 2003. U.S. Bureau of Reclamation and California Department of Fish and Game, Sacramento, CA.

Hansen, E. C., R. C. Scherer, E. Fleishman, B. G. Dickson, and D. Krolick. 2017. Relationships between Environmental Attributes and Contemporary Occupancy of Threatened Giant Gartersnakes (*Thamnophis gigas*). Journal of Herpetology, Vol. 51, No. 2, 274–283.

Hanson, B., R. W. Baird, J. K. B. Ford, J. Hempelmann-Halos, D. M. Van Doonik, J. R. Candy, C. K. Emmons, G. S. Schorr, B. Gisborne, K. L. Ayres, S. K. Wasser, K. C. Balcomb, K. Balcomb-Bartok, J. G. Sneva, and M. J. Ford. 2010. Species and stock identification of prey consumed by endangered southern resident killer whales in their summer range. Endangered Species Research 11:69–82

Hard, E. J. 2018. Progress Report Division of Boating and Waterways, California Department of Parks and Recreation (DBW) February 2018. Available: http://ucanr.edu/sites/DRAAWP/files/278760.pdf Accessed: December 30, 2018.

Harding, E. K., D. F. Doak, J. Albertson, and J. E. Takekawa. 1998. Predator management in San Francisco Bay wetlands: past trends and future strategies. Final Report prepared for U.S. Fish and Wildlife Service, Sacramento, CA.

Hart, J. L. 1973. Pacific fishes of Canada. Fisheries Research Board of Canada Bulletin No. 180.

Hart, J. L., and J. L. McHugh. 1944. The smelts (Osmeridae) of British Columbia. Fish. Res. Board of Canada Bull. No. 64.

Hartman, R., B. Herbold, K. Kayfetz, and S. Culberson. 2017. Chapter 3. Regional Transport Model Conceptual Model for Tidal Wetland Restoration. Pages 81-104 in S. Sherman, R. Hartman, and D. Contreras, editors. Effects of Tidal Wetland Restoration on Fish: A Suite of Conceptual Models. IEP Technical Report 91. California Department of Water Resources, Sacramento, CA.

Harvey, T. E. 1988. Breeding biology of the California clapper rail in south San Francisco Bay. Transactions of the Western Section of the Wildlife Society 24:98-104.

Hasenbein, M., I. Werner, L. A. Deanovic, J. Geist, E. B. Fritsch, A. Javidmehr, C, Foe, N. A. Fangue and R. E. Connon. 2014. Transcriptomic profiling permits the identification of pollutant sources and effects in ambient water samples. Science of the Total Environment 468: 688-698. doi: http://dx.doi.org/10.1016/j.scitotenv.2013.08.081

Hasenbein, M., N. A. Fangue, J. P. Geist, L. M. Komoroske and R. E. Connon. 2016. Physiological stress biomarkers reveal stocking density effects in late larval Delta Smelt (*Hypomesus transpacificus*). Aquaculture 450:108-115. doi: http://dx.doi.org/10.1016/j.aquaculture.2015.07.005

Hauser, D. D. W., M. G. Lodgson, E. E. Holmes, G. M. Van Blaricom, and R. W. Osborne. 2007. Summer distribution patterns of southern resident killer whales *Orcinus orca*: Core areas and spatial segregation of social groups. Marine Ecology Progress Series 351:301–210

Hay, D. 2002. The eulachon in Northern British Columbia. In T. Pitcher, M. Vasconcellos, S. Heymans, C. Brignall, and N. Haggan (eds.), Information supporting past and present ecosystem models of Northern British Columbia and the Newfoundland Shelf, p. 98-107. Fisheries Centre Research Reports, Volume 10 Number 1, Fisheries Centre, Univ. British Columbia, Vancouver.

Hay, D. E., and McCarter, P. B. 2000. Status of the eulachon Thaleichthys pacificus in Canada. Department of Fisheries and Oceans Canada, Canadian Stock Assessment Secretariat, Research Document 2000-145. Ottawa, Ontario.

Hay, D. E., R. Harbo, J. Boutillier, E. Wylie, L. Convey, and P. B. McCarter. 1999. Assessment of by-catch in the 1997 and 1998 shrimp trawl fisheries in British Columbia, with emphasis on eulachons. Canadian Stock Assessment Secretariat Research Document - 1999/179.

Hayhoe, K., D. Cayan, C. B. Field, P. C. Frumhoff, E. P. Maurer, N. L. Miller, S. C. Moser, S. H. Schneideri, K. N. Cahill, E. E. Cleland, L. Dale, R. Drapek, R. M. Hanemann, L. S. Kalkstein, J. Lenihan, C. K. Lunch, R. P. Neilson, S. C. Sheridan, and J. H. Verville. 2004. Emissions pathways, climate change, and impacts on California. Proceedings of the National Academy of Sciences of the United States of America 101(34):12422-12427. doi: http://dx.doi.org/10.1073/pnas.0404500101

Healey, M. C. 1991. Life History of Chinook Salmon (Oncorhynchus tshawytscha) in Pacific Salmon Life Histories. Groot, C. and Margolis, L. (ed.), Vancouver B.C.: UBC Press, pp 311-393.

Heim W. A., K. Coale, M. Stephenson. 2003. Assessment of Ecological and Human Health Impacts of Mercury in the Bay-Delta watershed. CALFED Bay-Delta Mercury Project Draft Final Report. 36 p.

Heimlich-Boran, J. R. 1986. Fishery Correlations with the Occurrence of Killer Whales in Greater Puget Sound. 113-131 In: Behavioral Biology of Killer Whales. Alan R. Liss, Inc., New York.

Helm, B. 1998. Biogeography of Eight Large Branchiopods Endemic to California. Pages 124–139 in C. W. Witham, E. T. Bauder, D. Belk, W. R. Ferrin, Jr., and R. Orduff (eds.), Ecology, Conservation, and Management of Vernal Pool Ecosystems—Proceedings from a 1996 Conference. Sacramento, CA: California Native Plant Society.

Heppell, S. S. 2007. Elasticity analysis of Green Sturgeon life history. Environ-mental Biology of Fishes 79:357–368.

Herbold B. and T. Vendlinski. 2012. Modeling Estuarine Habitat in the Bay Delta Unifying One and Three Dimensional Approaches to Modeling X2 and the Low Salinity Zone. Drafted for the Technical Workshop on Estuarine Habitat (27 March 2012). Available at https://www.epa.gov/sites/production/files/documents/modeling-estuarine-habitat.pdf.

Herman, D. P. D. G. Burrows. P. R. Wade. J. W. Durban, C. O. Matkin, R. G. LeDuc, L. G. Barrett-Lennard, M. M. Krahn. 2005. Feeding ecology of eastern North Pacific killer whales *Orcinus orca* from fatty acid, stable isotope, and organochlorine analyses of blubber biopsies. Marine Ecology Progress Series. 302: 275-291

Herren, J. R. and S. S. Kawasaki. 2001. Inventory of water diversions in four geographic areas in California's Central Valley. Pages 343-355 in R. L. Brown, ed. Contributions to biology of Central Valley salmonids, Vol . 2. CFG Fish Bulletin 179.

Hestir, E. L., D. H. Schoellhamer, J. Greenberg, T. Morgan-King, and S. L. Ustin. 2016. The Effect of Submerged Aquatic Vegetation Expansion on a Declining Turbidity Trend in the Sacramento-San Joaquin River Delta. Estuaries and Coasts 39(4):1100-1112.

Heublein, J., B. R., R. D. Chase, P. Doukakis, M. Gingras, D. Hampton, J. A. Israel, Z. J. Jackson, R. C. Johnson, O. P. Langness, S. Luis, E. Mora, M. L. Moser, L. Rohrbach, A. M. Seesholtz, T. Sommer, and J. S. Stuart. 2017a. Life History and Current Monitoring Inventory of San Francisco Estuary Sturgeon. National Marine Fisheries Service, NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-589.

Heublein, J., B. R., R. D. Chase, P. Doukakis, M. Gingras, D. Hampton, J. A. Israel, Z. J. Jackson, R. C. Johnson, O. P. Langness, S. Luis, E. Mora, M. L. Moser, L. Rohrbach, A. M. Seesholtz, and T. Sommer. 2017b. Improved Fisheries Management through Life Stage Monitoring: The Case for the Southern Distinct Population Segment of North American Green Sturgeon and the Sacramento-San Joaquin River White Sturgeon. National Marine Fisheries Service, NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-588.

Hindar, K., N. Ryman, F. Utter. 1991. Genetic effects of cultured fish on natural fish populations. Canadian Journal of Fisheries and Aquatic Sciences 48945-957.

Hobbs, J. A., Q.-z. Yin, J. Burton, and W. A. Bennett. 2005. Retrospective determination of natal habitats for an estuarine fish with otolith strontium isotope ratios. Marine and Freshwater Research 56(5):655-660.

Hobbs, J. A., Bennett, W. A., Burton, J. and M. Gras. 2007. Classification of larval and adult delta smelt to nursery areas by use of trace elemental fingerprinting. Transactions of the American Fisheries Society 136:518-527.

Hobbs, J. A., W. A. Bennett. and J. Burton. 2006. Assessing nursery habitat quality for native smelts (Osmeridae) in the low-salinity zone of the San Francisco Estuary. Journal of Fish Biology 69: 907-922.

Hoelzel, A. R. 1993. Foraging behavior and social group dynamics in Puget Sound killer whales. Animal Behaviour. 45: 581–591.

Hoelzel, A. R., A. Natoli, M. Dahlheim, C. Olavarria, R. Baird, and N. Black. 2002. Low worldwide genetic diversity in the killer whale (*Orcinus orca*): implications for demographic history. Proceedings of the Royal Society London 269:1467–1473.

Hoelzel, A. R., M. Dahlheim, and S. J. Stern. 1998. Low genetic variation among killer whales (*Orcinus orca*) in the eastern north Pacific and genetic differentiation between foraging specialists. Journal of Heredity 89(2):121–128

Holomuzki, J. R. 1986. Predator Avoidance and Diel Patterns of Microhabitat Use by Larval Tiger Salamanders. Ecology 67:737–748.

Holtby, L. Blair, and J. Charles Scrivener. 1989. Observed and simulated effects of climatic variability, clear-cut logging and fishing on the numbers of chum salmon (Oncorhynchus keta) and coho salmon(O. kisutch) returning to Carnation Creek, British Columbia. Canadian special publication of fisheries and aquatic sciences/Publication speciale canadienne des sciences halieutiques et aquatiques.

Hooper, E. T. 1938. Geographical variation in wood rats of the species *Neotorna fuscipes*. Univ. California Publ. Zool. 42: 213–246.

Horizon Water and Environment. 2017. Delta Research Station Project: Estuarine Research Station and Fish Technology Center Final Environmental Impact Report/Environmental Impact Statement. Volume I: Main Body. Prepared for: California Department of General Services on behalf of California Department of Water Resources and U.S. Fish and Wildlife Service.Howell, M., and Uusitalo, N. M. 2001. Eulachon (Thaleichthys pacificus) studies related to lower Columbia River channel deepening operations. Report to be submitted to the U.S. Army Corps of Engineers, Portland, Oregon. Keywords: Columbia River.

Huang, B., C. Langpap, R. M. Adams. 2011. Using instream water temperature forecasts for fisheries management: an application in the Pacific Northwest. Journal of the American Water Resources Association. 47:861–876.

Huber, E. R., and S. M. Carlson. 2015. Temporal Trends in Hatchery Releases of Fall-Run Chinook Salmon in California's Central Valley. San Francisco Estuary and Watershed Science 13(2).

Huff, D. D., S. T. Lindley, B. K. Wells, and F. Chai. 2012. Green sturgeon distribution in the Pacific Ocean estimated from modeled oceanographic features and migration behavior. PLoS One 7(9): e45852. 12 pp.

Hughes, J. M. 1999. “Yellow-billed Cuckoo (Coccyzus americanus).” In The Birds of North America Online. Edited by A. Poole. Ithaca, NY: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online. http://bna.birds.cornell.edu/ bna/species/418.

Hutton, P. H., Rath, J. S., and S. B. Roy. 2017. Freshwater flow to the San Francisco Bay-Delta estuary over nine decades (Part 2): Change attribution. Hydrological Processes. 31(14): 2516-2529. ICF International. 2015. Biological Assessment Of Effects On Listed Fishes From The West False River Emergency Drought Barrier Project. Draft. July 10. (ICF 00208.14.) Sacramento, CA. Prepared for AECOM, Sacramento, CA. Available at : https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfiw/exhibits/docs/petitioners_exhibit/dwr/part2/dwr1036/ICFInternational2015.pdf

ICF International. 2016. Biological Assessment for the California WaterFix. July. (ICF 00237.15.) Sacramento, CA. Prepared for United States Department of the Interior, Bureau of Reclamation, Sacramento, CA.

ICF Jones & Stokes. 2010. Final Hatchery and Stocking Program Environmental Impact Report/Environmental Impact Statement. (SCH # 2008082025.) Prepared for California Department of Fish and Game and U.S. Fish and Wildlife Service. January.

ICF. 2017. Public Water Agency 2017 Fall X2 Adaptive Management Plan Proposal. Submitted to United States Bureau of Reclamation and Department of Water Resources. Draft. August 30. (ICF 00508.17.) Sacramento, CA.

ICF. 2018. Fish Monitoring Report for the Rock Slough Fish Screen Facility – November 16-30, 2018. Submitted December 31, 2018. San Francisco, California.

Interagency Ecological Program (IEP). 2007a. Summary for Policymakers. Pp. 1–18. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor, and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY. 996 pp.

Interagency Ecological Program (IEP). 2015. An updated conceptual model of Delta Smelt biology: our evolving understanding of an estuarine fish. IEP Management, Analysis and Synthesis Team. Interagency Ecological Program for the San Francisco Bay/Delta Estuary. Technical Report 90. California Department of Water Resources. http://www.water.ca.gov/iep/docs/Delta_Smelt_MAST_Synthesis_Report_January%202015.pdf

Interagency Ecological Program for the Sacramento–San Joaquin Estuary. 2001. Suisun Ecological Workgroup final report to the State Water Resources Control Board. November. Technical Report 68. Sacramento, CA. Available at: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Environmental-Services/Interagency-Ecological-Program/Files/IEP-Technical-Reports/TR68-Suisun-Ecological-Workgroup-Final-Report-to-the-State-Water-Resources-Control-Board.pdf

Interagency Ecological Program Management, Analysis, and Synthesis Team (IEP MAST). 2015. An updated conceptual model of Delta Smelt biology: our evolving understanding of an estuarine fish. Technical Report 90. January. Interagency Ecological Program for the San Francisco Bay/Delta Estuary, Sacramento, CA.

Intergovernmental Panel on Climate Change (IPCC). 2007. The scientific basis. Contribution of the Working Group I to the 4th Assessment Report of the Intergovernmental Panel on Climate Change. Alley, R., T. Bernsten, N. L. Bindoff, Z. Chen, A. Chidthaisong, P. Friedlingstein, J. Gregory, G. Hegerl, M. Heimann, B. Hewiston, B. Hoskins, F. Joos, J. Jouzel, V. Kattsov, U. Lohmann, M. Manning, T. Matsumo, M. Molina, N. Nicholls, J. Overpeck, D. Qin, G. Raga, V. Ramaswamy, J. Ren, M. Rusticucci, S. Solomon, R. Somerville, T. F. Socker, P. Stott, R. F. Souffer, P. Whetton, R. A. Wood, D. Wratt. 21 pp. Available at <http;//www.ipcc.ch/>.

Israel, J. A., J. F. Cordes, M. A. Blumberg, and B. May. 2004. Geographic Patterns of Genetic Differentiation among Collections of Green Sturgeon. North American Journal of Fisheries Management 24:922–931.

Jabusch, T., P. Trowbridge, A. Wong, M. Heberger. 2018. Assessment of Nutrient Status and Trends in the Delta in 2001-2016: Effects of drought on ambient concentrations and trends. March 2018.

Jackson, Z. J. and J. P. Van Eenennaam. 2013. 2012 San Joaquin River sturgeon spawning survey. Stockton Fish and Wildlife Office, Anadromous Fish Restoration Program, U.S. Fish and Wildlife Service, Lodi, California.

James A. 2004. Decreasing sediment yields in northern California: Vestiges of hydraulic gold-mining and reservoir trapping. Conference paper: Sediment Transfer through the Fluvial System. Proceedings of the Moscow Symposium, August 2004. IAHS Publication 288.

Jameson, E. W., Jr., and H. J. Peeters. 1988. California Mammals. University of California Press.

Jassby, A. D. and J. E. Cloern. 2000. Organic matter sources and rehabilitation of the Sacramento-San Joaquin Delta (California, USA). Aquatic Conservation: Marine and Freshwater Ecosystems 10(5):323-352. https://sfbay.wr.usgs.gov/publications/pdf/jassby_2000_organic.pdf.

Jassby, A. D., J.E Cloern, and B. E. Cole. 2002. Annual primary production: patterns and mechanisms of change in a nutrient-rich tidal ecosystem. Limnology and Oceanography 47:698-712.

Jassby, A. D., W. J. Kimmerer, S. G. Monismith, C. Armor, J. E. Cloern, T. M. Powell, J. R. Schubel and T. J. Vendlinski. 1995. Isohaline position as a habitat indicator for estuarine populations. Ecological Applications 5(1): 272-289.

Jeffries, K. M., R. E. Connon, B. E. Davis, L. M. Komoroske, M. T. Britton, T. Sommer, A. Todgham and N. A. Fangue. 2016. Effects of high temperatures on threatened estuarine fishes during periods of extreme drought. Journal of Experimental Biology 219(11):1705-1716. doi: http://dx.doi.org/10.1242/jeb.134528

Jenkins, J., L. Takata, P. Goertler, B. Schreier, L. Conrad, N. Rasmussen, and H. Green. 2018. In the Weeds: Fish Predators and Predation Risk in North Delta Flooded Islands Treated and Untreated for Invasive Aquatic Vegetation. Poster presentation at 10th Biennial Bay-Delta Science Conference, Sacramento, CA, September 10-12, 2018.

Jennings, M. R., and M. P. Hayes. 1994. Amphibian and Reptile Species of Special Concern in California. Rancho Cordova, CA: California Department of Fish and Game, Inland Fisheries Division.

Johnson R. C., P. K. Weber, J. D. Wikert, M. L. Workman, R. B. MacFarlane, M. J. Grove. 2012. Managed Metapopulations: Do Salmon Hatchery ‘Sources’ Lead to In-River ‘Sinks’ in Conservation? PLoS ONE 7(2): e28880.

Johnson, R. and 15 others. 2017. Science advancements key to increasing management value of life stage monitoring networks for endangered Sacramento River winter-run Chinook Salmon in California. San Francisco Estuary and Watershed Science. 41 p.

Johnson, R. C., J. C. Garza, R. B. MacFarlane, C. B. Grimes, C. C. Phillis, P. L. Koch, P. K. Weber, and M. H. Carr. 2016. Isotopes and genes reveal freshwater origins of Chinook salmon *Oncorhynchus tshawytscha* aggregations in California's coastal ocean. Marine Ecology Progress Series 548:181-196.

Johnston, R. F. 1957. Adaptation of salt marsh mammals to high tides. Journal of Mammalogy, 38:529-531.

Johnston, R. F. 1956. Predation by short-eared owls on a Salicornia salt marsh. Wilson Bull. 68:91-102.

Katibah, E. F. 1984. A brief history of riparian forests in the Central Valley of California. In California Riparian Systems: Ecology, Conservation, and productive management. Edited by R.E. Warner and K.M. Hendrix. Univ. of Cal. Press, California. Pages 23–29.

Katz, J. V. E., C. Jeffres, J. L. Conrad, T. R. Sommer, J. Martinez, and S. Brumbaugh. 2017. Floodplain farm fields provide novel rearing habitat for Chinook salmon. PLoS ONE 12(6): e0177409. https://doi.org/10.1371/journal.pone.0177409

Kayfetz, K. and Kimmerer, W. 2017. Abiotic and biotic controls on the copepod Pseudodiaptomus forbesi in the upper San Francisco Estuary. Marine Ecology Progress Series. 581. 10.3354/meps12294.

Kelly, P. A., Edgarian, T. K., Lloyd, M. R., Phillips, and S. E. 2011. Conservation Principles for the Riparian Brush Rabbit & Riparian Woodrat. California State University Stanislaus Endangered Species Recovery Program.

Kelly, P. A. 2015. Personal Communication. Riparian Brush Rabbit Range in South Delta. Email to Heather Swinney, forward to Rebecca Sloan. Dec. 18, 2015.

Kennedy, T. 2008. Stanislaus River salmonid density and distribution survey report (2005-2007). Draft prepared by Fishery Foundation of California for the Bureau of Reclamation Central Valley Project Improvement Act.

Kennedy, T. and T. Cannon. 2005. Stanislaus River Salmonid Density and Distribution Survey Report (2002-2004). Fishery Foundation of California. Prepared for US Bureau of Reclamation, Central Valley project Improvement Act. October 2005. 20051027StanislausSnorkel_covers2002-2004.doc

Killam, D. 2008. Results of the 2007 Cow Creek Video Station fall-run Chinook salmon escapement. SRSSAP Technical Report No. 08-02.

Kimmerer, W. J. 2002. Effects of freshwater flow on abundance of estuarine organisms: Physical effects or trophic linkages? Marine Ecology Progress Series 243: 39-55.

Kimmerer, W. J. 2002a. Physical, biological and management responses to variable freshwater flow into the San Francisco Estuary. Estuaries 25: 1275-1290.

Kimmerer, W. J. 2004. Open water processes of the San Francisco Estuary: from physical forcing to biological processes. San Francisco Estuary and Watershed Science. Available on the internet at <http://repositories.cdlib.org/jmie/sfews/vol2/iss1/art1>.

Kimmerer, W. J. 2008. Losses of Sacramento River Chinook salmon and delta smelt to entrainment in water diversions in the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science, 6:2 (2). Available on the internet at <http://repositories.cdlib.org/jmie/sfews/vol6/iss2/art2>.

Kimmerer, W. J., and J. J. Orsi. 1996. Causes of long-term declines in zooplankton in the San Francisco Bay estuary since 1987, p. 403-424. In J. T. Hollibaugh [ed.], San Francisco Bay: The Ecosystem.

Kimmerer, W. J. and J. K. Thompson. 2014. Phytoplankton Growth Balanced by Clam and Zooplankton Grazing and Net Transport into the Low-Salinity Zone of the San Francisco Estuary. Estuaries and Coasts, Pre-print published online: January 7.

Kimmerer, W. J., and K. A. Rose. 2018. Individual-Based Modeling of Delta Smelt Population Dynamics in the Upper San Francisco Estuary III. Effects of Entrainment Mortality and Changes in Prey. Transactions of the American Fisheries Society 147(1):223-243.

Kimmerer, W. J., E. S. Gross, A. M. Slaughter, and J. R. Durand. 2018. Spatial Subsidies and Mortality of an Estuarine Copepod Revealed Using a Box Model. Estuaries and Coasts.

Kimmerer, W. J., E. S. Gross, and M. L. MacWilliams. 2009. Is the Response of Estuarine Nekton to Freshwater Flow in the San Francisco Estuary Explained by Variation in Habitat Volume? Estuaries and Coasts 32(2):375-389.

Kimmerer, W. J., J. H. Cowan, L. W. Miller, and K. A. Rose. 2000. Analysis of an estuarine striped bass (*Morone saxatilis*) population: influence of density-dependent mortality between metamorphosis and recruitment. Canadian Journal of Fisheries and Aquatic Sciences 57(2):478-486.

Kimmerer, W. J., M. L. MacWilliams, and E. S. Gross. 2013. Variation of Fish Habitat and Extent of the Low-Salinity Zone with Freshwater Flow in the San Francisco Estuary. San Francisco Estuary and Watershed Science 11(4).

Kimmerer, W. J., T. R. Ignoffo, K. R. Kayfetz, and A. M. Slaughter. 2018a. Effects of freshwater flow and phytoplankton biomass on growth, reproduction, and spatial subsidies of the estuarine copepod *Pseudodiaptomus forbesi*. Hydrobiologia 807:113-130.

Kimmerer, W., T. R. Ignoffo, B. Bemowski, J. Moderan, A. Holmes, and B. Bergamaschi. 2018c. Zooplankton Dynamics in the Cache Slough Complex of the Upper San Francisco Estuary. San Francisco Estuary and Watershed Science 16(3).

Kindel, F. 1984. Riparian protection from Corps of Engineers projects. Pp. 895-898, in California riparian systems ecology, conservation, and productive management (R. E. Warner and K. M. Hendrix, eds.). Univ. California Press, Berkeley, 1053 pp.

King, J. L., M. A. Simovich, and R. C. Brusca. 1996. Species Richness, Endemism and Ecology of Crustacean Assemblages in Northern California Vernal Pools. Hydrobiologia 328:85–116.

Kingsford, R. T. 2000. Ecological impacts of dams, water diversions and river management on floodplain wetlands in Australia . Austral Ecol 25: 109–127.

Kjelson M. A., P. F. Raquel, F. W. Fisher. 1981. The life-history of fall run juvenile Chinook salmon, Oncorhynchus-Tshawytscha, in the Sacramento San Joaquin Estuary of California. Estuaries. 4:285–285.Kjelson M. A., P. F. Raquel, F. W. Fisher.. 1982. Life history of fall-run juvenile chinook salmon, Oncorhynchus tshawytscha, in the Sacramento-San Joaquin estuary, California. Estuarine Comparisons. 393-411.

Klimley, A. P., E. D. Chapman, J. J. Cech, D. E. Cocherell, N. A. Fangue, M. Gingras, Z. Jackson, E. A. Miller, E. A. Mora, J. B. Poletto, A. M. Schreier, A. Seescholtz, K. J. Sulak, M. J. Thomas, D. Woodbury, M. T. Wyman. 2015. Sturgeon in the Sacramento-San Joaquin Watershed: New

Insights to Support Conservation and Management. San Francisco Estuary and Watershed Science. 13: 1-19.

Knowles, N. and D.R. Cayan. 2002. Potential effects of global warming on the Sacramento/San Joaquin watershed and the San Francisco estuary. Geophysical Research Letters 29(18). doi: http://dx.doi.org/10.1029/2001GL014339

Knutson, A. C. and J. J. Orsi. 1983. Factors Regulating Abundance and Distribution of the Shrimp Neomysis mercedis in the Sacramento-San Joaquin Estuary, Transactions of the American Fisheries Society, 112:4, 476-485, DOI: 10.1577/1548-8659(1983)112<476:FRAADO>2.0.CO;2.

Kocan R., P. Hershberger, G. Sanders, J. Winton. 2009. Effects of temperature on disease progression and swimming stamina in Ichthyophonus-infected rainbow trout, Oncorhynchus mykiss (Walbaum). J Fish Dis 32:835–843.

Komoroske, L., R. E. Connon, J. Lindberg, B. S. Cheng, G. Castillo, M. Hasenbein, N. A. Fangue. 2014. Ontogeny influencessensitivity to climate change stressors in an endangeredfish. Conserv Physiol 2:1–13.

Komoroske, M., K. M. Jeffries, R. E. Connon, J. Dexter, M. Hasenbein, C. Verhille and N. A. Fangue. 2016. Sublethal salinity stress contributes to habitat limitation in an endangered estuarine fish. Evolutionary Applications. doi: http://dx.doi.org/10.1111/eva.12385

Krahn, M. M., M. J. Ford, W. F. Perrin, P. R. Wade, R. P. Angliss, M. B. Hanson, B. L. Taylor, G. M. Ylitalo, M. E. Dahlheim, J. E. Stein, and R. S. Waples. 2002. Status review of southern resident killer whales (*Orcinus orca*) under the Endangered Species Act. U.S. Department of Commerce, NOAA Technical Memo NMFS-NWFSC-54.

Krahn, M. M., M. J. Ford, W. F. Perrin, P. R. Wade, R. P. Angliss, M. B. Hanson, B. L. Taylor, G. M. Ylitalo, M. E. Dahlheim, J. E. Stein, and R. S. Waples. 2004. Status review of southern resident killer whales (*Orcinus orca*) under the Endangered Species Act. U.S. Department of Commerce, NOAA Technical Memo NMFS-NWFSC-62.

Kratina, P., R. Mac Nally, W.J. Kimmerer, J.R. Thomson, M. Winder. 2014. Human-induced biotic invasions and changes in plankton interaction networks. Journal of Applied Ecology 51(4):1066-1074. doi: http://dx.doi.org/10.1111/1365-2664.12266

Kratville, D. 2010. California Department of Fish and Game Rationale for Effects of Exports. California Department of Fish and Game, Sacramento, CA.

Kruse, S. 1991. The interactions between killer whales and boats in Johnstone Strait, B.C. Pages 149-159 in K. Pryor and K.S. Norris, eds. Dolphin Societies: Discoveries and Puzzles. University of California Press, Berkeley, CA

Kuvila, K. M. and G. E. Moon. 2004. Potential Exposure of Larval and Juvenile Delta Smelt to Dissolved Pesticides in the Sacramento-San Joaquin Delta, California. American Fisheries Society Symposium. 39: 228-241.Kurobe, T., M.O. Park, A. Javidmehr, F.C. Teh, S.C. Acuña, C.J. Corbin, A.J. Conley, W.A. Bennett and S.J. Teh. 2016. Assessing oocyte development and maturation in the threatened Delta Smelt, *Hypomesus transpacificus*. Environmental Biology of Fishes 99(4):423-432. doi: http://dx.doi.org/10.1007/s10641-016-0483-z

Kus, B. E. 2002. Fitness consequences of nest desertion in an endangered host, the Least Bell's Vireo. Condor 104:795-802.

Kynard, B., E. Parker, and T. Parker. 2005. Behavior of Early Life Intervals of Klamath River Green Sturgeon, Acipenser medirosris, with a Note on Body Color. Environmental Biology of Fishes 72:85–97.

Laabs, D. M., M. L. Allaback, and S. G. Orloff. 2001. Pond and Stream Breeding Amphibians. Chapter 5. In: J. E. Vollmar (ed.). Wildlife and Rare Plant Ecology of Eastern Merced County's Vernal Pool Grasslands, Merced County. Merced, CA: University of California Development Office. 193–229.

Laetz, C. A., D. H. Baldwin, T. K. Collier, V. Hebert, J. D. Stark, and N. L. Scholz. 2009. The Synergistics Toxicity of Pesticides Mixtures: Implications for Risk Assessment and the Conservation of Endangered Pacific Salmon. Environmental Health Perspectives 117(3):348-353.

Lambson, G. H., 1899. U.S. Commission of Fish and Fisheries. Comm. Rept 1898. 53pp

Lambson, G. H., 1900. U.S. Commission of Fish and Fisheries. Comm. Rept 1899. 94pp

Lambson, G. H., 1901. U.S. Commission of Fish and Fisheries. Comm. Rept 1900. 85 pp.

Lambson, G. H., 1902. U.S. Commission of Fish and Fisheries. Comm. Rept 1901. 74pp.

Lambson, G. H., 1904. U.S. Commission of Fish and Fisheries. Comm. Rept 1902. 71pp.

Langer, O. E., B. G. Shepherd, and P. R. Vroom. 1977. Biology of the Nass River eulachon (Thaleichthys pacificus). Department of Fisheries and Environment Canada, Fisheries and Marine Service, Technical Report Series No. PAC, T-77-10.

Latour, R. J. 2016. Explaining Patterns of Pelagic Fish Abundance in the Sacramento-San Joaquin Delta. Estuaries and Coasts 39(1):233-247. doi: http://dx.doi.org/10.1007/s12237-015-9968-9

Lawler, S. P., D. Dritz, T. Strange, and M. Holyoak. 1999. Effects of Introduced Mosquitofish and Bullfrogs on the Threatened California Red-Legged Frog. Conservation Biology 13:613–622.

Laymon, S. A. 1980. Feeding and Nesting Behavior of the Yellow-Billed Cuckoo in the Sacramento Valley. Wildlife Management Administrative Report 80-2. Sacramento, CA: California Department of Fish and Game.

Laymon, S. A. 1998. Yellow-Billed Cuckoo (Coccycus americanus). In The Riparian Bird Conservation Plan: A Strategy for Reversing the Decline of Riparian-Associated Birds in California. California Partners in Flight. Available: http://www.prbo.org/calpif/htmldocs/species/riparian/yellow-billed_cuckoo.htm.

Laymon, S. A., and M. D. Halterman. 1987. Can the Western Subspecies of the Yellow-billed Cuckoo Be Saved from Extinction? Western Birds 18:19–25.

Lehman, P. W., Marr, K., Boyer, G.L., Acuna, S. and S. J. 2013. The long-term trends and causal factors associtated with Microsystis abundance and toxcity in San Francisco Estuary and immplications for climate change impacts. Hydrobilogia. 718: 141-158.

Lehman, P. W., Kendall, C., Guerin, M. A., Young, M. B., Silva, S. R., Boyer, G. L., and S. J. 2014. The Characterization of the Microcystis Bloom and Its Nitrogen Supply in San Francisco Estuary Using Stable Isotopes. Estuaries and Coasts. (38): 165-178.

Lehman, P., T. Kurobe, S. Lesmeister, M. Mizel, D. Baxa, A. Tung, and S. Teh. 2017. "Impacts of the 2014 severe drought on Microcystis blooms in the San Francisco Estuary." Harmful Algae 63(3): pp. 94-108. [Journal]. Viewed online at: https://www.sciencedirect.com/science/article/pii/S1568988316302177. Accessed: Oct. 29, 2018. Last updated: Feb. 17, 2017.

Lehman, P., S. Mayr, L. Mecum, and C. Enright. 2010. The freshwater tidal wetland Liberty Island, CA was both a source and sink of inorganic and organic material to the San Francisco Estuary. Aquatic Ecology 44(2):359–372.

Leicester, M. and J. Smith. 2014. Stevens Creek Environmental Conditions and Fish Resources in 2013. 21 January 2014. California Department of Fish and Wildlife and San Jose State University. 47 pp.

Leidy, R. A., and G. R. Leidy. 1984. Life stage periodicities of anadromous salmonids in the Klamath River Basin, northwestern California. US Fish and Wildlife Service, Division of Ecological Services.

Lessard, J., B. Cavallo, P. Anders, T. Sommer, B. Schreier, D. Gille, A. Schreier, A. Finger, T.-C. Hung, and J. Hobbs. 2018. Considerations for the Use of Captive-Reared Delta Smelt for Species Recovery and Research. San Francisco Estuary and Watershed Science 16(3).

Lewis, A. F. J., M. D. McGurk, and M. G. Galesloot. 2002. Alcan's Kemano River eulachon (Thaleichthys pacificus) monitoring program 1988-1998. Consultant's report prepared by Ecofish Research Ltd. for Alcan Primary Metal Ltd., Kitimat, BC.

Leyse, K. 2005. Intentional Introductions and Biodiversity in Fishless Waters: The Effects of Introduced Fish on Native Aquatic Species. PhD dissertation, University of California, Davis.

Ligon, F., A. Rice, G. Rynearson, D. Thornburgh, and W. Trush. 1999. Report of the Scientific Review Panel on California Forest Practice Rules and Salmonid Habitat. Prepared for The Resources Agency of California and the National Marin Fisheries Service. Sacramento, California. Available at http://www.krisweb.comwww.krisweb.com/biblio/cal_nmfs_ligonetal_1999_srprept.pdf.

Lindberg, J. C., G. Tigan, L. Ellison, T. Rettinghouse, M. M. Nagel and K. M. Fisch. 2013. Aquaculture methods for a genetically managed population of endangered Delta Smelt. North American Journal of Aquaculture 75(2):186-196. doi: http://dx.doi.org/10.1080/15222055.2012.751942

Lindley S. T., R. S. Schick, A. Agrawal, M. Goslin, T. E. Pearson, E. Mora, J. J. Anderson, B. May, S. Greene, C. Hanson, A. Low, D. McEwan, R. B. MacFarlane, C. Swanson, J. G. Williams. 2006. Historical population structure of Central Valley

Lindley, S. T., and Mohr, M. S. 2003. Modeling the effect of striped bass (Morone saxatilis) on the population viability of Sacramento River Winter-Run Chinook Salmon (Onchorhynchus tshawytscha). Fishery Bulletin, 101(2), 321-331.

Lindley, S. T., C. B. Grimes, M. S. Mohr, W. Peterson, J. Stein, J. T. Anderson, C. A. Busack, L.W. Botsford, T. K. Collier, D. L. Bottom, J. C. Garza, A. M. Grover, D. G. Hankin, R. G. Kope, P. W. Lawson, A. Low, J. Ferguson, R. B. MacFarlane, M. Palmer-Zwahlen, F. B. Schwing, J. Smith, C. Tracy, R. Webb, B. K. Wells. 2009. What caused the Sacramento River fall Chinook salmon stock collapse? NOAA, Tech. Memo., NMFS-SWFSC-447. Southwest Fisheries Science Center.

Lindley, S. T., C. Michel, P. T. Sandstrom. 2008. Estimating Reach-Specific Smolt Survival Rates and the Factors Influencing Them from Acoustic Tagging Data. 5th Biennial CALFED Science Conference. October 22-24. Sacramento, CA.

Lindley, S. T., R. Schick, B. P. May, J. J. Anderson, S. Greene, C. Hanson, A. Low, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2004. Population Structure of Threatened and Endangered Chinook Salmon ESU in California's Central Valley Basin. Public review draft. NOAA Technical Memorandum NMFS, Southwest Science Center, Santa Cruz, CA.

Lindley, S. T. 2004. Population structure of threatened and endangered Chinook salmon ESUs in California's Central Valley basin.

Lisle, T. E. 1989. Sediment transport and resulting deposition in spawning gravels, north coastal California. Water resources research, 25(6), pp.1303–1319.

Liu, L., J. Wood, N. Nur, D. Stralberg, and M. Herzog. 2009. California Clapper Rail (Rallus longirostris obsoletus) Population Monitoring: 2005-2008. Prepared for California Department of Fish and Game by PRBO Conservation Science. Sept. 29, 2009.

Liu, L., J. Wood, N. Nur, D. Stralberg, and M. Herzog. 2009. California Clapper Rail (Rallus longirostris obsoletus) Population Monitoring: 2005-2008. Prepared for California Department of Fish and Game by PRBO Conservation Science. Sept. 29, 2009.

Lopez, C. B., J. E. Cloern, T. S. Schraga, A. J. Little, L. V. Lucas, J. K. Thompson, and J. R. Burau. 2006. Ecological values of shallow-water habitats: implications for the restoration of disturbed ecosystems. Ecosystems 9:422–440.

Loredo, I., and D. van Vuren. 1996. Reproductive Ecology of a Population of the California Tiger Salamander. Copeia 1996:895–901.

Loredo, I., D. van Vuren, and M. L. Morrison. 1996. Habitat Use and Migration Behavior of the California Tiger Salamander. Journal of Herpetology 30:282–285.

Loredo-Prendeville, I., D. van Vuren, A. J. Kuenzi, and M. L. Morrison. 1994. California Ground Squirrels at Concord Naval Weapons Station: Alternatives for Control and Ecological Consequences. Pages 72–77 in W. S. Halverson and A. C. Crabb (eds.), Proceedings of the 16th Vertebrate Pest Conference. University of California Publications.

Lucas, L. V., J. E. Cloern, J. K. Thompson, and N. E. Monsen. 2002. Functional variability of habitats within the Sacramento-San Joaquin delta: restoration implications. Ecological Applications 12(5):1528–1547.

Lufkin, A. (ed.). 1996. California's Salmon and Steelhead, The Struggle to Restore an Imperiled Resource. Berkeley: University of California Press.

Mac Nally, R., J. R. Thomson, W. J. Kimmerer, F. Feyrer, K. B. Newman, A. Sih, W. A. Bennett, L. Brown, E. Fleishman, S. D. Culberson, and G. Castillo. 2010. Analysis of pelagic species decline in the upper San Francisco Estuary using multivariate autoregressive modeling (MAR). Ecological Applications 20:1417-1430.

Mack R. N., D. Simberloff, W. Mark Lonsdale, H. Evans, M. Clout, F. A. Bazzaz. 2000. Biotic invasions: causes, epidemiology, global consequences, and control. Ecological Applications, 10, 689–710.

Mack, R. N., D. Simberloff, W. M. Lonsdale, H. Evan, M. Clout, and F. A. Bazzaz. 2000. Biotic Invasions: Causes, Epidemiology, Global Consequences, and Control. Ecological Applications 10:689-710.

Macneale, K. H., P. M. Kiffney, and N. L. Scholz. 2010. Pesticides, Aquatic Food Webs, and the Conservation of Pacific Salmon. Frontiers in Ecology and the Environment 8:475-482

Mahardja, B., J. L. Conrad, L. Lusher, and B. Schreier. 2016. Abundance Trends, Distribution, and Habitat Associations of the Invasive Mississippi Silverside (*Menidia audens*) in the Sacramento–San Joaquin Delta, California, USA. San Francisco Estuary and Watershed Science 14(1).

Maley, J. M. and R. T. Brumfield. 2013 Mitochondrial and next-generation sequence data used to infer phylogenetic relationships and species limits in the Clapper/King rail complex. Condor 115:3 I 6-329.

Marine, K. R. 1992. A background investigation and review of the effects of elevated water temperature on reproductive performance of adult chinook salmon (Oncorhynchus tshawytscha). Prepared for East Bay Municipal Utility District.

Marschalek, D. A. 2006. California Least Tern Breeding Survey – 2005 Season. Final Report submitted to California Department of Fish and Game, Sacramento, CA.

Marschalek, D. A. 2008. California Least Tern Breeding Survey - 2007 Season. Final Report submitted to California Department of Fish and Game, Sacramento, CA.

Marschalek, D. A. 2009. California Least Tern Breeding Survey - 2008 Season. Final Report submitted to California Department of Fish and Game, Sacramento, CA.

Marschalek, D. A. 2011. California Least Tern Breeding Survey - 2010 Season. Final Report submitted to California Department of Fish and Game, Wildlife Branch, Sacramento, CA. Nongame Wildlife Program Report, 2011-06.

Marston, D., C. Mesick, A. Hubbard, D. Stanton, S. Fortmann-Roe, S. Tsao, and T. Heyne. 2012. Delta Flow Factors Influencing Stray Rate of Escaping Adult San Joaquin River Fall-Run Chinook Salmon (Oncorhynchus tshawytscha). San Francisco Estuary and Watershed Science. 10(4). 24p.

Martin, B. T., A. Pike, S. N. John, N. Hamda, J. Roberts, S. T. Lindley, and E. M. Danner. 2016. Phenomenological vs. biophysical models of thermal stress in aquatic eggs. Ecology Letters 2016.

Martin, B., A. Pike, S. John, N. Hamda, J.Roberts, and E. Danner. 2017. Phenomenological vs. biophysical models of thermal stress in aquatic eggs. Ecology Letters. 20:50-59.

Marty, J. 2005. Effects of Cattle Grazing on Diversity in Ephemeral Wetlands. Conservation Biology 19:1626–1632.

Marvin-DiPasquale, M., J. L. Agee. 2003. Microbial mercury cycling in sediments of the San Francisco Bay-Delta. Estuaries. 26(6):1517-1528.

Maslin, P., M. Lennox, J. Kindopp, and W. McKinney. 1997. Intermittent streams as rearing habitat for Sacramento River chinook salmon (Oncorhynchus tshawytscha). Department of Biological Sciences, California State University, Chico.

Massey, B. W. 1977. Occurrence and Nesting of the Least Tern and Other Endangered Species in Baja California, Mexico. Western Birds 8:67–70.

Massey, B. W. 1981. Second Wave Nesting of the California Least Tern: Age Composition and Reproductive Success. The Auk. 98: 596-605.

Matala, A. P., S. R. Narum, W. Young, and J. L. Vogel. 2012. Influences of Hatchery Supplementation, Spawner Distribution, and Habitat on Genetic Structure of Chinook Salmon in the South Fork Salmon River, Idaho. North American Journal of Fisheries Management 32(2):346-359.

Matern, S. A., P. B. Moyle and L. C. Pierce. 2002. Native and alien fishes in a California estuarine marsh: twenty-one years of changing assemblages. Transactions of the American Fisheries Society 131(5):797-816. doi: http://dx.doi.org/10.1577/1548-8659(2002)131<0797:NAAFIA>2.0.CO;2

Matkin, C.O., G. Ellis, L. G. Barrett-Lennard, H. Yurk, E. L. Saulitis, D. Scheel, P. Olesiuk, G. Ylitalo. 2003. Photographic and Acoustic Monitoring of Killer Whales in Prince William Sound and Kenai Fjords (Restoration Project 030012 Final Report). Exxon Valdez Oil Spill Restoration Project / North Gulf Oceanic Society

Maunder, M. N. and R. B. Deriso. 2011. A state–space multistage life cycle model to evaluate population impacts in the presence of density dependence: illustrated with application to delta smelt (*Hyposmesus transpacificus*). Canadian Journal of Fisheries and Aquatic Science 68: 1285–1306 DOI:10.1139/F2011-071

Mayfield, R. B. and Cech, J. J. 2004. Temperature Effects on Green Sturgeon Bioenergetics. Transactions of the American Fisheries Society 133(4):961–970.

McAllister, D. E. 1963. A revision of the smelt family, Osmeridae. National Museum of Canada, Biological Series 71, Bulletin No. 191:1-53.

McBain, S. and B. Trush. 2001. Final report: geomorphic evaluation of lower Clear Creek downstream of Whiskeytown Dam, California. Prepared for the Western Shasta Resource Conservation District. November.

McCullough D. 1999. A Review and Synthesis of Effects of Alterations to the Water Temperature Regime on Freshwater Life Stages of Salmonids, with Special Reference to Chinook Salmon. Prepared for the U.S. Environmental Protection Agency, Region 10, Seattle, Washington.

McCullough, D., S. Spalding, D. Sturdevant, and M. Hicks. 2001. Issue paper 5 summary of technical literature examining the physiological effects of temperature on salmonids: prepared as part of EPA Region 10 Temperature Water Quality Criteria Guidance Development Project. Seattle, WA, U.S. Environmental Protection Agency, Region 10.

McElroy K., Beakes M. and J. Merz. 2018. Hide and Seek: Turbidity, Cover, and Ontogeny Influence Aggregation Behavior in Juvenile Salmon. Ecosphere. https://doi.org/10.1002/ecs2.2175.

McEwan, D. 2001. Central Valley steelhead, In Contributions to the biology of Central Valley salmonids, R. L. Brown, editor, CDFW, Sacramento, CA, Fish Bulletin, Vol. 179, pp. 1-44.

McEwan, D., and T. A. Jackson. 1996. Steelhead restoration and management plan for California. California Department of Fish and Game, Sacramento, CA.

McHugh, J. L. 1939. The eulachon. Progress Report of the Pacific Biological Station, Nanaimo, B.C. and Pacific Fisheries Experimental Station, Prince Rupert, B.C. 40: 17-22.

McIntyre, J. K., J. W. Davis, R. C. Edmunds, J. Incardona, N. L. Scholz, J. Stark. 2015. Soil bioretention protects juvenile salmon and their prey from the toxic impacts of urban stormwater runoff. Chemosphere, 132:213-219.

McIntyre, J. K., J.W. Davis, J.P. Incardona, J.D. Stark, and N.L. Scholz, 2014. Zebrafish and clean water technology: assessing the protective effects of bioinfiltration as a treatment for toxic urban runoff. Science of the Total Environment, 500-501:173-180.

McLean J. E., P. Bentzen, T. P. Quinn. Nonrandom. 2005. Size- and timing-biased breeding in a hatchery population of steelhead trout. Conservation Biology. 2005;19:446–454.

McMillian, F.O., 1928. Electric Fish Screen. https://www.st.nmfs.noaa.gov/spo/FishBull/44-1/mcmillan.pdf

Merz, J. E., S. Hamilton, P. S. Bergman and B. Cavallo. 2011. Spatial perspective for delta smelt: a summary of contemporary survey data. California Fish and Game 97(4):164-189. http://www.genidaqs.net/reports/2011/CA_Fish-Game_97_164-189.pdf

Merz, J. E., P. S. Bergman, J. L. Simonis, D. Delaney, J. Pierson, P. Anders. Long-Term Seasonal Trends in the Prey Community of Delta Smelt (Hypomesus transpacificus) Within the Sacramento-San Joaquin Delta, California. Estuaries and Coasts (2016) 39:1526–1536. https://link.springer.com/content/pdf/10.1007%2Fs12237-016-0097-x.pdf

Ford, M. J. 2013. Status review update of Southern Resident killer whales. National Marine Fisheries Service. July 31.

Michel C. J, A. J. Ammann, S. T. Lindley, P. T. Sandstrom, E. D. Chapman, M. J. Thomas, G. P. Singer, A. P. Klimley, R. B. MacFarlane. 2015. Chinook salmon outmigration survival in wet and dry years in California's Sacramento River. Can J Fish Aquat Sci 72(11):1749–59. https://doi.org/10.1139/cjfas-2014-0528

Michel C. J., A. J. Amman, E. D. Chapman, P. T. Sandstrom, H. E. Fish, M. J. Thomas, G. S. Singer, S. T. Lindley, A. P. Kimley, and R. B. MacFarlane. 2012. The effects of environmental factors on the migratory movement patterns of Sacramento River yearling late-fall run Chinook salmon

(Oncorhynchus tshawytscha). Environmental Biology of Fishes. 96. (2-3): 257-271. https://doi.org/10.1007/s10641-012-9990-8.

Miller, L. W. 2000. The tow-net survey abundance index for delta smelt revisited. Interagency Ecological Program for the San Francisco Estuary (Newsletter)13(1):37-44. http://www.water.ca.gov/iep/newsletters/2000/2000winter.pdf

Miller, W. J., B. F. J. Manly, D. D. Murphy, D. Fullerton and R. R. Ramey. 2012. An investigation of factors affecting the decline of delta smelt (*Hypomesus transpacificus*) in the Sacramento-San Joaquin Estuary. Reviews in Fisheries Science (20)1:1-19. doi: http://dx.doi.org/10.1080/10641262.2011.634930

Miller, W. J., B. F. J. Manly, D. D. Murphy, D. Fullerton and R. R. Ramey. 2012. An investigation of factors affecting the decline of delta smelt (*Hypomesus transpacificus*) in the Sacramento-San Joaquin Estuary. Reviews in Fisheries Science (20)1:1-19. doi: http://dx.doi.org/10.1080/10641262.2011.634930

Missildine, B., R. Peters, R. Piaskowski, and R. Tabor. 2001. Habitat Complexity, Salmonid Use, and Predation of Salmonids at the Bioengineered Revetment at the Maplewood Golf Course on the Cedar River, Washington. Miscellaneous report. Lacey, WA: U.S. Fish and Wildlife Service, Western Washington Office.

Mitchell, L., Newman, K., and Baxter, R. 2017. A covered cod end and tow-path evaluation of midwater trawl gear efficiency for catching delta smelt (Hypomesus transpacificus).

Mitro, M. G., and A. V. Zale. 2002. Seasonal survival, movement, and habitat use of age-0 rainbow trout in the Henrys Fork of the Snake River, Idaho. Transactions of the American Fisheries Society 131:271-286.

Monaco, M. E., R. L. Emmett, S. A. Hinton, and D. M. Nelson. 1990. Distribution and abundance of fishes and invertebrates in West Coast estuaries. Volume I: Data summaries. ELMR Rep. No. 4, Strategic Assessment Branch, NOS/NOAA. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service.

Mora, E. A. 2016. A Confluence of Sturgeon Migration: Adult Abundance and Juvenile Survival. PhD Dissertation, Univ. Calif., Davis.

Mora, E. A., Lindley S.T., D. L. Erickson, and A. P. Klimley. 2009. Do impassable dams and flow regulation constrain the distribution of green sturgeon in the Sacramento River, California? Journal of Ichthyology 25 Supplement 2, 39-47.

Mora, E. A., R. D. Battleson, S. T. Lindley, M. J. Thomas, R. Bellmer, L. J. Zarri, A. P. Klimley. 2018. Estimating the annual spawning run size and population size of the southern distinct population segment of Green Sturgeon. Transactions of the American Fisheries Society 147:195-203

Mora, E., S. Lindley, E. Daniel, A. P. Klimley. 2015. Estimating the Riverine Abundance of Green Sturgeon Using a Dual-Frequency Identification Sonar. North American Journal of Fisheries Management. 35. 557-566. 10.1080/02755947.2015.1017119.

Morgan-King, T., D. H. Schoellhamer. 2013. Suspended-Sediment Flux and Retention in a Backwater Tidal Slough Complex near the Landward Boundary of an Estuary. Estuaries and Coasts. 36. 10.1007/s12237-012-9574-z.

Morinaka, J. 2013. Acute Mortality and Injury of Delta Smelt Associated With Collection, Handling, Transport, and Release at the State Water Project Fish Salvage Facility. Technical Report 89. November. Interagency Ecological Program, Sacramento.

Mount, J. F. 1995. California Rivers and Streams: the conflict between fluvial process and land use. University of California Press, Berkeley, CA.

Moyle P. B., J. D. Kiernan, P. K. Crain, and R. M. Quinones. 2013. Climate Change Vulnerability of Native and Alien Freshwater Fishes of California: A Systematic Assessment Approach. PLoS ONE 8(5): e63883. doi:10.1371/journal.pone.0063883

Moyle, P. B. and J. J. Cech. 2004. Fishes: An Introduction to Ichthyology, 5th Edition

Moyle, P. B., J. R. Lund, W. A. Bennett, and W. E. Fleenor. 2010. Habitat Variability and Complexity in the Upper San Francisco Estuary. San Francisco Estuary and Watershed Science [online serial] 8(3), Available at: http://www.escholarship.org/uc/item/0kf0d32x

Moyle, P. B. 2002. Inland Fishes of California. Berkeley, CA: University of California Press.

Moyle, P. B., J. A. Israel, and S. E. Purdy. 2008. Salmon, Steelhead, and Trout in California. Status of an Emblematic Fauna. A report commissioned by California Trout. Center for Watershed Sciences, University of California, Davis, Davis, CA.

Moyle, P. B., R. A. Daniels, B. Herbold, and D. M. Baltz. 1986. Patterns in distribution and abundance of a noncoevolved assemblage of estuarine fishes in California. Fishery Bulletin 84(1):105-117. http://fishbull.noaa.gov/841/moyle.pdf

Moyle, P. B., B. Herbold, D. E. Stevens, and L.W. Miller. 1992. Life history and status of delta smelt in the Sacramento-San Joaquin Estuary, California. Transactions of the American Fisheries Society 121:67-77.

Moyle, P. B., L. R. Brown and J. R. Durand. 2016. Delta smelt: life history and decline of a onceabundant species in the San Francisco Estuary. San Francisco Estuary and Watershed Science 14(2). http://escholarship.org/uc/item/09k9f76s

Mueller-Solger, A. B., A. D. Jassby, and D. C. Müller-Navarra. 2002. Nutritional quality of food resources for zooplankton (*Daphnia*) in a tidal freshwater system (Sacramento-San Joaquin River Delta). Limnology and Oceanography 47(5):1468-1476.

Murphy, D. D. and S. A. Hamilton. 2013. Eastern migration or marshward dispersal: exercising survey data to elicit an understanding of seasonal movement of delta smelt. San Francisco Estuary and Watershed Science 11(3). https://escholarship.org/uc/item/4jf862qz

Mussen T. D., D. Cocherell, J. B. Poletto, J. S. Reardon, Z. Hockett, A. Ercan, H. Bandeh, M. L. Kavvas, J. J. Cech, N. A. Fangue. 2014. Unscreened Water-Diversion Pipes Pose an Entrainment Risk to the Threatened Green Sturgeon, *Acipenser medirostris* . PLoS ONE 9: e86321. [PMC free article] [PubMed].

Myers, J. M., R. G. Kope, G. J. Bryant, D. Teel, L. J. Lierheimer, T. C. Wainwright, W. S. Grant, F. W. Waknitz, K. Neely, S. T. Lindley, and R. S. Waples. 1998. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. U.S. Department Commerce, NOAA Technical Memorandum NMFS-NWFSC-35.

Myrick, C. A. and J. J. Cech, Jr. 2001. Temperature Effects on Chinook Salmon and Steelhead: A Review Focusing on California's Central Valley Populations. Bay-Delta Modeling Forum Technical Publication 01-1.

Myrick, C. A., and J. J. Cech Jr. 2005. Effects of temperature on the growth, food consumption, and thermal tolerance of age-0 Nimbus-strain steelhead. North American Journal of Aquaculture. 67.4: 324-330.

Nakamoto, R. J., T. T. Kisanuki, and G. H. Goldsmith. 1995. Age and Growth of Klamath River Green Sturgeon (Acipenser medirostris). U.S. Fish and Wildlife Service. Project #93-FP-13. 20 pages.

National Marine Fisheries Service (NMFS). 1993. Biological Opinion for the Los Vaqueros Reservoir Project. Number 5004. Southwest Region, Long Beach, California. Issued March 18, 1993.

National Marine Fisheries Serivce (NMFS). 1996. Status Review of West Coast Steelhead From Washington, Idaho, Oregon, and California. Technical Memorandumn - NOAA Fisheries-NWFSC-27.

National Marine Fisheries Service (NMFS). 1997. Proposed Recovery Plan for the Sacramento River Winter-Run Chinook Salmon. Long Beach, CA: National Marine Fisheries Service, Southwest Region.

National Marine Fisheries Service (NMFS). 2000. Endangered Species Act - Reinitiated Section 7 Consultation – Biological Opinion and Incidental Take Statement. Effects of Pacific Coast Salmon Plan on California Central Valley spring-run Chinook, and California coastal Chinook salmon. NMFS, Protected Resources Division.April 28, 2000.

National Marine Fisheries Service (NMFS). 2002. Biological Opinion on Interim Operations of the Central Valley Project and State Water Project Between April 1, 2002 and March 31, 2004, on Federally Listed Threatened Central Valley Spring-Run Chinook Salmon and Threatened Central Valley Steelhead in Accordance With Section 7 of the Endangered Species Act of 1973, As Amended. Long Beach: National Marine Fisheries Service, Southwest Region.

National Marine Fisheries Service (NMFS). 2004. Supplemental Biological Opinion to the September 20, 2002 Spring-run/Steelhead Operating Criteria and Plan (OCAP) Biological Opinion. National Marine Fisheries Service. Long Beach, California.

National Marine Fisheries Service (NMFS). 2005. Green Sturgeon (Acipenser medirostris) Status Review Update, February 2005. Biological review team, Santa Cruz Laboratory, Southwest Fisheries Science Center.

National Marine Fisheries Service (NMFS). 2006. Designation of Critical Habitat for Southern Resident Killer Whales. National Marine Fisheries Service, Northwest Region, Seattle, WA

National Marine Fisheries Service (NMFS). 2006. Designation of Critical Habitat for Southern Resident Killer Whales. National Marine Fisheries Service, Northwest Region, Seattle, WA.

National Marine Fisheries Service (NMFS). 2007. Biological Opinion for the Contra Costa Water District's Alternative Intake Project. NOAA (National Oceanic and Atmospheric Administration), National Marine Fisheries Service. Issued July 13, 2007.

National Marine Fisheries Service (NMFS). 2008a. Biological opinion for water supply, flood control operations, and channel maintenance conducted by the U.S. Army Corps of Engineers, the Sonoma County Water Agency, and the Mendocino County Russian River Flood Control and Water Conservation Improvement District in the Russian River watershed. NMFS-Southwest Region, Long Beach, CA. 367 pp.

National Marine Fisheries Service (NMFS). 2008b. National Marine Fisheries Service Endangered Species Act Section 7 Consultation. Biological Opinion. Environmental Protection Agency Registration of Pesticides Containing Chlorpyrifos, Diazinon, and Malathion. Novmber 18. https://www.fisheries.noaa.gov/webdam/download/63806553

National Marine Fisheries Service (NMFS). 2008c. Recovery plan for southern resident killer whales (*Orcinus orca*). National Marine Fisheries Service, Northwest Region, Seattle, WA.

National Marine Fisheries Service (NMFS). 2009. Biological opinion and conference opinion on the long-term operations of the Central Valley Project and State Water Project. National Marine Fisheries Service Southwest Region. June 4.

National Marine Fisheries Service (NMFS). 2009. Biological Opinion on the Long-Term Central Valley Project and State Water Project Operations Criteria and Plan. NOAA (National Oceanic and Atmospheric Administration), National Marine Fisheries Service, Southwest Fisheries Service Center, Long Beach, California.

National Marine Fisheries Service (NMFS). 2010. Endangered Species Act Section 7 Consultation Biological Opinion. Environmental Protection Agency Registration of Pesticides Containing Azinphos methyl, Bensulide, Dimethoate, Disulfoton, Ethoprop, Fenamiphos, Naled, Methamidophos, Methidathion, Methyl parathion, Phorate and Phosmet. August 31. Available at: https://www.fisheries.noaa.gov/webdam/download/63806550

National Marine Fisheries Service (NMFS). 2010. Letter of concurrence to U.S. Bureau of Reclamation in response to Reclamation's request for concurrence that the Los Vaqueros Reservoir Expansion (LVE) Project is not likely to affect listed species or critical habitat. October 15, 2010.

National Marine Fisheries Service (NMFS). 2010. Interim endangered and threatened species recovery planning guidance. Version 1.3. National Marine Fisheries Service, Silver Spring, MD.

National Marine Fisheries Service (NMFS). 2011. REVIEW DRAFT – Recovery Plan for the North Central California Coast Domain, Northern California Steelhead, California Coastal Chinook Salmon, Central California Coast Steelhead. Center for Independent Experts Review Draft. Version – September 29, 2011.

National Marine Fisheries Service (NMFS). 2011b. Endangered Species Act Section 7 Consultation Biological Opinion. Environmental Protection Agency Registration of Pesticides, 2,4-D, Triclopry BEE, Diuron, Linuron, Captan, and Chlorothalonil. June 30. Available at: https://www.fisheries.noaa.gov/webdam/download/63806559

National Marine Fisheries Service (NMFS). 2011b. Endangered Species Act Section 7 Consultation Draft Conference and Biological Opinion for United States Environmental Protection Agency Registration of 2, 4-D, Triclopyr Bee, Diuron, Linuron, Captan, and Chlorothalonil.

National Marine Fisheries Service (NMFS). 2012. Public Draft Recovery Plan for Southern Oregon/Northern California Coast Coho Salmon (Oncorhynchus kisutch). National Marine Fisheries Service. Arcata, CA.

National Marine Fisheries Service (NMFS). 2012. Endangered Species Act Section 7 Consultation Final Biological Opinion. Environmental Protection Agency Registration of Pesticides Orysalin, Pendimethalin, Trifluralin. May 31. Available at: https://www.fisheries.noaa.gov/webdam/download/63806569

National Marine Fisheries Service (NMFS). 2013. Biological Opinion on the Suisun Marsh Long-Term Habitat Management, Preservation, and Restoration Plan. July 3. NOAA (National Oceanic and Atmospheric Administration), National Marine Fisheries Service, Southwest Fisheries Service Center, Long Beach, California.

National Marine Fisheries Service (NMFS). 2013. Endangered Species Act Section 7 Consultation Draft Conference and Biological Opinion for Uniteds States Environmental Protection Agency Registrations of Pesticides Containing iflurbenzuron, Fenbutatin Oxide, and Propargite.

National Marine Fisheries Service (NMFS). 2013. Killer Whale (*Orcinus orca*). Available at: http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/killerwhale.htm

National Marine Fisheries Service (NMFS). 2014. Endangered Species Action Section 7(a)(2) Concurrence Letter for the Lower Yolo Restoration Project. NMFS No. WCR-2014-278. May 20. Sacramento, CA: United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, West Coast Region.

National Marine Fisheries Service (NMFS). 2014. Possibility of natural producing spring-run Chinook salmon in the Stanislaus and Tuolumne Rivers. Authored by Sierra Franks, November 2012, updated June 2014.

National Marine Fisheries Service (NMFS). 2014. Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead. California Central Valley Area Office. July 2014.

National Marine Fisheries Service (NMFS). 2014b. Southern Resident Killer Whales: 10 Years of Research and Conservation. National Marine Fisheries Service Northwest Fisheries Science Center and West Coast Region. June 2014

National Marine Fisheries Service (NMFS). 2015. Southern Distinct Population Segment of the North American Green Sturgeon. 5-Year Review: Summary and Evaluation. West Coast Region. Long Beach, CA.

National Marine Fisheries Service (NMFS). 2015a. Endangered Species Act Section 7(a)(2) Concurrence Letter, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for Testing and Modifications of the Rock Slough Fish Screen. February 20. National Marine Fisheries Service, West Coast Region, Sacramento, CA.

National Marine Fisheries Service (NMFS). 2015b. Endangered Species Act Section 7(a)(2) Concurrence Letter, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the 2015 Rock Slough Mechanical Harvesting Project. September 30. National Marine Fisheries Service, West Coast Region, Sacramento, CA.

National Marine Fisheries Service (NMFS). 2016a. Status Review Update of Eulachon (Thaleichthys pacificus) Listed under the Endangered Species Act: Southern Distinct Population Segment. March 25.

National Marine Fisheries Service (NMFS). 2016b. 5-Year Review; Summary and Evaluation of Central Valley Spring-run Chinook Salmon Evolutionarily Significant Unit. April.

National Marine Fisheries Servic (NMFS). 2016c. 5-Year Status Review, Central California Coast Steelhead. April 2016. https://www.westcoast.fisheries.noaa.gov/publications/status_reviews/salmon_steelhead/steelhead/steelhead_status_reviews.html

National Marine Fisheries Service (NMFS). 2016d. 2016 5-Year Review: Summary & Evaluation of Eulachon. Portland, Oregon. Available at: https://www.westcoast.fisheries.noaa.gov/publications/status_reviews/other_species/eulachon/eulachon_2016_5-year_review.pdf

National Marine Fisheries Service (NMFS). 2017. https://www.westcoast.fisheries.noaa.gov/maps_data/california_species_list_tools.html

National Marine Fisheries Service (NMFS). 2017. Biological Opinion on NOAA's National Marine Fisheries Service's Implementation of the Mitchell Act Final Environmental Impact Statement Preferred Alternative and Administration of Mitchell Act Hatchery Funding. NMFS Consultation Number: Nwr-2014-697. January 15, 2017

National Marine Fisheries Service (NMFS). 2017. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Response for Rock Slough Fish Screen Facilities Improvement Project NMFS Consultation Number: ARN 151422WCR2014-SA00018 / PCTS# WCR-2017-6161. Issued June 29, 2017.

National Marine Fisheries Service (NMFS). 2017. Endangered Species Act Section 7(a)(2) Biological Opinion, Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response, and Fish and Wildlife Coordination Act Recommendations for the California WaterFix Project in Central Valley, California. NMFS Consultation Number: WCR-2016-5506. June 16. Portland, OR: United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, West Coast Region.

National Marine Fisheries Service (NMFS). 2017. Eulachon. Endangered Species Act Recovery Plan for the Southern Distinct Population Segment of Eulachon (*Thaleichthys pacificus*). National Marine Fisheries Service, West Coast Region, Protected Resources Division, Portland, OR.

National Marine Fisheries Service (NMFS). 2018. Recovery Plan for the Southern Distinct Population Segment of North American Green Sturgeon (Acipenser medirostris). National Marine Fisheries Service, Sacramento, CA.

National Oceanic and Atmospheric Administration (NOAA). 2009. Designation of Critical Habitat for the threatened Southern Distinct Population Segment of North American Green Sturgeon. Final Biological Report. Prepared by National Marine Fisheries Service. Southwest Region Protected Resources Division. Long Beach, California. Available at: https://www.westcoast.fisheries.noaa.gov/publications/protected_species/other/green_sturgeon/g_s_critical_habitat/gschd_finalbiologicalrpt.pdf.

National Oceanic and Atmospheric Administration (NOAA). 2016. Technical Memorandum U.S. Pacific Marine Mammal Stock Assessments: 2015.

National Oceanic and Atmospheric Administration (NOAA) Southwest Region and Washington Department of Fish and Wildlife (WDFW). 2018. Southern Resident Killer Whale Priority Chinook Stocks Report. June 22. Available: https://www.westcoast.fisheries.noaa.gov/publications/protected_species/marine_mammals/killer_whales/recovery/srkw_priority_chinook_stocks_conceptual_model_report___list_22june2018.pdf Accessed: November 21, 2018.

National Research Council (NRC). 2004. Endangered and Threatened Fishes in the Klamath River Basin: Causes of Decline and Strategies for RecoveryCommittee on Endangered and Threatened Fishes in the Klamath River Basin; Board on Environmental Studies and Toxicology. Washington, D.C.: The National Academies Press.

Newman, K. B. 2008. An evaluation of four Sacramento–San Joaquin River Delta juvenile salmon survival studies. U.S. Fish and Wildlife Service, Stockton, CA. Available at http://www.science.calwater.ca.gov/pdf/psp/PSP_2004_final/PSP_CalFed_FWS_salmon_studies_final_033108.pdf. Nielsen J.L., Lisle T.E., Ozaki V. 1994. Thermally stratified pools and their use by steelhead in northern California streams. Transactions of the American Fisheries Society 123:613–26.

Nobriga, M. L. 2002. Larval delta smelt diet composition and feeding incidence: environmental and ontogenetic influences. California Department of Fish and Wildlife 88:149-164.

Nobriga, M. L. 2002. Larval delta smelt diet composition and feeding incidence: environmental and ontogenetic influences. California Fish and Game 88:149-164.

Nobriga, M. L. and B. Herbold. 2009. The Little Fish in California's Water Supply: A Literature Review and Life-History Conceptual Model for Delta Smelt (*Hypomesus transpacificus*) for the Delta Regional Ecosystem Restoration and Implementation Plan (DRERIP). Delta Regional Ecosystem Restoration Implementation Plan (DRERIP). Sacramento, CA.

Nobriga, M. L. and F. Feyrer. 2007. Shallow-Water Piscivore-Prey Dynamics in California's Sacramento–San Joaquin Delta; San Francisco Estuary and Watershed Science; p. 9

Nobriga, M. L., F. Feyrer, R. D. Baxter and M. Chotkowski. 2005. Fish community ecology in an altered river delta: spatial patterns in species composition, life history strategies and biomass. Estuaries. 28:776-785.

Nobriga, M. L., Z. Matica, and Z. P. Hymanson. 2004. Evaluating Entrainment Vulnerability to Agricultural Irrigation Diversions: A Comparison among Open-Water Fishes. Pages 281-295 in F. Feyrer, L.R. Brown, R.L. Brown, and J.J. Orsi, editors. Early Life History of Fishes in the San Francisco Estuary and Watershed. American Fisheries Society, Symposium 39, Bethesda, Maryland.

Nobriga, M.L., T.R. Sommer, F. Feyrer and K. Fleming. 2008. Long-term trends in summertime habitat suitability for delta smelt. San Francisco Estuary and Watershed Science 6(1). http://escholarship.org/uc/item/5xd3q8tx

Northern California Water Association (NCWA). 2014. "The Bay-Delta Conservation Plan (BDCP) and its Impacts on Regional Sustainability in the North State. North State Water Alliance. Letter to Secretary John Laird, California Natural Resources Agency. Available at: http://www.norcalwater.org/wp-content/uploads/NSWA_BDCP_Submittal_7_2014.pdf.

Northern California Water Association (NCWA). 2018. Food Production Program Continues to Improve Delta Smelt Conditions. Available: https://mavensnotebook.com/wp-content/uploads/2018/10/FoodWeb_PressRelease_FactSheet.pdf

Northwest Fisheries Science Center (NWFSC). 2008. Data report and summary analyses of the California and Oregon pink shrimp fisheries, December 2008. NWFSC, Fishery Resource Analysis and Monitoring Division, West Coast Groundfish Observer Program, Seattle, WA. Online at http://www.nwfsc.noaa.gov/research/divisions/fram/observer/datareport/docs/ pink_shrimp_report_final.pdf

Olesiuk, P. F., M. A. Bigg, and G. M. Ellis. 1990. Life history and population dynamics of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. In Individual recognition of cetaceans: Use of photo-identification and other techniques to estimate population parameters, edited by Hammond, P. S., S. A. Mizroch, and G. P. Donovan

O'Geen, A. T., W. A. Hobson, R. A. Dahlgren, and D. B. Kelley. 2008. Evaluation of Soil Properties and Hydric Soil Indicators for Vernal Pool Catenas in California. *Soil Science Society of America Journal* 72:727–740.

O'Geen, A. T., W. A. Hobson, R. A. Dahlgren, and D. B. Kelley. 2008. Evaluation of Soil Properties and Hydric Soil Indicators for Vernal Pool Catenas in California. Soil Science Society of America Journal 72:727–740.

Okamura, B., H. Hartikainen, H. Schmidt-Posthaus, T. Wahli. 2011. Life cycle complexity, environmental change and the emerging status of salmonid proliferative kidney disease. Freshw Biol 56(4):735–753.

Olden J. D., R. J. Naiman. 2010. Incorporating thermal regimes into environmental assessments: modifying dam operations to restore freshwater ecosystem integrity. Freshw Biol 55:86–107.

Olesiuk, P. F., M. A. Bigg, and G. M. Ellis. 1990. Life history and population dynamics of resident killer whales (Orcinus orca) in the coastal waters of British Columbia and Washington State. In Individual recognition of cetaceans: Use of photo-identification and other techniques to estimate population parameters, edited by Hammond, P. S., S. A. Mizroch, and G. P. Donovan.

Olofson Environmental, Inc. 2011. California Clapper Rail Surveys for the San Francisco Estuary Invasive Spartina Project 2011. Prepared for the State Coastal Conservancy San Francisco Estuary Invasive Spartina Project. December 2011.

Olsen, N., J. A. Boutillier, and L. Convey. 2000. Estimated bycatch in the British Columbia shrimp trawl fishery. Canadian Stock Assessment Secretariat Research Document - 2000/168. Online at http://www.dfompo.gc.ca/csas/Csas/DocREC/2000/PDF/2000_168e.pdf

Orca Network. 2019. Southern Resident Orca Community Demographics, Composition of Pods, Births and Deaths since 1998. Updated January 11. Available at: https://www.orcanetwork.org/Main/index.php?categories_file=Births%20and%20Deaths

Orlando J. L., K. L. Smalling, T. J. Reilly, N. S. Fishman, A. Boehlke, M. T. Meyer. 2013. Occurrence of fungicides and other pesticides in surface water, groundwater, and sediment from three targeted-use areas in the United States, 2009. U.S. Geological Survey Data Series. 797:73. doi: http://dx.doi.org/10.3133/ds2013797

Orlando J. L., M. McWayne, C. Sanders, M. L. Hladik. 2014. Dissolved pesticide concentrations entering the Sacramento–San Joaquin Delta from the Sacramento and San Joaquin rivers, California, 2012–13. U.S. Geological Survey Data Series 28. doi: http://dx.doi.org/10.3133/ds876

Orsi, J. J. and W. L. Mecum. 1996. Food limitation as the probable cause of a long-term decline in the abundance of Neomysis mercedis the opossum shrimp in the Sacramento-San Joaquin Estuary. Pp 375–401 in San Francisco Bay: The Ecosystem, edited by J. T. Hollibaugh. Pacific Division, American Association for the Advancement of Science, San Francisco, CA

Osborne, R. 1999. A historical ecology of Salish Sea resident killer whales (Orcinus orca): With implications for management. PhD dissertation, University of Victoria, Victoria, BC, Canada.

Pacific Fishery Management Council. 2014. Pacific Coast Salmon Fishery Management Plan. September.

Pacific Legal Foundation. 2012. Petition of the Center for Environmental Science, Accuracy & Reliabilty, Empresas del Bosque, and Coburn Ranch to delist the Southern Resident Killer Whale Distinct Population Segment under the Endangered Species Act.

Padget-Flohr, G. E., and L. Isakson. 2003. A random sampling of salt marsh harvest mice in a muted tidal marsh. Journal of Wildlife Management. 67(3): 646–653.

Palmer-Zwahlen, M. L., and Kormos, B. 2015. Recovery of coded-wire tags from Chinook Salmon in California's Central Valley Escapement, Inland Harvest, and Ocean Harvest in 2012. In California Department of Fish and Game, Fisheries Branch Administrative Report 2015-4.

Parsons, K. M., K. C. Balcomb, J. K. B. Ford, and J. W. Durban. 2009. The social dynamics of southern resident killer whales and conservation implications for this endangered population. Animal Behaviour 77(4):963–971.

Pasternack, G. 2010. Gravel/Cobble Augmentation Implementation Plan (GAIP) for the Englebright Dam Reach of the Lower Yuba River, CA. Prepared for U.S. Army Corps of Engineers, Sacramento District. Sacramento, CA. Available at: http://pasternack.ucdavis.edu/files/3413/7581/8399/USACE_GAIP_FINAL_20100930.pdf.

Patton, R. T. 2002. California Least Tern Breeding Survey – 2000 Season. Final Report submitted to California Department of Fish and Game, Species Conservation and Recovery Program Report, Sacramento, CA.

Perrin, W.F., S. B. Reilly. 1984. Reproductive parameters of dolphin and small whales of the family Delphinidae. Report of the International Whaling Commission, Special Issue 6: 97-

Perry, R. W., J. R. Skalski, P. L. Brandes, P. T. Sandstrom, A. P. Klimley, A. Ammann, and B. MacFarlane. 2010. Estimating survival and migration route probabilities of juvenile Chinook salmon in the Sacramento-San Joaquin River Delta. North American Journal of Fisheries Management 30(1):142-156.

Perry, R. W., J. G. Romine, S. J. Brewer, P. E. LaCivita, W. N. Brostoff, and E. D. Chapman. 2012. Survival and migration route probabilities of juvenile Chinook salmon in the Sacramento-San Joaquin River Delta during the winter of 2009–10. U.S. Geological Survey Open-File Report 2012-1200. U.S. Geological Survey, Reston, VA.Perry, R. W., J. G. Romine, N. S. Adams, A. R. Blake, J. R. Burau, S. V. Johnston, and T. L. Liedtke. 2014. Using a non-physical behavioural barrier to alter migration routing of juvenile Chinook salmon in the Sacramento–San Joaquin River Delta. River Research and Applications 30(2):192-203.

Perry, R. W., P. L. Brandes, J. R. Burau, P. T. Sandstrom, and J. R. Skalski. 2015. Effect of tides, river flow, and gate operations on entrainment of juvenile salmon into the interior Sacramento–San Joaquin River Delta. Transactions of the American Fisheries Society 144(3):445–455.

Perry, R. W., A. C. Pope, J. G. Romine, P. L. Brandes, J. R. Burau, A. R. Blake, A. J. Ammann, C. J. Michel. 2018. Flow-mediated effects on travel time, routing, and survival of juvenile Chinook salmon in a spatially complex, tidally forced river delta. Canadian Journal of Fisheries and Aquatic Sciences, 2018, 75(11): 1886-1901.

Petranka, J. W. 1998. Salamanders of the United States and Canada. Washington, DC: Smithsonian Institution Press.

Phillis, C. C., A. M. Sturrock, R. C. Johnson, P.K. Weber. 2018. Endangered winter-run Chinook salmon rely on diverse rearing habitats in a highly altered landscape. ScienceDirect. January. https://doi.org/10.1016/j.biocon.2017.10.023. Volume 217:358-362.

Pittman S., and G. Matthews. 2007. Clear Creek Geomorphic Monitoring Project, Graham Mathews and Associates. Shasta County California. WY 2006 Annual Report. 140 p.

Polansky, L., K. B. Newman and M. L. Nobriga and L. Mitchell. 2018. Spatiotemporal models of an estuarine fish species to identify patterns and factors impacting their distribution and abundance. Estuaries and Coasts.

Poletto, J. B. C. E. Verhille, D. E. Cocherell, B. DeCourten, S. Baird, J. J. Cech, N. A. Fangue. 2014. Larval green and white sturgeon swimming performance in relation to water-diversion flows, Conservation Physiology, Volume 2, Issue 1, 1 January 2014, cou031, https://doi.org/10.1093/conphys/cou031

Poletto, J. B, B. Martin, E. Danner, S. E. Baird, D. E. Cocherell, N. Hamda, J. J.Jr. Cech, N. A. Fangue. 2018. Assessment of multiple stressors on the growth of larval Green Sturgeon *Acipenser medirostris*: implications for recruitment of early life-history stages. Fish Biology. Doi:10.1111/jfb.13805

Poytress, W. R. and F. D. Carrillo. 2010. Brood-year 2007 Winter Chinook Juvenile Production Indices with Comparisons to Juvenile Production Estimates Derived from Adult Escapement. Report of U.S. Fish and Wildlife Service to California Department of Fish and Game and U.S. Bureau of Reclamation.

Poytress, W. R. and F. D. Carrillo. 2011. Brood-year 2008 and 2009 Winter Chinook Juvenile Production Indices with Comparisons to Juvenile Production Estimates Derived from Adult Escapement. Report of U.S. Fish and Wildlife Service to California Department of Fish and Game and U.S. Bureau of Reclamation.

Poytress, W. R. and F. D. Carrillo. 2012. Brood-year 2010 Winter Chinook Juvenile Production Indices with Comparisons to Juvenile Production Estimates Derived from Adult Escapement. Report of U.S. Fish and Wildlife Service to California Department of Fish and Game and U.S. Bureau of Reclamation.

Poytress, W. R., J. J. Gruber, and J. Van Eenennaam. 2011. 2010 Upper Sacramento River Green Sturgeon Spawning Habitat and Larval Migration Surveys. Final Annual Report. February. Annual Report of U.S. Fish and Wildlife Service to U.S. Bureau of Reclamation, Red Bluff Fish Passage Program, Red Bluff, CA.

Poytress, W. R., J. J. Gruber, and J. Van Eenennaam. 2012. 2011 Upper Sacramento River Green Sturgeon Spawning Habitat and Larval Migration Surveys. Final Annual Report. March. Annual Report of U.S. Fish and Wildlife Service to U.S. Bureau of Reclamation, Red Bluff Fish Passage Program, Red Bluff, CA.

Poytress, W. R., J. J. Gruber, F. D. Carrillo and S. D. Voss. 2014. Compendium Report of Red Bluff Diversion Dam Rotary Trap Juvenile Anadromous Fish Production Indices for Years 2002-2012. Report of U.S. Fish and Wildlife Service to California Department of Fish and Wildlife and US Bureau of Reclamation.

Poytress, W. R., J. J. Gruber, J. P. Van Eenennaam and M. Gard. 2015. Spatial and Temporal Distribution of Spawning Events and Habitat Characteristics of Sacramento River Green Sturgeon, Transactions of the American Fisheries Society, 144:6, 1129-1142, DOI: 10.1080/00028487.2015.1069213

PRBO Conservation Science. 2009a. 2008 Annual Report: California Clapper Rail (Rallus longirostris obsoletus). TE-807078. PRBO Conservation Science, Petaluma, California.

Prince Rupert Forest Region. 1998. Science to Support Sustainability. Forest Science Program Annual Report 1998/1999. Available at: https://www.for.gov.bc.ca/hfd/pubs/docs/mr/Annual/AR98-99.pdf.

Pyke, C. R., and J. Marty. 2005. Cattle Grazing Mediates Climate Change Impacts on Ephemeral Wetlands. *Conservation Biology* 19:1619–1625.

Quinn T. P., B. A. Terhart, C. Groot. 1989. Migratory orientation and vertical movements of homing adult sockeye salmon, Oncorhynchus nerka, in coastal waters. Animal Behaviour. 37: 587–599.

Rains, M. C., G. E. Fogg, T. Harter, R. A. Dahlgren, and R. J. Williamson. 2006. The Role of Perched Aquifers in Hydrological Connectivity and Biogeochemical Processes in Vernal Pool Landscapes. Hydrological Processes. 20(5):1157-1175.

Rains, M. C., R. A. Dahlgren, R. J. Williamson, G. E. Fogg, and T. Harter. 2008. Geological Control of Physical and Chemical Hydrology in Vernal Pools, Central Valley, California. *Wetlands* 28:347–62.

Raleigh R. F., T. Hickman, R. C. Solomon, and P. C. Nelson. 1984. Habitat Suitability Information: Rainbow Trout. Washington, DC: U.S. Fish and Wildlife Service, FWS/OBS-82/10.60.

Raleigh, R. F., W. J. Miller, and P. C. Nelson. 1986. Habitat Suitability Index Models and Instream Flow Suitability Curves: Chinook Salmon. (Biological Report 82[10.122]). U.S. Fish and Wildlife Service.

Rayne, S., Ikonomou, M. G., Ellis, G. M., Barrett-Lennard, L. G., Ross, P. S. 2004. PBDEs, PBBs, and PCNs in three communities of free-ranging killer whales (Orcinus orca) from the northeastern Pacific Ocean. Environmental Science and Technology. 38: 4293-4299.

Reece, B. G. Swart, and R. C. Johnson. 2017. Scientific framework for assessing factors influencing endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) across the life cycle. NOAA Technical Memorandum NMFS-SWFSC-586. NOAA National Marine Fisheries Service, Southwest Fisheries Science Center Fisheries Ecology Division Santa Cruz, CA.

Reiser, D. W. and T. C. Bjornn. 1979. Influence of Forest and Rangeland Management of Anadromous Fish Habitat in Western North America - Habitat Requirements of Anadromous Salmonids. USDA Forest Service General Technical Report PNW-96.

Reyes, G. A., B. J. Halstead, J. P. Rose, J. S. M. Ersan, A. C. Jordan, A. M. Essert, K. J. Fouts, A. M. Fulton, K. B. Gustafson, R. F. Wack, , G. D. Wylie, and M. L. Casazza. 2017, Behavioral response of giant gartersnakes (*Thamnophis gigas*) to the relative availability of aquatic habitat on the landscape: U.S. Geological Survey Open-File Report 2017-1141, 134 pp., https://doi.org/10.3133/ofr20171141.

Reynolds, F. L., T. J. Mills, R. Benthin, and A. Low. 1993. Restoring Central Valley streams: a plan of action. California Department of Fish and Game, Sacramento.

Riparian Habitat Joint Venture (RHJV). 2004. The Riparian Bird Conservation Plan: a Strategy for Reversing the Decline of Riparian Associated Birds in California. California Partners in Flight. http://www.prbo.org/calpif/pdfs/riparian_v-2.pdf

Rible, E., M. Saldate, and R. Bilski. 2017 Lower Mokelumne River Salmonid Redd Survey Report: October 2016 through December 2016. 14 pp.

Richter, A., and Kolmes, S. A., 2005, Maximum temperature limits for Chinook, coho, and chum salmon, and steelhead trout in the Pacific Northwest: Reviews in Fisheries Science, V. 13.

Ricker, W. E., Manzer, D. F., and Neave, E. A. 1954. The Fraser River eulachon fishery, 1941-1953. Fisheries Research Board of Canada, Manuscript Report No. 583. 35 p.

Rigney, M., and S. Granholm. 2005. Least Tern. Species Account B234. California Wildlife Habitat Relationships System, California Department of Fish and Game, Sacramento, CA.

Riley, S. P. D., H. B. Shaffer, S. R. Voss, and B. M. Fitzpatrick. 2003. Hybridization Between a Rare, Native Tiger Salamander (Ambystoma californiense) and Its Introduced Congener. Ecological Applications 13:1263–1275.

River Partners. 2018. Dos Rios Ranch Preserve. Website. Available: https://www.riverpartners.org/project/dos-rios-ranch/. Accessed: December 7, 2018.

Robertson-Bryan, Inc. (RBI). 2017. Report on the Effects of the California WaterFix on Harmful Algal Blooms in the Delta. Prepared for California Department of Water Resources. March. Elk Grove, CA: Robertson-Bryan, Inc. Available: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/docs/petitioners_exhibit/dwr/DWR-653.pdf Accessed: December 10, 2018.

Robinson, D. G., Barraclough, W. E., and Fulton, J. D. 1968a. Data record: Number, size composition, weight and food of larval and juvenile fish caught with a twoboat surface trawl in the Strait of Georgia, May 1-4, 1967. Fisheries Research Board of Canada Manuscript Report Ser. No. 964.

Robinson, D. G., Barraclough, W. E., and Fulton, J. D. 1968b. Data record: Number, size composition, weight and food of larval and juvenile fish caught with a twoboat surface trawl in the Strait of Georgia, June 5-9, 1967. Fisheries Research Board of Canada Manuscript Report Ser. No. 972.

Rogers, D. C. 2001. Revision of the Neartic Lepidurus (Notostraca). Journal of Crustacean Biology. 21: 1002–1005.

Romine, J. G., R. W. Perry, A. C. Pope, P. Stumpner, T. L. Liedtke, K. K. Kumagai, and R. L. Reeves. 2016. Evaluation of a floating fish guidance structure at a hydrodynamically complex river junction in the Sacramento–San Joaquin River Delta, California, USA. Marine and Freshwater Research 68(5):878-888.

Rose K. A., W. J. Kimmerer, K. P. Edwards and W. A. Bennett. 2013a. Individual-based modeling of Delta Smelt population dynamics in the upper San Francisco Estuary: I. Model description and baseline results. Transactions of the American Fisheries Society 142(5):1238-1259. doi: http://dx.doi.org/10.1080/00028487.2013.799518

Rose, K. A., W. J. Kimmerer, K. P. Edwards and W. A. Bennett. 2013b. Individual-based modeling of Delta Smelt population dynamics in the upper San Francisco Estuary: II. Alternative baselines and good versus bad years. Transactions of the American Fisheries Society 142(5):1260-1272. doi: http://dx.doi.org/10.1080/00028487.2013.799519

Ross P. S., G. M. Ellis, M. G. Ikonomou, L. G. Barrett-Lennard, R. F. Addison. 2000. High PCB concentrations in free-ranging Pacific killer whales, *Orcinus orca*: effects of age, sex and dietary preference. Marine Pollution Bulletin. 40(6): 504-515.

Ruhl, C. A. and D. H. Schoellhamer. 2004. Spatial and temporal variability of suspendedsediment concentrations in a shallow estuarine environment. San Francisco Estuary and Watershed Science 2(2). http://escholarship.org/uc/item/1g1756dw

Ruiz, G. M., P. W. Fofonoff, J. T. Carlton, M. J. Wonham, and A. H. Hines. 2000. Invasions of Coastal Marine Communities in North America: Apparent Patterns, Process, and Bias. Annual Review Ecological Systems 31:481-531.

Ryman, N., F. Utter, L. Laikre. 1994. Protection of aquatic biodiversity. In: The State of the World's Fisheries Resources: Proceedings of the World Fisheries Congress plenary sessions, Voigtlander, C. W. (ed.), pp. 92–115. Oxford & IBH Publishing, New Dehli.

Sacramento Regional County Sanitation District. Sacramento Regional Wastewater Treatment Plant. 2015. Progress Report. Method of Compliance Work Plan and Schedule for Ammonia Effluent Limitations. Available at: https://www.regionalsan.com/sites/main/files/file-attachments/progress_report_no._5_february_1_2015.pdf.

Salmon, T. P., and R. H. Schmidt. 1984. An Introductory Overview to California Ground Squirrel Control. In: D.O. Clark (ed.). Proceedings of the Eleventh Vertebrate Pest Conference. March 6–8, 1984. Sacramento, CA. Pages 32–37.

San Francisco Estuary Partnership. 2015. State of the Estuary Report: Status trends and update of 33 indicators of Ecosystem Health, San Francisco Bay and Sacramento-San Joaquin River Delta. pg 96 http://ebooks.sfei.org/soter2015/

San Joaquin County Multi-Species Habitat Conservation and Open Space Plan (SJMSCP). 2000. November 14.

San Joaquin River Restoration Program (SJRRP). 2010. Conceptual Models of Stressors and Limiting Factors for San Joaquin River Chinook Salmon Fisheries. Exhibit A. Management Plan: A Framework for Adaptive Management in the San Joaquin River Restoration Program.

Sandercock, F.K. 1991. Life history of coho salmon (Oncorhynchus kisutch). In: C. Groot and L. Margolis (editors), Pacific salmon life histories, p. 396-445. Univ. British Columbia Press, Vancouver.

Sardella, B. A., D. Kultz. 2014. The Physiological Response of Green Sturgeon (Acipenser medirostris) to Potential Global Climate Change Stressors. Physiological and Biochemical Zoology. 87: 456-463.

Satterthwaite, W. H., Carlson, S. M. and Anne Criss. 2017. Ocean Size and Corresponding Life History Diversity among the Four Run Timings of California Central Valley Chinook Salmon, Transactions of the American Fisheries Society, 146:4, 594-610, DOI: 10.1080/00028487.2017.1293562.

Satterthwaite, W. H., F. Cordoleani, M. R. O'Farrell. 2018. Central Valley Spring-Run Chinook Salmon and Ocean Fisheries: Data Availability and Management Possibilities. San Francisco Estuary and Watershed Science. 16: 1-23.

Saulitis, E., C. Matkin, L. Barett-Lennard, K. Heise, and G. Ellis. 2000. Foraging strategies of sympatric killer whale (Orcinus orca) populations in Prince William Sound, Alaska. Marine Mammal Science 16(1):94–109.

Schick, R. S., A. L. Edsall, and S. T. Lindley. 2005. Historical and current distribution of Pacific salmonids in the Central Valley, CA. National Oceanic and Atmospheric Administration. National Marine Fisheries Service. Technical Memorandum NOAA-TM-NMFS-SWFSC- 369:1-30. Santa Cruz, CA.

Schoellhamer, D. H. 2011. Sudden clearing of estuarine waters upon crossing the threshold from transport as an erodible sediment pool is depleted: San Francisco Bay, 1999. Estuaries and Coasts 34: 885-899.

Schoellhamer, D. H., S. A. Wright, and J. Drexler. 2012. A Conceptual Model of Sedimentation in the Sacramento–San Joaquin Delta. San Francisco Estuary and Watershed Science 10(3).

Scholz, N. L., E. Fleishman, I. W. L. Brown, M.L. Johnson, M.L. Brooks, C. L. Mitchelmore, and a. D. Schlenk. 2012. A Perspective on Modern Pesticides, Pelagic Fish Declines, and Unknown Ecological Resilience in Highly Managed Ecosystems. Biosciences 62(4):428-434.

Scholz, N. L., M. S. Myers, S. G. McCarthy, J. S. Labenia, J. K. McIntyre. 2011. Recurrence Die-Offs of Adult Coho Salmon Returning to Spawn in Puget Sound Lowland Urban Streams. PLos ONE 6(12):e28013. doi:10.1371/journal.pone.0028013.

Schreier, B. M., Baerwald, M. R., Conrad, J. L., Schumer G. and B. May. 2016. Examination of Predation on Early Life Stage Delta Smelt in the San Francisco Estuary Using DNA Diet Analysis, Transactions of the American Fisheries Society. 145 (4): 723-733, DOI: 10.1080/00028487.2016.1152299.

Schroeter, R. E., and P. B. Moyle. 2004. Dissolved Oxygen sags in Suisun Marsh, 2004. Unpublished report. 9 pages.

Schwarzbach, S. E., J. D. Albertson, and C. M. Thomas. 2006. Effects of predation, flooding, and contamination on reproductive success of California Clapper Rails (Rallus longirostris obsoletus) in San Francisco Bay. Auk 123:45-60. http://dx.doi.org/10.1642/0004-8038(2006)123[0045:EOPFAC]2.0.CO;2

Scott, G. R. and Sloman, K. A. 2004. The Effects of Environmental Pollutants on Complex Fish Behavior: Integrating Behavioral and Physiological Indicators of Toxicity. Aquatic Toxicology. (68) 369-392. https://doi.org/10.1016/j.aquatox.2004.03.016Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin No. 184.

Seesholtz, A., M. Manuel, J.V. Eenennaam. 2012. 2011 and 2012 Lower Feather River Green Sturgeon Spawning Survey. Draft Report. Department of Water Resources, West Sacramento, CA.

Seesholtz, A. M., M. J. Manuel, and J. P. Van Eenennaam. 2015. First docu-mented spawning and associated habitat conditions for Green Sturgeonin the Feather River, California. Environmental Biology of Fishes 98:905–912.

Semlitsch, R. D., D. E. Scott, J. H. K. Pechmann, and J. W. Gibbons. 1996. Structure and Dynamics of an Amphibian Community: Evidence From A 16-Year Study of a Natural Pond.

Shaffer, H. B., and P. C. Trenham. 2005. Ambystoma californiense. Pages 1093–1102 in M. J. Lannoo (ed.), Status and Conservation of U.S. Amphibians. Volume 2: Species Accounts. Berkeley, CA: University of California Press.

Shaffer, H. B., R. N. Fisher, and S. E. Stanley. 1993. Status Report: the California Tiger Salamander (Ambystoma californiense). Final report for the California Department of Fish and Game.

Shellhammer, H. and L. Barthman-Thompson. 2015. Appendix 5.1- Case Study: Salt Marsh Harvest Mouse (*Reithrodontomys raviventris*). Science Foundation Chapter 5. Baylands Ecosystem Habitat Goals Science Update. Available: https://baylandsgoals.org/wp-content/uploads/2015/10/BEHGU_5.1_CaseStudy_SMHM-1.pdf. Accessed: December 12, 2018.

Shellhammer, H. and R. Duke. 2010. Salt marsh harvest mice and width of salt marshesin the South San Francisco Bay. California Fish and Game. 96(2): 165–170.

Shellhammer, H., R. Duke, and M. C. Orland. 2010. Use of brackish marshes in the south San Francisco Bay by salt marsh harvest mice. California Fish and Game. 96(4): 256–259.

Shields, I. A. 1936. Application of Similarity Principles and Turbulence Research to Bed-Load Movement. California Institute of Technology, Soil Conservation Service Cooperative Laboratory. Available at: https://authors.library.caltech.edu/25992/1/Sheilds.pdf. Shuford, W. D. 1993. The Marin County breeding bird atlas. Bushtit Books, Bolinas, CA.

Siegfried, L. J., W. E. Fleenor, and J. R. Lund. 2014. Physically Based Modeling of Delta Island Consumptive Use: Fabian Tract and Staten Island, California. San Francisco Estuary and Watershed Science 12(4).

Simberloff, D., I.M. Parker, and P.N. Windle. 2005. Introduced Species Policy, Management, and Future Research Needs. Frontiers in Ecology and the Environment 3(1):12-20.

Slater, S.B. and R.D. Baxter. 2014. Diet, prey selection, and body condition of age-0 delta smelt, in the Upper San Francisco Estuary. San Francisco Estuary Watershed Science 12(3). doi: http://dx.doi.org/10.15447/sfews.2014v12iss3art1.

Slotten D. G., S. M. Ayers, T. H. Suchanek, R. D. Weyand, A. M. Liston, C. Asher, D. C. Nelson, B. Johnson. 2002. The effects of wetland restoration on the production and 15 bioaccumulation of methyl mercury in the Sacramento-San Joaquin Delta, California. CALFED Bay-Delta Program Draft Report. 49 p.

Smith, W. 2018. A general linear model relating an index of proportional entrainment loss to turbidity and Old and Middle River flow. Draft. 4 October. Sacramento, CA: U.S. Fish and Wildlife Service, San Francisco Bay-Delta Fish and Wildlife Office.

Smith, W. E., and Saalfeld, R. W. 1955. Studies on Columbia River smelt Thaleichthys pacificus (Richardson). Washington Department of Fisheries, Fisheries Research Paper 1(3): 3–26.

Snieder and Titus, 2000. Timing, Composition, and Abundance of Juvenile Anadromous Salmonid Emigration in the Sacramento River Near Knights Landing. October 1997-September 1998. Department of Fish and Wildlife.

Sommer, T. R., M. L. Nobriga, W. C. Harrell, W. Batham, and W. J. Kimmerer. 2001a. "Floodplain Rearing of Juvenile Chinook Salmon: Evidence of Enhanced Growth and Survival." *Canadian Journal of Fisheries and Aquatic Science* 58: 325–333.

Sommer, T. and F. Mejia. 2013. A place to call home: a synthesis of Delta Smelt habitat in the upper San Francisco Estuary. San Francisco Estuary and Watershed Science 11(2). https://escholarship.org/uc/item/32c8t244

Sommer, T. C., Mejia, F., Nobriga, M. L., Feyrer, F., and L. Grimaldo. 2011. The Spawning Migration of Delta Smelt in the Upper San Francisco Estuary. San Francisco Estuary and Watershed Science, 9(2). San Francisco Estuary and Watershed Science, John Muir Institute of the Environment, UC Davis. Available on the internet at <http://escholarship.org/uc/item/86m0g5sz>.

Sommer, T. R., M. L. Nobriga, W. C. Harrell, W. Batham, and W. J. Kimmerer. 2001. Floodplain Rearing of Juvenile Chinook Salmon: Evidence of Enhanced Growth and Survival. Canadian Journal of Fisheries and Aquatic Sciences 58(2):325–333.

Sommer, T. R., W. C. Harrell, and M. L. Nobriga. 2005. Habitat Use and Stranding Risk of Juvenile Chinook Salmon on a Seasonal Floodplain. North American Journal of Fisheries Management 25:1493–1504

Sommer, T., and F. Mejia. 2013. A Place to Call Home: A Synthesis of Delta Smelt Habitat in the Upper San Francisco Estuary. San Francisco Estuary and Watershed Science 11(2).

Sommer, T., F. Mejia, K. Hieb, R. Baxter, E. Loboschefsky, and F. Loge. 2011. Long-Term Shifts in the Lateral Distribution of Age-0 Striped Bass in the San Francisco Estuary. Transactions of the American Fisheries Society 140(6):1451-1459.

Sommer, T., L. Conrad, and M. Koller. 2018. Suisun Marsh Salinity Control Gate Study. Briefing to Collaborative Science and Adaptive Management Group. December.

Spangler, E. A. K. 2002. The ecology of eulachon (Thaleichthys pacificus) in Twentymile River, Alaska. M.S. Thesis. University of Alaska, Fairbanks.

Spence, B. C., G. A. Lomnicky, R .M. Hughes and R. P. Novitzki. 1996. An Ecosystem Approach to Salmonid Conservation. Funded jointly by the U.S. EPA, U.S. Fish and Wildlife Service and National Marine Fisheries Service. TR-4501-96-6057. Man Tech Environmental Research Services Corp., Corvallis, OR. http://www.nwr.noaa.gov/1habcon/habweb/ManTech/front.htm#TOC.

Spence, B., E. P. Bjorkstedt, J.C. Garza, J.J. Smith, D.G. Hankin, D. Fuller, W.E. Jones, R. Macedo, T.H. Williams and E. Mora. 2008. A framework for assessing the viability of threatened and endangered salmon and steelhead in North-Central California Coast Recovery Domain. NOAA-TM-NMFS-SWFSC-423.

Spence, B. C., E. P. Bjorkstedt, S. Paddock, and L. Nanus. 2012. Updates to biological viability criteria for threatened steelhead populations in the North-Central California Coast Recovery Domain. National Marine Fisheries Service, Southwest Fisheries Science Center, Fisheries Ecology Division, Santa Cruz, CA.

Spromberg, J. A. and N. L. Scholz. 2011. Estimating the Future Decline of Wild Coho Salmon Populations Resulting from Early Spawner Die-Offs in Urbanizing Watersheds of the Pacific Northwest, USA. Integrated Environmental Assessment and Management 7(4):648-656.

Stachowicz, J. J. and J. E. Byrnes. 2006. Species Diversity, Invasion Success, and Ecosystem Functioning: Disentangling the Influence of Resource Competition, Facilitation, and Extrinsic Factors. Marine Ecology Progress Series 311:251-262.

Stanislaus Operations Group. 2018. Annual Report of Activities Water Year 2018. November.

State Water Resources Control Board (SWRCB). 1990. Order: WR 90-5. Order Setting Terms and Conditins for Fishery Protection and Setting a Schedule for Completion of Tasks. Available at https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/docs/swrcb_24.pdf.

State Water Resources Control Board (SWRCB). 2003. SWRCB Order WR 2003-0016 In the Matter of Fishery Resources and Water Right Issues of the Lower Yuba River. Order Vacating Water Right Decision 1644 and Adopting Revised Water Right Decision 1644 Following Consideration of Additional Evidence Specified by Yuba County Superior Court.

State Water Resources Control Board (SWRCB). 2003. Revised Water Right Decision 1644 in the Matter of Fishery Resources and Water Right Issues of the Lower Yuba River.State Water Resources Control Board (SWRCB). 1990. Order: WR 90-5. Order Setting Terms and Conditions for Fishery Protection and Setting a Schedule for Completion of Tasks. Available at https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/docs/swrcb_24.pdf.

State Water Resources Control Board (SWRCB). 2010. Resolution No. 2010-0020; Water Quality Control 3 Policy on the use of Coastal and Estuarine Water for Power Plant Cooling. Available: 4 SWRCB_2010_PowerPlantWaterResolution.

Stebbins, R. C. 2003. A Field Guide to Western Reptiles and Amphibians. Third Edition. Peterson Field Guide Series. Boston: Houghton Mifflin Company.

Stevens, D. E. 1977. Striped bass (*Morone saxatilis*) year class strength in relation to river flow in the Sacramento-San Joaquin Estuary, California. Transactions of the American Fisheries Society 106(1):34-42. doi: http://dx.doi.org/10.1577/1548-8659(1977)106<34:SBMSYC>2.0.CO;2

Stevens, D. E. and L. W. Miller. 1983. Effects of river flow on abundance of young Chinook salmon, American shad, longfin smelt, and delta smelt in the Sacramento-San Joaquin river system. North American Journal of Fisheries Management 3:425-437.

Stillwater Sciences. 2006. Upper Yuba River Water Temperature Criteria for Chinook Salmon and Steelhead. Technical Appendix.

Stone, L., 1893. Baird Station, California. U.S. Fish Comm. Report for 1888: XXXV-XXXVI

Stone, L., 1895. U.S. Commission of Fish and Fisheries. Comm. Rept. 1893. 117pp

Stone, L., 1896a. U.S. Commission of Fish and Fisheries. Comm. Rept. 1896. 66 pp

Stone, L., 1896b. U.S. Commission of Fish and Fisheries. Comm. Rept. 1895. 44 pp

Stone, L., 1896c. U.S. Commission of Fish and Fisheries. Comm. Rept. 1893. 49 pp

Stone, L., 1898. U.S. Commission of Fish and Fisheries. Comm. Rept. 1897. 64 pp

Storer, T. I. 1925. A Synopsis of the Amphibia of California. University of California Publications in Zoology 27:60–71.

Sturdevant, M. V. 1999. Forage Fish Diet Overlap, 1994-1996. APEX Project: Alaska Predator Ecosystem Experiment in Prince William Sound and the Gulf of Alaska. Exxon Valdez Oil Spill Restoration Project Final Report (Restoration Project 98163C), Auke Bay Laboratory, National Marine Fisheries Service, Juneau, Alaska.

Sustaita, D., P. Finfrock Quickert, L. Patterson, L. Barthman Thompson, and S. Estrella. 2011. Salt marsh harvest mouse demography and habitat use in the Suisun Marsh. Journal of Wildlife Management 75: 1498–1507.

Sutphin, Z. A., and C. D. Svoboda. 2016. Effects of hydraulic conditions on salvage efficiency of adult delta smelt at the Tracy Fish Collection Facility. Tracy Fish Collection Facility Studies, Volume 43. U.S. Bureau of Reclamation, Mid-Pacific Region and Denver Technical Service Center. 63 pp. Swank, Dave. 2015. National Marine Fisheries Service, Sacramento, California. Oral conversation on 6/19/2015.

Swanson, C., T. Reid, P. S. Young, J. J. Cech Jr. 2000. Comparative environmental tolerances of threatened delta smelt (Hypomesus transpacificus) and introduced wakasagi (H. nipponensis) in an altered California estuary. Oecologia 123:384-390.

Sweeney, B. W. , Bott, T. L. , Jackson, J. K. , Kaplan, L. A. , Newbold, J. D. , Standley, L. J. ,Hession, W. C. , and R. J. Horwitz. 2004. Riparian deforestation, stream narrowing, and loss of stream ecosystem services. National Academy of Sciences 101:14132-14137.

Sweetnam, D. A. 1999. Status of delta smelt in the Sacramento-San Joaquin Estuary. California Fish and Wildlife 85:22-27.

Ta, J., L. W. Anderson, M. A. Christman, S. Khanna, D. Kratville, J. D. Madsen. 2017. Invasive Aquatic Vegetation Management in the Sacramento–San Joaquin River Delta: Status and Recommendations. San Francisco Estuary and Watershed Science, 15(4). Available at: https://escholarship.org/uc/item/828355w6

Takata, L., T. R. Sommer, J. L. Conrad, B. M. Schreier. 2017. Rearing and migration of juvenile Chinook Salmon (Oncorhynchus tshawytscha) in a large river floodplain. Env Biology Fish 100:1105 - 1120. https://doi.org/10.1007/s10641-017-0631-0

Talley, T. S., and M. Holyoak. 2009. Effects of Highways and Highway Construction Activities on Valley Elderberry Longhorn Beetle Habitat. No. FHWA/CA 09-0925. California Department of Transportation.

Talley, T. S., D. Wright, and M. Holyoak. 2006. Assistance with the 5-year review of the valley elderberry longhorn beetle (Desmocerus californicus dimorphus). Report to the U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, Sacramento, California. 74 pp. + appendix.

Talley, T. S., E. Fleishman, M. Holyoak, D. D. Murphy, and A. Ballard. 2007. Rethinking a rare species conservation strategy in an urban landscape: The case of the valley elderberry longhorn beetle. Biological Conservation 135:21–32.

Tenera Environmental. 2018a. Unpublished fish monitoring data from the Rock Slough Fish Screen from 2011-2018. Salmon/Steelhead Log (spreadsheet). Revised February 2018. Lafayette, California.

Tenera Environmental. 2018b. Fish Monitoring Report for the Rock Slough Fish Screen Facility – December 16-31, 2017. Submitted January 16, 2018. Lafayette, California.

Thomas, M. J., M. L. Peterson, N. Friedenberg, J. P. Van Eenennaam, J. R. Johnson, J. J. Hoover, and A. P. Klimley. 2013. Stranding of Spawning Run Green Sturgeon in the Sacramento River: Post-Rescue Movements and Potential Population-Level Effects. North American Journal of Fisheries Management 33(2):287-297.

Thompson, John, 1957, The settlement geography of the Sacramento-San Joaquin Delta, California: Palo Alto, Calif., Stanford University, Ph.D. dissertation, 551 p.

Thompson B., S. Lowe, and M. Kellogg. 2000. Results of the benthic pilot study, 1994–1997. Part 1–microbenthic assemblages of the San Francisco Bay–Delta, and their responses to abiotic factors. Regional Monitoring Program Technical Report 39. Oakland (CA): San Francisco Estuary Institute.

Thompson, B. C., J. A. Jackson, J. Burger, L. A. Hill, E. M. Kirsch, and J. L. Atwood. 1997. Least Tern (Sterna antillarum). The Birds of North America Online (A. Poole, ed.). Ithaca: Cornell Lab of Ornithology. Available: <http://bna.birds.cornell.edu/bna/species/290>.

Thomson, J. R., W. J. Kimmerer, L. R. Brown, K. B. Newman, R. Mac Nally, W. A. Bennett, F. Feyrer, and E. Fleishman. 2010. Bayesian change point analysis of abundance trends for pelagic fishes in the upper San Francisco Estuary. Ecological Applications 20(5):1431-1448.

Tockner, K., Stanford, J. 2002. Riverine flood plains: Present state and future trends. Environmental Conservation, 29(3), 308-330. doi:10.1017/S037689290200022X.

Trenham, P. C., W. D. Koenig, and H. B. Shaffer. 2001. Spatially Autocorrelated Demography and Interpond Dispersal in the Salamander Ambystoma californiense. Ecology 82:3519–3530.

Trush, W. J., S. M. McBain and L. B. Leopold, 2000. Attributes of an alluvial river and their relation to water policy and management. Proceedings of the National Academy of Sciences of the United States of America, 97 (22): 11858-11863.

Tucker, M. E., C. M. Williams, R. R. Johnson. 1998. Abundance, food habits and life history aspects of Sacramento squawfish and striped bass at the Red Bluff Diversion Complex, including the Research Pumping Plant, Sacramento River, California, 1994-1996. Red Bluff Research Pumping Plant Report Series, Volume 4. U.S. Fish and Wildlife Service, Red Bluff, California.

Turlock Irrigation District and Modesto Irrigation District. 2017. La Grange Hydroelectric Project FERC No. 14581. Final License Application. Attachment E - Applicant-Prepared Biological Assessment for California Central Valley Steehlhead (Oncycorhynchus mykiss) Distinct Population Segment. September.

Turner, J. L. and H. K. Chadwick. 1972. Distribution and Abundance of of young-of-the-year striped bass, *Morone saxatilis*, in relation to river flow in the Sacramento-San Joaquin estuary. Transactions of the American Fisheries Society 101(3):442-452.

Twitty, V. C. 1941. Data on the Life History of Ambystoma tigrinum californiense Gray. Copeia 1941:1–4.

U. S. Army Corps of Engineers. 2014. Biological Opinion on the Operation and Maintenance of Daguerre point Dam and Fish Ladders. May 12. Available at: https://www.spk.usace.army.mil/Portals/12/documents/parks_lakes/Englebright/20140512_Yuba_2014_Daguerre_BiOp_and_Cover_Letter_Signed.pdf

U.S. Bureau of Reclamation (Reclamation). 2008a. Biological Assessment on the Continued Long-term Operations of the Central Valley Project and the State Water Project. Sacramento, CA: Mid-Pacific Region.

U.S. Bureau of Reclamation (Reclamation). 2008b. Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project (CVP) and State Water Project (SWP). Biological Opinion. December 15. Fish and Wildlife Service, Region 8. Sacramento, CA. Available at: http://www.fws.gov/sfbaydelta/documents/SWP-CVP_OPs_BO_12-15_final_OCR.pdf.

U.S. Bureau of Reclamation (Reclamation). 2011. Adaptive management of fall outflow for delta smelt protection and water supply reliability. U.S. Bureau of Reclamation, Sacramento, CA. Available at: http://www.usbr.gov/mp/ BayDeltaOffice/docs/Adaptive%20Management%20of%20Fall%20Outflow%20for%20Delta%20Smelt%20 Protection%20and%20Water%20Supply%20Reliability.pdf.

U.S. Bureau of Reclamation (Reclamation). 2012. Adaptive management of fall outflow for delta smelt protection and water supply reliability. U.S. Bureau of Reclamation, Sacramento, CA. Available at: http://deltacouncil.ca.gov/sites/default/files/documents/files/Revised_Fall_X2_Adaptive_MgmtPlan_EVN_06_29_2012_final.pdf.

U.S. Bureau of Reclamation (Reclamation). 2012. Final Biological Assessment and Essential Fish Habitat Determination on the Proposed Removal of Four Dams on the Klamath River. August. U.S. Department of the Interior, Bureau of Reclamation.

U.S. Bureau of Reclamation (Reclamation). 2016. Environmental Assessment, Lower American River Anadromous Fish Habitat Restoration Project. 68 p. https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=24637

U.S. Bureau of Reclamation (Reclamation). 2016. Environmental Assessment, Lower American River Anadromous Fish Habitat Restoration Project. 68 p. https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=24637

U.S. Bureau of Reclamation (Reclamation). 2016. Biological Assessment for the California WaterFix. Chapter 5. Effects analysis for Chinook salmon, Central Valley steelhead, green sturgeon and killer whale. July 2016

U.S. Bureau of Reclamation (Reclamation). 2016. Biological Assessment for the California WaterFix. Chapter 5. Effects analysis for Chinook salmon, Central Valley steelheadCentral Valley Steelhead, green sturgeonGreen Sturgeon and Killer Whale. July 2016

U.S. Bureau of Reclamation (Reclamation). 2017. Yolo Bypass Salmonid Habitat Restoration and Fish Passage. Draft Environmental Impact Statement/Environmental Impact Report. December.

U.S. Bureau of Reclamation (Reclamation). 2018. Environmental Assessment. Sacramento Deep Water Ship Channel Nutrient Enrichment Project. June. U.S. Department of the Interior, Bureau of Reclamation.

U.S. Bureau of Reclamation (Reclamation). 2018a. NMFS Biological Opinion RPA IV.2.2: 2011 Six-Year Acoustic Telemetry Steelhead Study. Contributions by Buchanan, R., J. Israel, P. Brandes. E. Buttermore. Reclamation Bay-Delta Office, Mid-Pacific Region, Sacramento, CA. FINAL REPORT May 14, 2018, 144p.

U.S. Bureau of Reclamation (Reclamation). 2018b. NMFS Biological Opinion RPA IV.2.2: 2012 Six-Year Acoustic Telemetry Steelhead Study. Contributions by Buchanan, P. Brandes, R., J. Israel, E. Buttermore. Reclamation Bay-Delta Office, Mid-Pacific Region, Sacramento, CA. FINAL REPORT May 16, 2018, 172p.

U.S. Bureau of Reclamation (Reclamation). 2018c. NMFS Biological Opinion RPA IV.2.2: 2013 Six-Year Acoustic Telemetry Steelhead Study. Contributions by Buchanan, P. Brandes, R., J. Israel, E. Buttermore. Reclamation Bay-Delta Office, Mid-Pacific Region, Sacramento, CA. FINAL REPORT July 2018. 197p.

U.S. Bureau of Reclamation (Reclamation) and California Department of Water Resources (DWR). 2013. Bay Delta Conservation Plan Public Draft. Sacramento, CA. Available at: http://baydeltaconservationplan.com/EnvironmentalReview/EnvironmentalReview/2013-2014PublicReview/2013PublicReviewDraftBDCP.aspx.

U.S. Bureau of Reclamation (Reclamation) and California Department of Fish and Wildlife (CDFW). 2017. Hatchery and Genetics Management Plan for Trinity River Hatchery coho salmon. Shasta Lake, CA, December 2017. 117 pages.

U.S. Department of the Interior. 2000. Trinity River mainstem fishery restoration EIS. Department of Interior. Sacramento.

U.S. Environmental Protection Agency (EPA). 2001. Trinity River Total Maximum Daily Load for Sediment. Region IX.

U.S. Environmental Protection Agency (EPA). 2003. EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards. EPA 910-B-03-002.

U.S. Environmental Protection Agency (EPA). 2015. 2015 Drinking Water Health Advisories for Two Cyanobacterial Toxins. Viewed online at: https://www.epa.gov/sites/production/files/2017-06/documents/cyanotoxins-fact_sheet-2015.pdf. Accessed: Dec. 13, 2018.

U.S. Fish and Wildlife Service (USFWS). 1984. Valley Elderberry Longhorn Beetle Recovery Plan.

U.S. Fish and Wildlife Service (USFWS). 1985. Revised California least tern recovery plan. U.S. Fish and Wildlife Service, Region 1, Portland, Oregon.

U.S. Fish and Wildlife Service (USFWS). 1991. Endangered and threatened wildlife and plants; proposed threatened status for the delta smelt. Federal Register 56: 50075-50082.

U.S. Fish and Wildlife Service (USFWS). 1993. Endangered and threatened wildlife and plants; final rule, determination of threatened status of the delta smelt. Federal Register 58: 12854-12864.

U.S. Fish and Wildlife Service (USFWS). 1993. Formal Consultation on Effects of the Proposed Los Vaqueros Reservoir Project on Delta Smelt, Contra Costa County, California. Service File Number 1-1-93-F-35. Issued September 9, 1993.

U.S. Fish and Wildlife Service (USFWS). 1994. Endangered and threatened wildlife and plants; final rule critical habitat determination for the delta smelt. Federal Register 59: 65256-65277.

U.S. Fish and Wildlife Service (USFWS). 1994. Endangered and Threatened Wildlife and Plants; Critical Habitat Determination for Delta Smelt. 50 CFR Part 17. RIN 1018-AB66. December 19.

U.S. Fish and Wildlife Service (USFWS). 1995. Working Paper on Restoration Needs: Habitat Restoration Actions to Double Natural Production of Anadromous Fish in the Central Valley of California. Volume 2. May 9. Prepared for the U.S. Fish and Wildlife Service under the direction of the Anadromous Fish Restoration Program Core Group, Stockton, CA.

U.S. Fish and Wildlife Service (USFWS). 1996. Recovery Plan for the Sacramento–San Joaquin Delta Native Fishes, November 26. Portland, Oregon. Available at: http://ecos.fws.gov/docs/recovery_plan/961126.pdf.

U.S. Fish and Wildlife Service (USFWS). 1998. Juvenile Salmonid Monitoring on the Mainstem Trinity River at Willow Creek and Mainstem Klamath River at Big Bar, 1992–1995. Annual Report of the Klamath River Fisheries Assessment Program. Coastal California Fish and Wildlife Office, Arcata, CA.

U.S. Fish and Wildlife Service (USFWS). 1998. Recovery plan for upland species of the San Joaquin Valley, California. Region 1, Portland, OR. 319 pp.

U.S. Fish and Wildlife Service (USFWS). 1999. Draft Recovery Plan for the Giant Garter Snake (*Thamnophis gigas*). U.S. Fish and Wildlife Service, Portland, Oregon. x + 192 pp.

U.S. Fish and Wildlife Service (USFWS). 1999. Effect of temperature on early-life survival of Sacramento River fall- and winter-run chinook salmon. Red Bluff, CA: Northern Central Valley Fish and Wildlife Office, January 1999.

U.S. Fish and Wildlife Service (USFWS). 2000. Endangered and Threatened Wildlife and Plants; Final Rule to List the Riparian Brush Rabbit and the Riparian, or San Joaquin Valley Woodrat as endangered. Federal Register 65 8881-8890.

U.S. Fish and Wildlife Service (USFWS). 2000. Formal Consultation Pursuant to Section 7 of the Endangered Species Act of 1973; as Amended, on Contra Costa Water District's Construction of a Multipurpose Pipeline and Future Water Supply Implementation Program, Contra Costa County, California. Service File Number 1-1-99-F-93. Issued April 27.

U.S. Fish and Wildlife Service (USFWS). 2000a. Outmigrant Trapping of Juvenile Salmonids in the Lower Stanislaus River, Caswell State Park Site 1999. Prepared by S. P. Cramer & Associates, Inc.

U.S. Fish and Wildlife Service (USFWS). 2000b. September 2000 Standard Grants. Division of Bird Habitat Conservation. Available at: http://www.fws.gov/birdhabitat/grants/nawca/standard/us/2000_Sept.shtm.

U.S. Fish and Wildlife Service (USFWS). 2001. Final Restoration Plan for the Anadromous Fish Restoration Program. Available at: https://www.fws.gov/cno/fisheries/CAMP/Documents/Final_Restoration_Plan_for_the_AFRP.pdf. Accessed: January 31, 2019.

U.S. Fish and Wildlife Service (USFWS). 2003. California Tiger Salamander. Sacramento: Endangered Species Division. Available at: http://sacramento.fws.gov/es/animal_spp_acct/california_tiger_salamander.htm

U.S. Fish and Wildlife Service (USFWS). 2004. 5-year review of the delta smelt. http://www.fws.gov/sacramento/es/documents/DS%205-yr%20rev%203-31-04.pdf.

U.S. Fish and Wildlife Service (USFWS). 2004. Long-Term Central Valley Project and State Water Project Operations Criteria Plan Biological Opinion for Delta Smelt. Service file #1-1-05-F-0055.

U.S. Fish and Wildlife Service (USFWS). 2005. Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon. Region 1. Portland, Oregon. December 15.

U.S. Fish and Wildlife Service (USFWS). 2005. Reinitiation of Formal and Early Section 7 Endangered Species Consultation on the Coordinated Operations of the Central Valley Project and State Water Project and the Operational Criteria and Plan to Address Potential Critical Habitat Issues. United States Fish and Wildlife Service, Sacramento, CA.

U.S. Fish and Wildlife Service (USFWS). 2006a. Least Bell's Vireo (Vireo bellii pusillus) 5-Year Review Summary and Evaluation. Carlsbad, CA: U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. September.

U.S. Fish and Wildlife Service (USFWS). 2006d. California least tern (Sternula antillarum browni) 5-Year Review Summary and Evaluation. Carlsbad, CA: U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. September.

U.S. Fish and Wildlife Service (USFWS). 2007. Vernal Pool Fairy Shrimp, Branchinecta lynchi, Conservation 5-year Review. Available: < https://www.fws.gov/cno/es/images/graphics/vpfs_5-yr%20review%20cno%20final%2027sept07.pdf >.

U.S. Fish and Wildlife Service (USFWS). 2007. Formal Consultation on the Contra Costa Water District Alternative Intake Project, Contra Costa County, California. Service File Number 1-1-07-F-044. Issued April 27.

U.S. Fish and Wildlife Service (USFWS). 2008a. Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project (CVP) and State Water Project (SWP), USFWS File No. 81420-2008-F-1481-5. Available on the internet at: <http://www.fws.gov/sfbaydelta/ocap/>.

U.S. Fish and Wildlife Service (USFWS). 2008b. Biological Opinion on the Effects of Long Term Coordinated Operations of the Central Valley (CVP) and State Water Project (SWP) on Delta Smelt and its Designated Critical Habitat. December.

U.S. Fish and Wildlife Service (USFWS). 2009. Species Account. Valley Elderberry Longhorn Beetle. Desmocerus californicus dimorphus. Sacramento, California. Last updated: May 20, 2009.

U.S. Fish and Wildlife Service (USFWS). 2009a. Cordylanthus mollis spp. mollis (Soft Bird's-Beak) 5-Year Review: Summary and Evaluation. Sacramento: U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office. January.

U. S. Fish and Wildlife Service (USFWS). 2009b. Cirsium hydrophilum var. hydrophilum (Suisun Thistle). 5-Year Review: Summary and Evaluation. Sacramento, California. January.

U. S. Fish and Wildlife Service (USFWS). 2010b. Endangered and threatened wildlife and plants; 12-month finding on a petition to reclassify the delta smelt from threatened to endangered throughout its range. Federal Register 75:17667-17680. https://www.gpo.gov/fdsys/pkg/FR-2010-04-07/pdf/2010-7904.pdf

U.S. Fish and Wildlife Service (USFWS). 2010. Concurrence on the Los Vaqueros Reservoir Expansion Project is Not Likely to Adversely Affect the Delta Smelt (File MP-730 ENV -7.0). File Number 81410-2011-1-0001. Dated November 1.

U.S. Fish and Wildlife Service (USFWS). 2010a. 5-year review delta smelt (*Hypomesus transpacificus*). http://ecos.fws.gov/docs/five_year_review/doc3570.pdf

U.S. Fish and Wildlife Service (USFWS). 2010b. Endangered and threatened wildlife and plants; 12-month finding on a petition to reclassify the delta smelt from threatened to endangered throughout its range. Federal Register 75:17667-17680. https://www.gpo.gov/fdsys/pkg/FR-2010-04-07/pdf/2010-7904.pdf

U.S. Fish and Wildlife Service (USFWS). 2010c. Notice of Findings on Delta Smelt uplisting. Federal Register 75:69222-69294. https://www.gpo.gov/fdsys/pkg/FR-2010-11-10/pdf/2010-27686.pdf#page=2

U.S. Fish and Wildlife Service (USFWS). 2011. First Draft Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project and State Water Project. Sacramento, CA.

U.S. Fish and Wildlife Service (USFWS). 2012b. Endangered and Threatened Wildlife and Plants; Review of Native Species That Are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions; Proposed Rule. November 21. Available at: https://www.fws.gov/policy/library/2012/2012-28050.html

U.S. Fish and Wildlife Service (USFWS). 2012. About the Refuge. San Joaquin River National Wildlife Refuge. Website. Available: https://www.fws.gov/Refuge/San_Joaquin_River/about.html. Last updated: December 21, 2012. Accessed: December 7, 2018.

U.S. Fish and Wildlife Service (USFWS). 2012. Giant Garter Snake (*Thamnophis gigas*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Office, Sacramento, California.

U.S. Fish and Wildlife Service (USFWS). 2013. Recovery plan for tidal marsh ecosystems of northern and central California. [Sacramento (CA)]: U.S. Fish and Wildlife Service [Internet]. 623 p. Available from: https://www.fws.gov/sfbaydelta/documents/tidal_marsh_recovery_plan_v1.pdf

U.S. Fish and Wildlife Service (USFWS). 2013. Biological Opinion on the Proposed Suisun Marsh Habitat Management, Preservation, and Restoration Plan and the Project-Level Actions in Solano County, California. Service File No. 08ESMF00-2012-F-0602-2. June 10. Sacramento, CA: U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office.

U.S. Fish and Wildlife Service (USFWS). 2013. Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California. Sacramento, California. xviii + 605 pp.

U.S. Fish and Wildlife Service (USFWS). 2013. The Delta Juvenile Fish Monitoring Program. Stockton Fish and Wildlife Office. Available at: http://www.fws.gov/stockton/jfmp/.

U.S. Fish and Wildlife Service (USFWS). 2013. Biological Opinion for the 2013–2017 *Egeria densa* Control Program in the Sacramento-San Joaquin Delta, California. Service File No. 08FBDT00-2013-F-0015. May 3. Sacramento, CA: U.S. Fish and Wildlife Service, San Francisco Bay-Delta Fish and Wildlife Office.

U.S. Fish and Wildlife Service (USFWS). 2014. Endangered and Threatened Wildlife and Plants; Withdrawal of the Proposed Rule To Remove the Valley Elderberry Longhorn Beetle From the Federal List of Endangered and Threatened Wildlife. Federal Register 79(180):55874-55917.

U.S. Fish and Wildlife Service (USFWS). 2014b. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for the Western Distinct Population Segment of the Yellow-Billed Cuckoo. Federal Register 79(158):48548-48652.

U.S. Fish and Wildlife Service (USFWS). 2015. Reinitiation of Programmatic Formal Consultation for Bureau of Reclamation's Proposed Central Valley Project Long Term Water Transfers (2015–2024) with Potential Effects on the Giant Garter Snake with Sacramento Valley, California. June 4, 2015. Available: https://www.usbr.gov/mp/cvp/docs/June-4-2015-Biological-Opinion-CVP-Long-Term-Water-Transfers.pdf. Accessed: December 6, 2018.

U.S. Fish and Wildlife Service (USFWS). 2015. Sacramento River tributaries Habitat Synthesis Report. Anadromous Fish Restoration Program. January 9, 2015.

U.S. Fish and Wildlife Service (USFWS). 2017. Amendment of the 2005 Biological Opinion on the Operations and Maintenance Program Occurring on Bureau of Reclamation Lands within South-Central California Area Office (Service File No: 1-1-04-F-036S) to include the Rock Slough Fish Screen Facility Improvement Project (Bureau of Reclamation File No: 423 ENV 7.00). Service File Number 08FBDT00-2017-F-0072. November 2.

U.S. Fish and Wildlife Service (USFWS). 2017. Recovery Plan for the Central California Distinct Population Segment of the California Tiger Salamander (Ambystoma californiense). U.S. Fish and Wildlife Service, Pacific Southwest Region, Sacramento, California. v + 6.

U.S. Fish and Wildlife Service (USFWS). 2017. Recovery Plan for the Giant Garter Snake (*Thamnophis gigas*). U.S. Fish and Wildlife Service, Pacific Southwest Region, Sacramento, California. vii + 71 pp.

U.S. Fish and Wildlife Service (USFWS). 2017a. Biological Opinion for the California WaterFix. Service File No. 08FBDT00-2016-F-0247. June 23. Sacramento, CA: U.S. Fish and Wildlife Service, San Francisco Bay-Delta Fish and Wildlife Office.

U.S. Fish and Wildlife Service (USFWS). 2017b. Biological Opinion for the Yolo Flyway Farms Restoration Project (U.S. Army Corps of Engineers File No. SPK-2015-00160). August 24. Sacramento, CA: U.S. Fish and Wildlife Service, San Francisco Bay-Delta Fish and Wildlife Office.

U. S. Fish and Wildlife Service (USFWS). 2017c. Framework for Assessing Impacts to the Valley Elderberry Longhorn Beetle (Desmocerus californicus dimorphus). U. S. Fish and Wildlife Service. Sacramento, California. 28pp.

U.S. Fish and Wildlife Service (USFWS). 2018. Biological Opinion for the California WaterFix. Service File No. 08FBDT00-2017-F-0042. February 14. Sacramento, CA: U.S. Fish and Wildlife Service, San Francisco Bay-Delta Fish and Wildlife Office.

U.S. Fish and Wildlife Service (USFWS). 2018. EDSM. Enhanced Delta Smelt Monitoring 2018 Phase 3 Sampling Preliminary Analysis. Draft. November 30. Available: https://www.fws.gov/lodi/juvenile_fish_monitoring_program/jfmp_index.htm Accessed: December 29, 2018.

U.S. Fish and Wildlife Service (USFWS). 2018. SWG. Summary Report on the Transactions of the Smelt Working Group in Water Year 2018. November. Sacramento, CA: U.S. Fish and Wildlife Service, San Francisco Bay-Delta Fish and Wildlife Office.

U.S. Fish and Wildlife Service (USFWS). 2018a. Information for Planning and Consultation. Available at: https://ecos.fws.gov/ipac/. Accessed February 6, 2019.

U.S. Fish and Wildlife Service (USFWS). Undated. Draft Habitat Assessment Guidelines & Survey Protocol for the Riparian Brush Rabbit and the Riparian Woodrat. Available at: https:www.fws.gov/sacramento/es/Survey-Protocol-Guidelines/.

U.S. Fish and Wildlife Service (USFWS). Undated. Red Bluff Diversion Dam- Green Sturgeon https://www.fws.gov/redbluff/rbdd_greensturgeon.html. Accessed: September 28, 2018.

U.S. Fish and Wildlife Service (USFWS) and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, and Hoopa Valley Tribe, U.S. Department of the Interior, Washington, DC.

Van Eenennaam, J. P., J. Linares-Casenave, X. Deng, and S. I. Doroshov. 2005. Effect of Incubation Temperature on Green Sturgeon Embryos, Acipenser medirostris. Environmental Biology of Fishes 72(2):145–154.

Van Eenennaam, J. P., M. A. H. Webb, X. Deng, and S. I. Doroshov. 2001. Artificial Spawning and Larval Rearing of Klamath River Green Sturgeon. Transactions of the American Fisheries Society 130:159–165.

Vincik, R. F. and J. M. Julienne. 2012. Occurrence of delta smelt (*Hypomesus transpacificus*) in the lower Sacramento River near Knights Landing, California. California Fish and Game 98(3):171-174. https://www.wildlife.ca.gov/Publications/Journal

Vogel J. and D. Beachamp. 1999. Effects of Light, Prey Size, and Turbidity on Reaction Distances of Lake Trout (Salvelinus namaycush) to Salmonid Prey. Canadian Journal of Fisheries and Aquatic Sciences. 56(7): 1293-1297.

Vogel, D. A. and K. R. Marine. 1991. Guide to upper Sacramento Chinook salmon life history. Report to U.S. Bureau of Reclamation, Central Valley Project. CH2M Hill, Inc., Redding, California. 55 pp.

von Westernhagen, H., D. Volkert, P. Cameron and D. Janssen. 1987. Chlorinated hydrocarbon r esidues in gonads of marine fish and effects on reproduction. Sarsia. 72(3-4).

Voss, S. D. and W. R. Poytress. 2018. Brood Year 2016 Juvenile Salmonid Production and Passage Indices at Red Bluff Diversion Dam. Prepared for: U.S. Bureau of Reclamation 2016 Annual RBDD Juvenile Fish Monitoring Report. U.S. Fish and Wildlife Service. Red Bluff, California. July.

Wagner, R. W., M. Stacey, L. R. Brown, and M. Dettinger. 2011. Statistical models of temperature in the Sacramento–San Joaquin Delta under climate-change scenarios and ecological implications. Estuaries and Coasts 34(3):544-556.

Waples, R. S. 1995. Evolutionarily significant units and the conservation of biological diversity under the Endangered Species Act. In: Nielsen JL, editor. Evolution and the aquatic ecosystem: defining unique units in population conservation. American Fisheries Society Symposium 17. Bethesda (MD). Ward and Stanford 1983

Water Forum. 2005. Addendum to the Report Titled Impacts on the Lower American River Salmonids and Recommendations Associated with Folsom Reservoir Operations to Meet Delta Water Quality Objectives and Demands. September.

WDFW and ODFW. 2001. Washington and Oregon Eulachon Management Plan. Washington Department of Fish and Wildlife, Olympia, WA. WEF 2018.

Weston, D. P., D. Chen and M. J. Lydy. 2015. Stormwater-related transport of the insecticides bifenthrin, fipronil, imidacloprid and chlorpyrifos into a tidal wetland, San Francisco Bay, California. Science of the Total Environment. 527-528: 18-25.

Weston, D. P., A. M. Asbell, S. A. Lesmeister, S. J. Lydy, M. J. 2014. Urban and agricultural pesticide inputs to a critical habitat for the threatened delta smelt (Hypomesus transpacificus). Environmental Toxicology and Chemistry. 33:4, pp 920-929.

Weston, D. P., and M. J. Lydy. 2010. Urban and agricultural sources of pyrethroid insecticides to the Sacramento-San Joaquin Delta of California. Environ. Sci. Technol. 44: 1833Ð1840.

Weston, D. P., A. M. Asbell, S. A. Lesmeister, S. J. Teh, M. J. Lydy. 2014. Urban and agricultural pesticide inputs to a critical habitat for the threatened delta smelt (Hypomesus transpacificus). Environ. Toxicol. Chem. 33, 920–929.

Weston, D. P., D. Schlenk, N. Riar, M. J. Lydy, M. L. Brooks. 2015. Effects of pyrethroid insecticides in urban runoff on Chinook salmon, steelhead trout, and their invertebrate prey. Environ. Toxicol. Chem. 34, 649–657.

Whipple, A. Historical Ecology of the Delta: Habitat characteristics of a fluvial-tidal landscape [Internet]. Sacramento, CA; 2010. http://www.sfei.org/DeltaHEStudy

Wicks, B. J., R. Joensen, Q. Tang, and D. J. Randall. 2002. Swimming and ammonia toxicity in salmonids: the effect of sub lethal ammonia exposure on the swimming performance of coho salmon and the acute toxicity of ammonia in swimming and resting rainbow trout. Aquatic Toxicology. 59(1-22): 55-69.Wiener JG, Gilmour CC, Krabbenhoft DP. 2003. Mercury strategy for the Bay-Delta ecosystem: a unifying framework for science, adaptive management, and ecological restoration. Final report to the California Bay-Delta Authority. 59 p.

Wiles, G. J. 2004. Washington state status report for the killer whale. Washington Department of Fish and Wildlife, Olympia, Washington.

Wilkerson, F. P., R. C. Dugdale, V.E. Hogue, A. Marchi. 2006. Phytoplankton blooms and nitrogen productivity in San Francisco Bay. Estuaries and Coasts 29, 401–416.

Williams, D. F. 1993. Population Censuses of Riparian Brush Rabbits and Riparian Woodrats at Caswell Memorial State Park during January 1993. Lodi, CA: California Department of Parks and Recreation.

Williams, G. B. Jr. 1893. U.S. Commission of Fish and Fisheries. Commission Report 1889–91. 49 p.

Williams, G .B. Jr. 1894. U.S. Commission of Fish and Fisheries. Commission Report 1892. Part XVIII. LVII.

Williams, D. F. 1988. Ecology and management of the riparian brush rabbit in Caswell Memorial State Park. California Dept. Parks and Recreation, Lodi, Final Rep. Interagency Agreement 4-305-6 108, 38 pp.

Williams, D. F. 1988. Ecology and management of the riparian brush rabbit in Caswell Memorial State Park. California Dept. Parks and Recreation, Lodi, Final Rep. Interagency Agreement 4-305-6 108, 38 pp.

Williams, D. F. 1986. Mammalian Species of Special Concern in California. Administrative Report 86-1. California Department of Fish and Game, Wildlife Management Division.

Williams, D. F. 1993. Population censuses of riparian brush rabbits and riparian woodrats at Caswell Memorial State Park during January 1993. California Dept. Parks and Recreation, Lodi, Final Rep., 15 pp.

Williams, D. F., L. P. Hamilton, M. R. Lloyd, E. Vincent, C. Lee, A. Edmondson, J. J. Youngblom, K. Gilardi, and P. A. Kelly. 2002. Controlled Propagation and Translocation of Riparian Brush Rabbits: Annual Report for 2002. Report to the Bureau of Reclamation, U.S. Fish and Wildlife Service, and California Department of Fish and Game, Sacramento, CA.

Williams, D. F., P. A. Kelly and L. P. Hamilton. 2002. *Controlled propagation and reintroduction plan for the riparian brush rabbit (Sylvilagus bachmani riparius)*. Endangered Species Recovery Program, California State University, Stanislaus. 75 pp.

Williams, J. G., 2001. Chinook salmon in the lower American River, California's largest urban stream. Fish Bulletin, 179(2), pp.1-38.

Williams, J. G., 2006. Central Valley salmon: a perspective on Chinook and steelhead in the Central Valley of California. San Francisco Estuary and Watershed Science, 4(3).

Williams, R., A. W. Trites, D. E. Bain, 2002. Behavioural responses of killer whales to (Orcinus orca) whale-watching traffic: Opportunistic observations and experimental approaches. Journal of Zoology. 256: 255-270.

Williams, T. H., B. C. Spence, D. A. Boughton, R. C. Johnson, L. Crozier, N. Mantua, M. O'Farrell, and S. T. Lindley. 2016. Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest. 2 February 2016 Report to National Marine Fisheries Service – West Coast Region from Southwest Fisheries Science Center, Fisheries Ecology Division 110 Shaffer Road, Santa Cruz, California 95060

Williamson, R., G. Fogg, M. Rains, and T. Harter. 2005. Hydrology of Vernal Pools at Three Sites, Southern Sacramento Valley. Final technical report. Sacramento, CA: California Department of Transportation.

Wilson, A. E., W. A. Wilson, and M. E. Hay. 2006. Intraspecific Variation in Growth and Morphology of the Bloom-Forming Cyanobacterium Microcystis aeruginosa. Applied and Environmental Microbiology 72(11):7386–7389.

Windell, S., P. L. Brandes, J. L. Conrad, J. W. Ferguson, P. A. L. Goertler, B. N. Harvey, J. Heublein, J. A. Israel, D. W. Kratville, J. E. Kirsch, R. W. Perry, J. Pisciotto, W. R. Poytress, K. Reece, B. G.

Swart, and R. C. Johnson. 2017. Scientific framework for assessing factors influencing endangered Sacramento River winter-run Chinook salmon (Oncorhynchus tshawytscha) across the life cycle. NOAA Technical Memorandum NMFS-SWFSC-586. NOAA National Marine Fisheries Service, Southwest Fisheries Science Center Fisheries Ecology Division Santa Cruz, CA.

Winder, M., A. D. Jassby, and R. Mac Nally. 2011. Synergies between climate anomalies and hydrological modifications facilitate estuarine biotic invasions. Ecology Letters 14(8): 749-757. DOI: 10.1111/j.1461-0248.2011.011635.x.

Winder, M., and A. D. Jassby. 2011. Shifts in Zooplankton Community Structure: Implications for Food Web Processes in the Upper San Francisco Estuary. Estuaries and Coasts 34:675–690.

Winemiller, K. O. and K. A. Rose. 1992. Patterns of life-history diversification in North American fishes: implications for population regulation. Canadian Journal of Fisheries and Aquatic Sciences 49:2196-2218.

Wood Rogers. 2018. Bulkhead Alternatives Analysis Report. Prepared for the City of West Sacramento. Available at https://www.cityofwestsacramento.org/Home/ShowDocument?id=8011.WRA Environmental. 2005. California Tiger Salamander Site Assessment. Staples Ranch Pleasanton, Alameda County California. October. Prepared for Davis Environmental Consulting, LLC. Davis, CA.

Wright, S. A., and D. H. Schoellhamer. 2004. Trends in the Sediment Yield of the Sacramento River, 1957–2001. San Francisco Estuary & Watershed Science 2(2). Available at: http://escholarship.org/uc/item/891144f4.

Wright, S. A., and D. H. Schoellhamer. 2005. Estimating sediment budgets at the interface between rivers and estuaries with application to the Sacramento-San Joaquin River Delta. Water Resources Research 41(9):W09428.

Wylie, G. D., and M. L. Casazza. 2000a. Investigations of the giant garter snakes in the Natomas Basin: 1998-1999. "Unpublished report. U.S. Geological Survey, Biological Resources Division, Dixon Field Station, Dixon, California. March 2000. 20 pp.

Wylie, G. D., and M. L. Casazza. 2000b. Investigations of giant garter snakes in the Natomas Basin: 2000 field season. Unpublished report. U.S. Geological Survey, Biological Resources Division, Dixon Field Station, Dixon, California.

Wylie, G. D., M. L. Casazza, and N. M. Carpenter. 2002. Monitoring giant garter snakes at Colusa National Wildlife Refuge: 2001 progress report. Unpublished report. U U.S. Geological Survey, Biological Resources Division, Dixon Field Station, Dixon, California. April 2002. 10 pp.

Wyman, W. T., M. J. Thomas, R. R. McDonald, A. R. Hearn, R. D. Battleson, E. D. Chapman, P. Kinzel, J. T. Minear, E. A. Mora, J. M. Nelson, M. D. Pagel, and A. P. Klimley. 2017. Fine-scale habitat selection of Green Sturgeon (Acipenser medirostris) within three spawning locations in the Sacramento River, California. Canadian Journal of Fish and Aquatic Sciences. 1-13.

Wyman, M. T., M. J. Thomas, R. R. McDonald, A. R. Hearn, R. D. Battleson, E. D. Chapman, P. Kinzel, J. T. Minear, E. A. Mora, J. M. Nelson, M. D. Pagel, and A. P. Klimley. 2018. Fine-Scale Habitat

Selection of Green Sturgeon (Acipenser medirostris) within Three Spawning Locations in the Sacramento River, California. Canadian Journal of Fisheries and Aquatic Sciences 75(5):779-791.

Yang, M. S., K. Dodd, R. Hibpshman, and A. Whitehouse. 2006. Food habitsof groundfishes in the Gulf of Alaska in 1999 and 2001. NOAA TechnicalMemorandum NMFS-AFSC-164.

Yates, D., H. Galbraith, D. Purkey, A. Huber-Lee, J. Sieber, J. West, S. Herrod-Julius, B. Joyce. 2008. Climate warming, water storage, and Chinook salmon in California’s Sacramento Valley. Clim Change 91:335–350.

Ylitalo, G. M., C. O. Matkin, J. Buzitis, M. Krahan, L. L. Jones, R. Rowles, and J. E. Stein. 2001. Influence of life-history parameters on organochlorine concentrations in free-ranging killer whales (*Orcinus orca*) from Prince William Sound, AK. Science of the Total Environment 281:183–203.

Yoshiyama R. M., E. R. Gerstung, F. W. Fisher, and P. B. Moyle. Historic and present distribution of chinook salmon in the central valley drainage of california. In R. L. Brown, editor, Fish Bulletin 179: Contributions to the biology of Central Valley salmonids., volume 1, pages 71– 176. California Department of Fish and Game, Sacramento, CA, 2001.

Yoshiyama, R. M., E. R. Gerstung, F. W. Fisher, and P. B. Moyle. 1996. Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California. Sierra Nevada Ecosystem Project: Final Report to Congress, Vol. III, Assessments, Commissioned Reports, and Background Information. University of California, Davis, Centers for Water and Wildland Resources.

Yoshiyama, R. M., F. W. Fisher, P. B. Moyle. 1998. Historical Abundance and Decline of Chinook Salmon in the Central Valley Region of California. North American Journal of Fisheries Management 18:487–521.

Zeug, S. and Cavallo, B. 2014. Controls on the Entrainment of Juvenile Chinook Salmon (Oncorhynchus tshawytscha) into Large Water Diversions and Estimates of Population-Level Loss. Plos One. Available at https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0101479.

Zeug, S. C., K. Sellheim, C. Watry, J. D. Wikert, J. Merz. 2014. Response of juvenile Chinook salmon to managed flow: Lessons learned from a population at the southern extent of their range in North America Fisheries Management and Ecology. 21: 155-168. DOI: 10.1111/fme.12063.

Zhou, Y. 2018. Assessing the Impacts of Suisun Marsh Salinity Control Gates’ Summer Operation on Delta Water Quality. Oral presentation at 10th Biennial Bay-Delta Science Conference, Sacramento, CA, September 11, 2018.

Zimmerman, C. E., G. W. Edwards, and K. Perry. 2009. Maternal Origin and Migratory History of Steelhead and Rainbow Trout Captured in Rivers of the Central Valley, California. Transactions of the American Fisheries Society 138(2):280-291.

8.2 Personal Communications

Poytress, B. 2017. Personal Communication. January 17, 2018

Appendix A Facility Descriptions and Operations

Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project

This appendix describes the surface water resources, water supplies, and facilities within the Central Valley Project (CVP) and State Water Project (SWP) that may be affected by the Proposed Action. Some facilities that would not be affected by the Proposed Action have been included as supplementary information. The appendix is intended to provide relevant background information about the facilities and their operations.

A.1 Introduction

This section provides an overview of the CVP and of the SWP facilities. The sections that follow provide an overview of hydrologic conditions and CVP and SWP facilities and operations in the Trinity River, Sacramento Valley, San Joaquin Valley, and the Delta and Suisun Marsh.

A.1.1 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 USACE (Reclamation 1997; Reclamation 2011a). When the Rivers and Harbors Act was reauthorized in 1937, the construction and operation of the CVP was assigned to 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 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.

- 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 and Mendota Pool.
- Delta-Mendota Canal/California Aqueduct Intertie downstream of the CVP Jones Pumping Plant and the SWP Banks Pumping Plant.
- San Luis Reservoir-related facilities, including the CVP facilities consisting of the O'Neill Forebay, Pumping Plant, and Canal; Coalinga Canal, Pleasant Valley Pumping Plant, and San Luis Drain. The O'Neill Forebay is operated in coordination with the SWP. The SWP facilities operated in coordination with the CVP include the B.F. Sisk San Luis Dam (the major dam that forms San Luis Reservoir), San Luis Canal, Los Banos and Little Panoche dams, and associated pumping plants.
- 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.

The CVP reservoirs are listed in Table A.1-1 and shown on Figures A.1-1 through A.1-5. Table A.1-1 also includes reservoirs of the Bureau of Reclamation Orland Project (which are not part of CVP) because these reservoirs also affect hydrology of Stony Creek, a tributary to the Sacramento River.

Table A.1-1. Major Central Valley Project and Orland Project Reservoirs

Project	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
CVP	Millerton Lake	Friant	San Joaquin River	1942	524,000
CVP	Shasta Lake	Shasta	Sacramento River	1945	4,552,000
CVP	Keswick Reservoir	Keswick	Sacramento River	1950	23,772
CVP	Trinity Lake	Trinity	Trinity River	1962	2,447,650
CVP	Lewiston Reservoir	Lewiston	Trinity River	1963	14,660
CVP	Spring Creek Reservoir	Spring Creek Debris Dam	Spring Creek (tributary of Sacramento River)	1963	5,874
CVP	Whiskeytown Lake	Whiskeytown	Clear Creek (tributary of Sacramento River)	1963	241,100
CVP	Folsom Lake	Folsom	American River	1956	967,000
CVP	Lake Natoma	Nimbus	American River	1955	9,000
CVP	Contra Loma Reservoir	Contra Loma	Off-Stream	1967	2,627
CVP	Martinez Reservoir	Martinez	Wildcat Creek	1938	268
CVP	San Luis Reservoir	B.F. Sisk	San Luis Creek	1967	2,041,000
CVP	O'Neill Forebay	O'Neill	San Luis Creek	1967	56,400
CVP	Los Banos Creek Reservoir	Los Banos Detention	Los Banos Creek	1965	34,600
CVP	Little Panoche Creek Reservoir	Little Panoche Detention	Little Panoche Creek	1966	5,580
CVP	San Justo Reservoir	San Justo	Offstream	1985	10,300
CVP	Funks Reservoir	Funks	Funks Creek	1976	2,460
CVP	New Melones Reservoir	New Melones	Stanislaus River	1979	2,400,000

Project	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
CVP	Hensley Lake	Hidden	Fresno River	1975	90,000
CVP	H.V. Eastman Lake	Buchanan	Chowchilla River	1975	150,000
Orland	East Park Reservoir	East Park	Little Stony Creek (tributary of Sacramento River)	1910	51,000
Orland	Stony Gorge Reservoir	Stony Gorge	Stony Creek (tributary of Sacramento River)	1928	50,350

Sources: DWR 2014b; Reclamation 1994, 2014a, 2014b.
Note: CVP is Central Valley Project; Orland is Orland Project

Figure A.1-1. California Major Water Supply Facilities

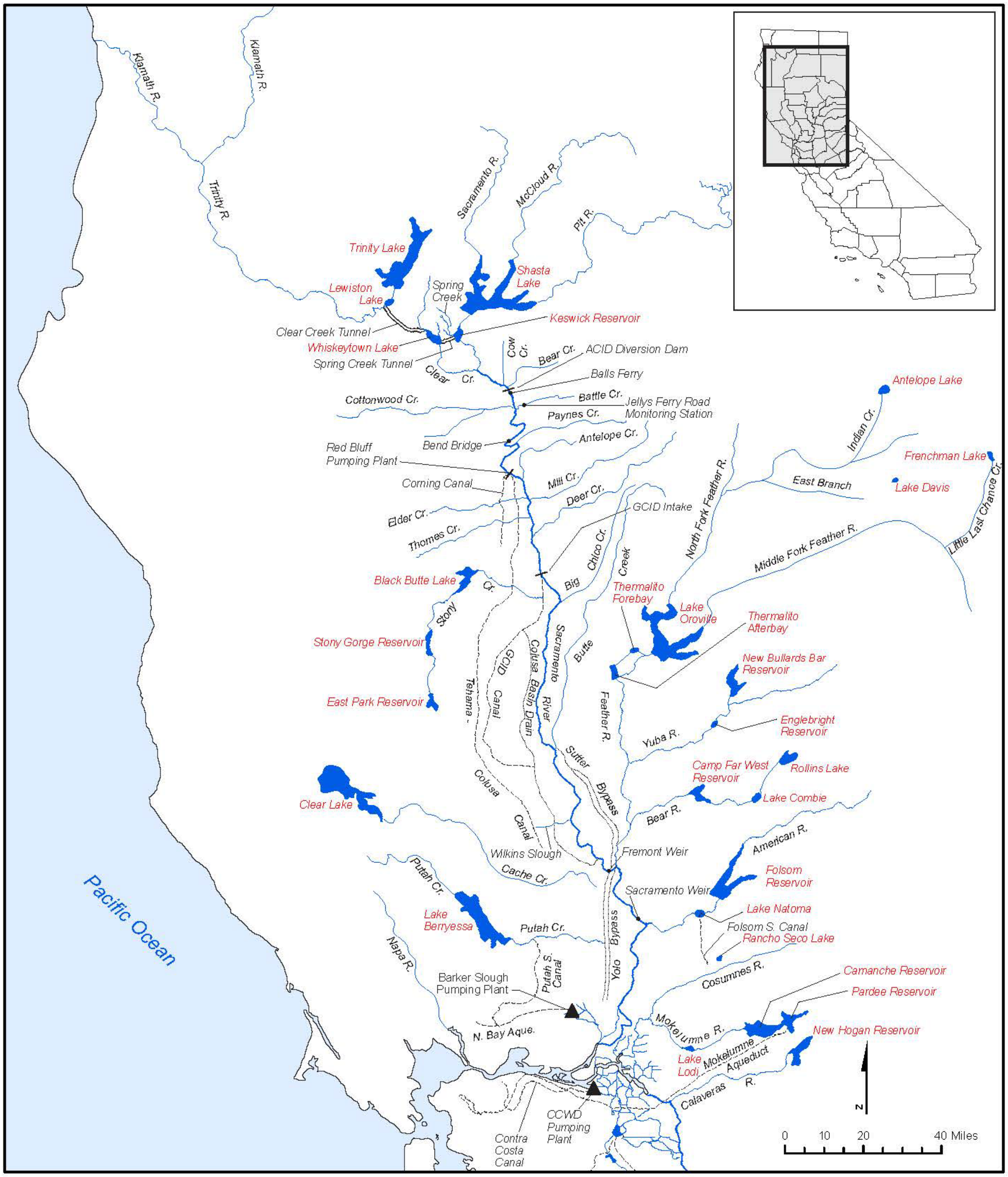


Figure A.1-2. Northern California Major Water Supply Facilities

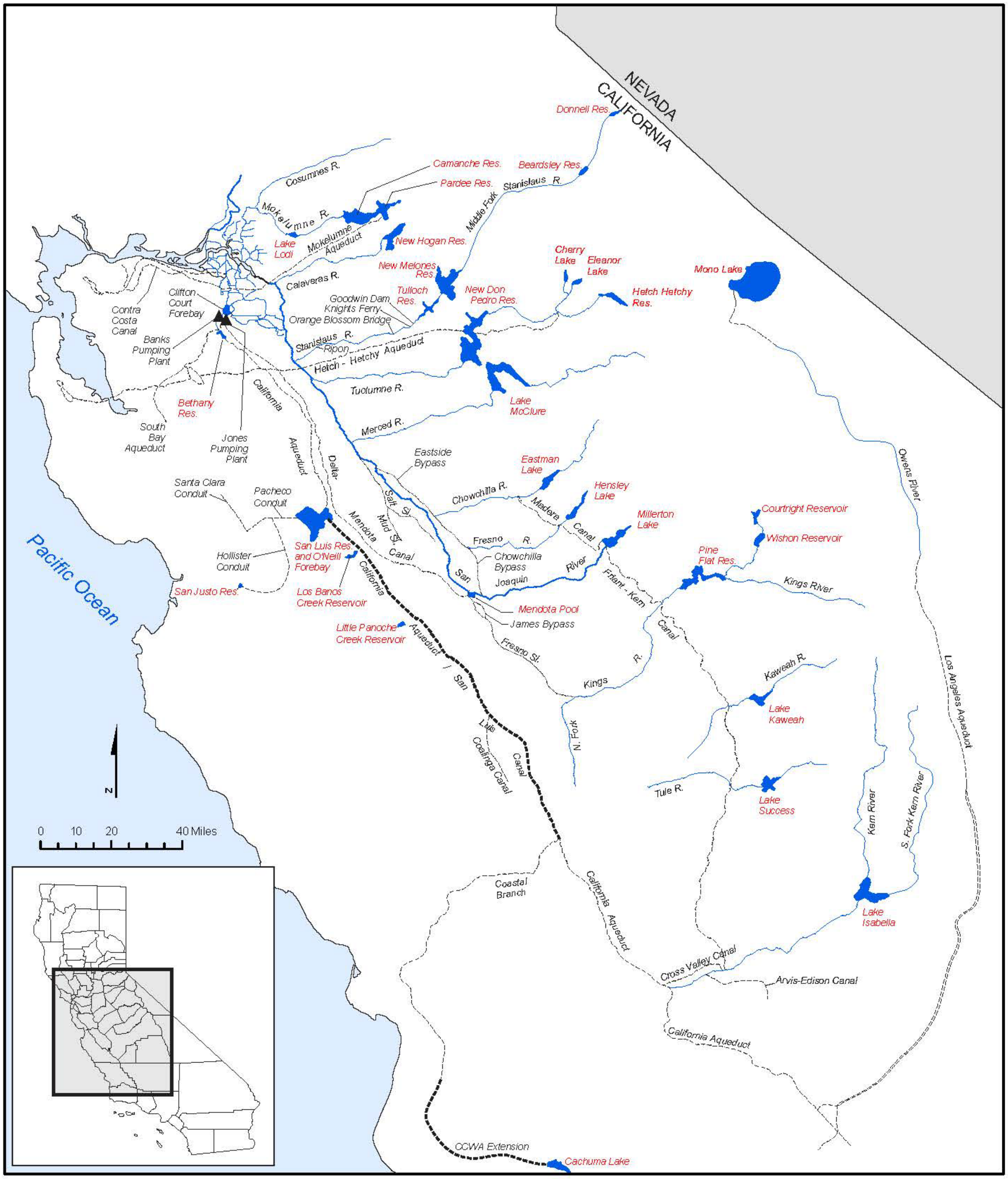


Figure A.1-3. San Joaquin Valley and Tulare Lake Major Water Supply Facilities

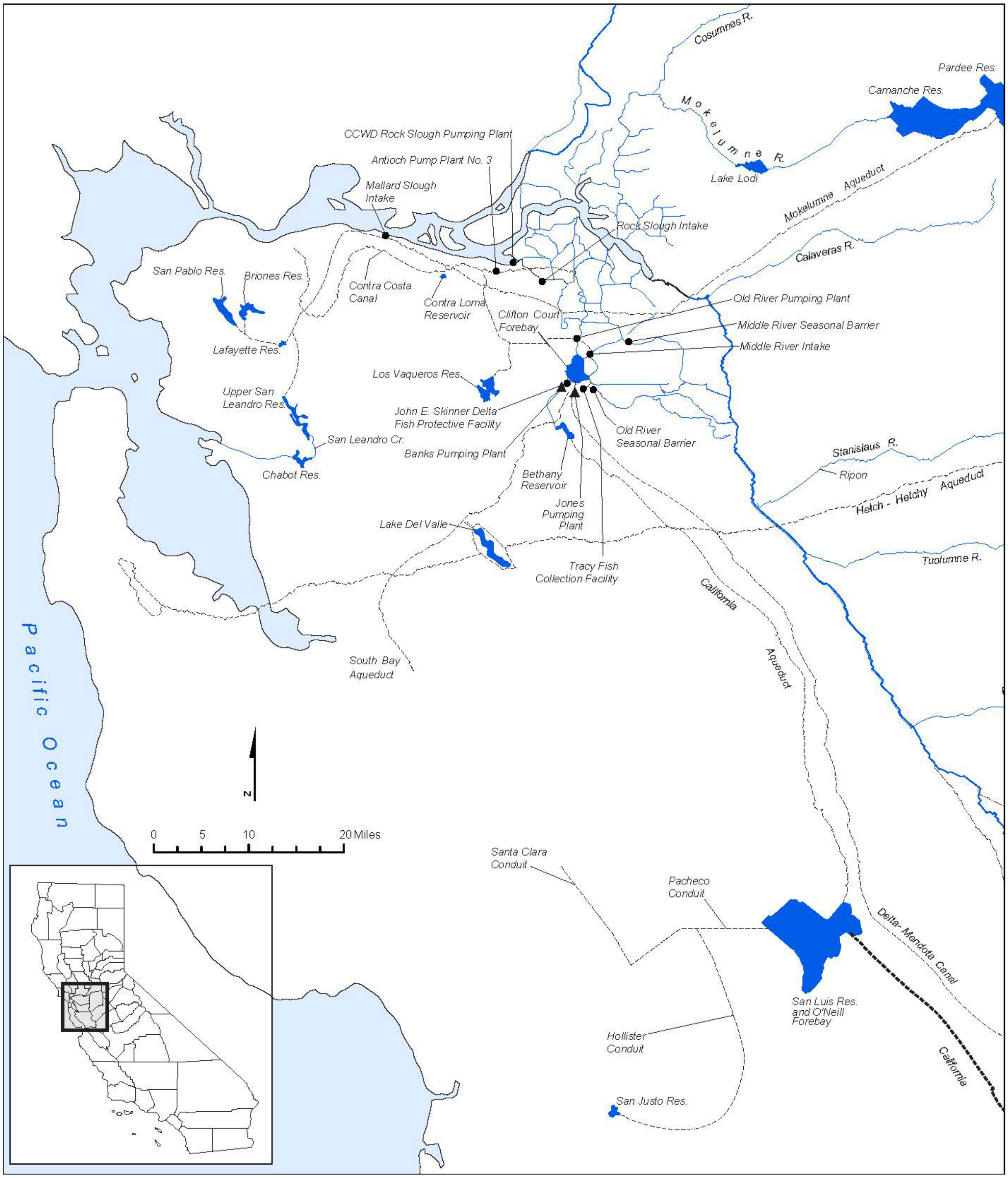


Figure A.1-4. San Francisco Bay Area Major Water Supply Facilities

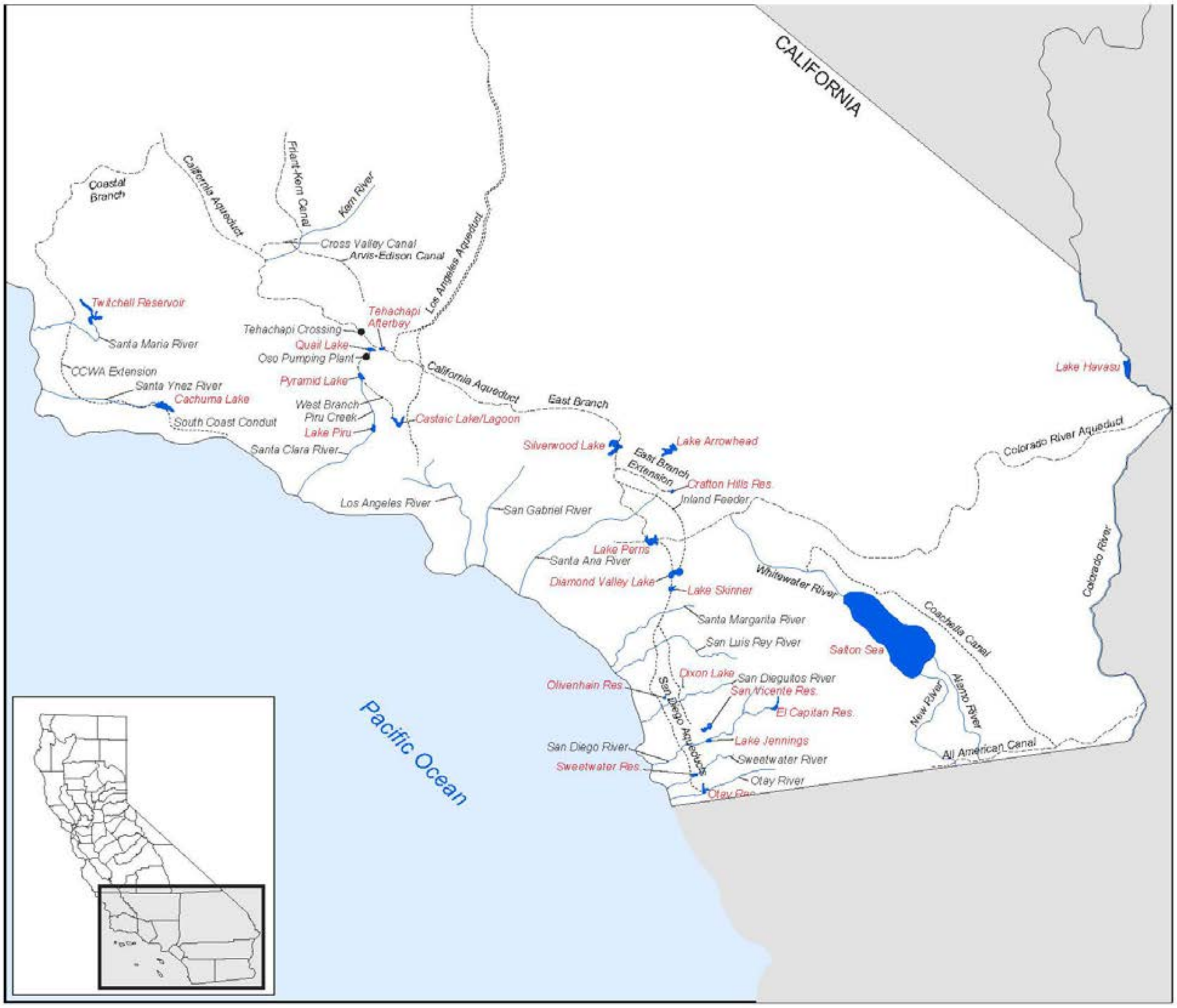


Figure A.1-5. Central Coast and Southern California Major Water Supply Facilities

A.1.2 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 in the Central Coast Region, and southern California (DWR 1957, 2012; Reclamation 2011a). The study identified a seasonal deficiency of 2.675 MAF/year in 1950 that resulted in groundwater overdraft throughout many portions of California. The report described facilities to meet the water demands and reduce groundwater overdraft, including facilities that would become part of the SWP.

In 1960, California voters authorized the Burns-Porter Act to construct the initial SWP facilities. The SWP facilities, as shown on Figures A.1-1 through A.1-5, include:

- Antelope Lake, Lake Davis, and Frenchman Lake on the upper Feather River upstream of Oroville Dam.
- Oroville Dam and Thermalito Diversion Dam on the Feather River.
- Barker Slough Pumping Plant in the north Delta which delivers water to the North Bay Aqueduct (NBA).
- Clifton Court Forebay and Harvey O. Banks Pumping Plant (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 (SBA) and Lake Del Valle.
- San Luis Reservoir-related facilities, including the SWP facilities B.F. Sisk San Luis Dam (the major dam that forms San Luis Reservoir), San Luis Canal, Los Banos and Little Panoche dams, and associated pumping plants, and the CVP O'Neill Forebay. These facilities are operated in coordination between the SWP and CVP.
- 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. The California Aqueduct reach in southern California also includes Quail Lake, Pyramid Lake, Castaic Lake, Silverwood Lake, Crafton Hills Reservoir, and Lake Perris.
- The Coastal Branch of the California Aqueduct to deliver water from the California Aqueduct to San Luis Obispo and Santa Barbara counties.

Major SWP reservoirs are listed in Table A.1-2.

Table A.1-2. State Water Project Reservoirs

Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
Frenchman Lake	Frenchman	Little Last Chance Creek (tributary of Feather River)	1961	55,477
Antelope Lake	Antelope	Indian Creek (tributary of Feather River)	1964	22,566
Lake Davis	Grizzly Valley	Big Grizzly Creek (tributary of Feather River)	1966	83,000
Oroville Reservoir	Oroville	Feather River	1968	3,537,577
Thermalito Pool	Thermalito Diversion	Feather River	1967	13,328
Thermalito Forebay	Thermalito Forebay	Cottonwood Creek (tributary of Feather River)	1967	11,768
Thermalito Afterbay	Thermalito Afterbay	Feather River	1967	57,041
Clifton Court Forebay	Clifton Court Forebay	Old River	1970	29,000
Bethany Forebay	Bethany Forebay	Italian Slough	1961	5,250
Patterson Reservoir	Patterson	Offstream	1962	98
Lake Del Valley	Del Valle	Arroyo Valle	1968	77,100
Quail Lake	No dam	Offstream	Historic	5,654

Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
Pyramid Lake	Pyramid	Piru Creek	1973	180,000
Castaic Lake	Castaic	Castaic Creek	1973	323,700
Silverwood Lake	Cedar Springs	Mojave River (West Fork)	1971	78,000
Crafton Hills Reservoir	Crafton Hills	Yucaipa Creek	2001	130
Lake Perris	Perris	Bernasconi Pass	1973	131,452

Sources: DWR 2014b, 2014c.

A.1.3 Other Major Water Supply and Flood Management Reservoirs

During the past 100 years, numerous water supply, flood management, and hydroelectric generation reservoirs were constructed throughout California. Many of these projects were constructed on tributaries to the Sacramento and San Joaquin rivers and tributaries to the Tulare Lake Basin. Operations of these non-CVP and non-SWP reservoirs affect flow patterns into the Sacramento and San Joaquin rivers and the Delta.

Major non-CVP and non-SWP reservoirs in the Sacramento Valley and San Joaquin Valley watersheds, generally with storage capacities greater than 100,000 acre-feet, which could affect operations of CVP or SWP reservoirs or Delta facilities or could be affected by operations of the CVP or SWP, are listed in Tables A.1-3 and A.1-4. None of these facilities are included in the Proposed Action.

Table A.1-3. Major Non-Central Valley Project and Non-State Water Project Reservoirs in the Sacramento Valley Watershed Considered

Owner	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
U.S. Army Corps of Engineers	Black Butte Reservoir	Black Butte	Stony Creek (tributary of Sacramento River)	1963	143,700
Yuba County Water Agency	Bullards Bar Reservoir	New Bullards Bar	Yuba River (North Fork)	1970	969,600
U.S. Army Corps of Engineers	Englebright Reservoir	Englebright	Yuba River	1941	70,000
South Sutter Water District	Camp Far West Reservoir	Camp Far West	Bear River	1963	104,500
Pacific Gas & Electric Company	Bucks Lake	Bucks Storage	Bucks Creek (tributary of Feather River)	1928	103,000
Pacific Gas & Electric Company	Lake Almanor	Lake Almanor	Feather River (North Fork)	1927	1,308,000
South Feather Water And Power Agency	Little Grass Valley Reservoir	Little Grass Valley	Feather River (South Fork)	1961	93,010
Pacific Gas & Electric Company	Salt Springs Reservoir	Salt Springs	Mokelumne River (North Fork)	1931	141,900
East Bay Municipal Utility District	Pardee Lake	Pardee	Mokelumne River	1929	209,950
East Bay Municipal Utility District	Camanche Lake	Camanche	Mokelumne River	1963	417,120

Owner	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
Sacramento Municipal Utility District	Union Valley Reservoir	Union Valley	Silver Creek (tributary of American River)	1963	230,000
Placer County Water Agency	French Meadows Reservoir	L. L. Anderson	American River (Middle Fork)	1965	136,400
Placer County Water Agency	Hell Hole Reservoir	Lower Hell Hole	Rubicon River (tributary of American River)	1966	208,400

Sources: DWR 2014b, 2014c.

Table A.1-4. Major Non-Central Valley Project and Non-State Water Project Reservoirs in the San Joaquin Valley Watersheds Considered

Owner	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
Southern California Edison Company	Lake Thomas A. Edison	Vermilion Valley	Mono Creek (tributary of San Joaquin River)	1954	125,000
Southern California Edison Company	Shaver Lake	Shaver Lake	Stevenson Creek (tributary of San Joaquin River)	1927	135,283
Merced Irrigation District	Lake McClure	New Exchequer	Merced River	1967	1,032,000
San Francisco Public Utilities Commission	Cherry Lake	Cherry Valley	Cherry Creek (tributary of Tuolumne River)	1956	273,500
San Francisco Public Utilities Commission	Hetch Hetchy Reservoir	O' Shaughnessy	Tuolumne River	1923	360,000
Turlock Irrigation District	New Don Pedro Reservoir	New Don Pedro	Tuolumne River	1971	2,030,000
Calaveras County Water District	New Spicer Meadow Reservoir	New Spicer Meadow	Highland Creek (tributary of Stanislaus River)	1989	190,000
Tri-Dam Project	Donnells Reservoir	Donnells	Stanislaus River (Middle Fork)	1958	56,893
Tri-Dam Project	Beardsley Reservoir	Beardsley	Stanislaus River (Middle Fork)	1957	77,600
Tri-Dam Project	Tulloch Reservoir	Tulloch	Stanislaus River	1958	68,400
Oakdale Irrigation District and South San Joaquin Irrigation District	Goodwin Diversion	Goodwin	Stanislaus River	1912	500
South San Joaquin Irrigation District	Woodward Reservoir	Woodward	Simmons Creek (tributary of Stanislaus River)	1918	35,000
U.S. Army Corps of Engineers	New Hogan Lake	New Hogan	Calaveras River	1963	317,000

Sources: DWR 2014b, 2014c.

Major reservoirs used to store CVP and SWP water supplies in the San Francisco Bay Area, Central Coast and Southern California regions are shown on Figures A.1-4 and A.1-5 and listed in Tables A.1-5, A.1-6, and A.1-7.

Table A.1-5. Major Non-Central Valley Project and Non-State Water Project Reservoirs in the San Francisco Bay Area Region Used to Store Central Valley Project and/or State Water Project Water

Owner	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
Contra Costa Water District	Los Vaqueros Reservoir	Los Vaqueros	Kellogg Creek	1997	160,000
East Bay Municipal Utility District	Briones Reservoir	Briones	Bear Creek	1964	67,520
East Bay Municipal Utility District	San Pablo Reservoir	San Pablo	Bear Creek	1964	38,600
East Bay Municipal Utility District	Lafayette Reservoir	Lafayette	Marsh Creek	1963	4,250
East Bay Municipal Utility District	Upper San Leandro Reservoir	Upper San Leandro	San Leandro Creek	1977	37,960
East Bay Municipal Utility District	Chabot Reservoir	Chabot	San Leandro Creek	1892	10,281

Sources: DWR 2014b, 2014c; East Bay Municipal Utility District (EBMUD) 2011; City and County of San Francisco (CCSF) 2009; Santa Clara Valley Water District (SCVWD) 2011.
Note:
a. Anderson Reservoir capacity is restricted due to California Department of Safety and Dams (SCVWD 2011).

Table A.1-6. Major Non-Central Valley Project and Non-State Water Project Reservoirs in the Central Coast Region Used to Store State Water Project Water

Owner	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
Bureau of Reclamation	Cachuma Lake	Bradbury	Santa Ynez River	1953	205,000

Sources: DWR 2014b; Reclamation 2014c.

Table A.1-7. Major Non-Central Valley Project and Non-State Water Project Reservoirs in the Southern California Region Used to Store State Water Project Water

Owner	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
United Water Conservation District	Lake Piru	Santa Felicia	Piru Creek	1955	100,000
Metropolitan Water District Of Southern California	Diamond Valley Lake	Diamond Valley Lake	Domenigoni Valley Creek	2000	800,000
Metropolitan Water District Of Southern California	Lake Skinner	Robert A Skinner	Tucalota Creek	1973	43,800

Owner	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
Rancho California Water District	Vail Lake	Vail	Temecula Creek	1949	51,000
City of Escondido	Dixon Lake	Dixon	Escondido Creek	1970	2,500
San Diego County Water Authority	Olivenhain Reservoir	Olivenhain	Escondido Creek	2003	24,900
City of San Diego	Lake Hodges	Lake Hodges	San Dieguito River	1918	37,700
City of San Diego	San Vincente Reservoir	San Vicente	San Vicente Creek	1943	146,994
City of San Diego	El Capitan Reservoir	El Capitan	San Diego River	1934	112,800
Helix Water District	Lake Jennings	Chet Harritt	Quail Canyon Creek	1962	9,790
Sweetwater Authority	Sweetwater Reservoir	Sweetwater	Sweetwater River	1888	27,700
City of San Diego	Murray Reservoir	Murray	Off-stream	1918	4,818
City of San Diego	Morena Reservoir	Morena	Cottonwood Creek	1912	50,694
City of San Diego	Lower Otay Reservoir	Savage	Otay River	1919	49,849

Sources: DWR 2014b, 2014c; City of San Diego 2014a, 2014b, 2014c, 2014d; SDCWA and USACE 2008.

Major reservoirs used to store CVP and SWP water supplies in the San Francisco Bay Area, Central Coast, and Southern California regions are shown on Figures A.1-4 and A.1-5 and listed in Tables A.1-5, A.1-6, and A.1-7.

A.2 Trinity River Region

The Trinity River Region includes the area along the Trinity River from Trinity Lake to the confluence with the Klamath River; and along the lower Klamath River from the confluence with the Trinity River to the Pacific Ocean. The Trinity River Region includes Trinity Lake, Lewiston Reservoir, the Trinity River between Lewiston Reservoir and the confluence with the Klamath River, and along the lower Klamath River.

A.2.1 Trinity River Watershed

The Trinity River watershed 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 (California North Coast Regional Water Quality Control Board [NCRWQCB] et al. 2009; U.S. Fish and Wildlife Service [USFWS] et al. 1999). Average precipitation in the Trinity River watershed 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 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 Trinity and Humboldt counties.

Trinity Lake, a CVP facility on the Trinity River formed by the Trinity Dam, was constructed by 1962. The 2.4-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 constructed by 1963 and is located 7 miles downstream of 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. 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.

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 of 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 of 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 (Department of the Interior [DOI] 2000). In response to the reductions in fish populations, Congress enacted legislation and directed that restoration actions be evaluated for the Trinity River. In December 2000, the U.S. Department of the Interior (DOI) adopted the Trinity River Mainstem Fishery Restoration Record of Decision (Trinity River ROD) which restored Trinity River flow and habitat to produce a healthy, functioning alluvial river system. 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.

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 Trinity River Division, 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 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. 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 (DOI 2014; Trinity River Restoration Program [TRPP] 2014).

Temperature objectives for the Trinity River are set forth in State Water Resources Control Board (SWRCB) Water Rights Order 90-5, as summarized below. 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.

Water storage volumes and water storage elevations for Trinity Lake for Water Years 2001 through 2018 are presented on Figures A.2-1 and A.2-2 (DWR 2018a, 2018b). Trinity Lake storage varies in accordance with upstream hydrology and downstream water demands and instream flow requirements. Reclamation maintains at least 600 TAF in Trinity Reservoir, except during the 10 to 15 percent of the years when Shasta Lake is also drawn down.

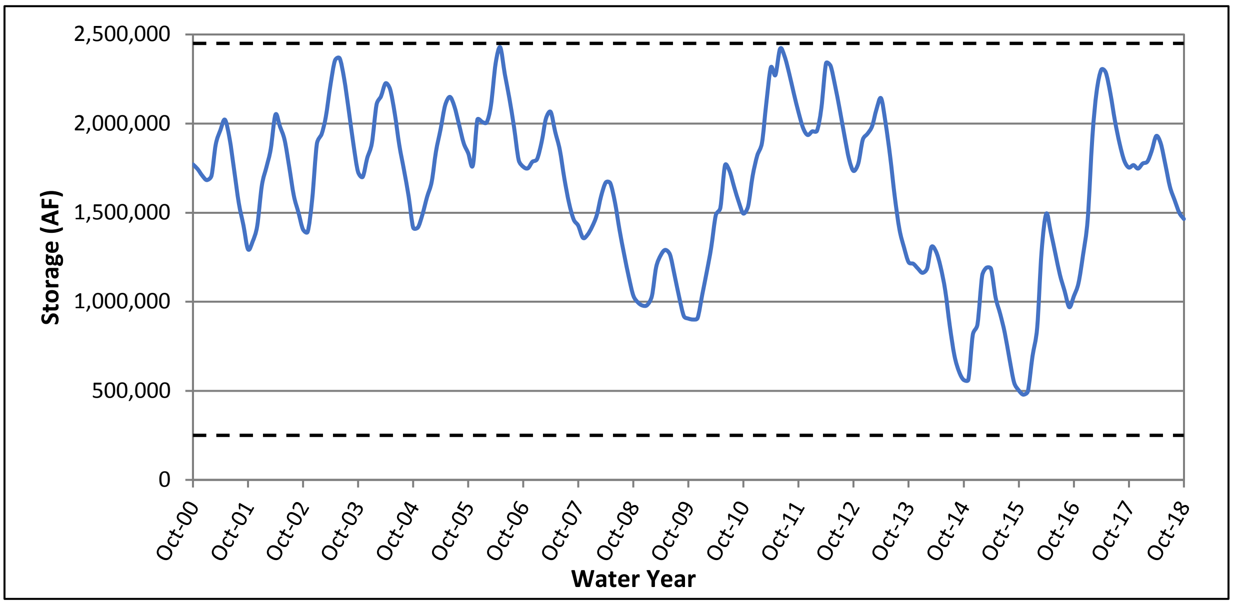


Figure A.2-1. Trinity Lake Storage

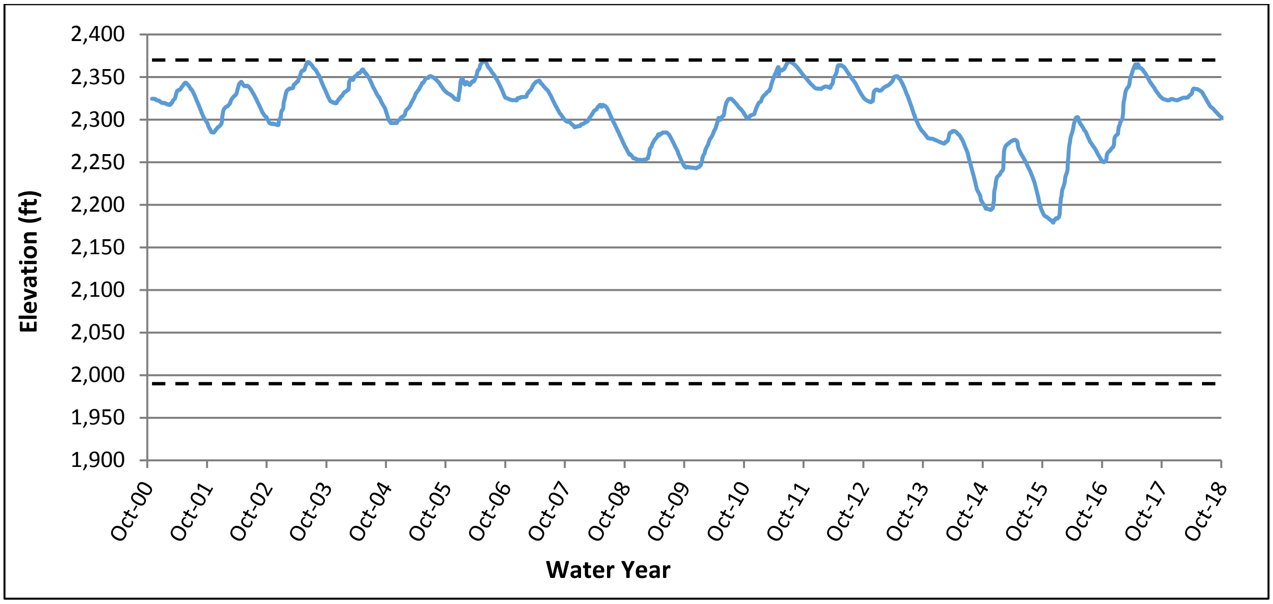


Figure A.2-2. Trinity Lake Elevation

Historical water storage volumes and water storage elevations in Lewiston Reservoir for Water Years 2001 through 2018 are presented on Figures A.2-3 and A.2-4 (DWR 2018c, 2018d). The Lewiston Reservoir water storage volume is more consistent throughout the year because this reservoir is used to regulate flow releases to the powerplant and other downstream uses; and not to provide long-term water storage.

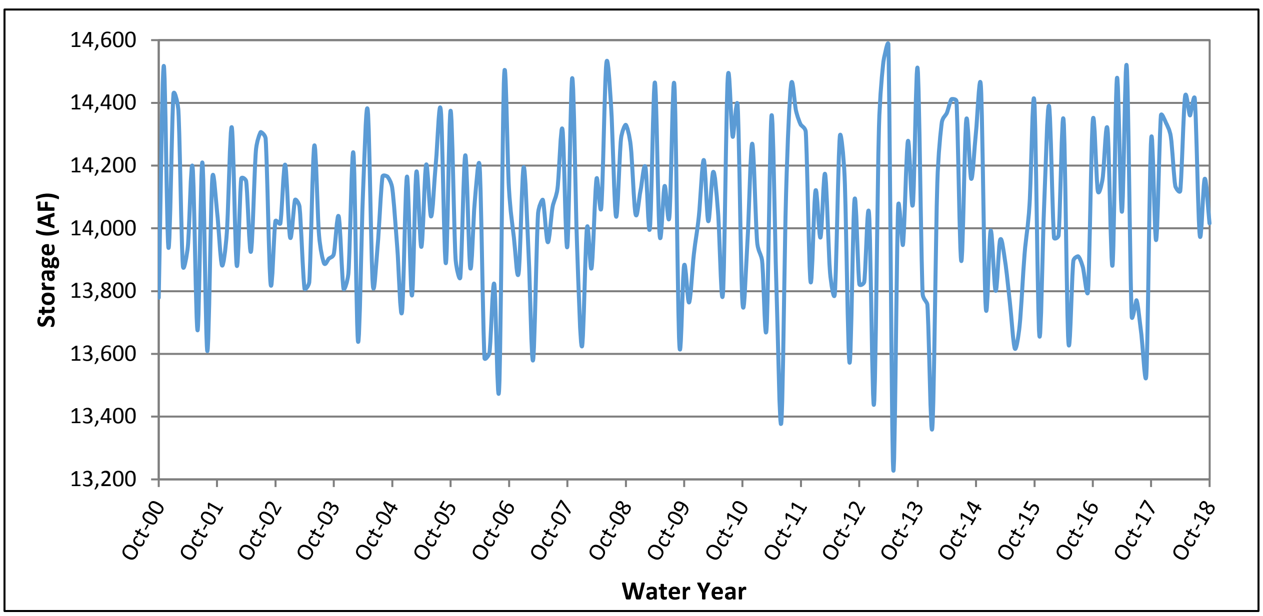


Figure A.2-3. Lewiston Reservoir Storage

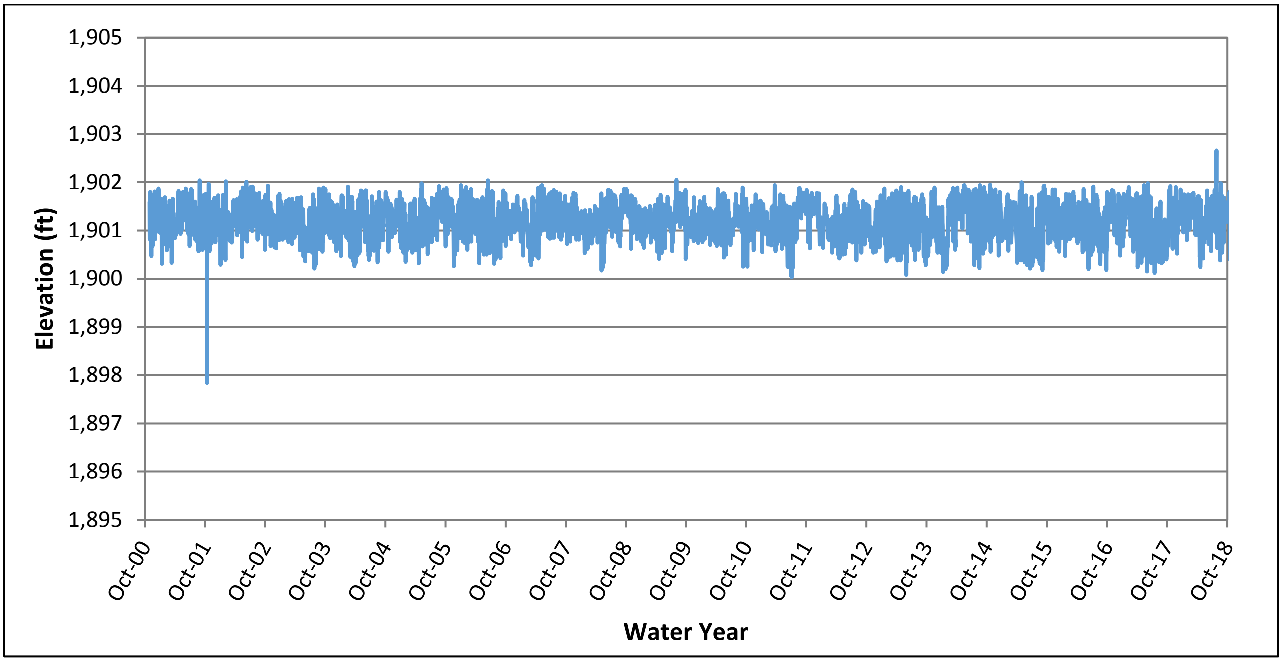


Figure A.2-4. Lewiston Reservoir Elevation

Trinity River flows downstream of Lewiston Reservoir at Douglas City are presented on Figure A.2-5 (DWR 2018e). The flow record is limited at the Douglas City gauge to 2003 through 2018. The mean monthly flows reflect the wet year pattern in 2006 and the drier year patterns in 2008 and 2009.

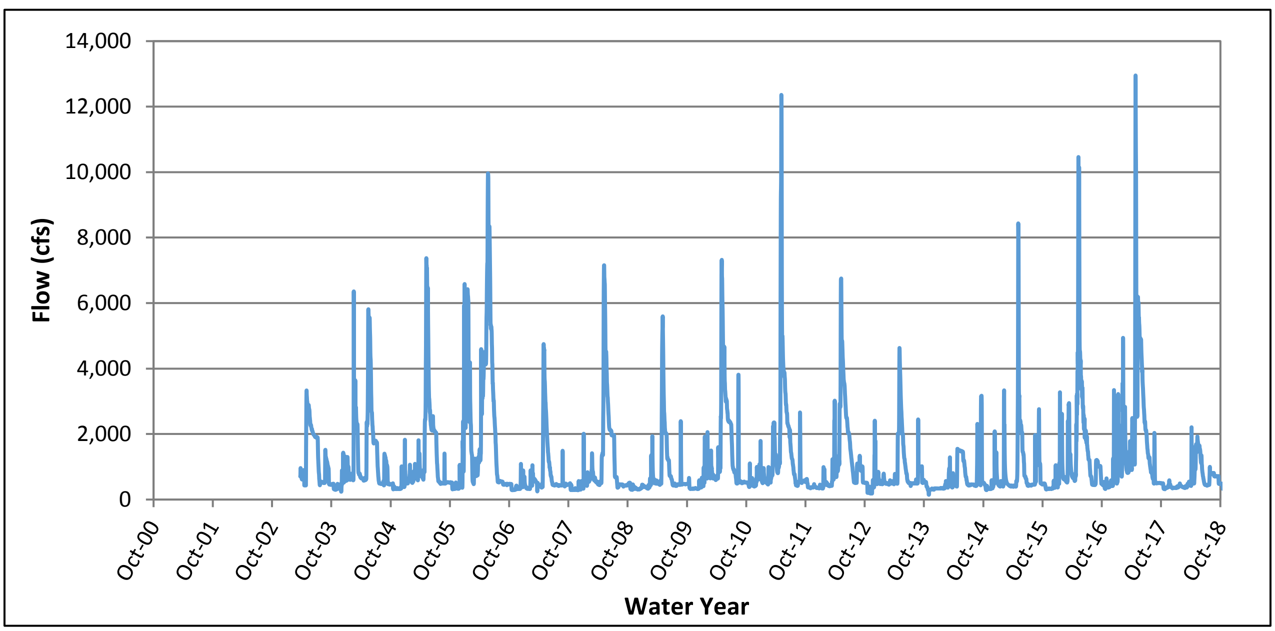


Figure A.2-5. Trinity River Near Douglas City

A.2.2 Trinity River Division Operations

Natural flows began to be stored along the Trinity River in November 1960, affecting river hydraulic function. The Trinity River Division, completed in 1964, includes facilities to store and regulate water in the Trinity River, as well as facilities to divert water to the Sacramento River Basin. The Trinity River Division includes the Trinity River and Dam, Lewiston Dam, Whiskeytown Reservoir and Dam, Clear Creek, and Spring Creek and Debris Dam. Trinity Dam is located on the Trinity River and regulates the flow from a drainage area of approximately 720 square miles. The dam was completed in 1962, forming Trinity Lake, which has a maximum storage capacity of approximately 2.4 MAF.

Water is diverted from the Trinity River at Lewiston Dam via the Clear Creek Tunnel and passes through the Judge Francis Carr Powerhouse as it is discharged into Whiskeytown Lake on Clear Creek. From Whiskeytown Lake, water is released through the Spring Creek Power Conduit to the Spring Creek Power Plant and into Keswick Reservoir. Water diverted from the Trinity River, plus a portion of Clear Creek flows, is diverted through the Spring Creek Power Conduit into Keswick Reservoir and Whiskeytown Dam providing flow to Clear Creek below.

Spring Creek also flows into the Sacramento River and enters at Keswick Reservoir. Flows on Spring Creek are partially regulated by the Spring Creek Debris Dam. Historically (1964–1992), an average annual quantity of 1,269 TAF of water has been diverted from Whiskeytown Lake to Keswick Reservoir. This annual quantity is approximately 17 percent of the flow measured in the Sacramento River at Keswick.

The mean annual inflow to Trinity Lake is 1.26 MAF per year (water years 2001-2017). From water year 1965 through 1980, an average of 80% of inflow was diverted. Under a secretarial decision, an average of 61% of inflow was diverted for water years 1981 through 2000. Under a second secretarial decision, an average of 51% of inflows has since been diverted (water years 2001 - 2017).

A.2.2.1 *Safety of Dams at Trinity Reservoir*

Periodically, increased water releases are made from Trinity Dam consistent with Reclamation Safety of Dams criteria intended to prevent overtopping of Trinity Dam. Although flood control is not an authorized purpose of the Trinity River Division, flood control benefits are provided through normal operations.

The Safety of Dams release criteria specify that Carr power plant capacity be used as a first preference destination for Safety of Dams releases made at Trinity Dam. Trinity River releases are made as a second preference destination. During significant Northern California high-water flood events, the Sacramento River water stages are also often at concern levels. Under such high-water conditions, the water that would otherwise move through the Carr power plant is routed to the Trinity River so as to avoid exacerbating any flooding concerns on the Sacramento River side. Total river releases are capped at 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. The Safety of Dams criteria provide seasonal storage targets and recommended releases November 1 to March 31.

A.2.2.2 *Fish and Wildlife Requirements on Trinity River*

Based on the Trinity River Main-stem Fishery Restoration ROD, dated December 19, 2000, 368.6 TAF to 815 TAF is allocated annually for Trinity River flows, depending on water year type. This amount is scheduled in coordination with USFWS and other in-basin partners to best meet habitat, temperature, and sediment transport objectives in the Trinity Basin.

Water temperature objectives for the Trinity River are set forth in SWRCB Water Rights Order 90-5, as summarized in Table A.2-1. 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.

Table A.2-1. Water Temperature Objectives for the Trinity River during the Summer, Fall, and Winter as Established by the California Regional Water Quality Control Board North Coast Region

Date	Temperature Objective (°F) Douglas City (RM 93.8)	Temperature Objective (°F) North Fork Trinity River (RM 72.4)
July 1 through September 14	60	–
September 15 through September 30	56	–
October 1 through December 31	–	56

The Long-Term Plan to Protect Adult Salmon on the Lower Klamath River ROD, dated April 20, 2017, includes supplemental flows from Lewiston Dam to prevent a disease outbreak (*Ichthyophthirius multifiliis*) in the lower Klamath River in years when the flow in the lower Klamath River is projected to be less than 2,800 cfs. The water for these supplemental flows would come from water stored in Trinity Reservoir, with releases of not less than 50 TAF. The three flow augmentation 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 one-day preventive pulse flow (targeting 5,000 cfs in the lower Klamath River) to be used as a secondary measure to alleviate continued poor environmental conditions and signs of *Ichthyophthirius multifiliis* infection in the lower Klamath River; and
3. a five-day emergency pulse flow (targeting 5,000 cfs in the lower Klamath River) 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 are not successful at meeting intended objectives.

The 2017 ROD cited proviso 1 of Section 2 of the 1955 Act as authority for the releases. Separate and apart from the 2017 ROD, another proviso of Section 2 states that “not less than 50,000 acre-feet shall be released annually from the Trinity Reservoir and made available to Humboldt County and downstream water users.” Reclamation entered into a 1959 contract with Humboldt County wherein it agreed to make that water available for the beneficial use of Humboldt County and other downstream users pursuant to this authority and other factors as determined by Reclamation.

A.2.2.3 *Fish and Wildlife Requirements in Grass Valley Creek*

Reclamation proposes to release water from Buckhorn Dam to Grass Valley Creek in accordance with requirements published in the Buckhorn dam and reservoir standard operating procedures manual for water rights permit 18879 issued to DWR, which establishes the timing and magnitude of minimum flows and flushing flows from the dam.

In addition, Reclamation proposes to increase flow from the dam outlet works for maintenance of the outlet channel and to cue juvenile salmonids in the reach to begin their downstream migration to the Trinity River. Pulse flows will occur when the reservoir water elevation exceeds 2,803.13 ft above sea level between March 1 and April 15. Pulse discharge magnitudes will be up to 100 cfs, to mobilize gravel in the outlet channel upstream of the spillway outlet. The pulse discharge may occur in a discrete event or by accumulation of multiple events lasting 5 to 7 days.

Reclamation also proposes to increase flow in the outlet channel when necessary in October and November to provide adult coho sufficient flow for upstream migration and spawning. For this purpose, flow released from the outlet works will be increased to provide flow depths that are ≥0.60 ft on 25% of riffle crests within a downstream distance of 600 ft from the upstream extent of the run-of-river channel and increased discharge at the USGS stream gage near Lewiston to ≥10 cfs.

A.2.2.4 *Transbasin Diversions*

Diversion of Trinity water to the Sacramento Basin provides water supply and major hydroelectric power generation for the CVP and plays a key role in water temperature control in the Trinity River and upper Sacramento River.

The seasonal timing of Trinity exports, detailed in Table A.2-2, is a result of determining how to make best use of a limited volume of Trinity export (in concert with releases from Shasta Lake) to help conserve cold water pools and meet temperature objectives on the upper Sacramento and Trinity Rivers, as well as power production economics. A key consideration in the export timing determination is the thermal degradation that occurs in Whiskeytown Lake due to the long residence time of transbasin exports in the lake.

Table A.2-2. Average Trinity Lake inflow, release, and export for water years 2001-2017

Month	Average Trinity Lake Inflow (AF)	Average Release to Trinity River (AF)	Average Export to CVP (AF)
January	128,945	30,591	15,349
February	147,763	21,423	19,385
March	194,151	21,209	27,709
April	200,039	41,497	36,030
May	237,307	218,873	44,001
June	128,484	110,756	84,820
July	38,753	51,835	114,410
August	11,294	37,399	108,121
September	6,659	38,170	84,144
October	17,921	23,416	61,594
November	34,837	18,777	28,253
December	116,490	19,486	19,282

To minimize the thermal degradation effects, transbasin export patterns are typically scheduled to provide an approximate 120 TAF volume to occur in late spring to create a thermal connection to the Spring Creek Powerhouse before larger transbasin volumes are scheduled to occur during the hot summer months. Typically, the water flowing from the Trinity Basin through Whiskeytown Lake must be sustained at fairly high rates to avoid warming and to function most efficiently for temperature control. The time period for which effective temperature control releases can be made from Whiskeytown Lake may be compressed when the total volume of Trinity water available for export is limited.

Export volumes from Trinity are made in coordination with the operation of Shasta Lake. Other considerations affecting the timing and magnitude of Trinity exports are power generation demand, and the maintenance schedule of the diversion works and generation facilities.

Maximum storage levels generally occur in April or May. Reclamation maintains at least 600 TAF in Trinity Reservoir, except during the 10 to 15 percent of the years when Shasta Lake is also drawn down. Reclamation addresses end-of-water-year carryover on a case-by-case basis in dry and critically dry water year types with considerations provided by the USFWS and NMFS through the WOMT.

A.2.3 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 Klamath River watershed is generally divided into two or three subbasins. For the purpose of this study, 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. The lower Klamath River flows 43.5 miles from the confluence with the Trinity River to the Pacific Ocean (USFWS et al. 1999). Downstream of the Trinity River confluence, the Klamath River flows through Humboldt and Del Norte counties and through the Hoopa Indian Reservation, Yurok Indian Reservation, and Resighini Indian Reservation within Humboldt and Del Norte counties (DOI and Department of Fish and Game [now known as Department of Fish and Wildlife] DFG 2012).

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 of 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 (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 from approximately 5 miles upstream of 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. Klamath River flows at Klamath within the Klamath River estuary are affected by tidal influence within the estuary, as presented on Figure A.2-6 (DWR 2018f).

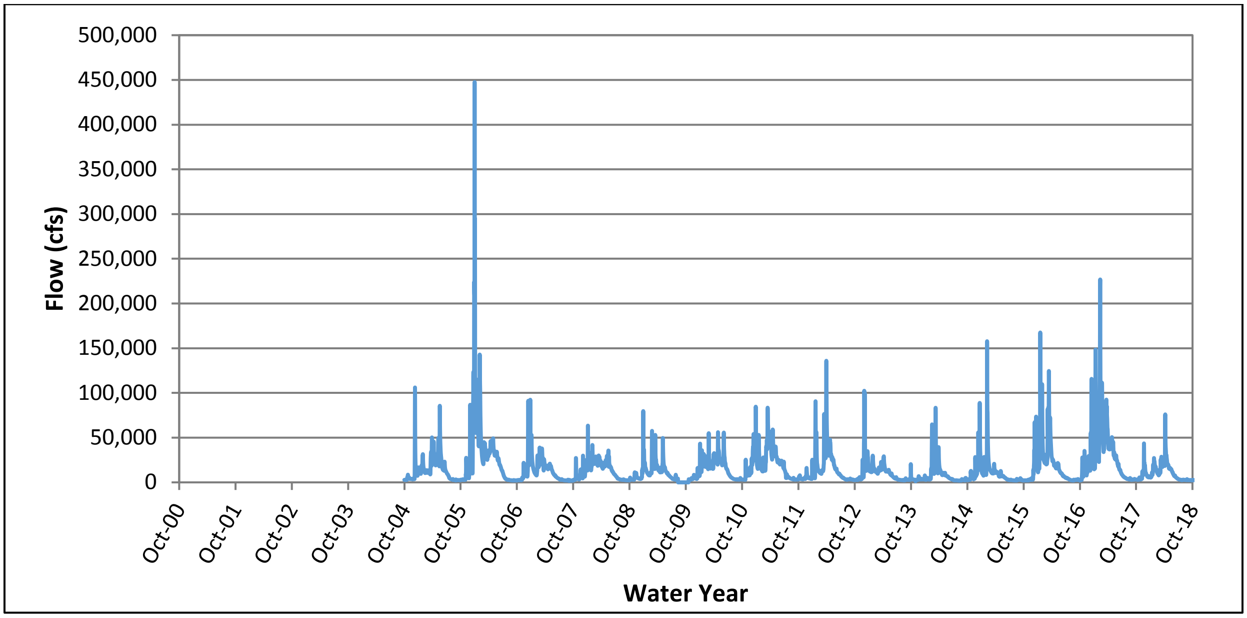


Figure A.2-6. Klamath River Near Klamath

A.3 Sacramento Valley

Rivers in the Sacramento Valley that could be affected by changes in CVP and SWP operations include the following:

- Clear Creek from Whiskeytown Reservoirs to the confluence with the Sacramento River
- Sacramento River from Shasta Lake to the confluence with the San Joaquin River in the Delta
- Feather River from upstream of Oroville Reservoir to the confluence with the Sacramento River
- Yuba River from New Bullards Bar Reservoir to the confluence with the Feather River
- Bear River from Camp Far West Reservoir to the confluence with the Feather River
- American River from Folsom Lake to the confluence with the Sacramento River

Flows from smaller tributaries to the Sacramento River and the Cosumnes and Mokelumne rivers in the Sacramento Valley contribute substantial flows into the Sacramento River and affect CVP and SWP operations; however, flows in these rivers would not be affected by changes in CVP and SWP operations. Therefore, hydrologic conditions on these water bodies are not described.

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

Ground surface elevations in the northern portion of the Sacramento River watershed range from approximately 14,000 feet above mean sea level in the headwaters of the Sacramento River to approximately 1,070 feet at Shasta Lake (Reclamation 2013a). In the mountains surrounding the valley, annual average precipitation generally ranges between 60 and 70 inches up to 90 inches, with snow prevalent at higher elevations. The floor of the Sacramento Valley is relatively flat, with elevations ranging from approximately 60 to 300 feet above mean sea level. This area is characterized by hot dry summers and mild winters. Average precipitation ranges from 15 to 20 inches per year, falling mostly as rain.

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 2013a). 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 Sacramento River also receives imported flows from the Trinity River watershed, as discussed above. 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.

A.3.1 Upper Sacramento River Watershed Hydrology

The portion of the watershed upstream of Keswick Dam includes the McCloud River, Pit River, Squaw Creek, headwaters of the Sacramento River, and Goose Lake basins. The Goose Lake basin is located within the Pit River watershed; however, water rarely spills from Goose Lake into the Pit River. The last recorded spill occurred in 1880 (Reclamation 2013a). Long-term average annual inflows into Shasta Lake are approximately 4.875 MAF between the mid-1940s and 2010.

The McCloud River watershed extends over approximately 402,000 acres (Reclamation 2013a). The McCloud River flows approximately 59 miles from the headwaters in Moosehead Creek located southeast of Mount Shasta, through McCloud Reservoir, and into Shasta Lake. McCloud Reservoir is operated primarily to generate hydroelectric power. The Pit River watershed extends over approximately 3,008,000 acres along the north and south forks of the Pit River basins and includes 21 named tributaries and numerous smaller tributaries (Reclamation 2013a). Pacific Gas and Electric Company operate several hydropower diversions and reservoirs within the Pit River watershed.

The Squaw Creek watershed extends over approximately 66,000 acres located to the east of Shasta Lake (Reclamation 2013a).

The Sacramento River extends approximately 40 miles from the headwaters to Shasta Lake downstream of the town of Delta (Reclamation 2013a). The basin extends into portions of Mount Shasta and the Trinity and Klamath mountains.

A.3.2 Clear Creek Watershed

The Clear Creek watershed is 238 square miles, extending from the Trinity Mountains to the confluence with the Sacramento River downstream of the City of Redding (DWR 1986 and Western Shasta Resource Conservation District [WSRCD] 2004). Hydrology in the watershed is divided into the upper 238-square mile watershed upstream of Whiskeytown Dam at River Mile 18.1, and the lower 49 square miles watershed downstream of the dam. Clear Creek flows approximately 17 miles from the Trinity Mountains into Whiskeytown Lake. Clear Creek continues for 18.1 miles downstream of Whiskeytown Lake into the Sacramento River downstream of the CVP Keswick Dam and south of the City of Redding.

A.3.2.1 *Whiskeytown Lake*

Whiskeytown Dam, a CVP facility constructed by 1963, is the only dam on Clear Creek and is located approximately 16.5 miles downstream of 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).

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.

The capacity of the outlet from Whiskeytown Dam that conveys water to Clear Creek is 1,240 cfs when the water elevation in Whiskeytown Lake is at 1,220.5 feet. To provide flows into Clear Creek in excess of 1,240 cfs, the Whiskeytown Reservoir water elevations need to be raised higher than 1,220 feet to allow water to flow through the Glory Hole spillway, as described below (CALFED 2004; Reclamation 2009a).

Water storage volume and water storage elevations related to Whiskeytown Lake for Water Years 2001 through 2018 are presented on Figures A.3-1 and A.3-2 (DWR 2018g, 2018h). Whiskeytown Lake storage is relatively constant due to agreements between Reclamation and the National Park Service to maintain certain winter and summer lake elevations for recreation. Whiskeytown Lake outflow variations were greater prior to 2006 when Trinity River restoration flows were implemented which reduced the amount of water available for conveyance to CVP water users. In addition, hydrologic conditions in the years following 2006 were drier than the water years between 2001 and 2006.

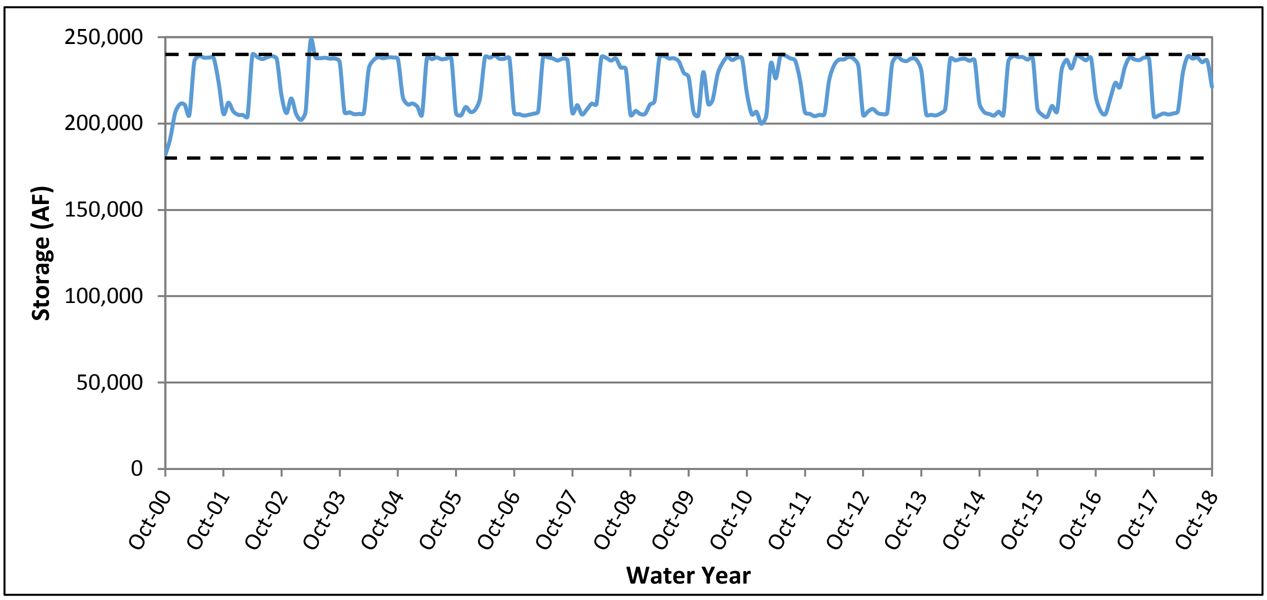


Figure A.3-1. Whiskeytown Lake Storage

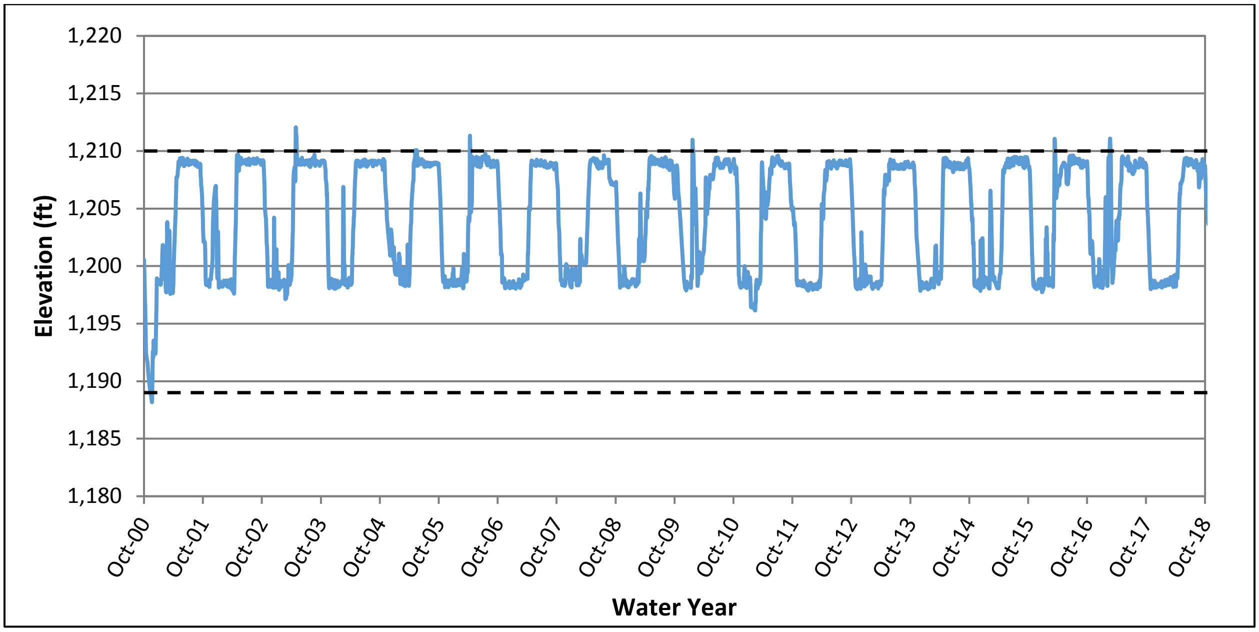


Figure A.3-2. Whiskeytown Lake Elevation

A.3.2.1.1 Whiskeytown Reservoir Operations

Whiskeytown Reservoir is normally operated to (1) regulate inflows for power generation and recreation; (2) support upper Sacramento River temperature objectives; and (3) provide for releases to Clear Creek. Although it stores up to 241 TAF, this storage is held fairly constant from May through October in most years. Two fully functional water temperature curtains exist in Whiskeytown Reservoir. These curtains have been subject to repairs since their initial installation in 1993. The purpose of these curtains is to improve passage of cold source water through the reservoir during the warm months of the year for downstream cold-water needs (i.e., threatened and endangered fish). The Oak Bottom Temperature Control Curtain or OBTCC is located in the upstream portion of the reservoir and the Spring Creek curtain is located in front of the Spring Creek tunnel at the eastern end of Whiskeytown Reservoir.

A.3.2.1.2 Historic Spillway Flows below Whiskeytown Lake

Whiskeytown Lake storage is annually drawn down by approximately 35 TAF during the wet season (November through April) to assist in regulating excessive winter storm runoff. Heavy rainfall events occasionally result in glory hole discharges to Clear Creek, as shown in Table A.3-1 below.

Table A.3-1. Days of Spilling below Whiskeytown and 40-30-30 Index from Water Year 1978 to 2012

Water Year	Days of Spilling	40-30-30 Index
1978	5	AN
1979	0	BN
1980	0	AN
1981	0	D
1982	63	W
1983	81	W
1984	0	W

Water Year	Days of Spilling	40-30-30 Index
1985	0	D
1986	17	W
1987	0	D
1988	0	C
1989	0	D
1990	8	C
1991	0	C
1992	0	C
1993	10	AN
1994	0	C
1995	14	W
1996	0	W
1997	5	W
1998	8	W
1999	0	W
2000	0	AN
2001	0	D
2002	0	D
2003	8	AN
2004	0	BN
2005	0	AN
2006	4	W
2007	0	D
2008	0	C
2009	0	D
2010	6	BN
2011	0	W
2012	0	BN

Notes: W = Wet Year Water Year Type; AN = Above Normal Water Year Type; BN = Below Normal Water Year Type; D = Dry Water Year Type; and C = Critical Dry Water Year Type.

Operations at Whiskeytown Lake during flood conditions are complicated by its operational relationship with the Trinity River, Sacramento River, and Clear Creek. On occasion, imports of Trinity River water to Whiskeytown Reservoir may be suspended to avoid aggravating high flow conditions in the Sacramento Basin.

A.3.2.2 *Clear Creek*

Substantial modifications of the Clear Creek stream channel occurred due to placer mining activities from the mid-1800s through the early 1900s. In addition, several irrigation diversions were constructed along the lower Clear Creek reach during the late 1800s and early 1900s. One of the largest diversions was the 15-foot-high, 200-foot-wide McCormick-Saeltzer Dam constructed in 1903 at River Mile 6.5 (approximately 12 miles downstream of Whiskeytown Dam). The downstream of Whiskeytown Dam was constructed upstream of a steep gorge along Clear Creek and removed in 2001. More recent channel modifications occurred in the lower Clear Creek due to gravel extraction activities from the 1950s to 1970s.

Construction of Whiskeytown Dam modified the hydraulics, gravel loading, and sediment transport in the lower Clear Creek. The overall average annual flow in the lower Clear Creek was reduced by 87 percent following construction of the dam (DWR 1984, 1986). The dam also reduced gravel loading into the lower Clear Creek and the frequency of high flow events that move the gravel and remove fine sediments from riffles. This change in hydrology and loss of gravel loading adversely affected the salmonid habitat downstream of Whiskeytown Dam, including compaction of riffles with sand. Recently, minimum flow releases from Whiskeytown Lake into Clear Creek occur in accordance with Federal and state requirements (DWR 1984). Historical flow data has been collected since 1941 at the Igo Gage at River Mile 10.9 (approximately 7.2 miles downstream of Whiskeytown Dam) (DWR 1986 and WSRCD 2004).

Since the early 1980s, numerous studies were conducted to evaluate methods to rehabilitate and/or restore habitat along lower Clear Creek. In the 1990s, additional studies were conducted following the adoption of the 1992 Central Valley Project Improvement Act (CVPIA). In 1998, a watershed management plan prepared by the WSRCD evaluated methods to achieve healthy fish populations, diverse biological habitats, recreational opportunities, clean and safe conditions for visitors, and protection of property rights developed by the Lower Clear Creek Coordinated Resource Management and Planning Group of local landowners, stakeholders, and agencies (WSRCD 1998). The recommendations included the following:

- Removal of the McCormick-Saeltzer Dam.
- Inject gravel downstream of Whiskeytown Dam and reconstruct gravel channels below McCormick-Saeltzer Dam to reduce stranding.
- Modify water release patterns from Whiskeytown Dam.
- Reduce exotic vegetation along Clear Creek.
- Reduce sands in Clear Creek through erosion control programs in the lower watershed.

This and other studies led to the formation of the Lower Clear Creek Floodway Rehabilitation Project that was implemented under CVPIA (CALFED 2004, WSRCD 2003). Initial actions under this program included gravel augmentation initiated in 1996, increase in Whiskeytown Dam releases initiated in 2001, removal of the McCormick-Saeltzer Dam in 2001, reconstruction and revegetation of the floodway, and reduction of watershed erosion.

Following the removal of the McCormick-Saeltzer Dam, extensive geomorphological studies have been conducted to recommend approaches for restoration of the channel and adjacent floodplain downstream of the McCormick-Saeltzer Dam site. Based upon hydrological data collected at the Igo gage, one of the studies discussed that peak flow events in lower Clear Creek following completion of Whiskeytown Dam occur about once every 3 years; although, the pre-dam frequency was approximately once every 2 years. Clear Creek flows at Igo between 2001 and 2018 are presented on Figure A.3-3 14 (DWR 2018i). High flow events: 1) naturally moved gravel placed downstream of Whiskeytown Dam and along Clear Creek; 2) developed and maintained Clear Creek channel and adjacent floodplain habitat for spring-run and fall-run Chinook Salmon and steelhead; 3) created and maintained deep pools in the channel to support spawning of spring-run Chinook Salmon and steelhead, and create appropriate salmonid habitat within and along Clear Creek; and 4) established and maintained nesting and foraging habitat for neotropical migrant birds, native resident birds, and amphibians.

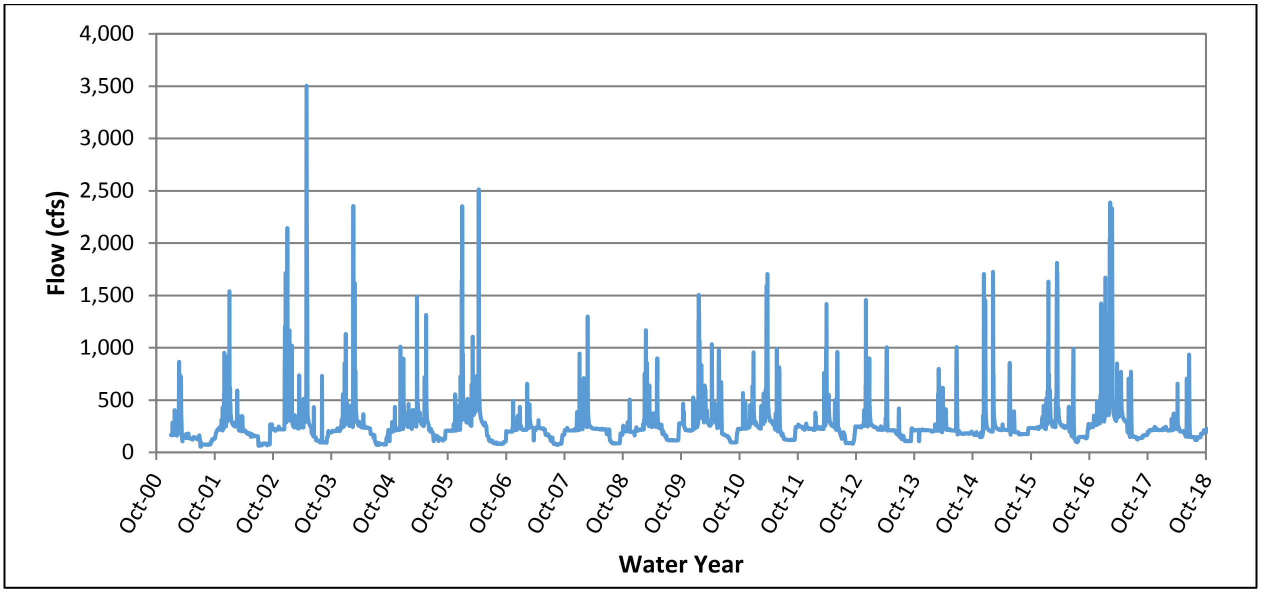


Figure A.3-3. Clear Creek Near Igo

Following removal of McCormick-Saeltzer Dam, the Clear Creek channel and adjacent floodplain geomorphology changed. The Clear Creek channel capacity is generally about 3,000 cfs. The 2004 studies indicated that flows in excess of 3,000 cfs are required to overflow from the Clear Creek channel onto the adjacent floodplains. The study discussed that during pre- and post-Whiskeytown periods, the 5-year flood event at Igo decreased from 9,000 to 3,400 cfs and the 2.5-year flood event decreased from 6,200 to 1,800 cfs. Therefore, the study discussed that flows in excess of 5,000 cfs did not occur more frequently than 3 times in 10 years (CALFED 2004).

A.3.2.2.1 Fish and Wildlife Requirements on Clear Creek

Historical Perspective

CVPIA (b)(2) operations and water rights permits issued by the SWRCB for diversions from Trinity River and Clear Creek specify minimum downstream releases from Lewiston and Whiskeytown Dams, respectively. The following agreements govern releases from Whiskeytown Lake:

- A 1960 Memorandum of Agreement (MOA) with CDFW established minimum flows to be released to Clear Creek at Whiskeytown Dam, as summarized in Table A.3-2.
- A 1963 release schedule for Whiskeytown Dam was developed with USFWS and implemented, but never finalized. Although this release schedule was never formalized, Reclamation has used this flow schedule for minimum flows since May 1963.
- Water rights permit modification in 2002 that allowed release of water from Whiskeytown Lake into Clear Creek for the purposes of maintenance of fish and wildlife resources as provided for in Provision 2.1 of Instream Flow Preservation Agreement by and among Reclamation, USFWS, and DFW, dated August 11, 2000.
- Dedication of (b)(2) water on Clear Creek provides instream flows below Whiskeytown Dam greater than the minimum flows (that would have occurred under pre-CVPIA conditions). Reclamation proposes a minimum flow year-round of 150 cfs except for during Critical year types, to consider water temperature objectives for steelhead in the summer and in late summer for spring-run Chinook Salmon. In Critical years, Clear Creek base flows may be reduced below

150 cfs based on available water from Trinity Reservoir. Additional flow may be required for temperature management during the fall.

Table A.3-2. Minimum Flows at Whiskeytown Dam

Period	Minimum flow (cfs)
1960 MOA with CDFW	
January 1–February 28(29)	50
March 1–May 31	30
June 1–September 30	0
October 1–October 15	10
October 16–October 31	30
November 1–December 31	100
1963 USFWS Proposed Normal year flow	
January 1–October 31	50
November 1–December 31	100
1963 USFWS Proposed Critical year flow	
January 1–October 31	30
November 1–December 31	70
2002 Water Right Modification for Critical year flow	
January 1–October 31	50
November 1–December 31	70

A.3.2.3 *Current Status*

Reclamation proposes to release Clear Creek flows in accordance with the 1960 Memorandum of Agreement (MOA) with CDFW, and the April 15, 2002 SWRCB permit, which established minimum flows to be released to Clear Creek at Whiskeytown Dam. Reclamation proposes a minimum baseflow in Clear Creek of 150 cfs year-round in all year types except Critical year types. In Critical years, Clear Creek base flows may be reduced below 150 cfs based on available water from Trinity Reservoir. Additional flow may be required for temperature management during the fall.

In addition, Reclamation proposes to create pulse flows for both channel maintenance and spring attraction flows. For spring attraction flows, Reclamation would release 10 TAF (measured at the release), with daily release up to the safe release capacity (approximately 900 cfs, depending on reservoir elevation and downstream capacity), in all year-types except for Critical year-types to be shaped by the Clear Creek Implementation Team in coordination with CVO. For channel maintenance flows, Reclamation would release 10 TAF from Whiskeytown, with a daily release up to the safe release capacity, in all year-types except for Dry and Critical year-types (based on the Sacramento Valley index) to be shaped by the Clear Creek Implementation Team in coordination with CVO. Pulses would be scheduled with CVO. No channel maintenance flows would be scheduled before January 1. For each storm event that results in a Whiskeytown Gloryhole spill of at least 3,000 cfs for 3 days, then Reclamation will reduce the channel maintenance flow volume for this year or the following year by 5,000 acre-feet. If two Gloryhole spills occur that meet this criteria in a year, additional channel maintenance flows would not be released in that year. In Critical years, Reclamation would release one spring attraction flow of up to the safe release capacity (approximately 900 cfs) for up to three days and would not release any channel maintenance flows. Reclamation could instead, or in addition, use mechanical methods to mobilize gravel if needed to meet biological objectives as part of adaptive management.

The outlet from Whiskeytown Reservoir to Clear Creek is equipped with outlets at two different elevations. Releases can be made from either or both outlets to manage downstream temperature releases. Reclamation proposes to manage Whiskeytown releases to meet a daily average water temperature of: 1) 60°F at the IGO gage from June 1 through September 15; and 2) 56°F at the IGO gage from September 15 to October 31. Reclamation may not be able to meet these temperatures in Critical or Dry water year types. In these years, Reclamation will operate to as close to these temperatures to the extent possible.

A.3.2.3.1 Spring Creek Debris Dam Operations

The Spring Creek Debris Dam (SCDD) is a feature of the Trinity Division of the CVP. It was constructed to regulate runoff containing debris and acid mine drainage from Spring Creek, a tributary to the Sacramento River that enters Keswick Reservoir. The SCDD can store approximately 5.8 TAF of water. Operation of SCDD and Shasta Dam has allowed some dilution. In January 1980, Reclamation, CDFW, and SWRCB executed a Memorandum of Understanding (MOU) to implement actions that protect the Sacramento River system from heavy metal pollution from Spring Creek and adjacent watersheds.

The MOU states that Reclamation agrees to operate to dilute releases from SCDD (according to the criteria and schedules provided), that such operation would not cause flood control parameters on the Sacramento River to be exceeded and would not unreasonably interfere with other Project requirements as determined by Reclamation. The MOU also specifies a minimum schedule for monitoring copper and zinc concentrations at SCDD and in the Sacramento River below Keswick Dam. Reclamation has primary responsibility for the monitoring; however, CDFW and RWQCB also collect and analyze samples on an as-needed basis. Due to more extensive monitoring, improved sampling and analysis techniques, and continuing cleanup efforts in the Spring Creek drainage basin, Reclamation now operates SCDD to target the more stringent Central Valley Region Water Quality Control Board Plan (CVRWQCB Basin Plan) criteria in addition to the MOU goals. Instead of the total copper and total zinc criteria contained in the MOU, Reclamation operates SCDD releases and Keswick dilution flows to not exceed the CVRWQCB Basin Plan standards of 0.0056 milligrams per liter (mg/L) dissolved copper and 0.016 mg/L dissolved zinc. Release rates are estimated from a mass balance calculation of the copper and zinc in the debris dam release and in the river.

In order to minimize the build-up of metal concentrations in the Spring Creek arm of Keswick Reservoir, releases from the debris dam are coordinated with releases from the Spring Creek Power Plant to keep the Spring Creek arm of Keswick Reservoir in circulation with the main water body of Keswick Lake.

The operation of SCDD is complicated during major heavy rainfall events. SCDD reservoir can fill to uncontrolled spill elevations in a relatively short time period, anywhere from days to weeks. Uncontrolled spills at SCDD can occur during major flood events on the upper Sacramento River and also during localized rainfall events in the Spring Creek watershed. During flood control events, Keswick releases may be reduced to meet flood control objectives at Bend Bridge when storage and inflow at Spring Creek Reservoir are high.

Because SCDD releases are maintained as a dilution ratio of Keswick releases to maintain the required dilution of copper and zinc, uncontrolled spills can and have occurred from SCDD. In this operational situation, high metal concentration loads during heavy rainfall are usually limited to areas immediately downstream of Keswick Dam because of the high runoff entering the Sacramento River, adding dilution flow. In the operational situation when Keswick releases are increased for flood control purposes, SCDD releases are also increased to reduce spill potential.

In the operational situation when heavy rainfall events would fill SCDD and Shasta Lake would not reach flood control conditions, increased releases from CVP storage may be required to maintain desired dilution ratios for metal concentrations. Reclamation has voluntarily released additional water from CVP storage to maintain release ratios for toxic metals below Keswick Dam. Reclamation has typically attempted to meet the CVRWQCB Basin Plan standards, but these releases have no established criteria and are dealt with on a case-by-case basis. Since water released for dilution of toxic spills is likely to be in excess of other CVP requirements, such releases increase the risk of a loss of water for other beneficial purposes.

A.3.3 Shasta and Sacramento River Divisions

A.3.3.1 *Facilities*

A.3.3.1.1 <u>CVP Shasta Division</u>

The Shasta Division includes Shasta Dam, Lake, and Power Plant; Keswick Dam, Reservoir, and Power Plant, and the Shasta Temperature Control Device. The CVP's Shasta Division includes facilities that conserve water in the Sacramento River for:

- Flood control
- Navigation maintenance
- Agricultural water supplies
- M&I water supplies
- Hydroelectric power generation
- Conservation of fish in the Sacramento River
- Protection of the Delta from intrusion of saline ocean water.

The CVP Shasta and Keswick dams are located at approximately Sacramento River Miles 308 and 299, respectively. Shasta Lake, a CVP facility on the Sacramento River formed by Shasta Dam, is located near Redding. Shasta Dam is located on the Sacramento River just below the confluence of the Sacramento, McCloud, and Pit Rivers. The dam regulates the flow from a drainage area of approximately 6,649 square miles. Shasta Dam was completed in 1945, forming Shasta Lake, which has a maximum storage capacity of 4.552 MAF. Water in Shasta Lake is released through or around the Shasta Power Plant to the Sacramento River, where it is re-regulated downstream by Keswick Dam. A small amount of water is diverted directly from Shasta Lake for M&I uses by local communities.

Historical water storage volumes and water storage elevations for Shasta Lake for Water Years 2001 through 2018 are presented on Figures A.3-4 and A.3-5 (DWR 2018j, 2018k). Shasta Lake storage varies in accordance with upstream hydrology and downstream water demands and instream flow requirements. For example, storage declined during the drier years in 2008 and 2009.

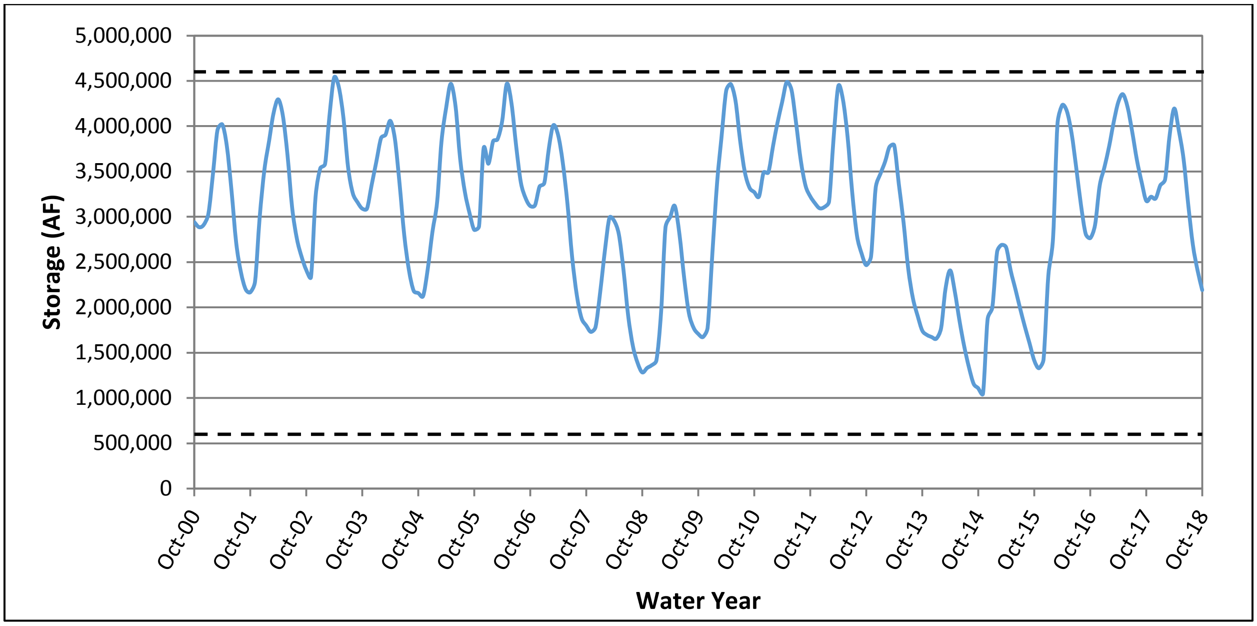


Figure A.3-4. Shasta Storage

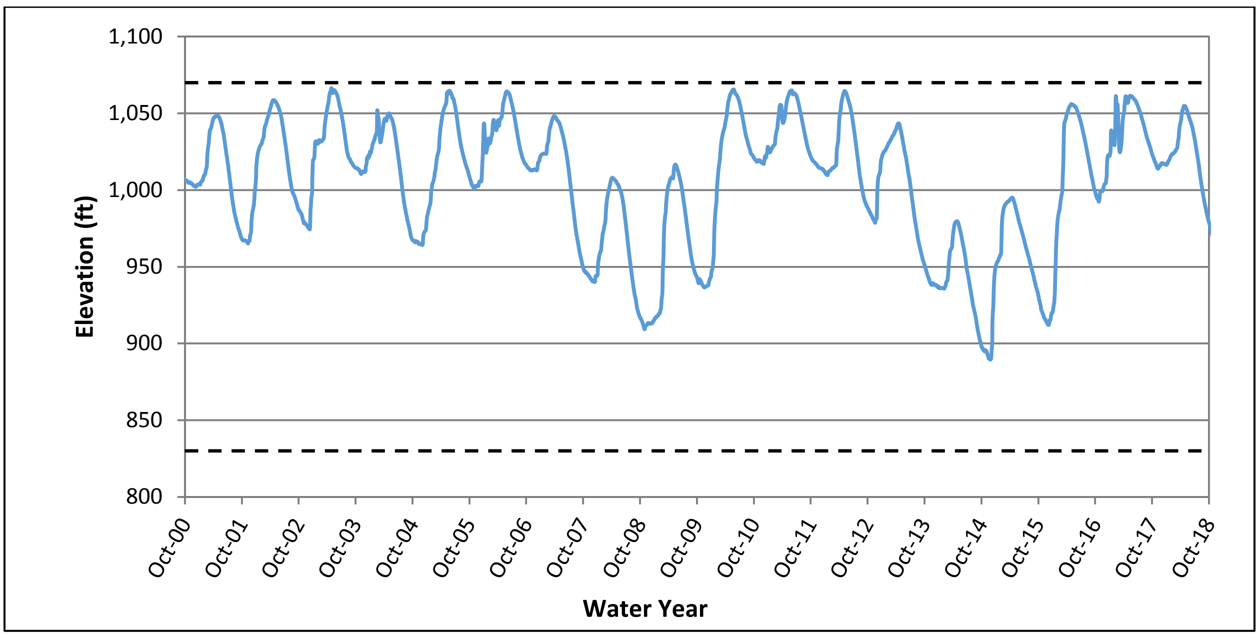


Figure A.3-5. Shasta Elevation

Keswick Reservoir was formed by the completion of Keswick Dam in 1950. It has a capacity of approximately 23.8 TAF and serves as an afterbay for releases from Shasta Dam and for discharges from the Spring Creek Power Plant. 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 of Keswick Reservoir. All releases from Keswick Reservoir are made to the Sacramento River from Keswick Dam. The dam has a fish trapping facility that operates in conjunction with the Coleman National Fish Hatchery on Battle Creek.

The Keswick Reservoir water storage volume is more consistent throughout the year because this reservoir is used to regulate flow releases to the powerplant and other downstream uses and not to provide long-term water storage, as shown on Figures A.3-6 and A.3-7 (DWR 2018l, 2018m).

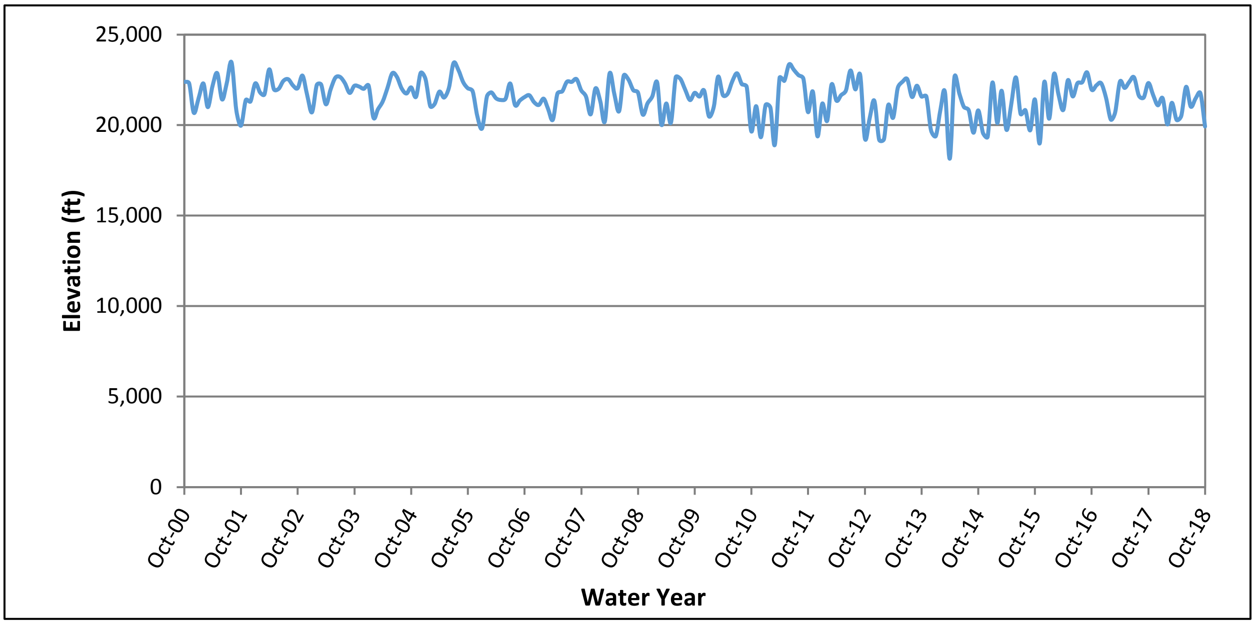


Figure A.3-6. Keswick Reservoir Storage

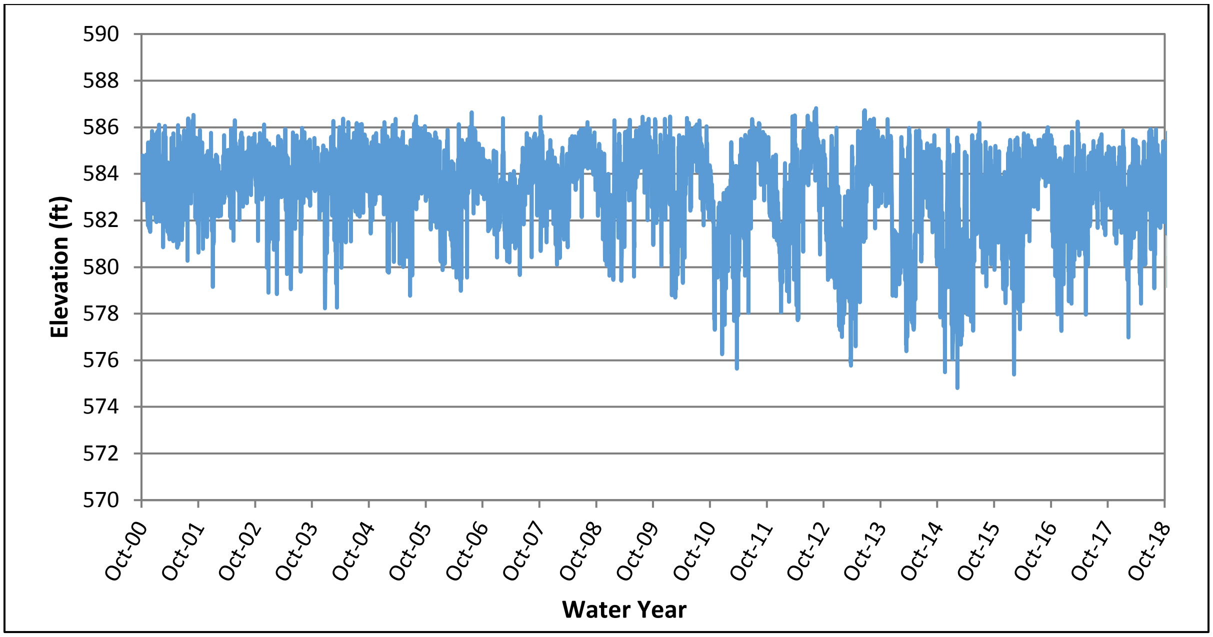


Figure A.3-7. Keswick Reservoir Elevation

A.3.3.1.2 CVP Sacramento River Division

The Sacramento River Division was authorized after completion of the Shasta Division. The Sacramento River Division includes facilities for the diversion and conveyance of water to CVP contractors on the west side of the Sacramento River. The division includes the Sacramento Canals Unit, which was authorized in 1950 and consists of the Red Bluff Pumping Plant, the Corning Pumping Plant, and the Corning and Tehama-Colusa Canals. Total authorized diversions for the Sacramento River Division are approximately 2.8 MAF. Historically the total diversion has varied from 1.8 MAF in a critically dry year to the full 2.8 MAF in a wet year, including diversions by Sacramento River Settlement contractors and CVP water service contractors. Sacramento River Settlement contractors divert water under their own water rights and through their own facilities.

The Sacramento Canals Unit was authorized to supply irrigation water to over 200,000 acres of land in the Sacramento Valley, principally in Tehama, Glenn, Colusa, and Yolo counties. Black Butte Dam, which is operated by the U.S. Army Corps of Engineers (USACE), also provides supplemental water to the Tehama-Colusa Canals as it crosses Stony Creek. The operations of the Shasta and Sacramento River divisions are presented together because of their operational inter-relationships.

A.3.3.1.2.1 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 2013a). 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 of the confluence with the American River.

Moderately high releases (greater than 10,000 cfs) are typically sustained during the major irrigation season of June through September. Flows are released in the fall months from CVP and SWP reservoirs to meet water temperature criteria for winter-run Chinook Salmon spawning and incubation, to provide suitable habitat for spring-run and early returning fall-run Chinook Salmon, provide water supplies to rice farms for rice stubble decomposition, and to provide water for wildlife refuges.

A.3.3.1.2.2 Sacramento River from Keswick Dam to Red Bluff

The Sacramento River between Keswick Dam and the City of Red Bluff flows through the northern foothills of the Sacramento Valley. Flows are influenced by outflow from Keswick Reservoir and inflows from Clear Creek (described above); and Cow Creek, Bear Creek, Cottonwood Creek, Battle Creek, and Paynes Creek which provide 15 to 20 percent of the flows in this reach as measured at Bend Bridge. There are several moderate major diversions along the Sacramento River upstream of Red Bluff, including the CVP Wintu Pumping Plant to provide water for the Bella Vista Water District, and the Anderson-Cottonwood Irrigation District Diversion. Both of these diversions near Redding provide water to agricultural, municipal, and industrial water users (Reclamation 1997). No major storage or diversion structures have been constructed in the tributary watersheds in this reach of the Sacramento River, although several small diversions for irrigation, domestic use, and hydroelectric power generation are present (Reclamation 1997). Flow patterns on one major tributary in this reach, Battle Creek, are undergoing changes as the Battle Creek Salmon and Steelhead Restoration Project is implemented to restore ecological processes along 42 miles of Battle Creek and 6 miles of tributaries while minimizing reductions to hydroelectric power generation through the decommissioning of five powerplants.

Reclamation operates the Shasta, Sacramento River, and Trinity River divisions of the CVP to meet (to the extent possible) the provisions of SWRCB Order 90-05. An April 5, 1960 Memorandum of Agreement between Reclamation and California Department of Fish and Wildlife (CDFW) originally established flow objectives in the Sacramento River for the protection and preservation of fish and wildlife resources. The agreement provided for minimum releases into the natural channel of the Sacramento River at Keswick Dam for normal and critically dry years. Since October 1981, Keswick Dam has operated based on a minimum release of 3,250 cfs for normal years from September 1 through the end of February, in accordance with an agreement between Reclamation and CDFW. This release schedule was included in SWRCB Order 90-05, which maintains a minimum release of 3,250 cfs at Keswick Dam and Red Bluff Pumping Plant from September through the end of February in all water years except critically dry years.

Generally, releases from Keswick Reservoir are implemented to comply with the minimum fishery requirement by October 15 each year and to minimize changes in Keswick releases between October 15 and December 31. Releases may be increased during this period to meet downstream needs such as higher outflows in the Delta to meet water quality requirements, or to meet flood control requirements. Releases from Keswick Dam may be reduced when downstream tributary inflows increase to a level that will meet flow needs. Reclamation attempts to establish a base flow that minimizes release fluctuations to reduce impacts to fisheries and bank erosion from October through December.

A.3.3.1.2.3 Sacramento River from Red Bluff to the Delta

Between Red Bluff and Colusa, the Sacramento River is a meandering stream, migrating through alluvial deposits between widely spaced levees. From Colusa to the northern boundary of the Delta near Freeport, flows increase due to the addition of the Feather and American rivers flows.

Major streams entering the Sacramento River between Red Bluff and the Feather River include Antelope, Elder, Mill, Thomes, Deer, Stony, Big Chico, and Butte creeks. No major storage or diversion structures have been constructed on Antelope, Elder, Mill, and Thomes creeks, although several small seasonal diversions for irrigation, domestic use, and hydroelectric power generation are present (Reclamation 1997). Moderate non-CVP and non-SWP diversion dams are located on Deer, Big Chico, and Butte creeks.

Stony Creek flows are controlled by East Park Dam, Stony Gorge Dam, and Black Butte Dam (Reclamation 1997). East Park and Stony Gorge reservoirs store surplus water for irrigation deliveries and are operated by Reclamation as part of the Orland Project which is independent of the CVP. Black Butte Dam is operated by the USACE for flood control and irrigation supply. Black Butte Dam operations are coordinated with the CVP. The GCID canal, which crosses Stony Creek downstream of Black Butte Dam, includes a seasonal gravel dam constructed across the creek on the downstream side of the canal.

The Sacramento River between Red Bluff and Chico Landing, the Sacramento River Flood Control Project has provided bank protection and incidental channel modification since 1958 (DWR 2013b). Between Chico Landing and Colusa, the flood management facilities consist of levees and overflow areas. Black Butte Reservoir regulates Stony Creek flood flows, which enter the Sacramento River downstream of Hamilton City. Right bank levees from Ord Ferry through Colusa prevent Sacramento River flood water from entering the Colusa Basin, except when flows exceed 300,000 cfs near Ord Ferry (DWR 2013b). Three flood relief weirs along the right bank, downstream of Chico Landing, allow flood flows to spill into the Butte Basin Overflow Area. The left bank levee begins midway between Ord Ferry and Butte City and extends south through Verona and includes the Moulton and Colusa weirs that allow flood flows to spill into the Butte Basin Overflow Area. The natural Sutter Basin overflow (Sutter Bypass) to the east of the Sacramento River and downstream of the Sutter Buttes was included in the Sacramento River Flood Control Project. The Sutter Bypass conveys floodwaters from the Butte Basin Overflow Area, Butte Creek, Wadsworth Canal, and Reclamation Districts 1660 and 1500 drainage plants, state drainage plants, and Tisdale Weir to the confluence of the Sacramento and Feather rivers. Downstream of Colusa, Reclamation Districts 70, 108, and 787 pump flood waters from adjacent closed basin lands into the river.

The Colusa Basin Drain provides drainage for a large portion of the irrigated lands on the western side of the Sacramento Valley in Glenn, Colusa, and Yolo counties; and supplies irrigation water to lands in this area. Water from the drain is discharged to the Sacramento River through the Knights Landing Outfall, a gravity flow structure and prevents the Sacramento River from flowing into the Colusa Basin.

Recent mean daily flows in the Sacramento River at Bend Bridge (near Red Bluff), Vina Bridge (near Tehama), Hamilton City, Wilkins Slough (upstream of the Feather River confluence), Verona (downstream of the Feather River confluence), and Freeport (downstream of the American River Confluence and near the northern boundary of the Delta), are presented on Figures A.3-8 through A.3-13 (DWR 2018n, 2018o, 2018p, 2018q, 2018r, 2018s).

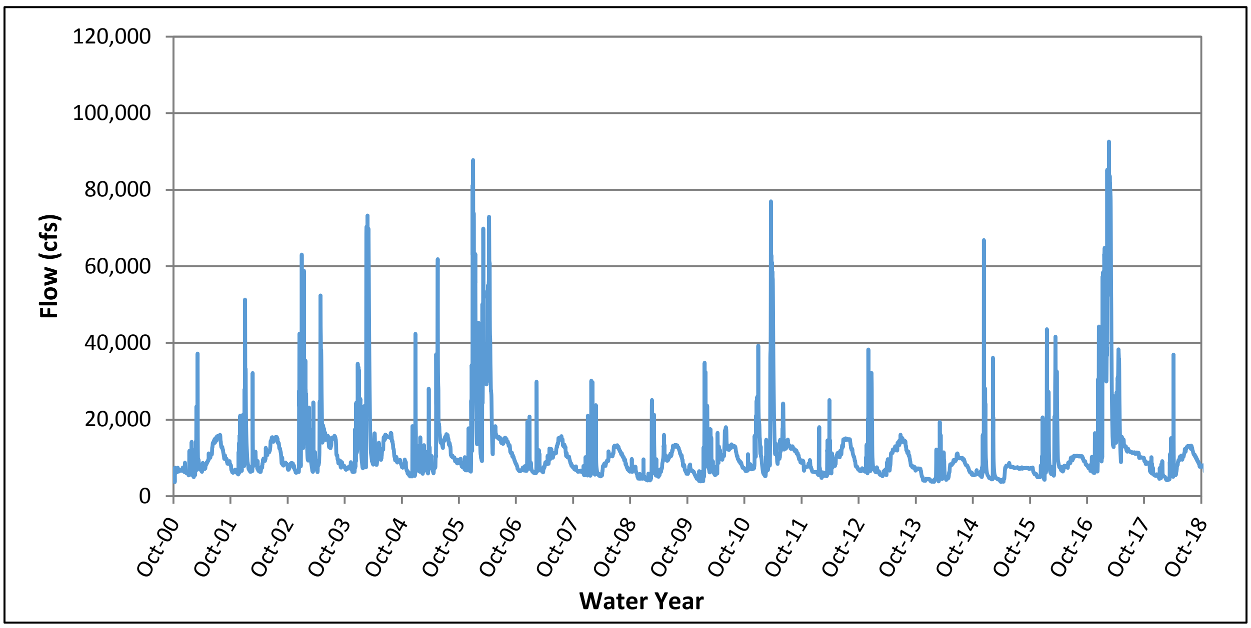


Figure A.3-8. Sacramento River at Bend Bridge

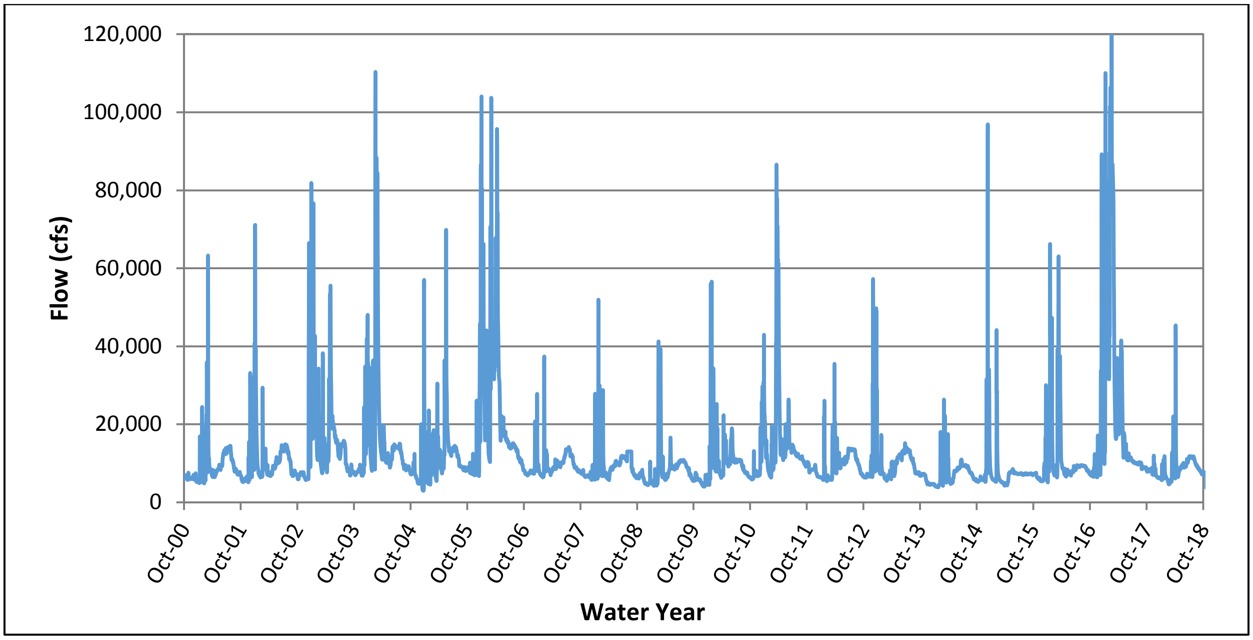


Figure A.3-9. Sacramento River at Vina Bridge

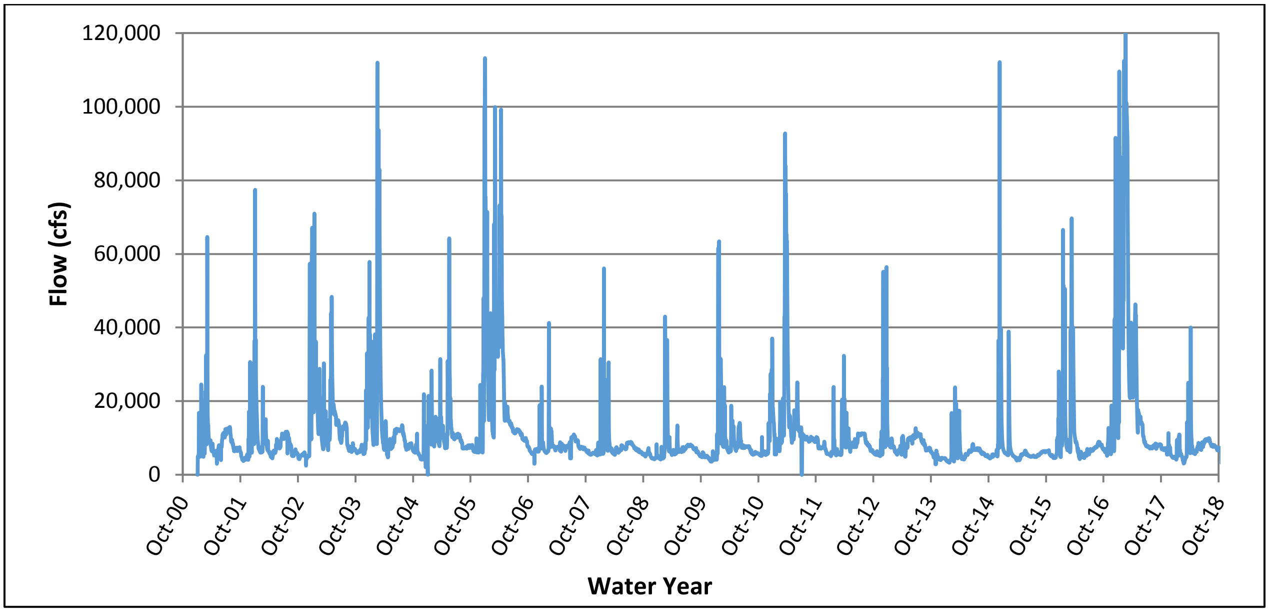


Figure A.3-10. Sacramento River at Hamilton City

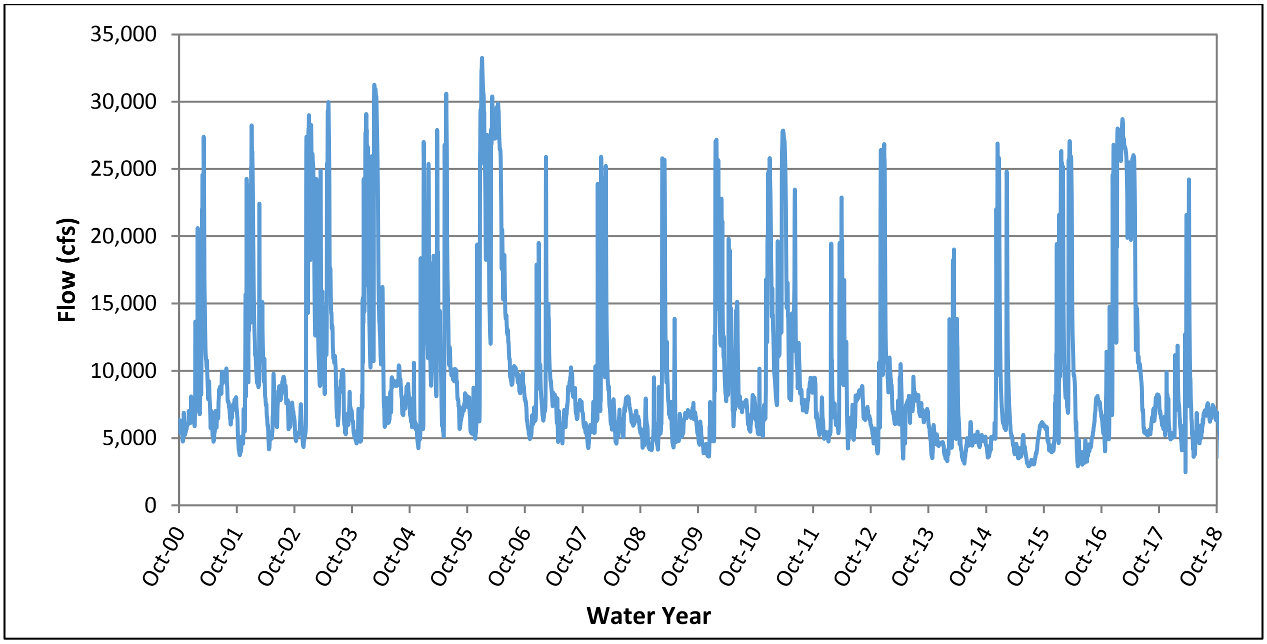


Figure A.3-11. Sacramento River at Wilkins Slough

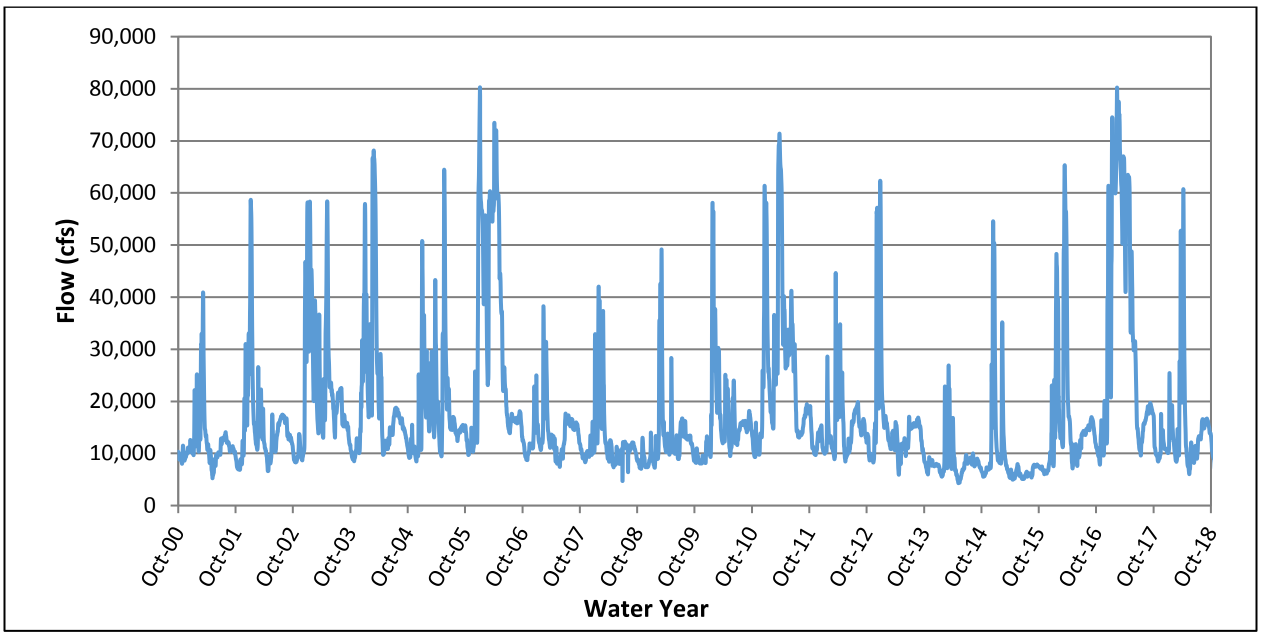


Figure A.3-12. Sacramento River at Verona

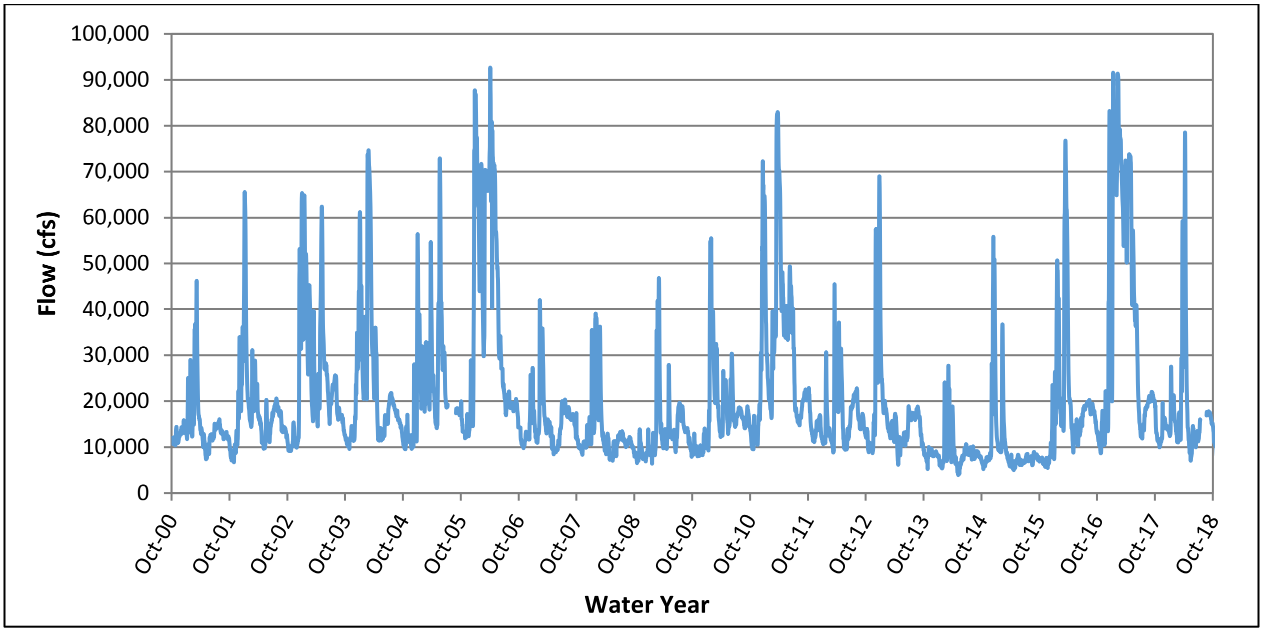


Figure A.3-13. Sacramento River at Freeport

Flows in the Sacramento River generally peak during winter and spring storm events. Upstream of Hamilton City, sharp increases in flow occur during rainfall events, such as events in February 2004, December 2005/January 2006, and January 2010. Downstream of Hamilton City, the high flow events occur over a longer period of time as water flows into the river from the tributaries.

A.3.3.1.2.3.1 Major Diversions

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 facility includes a 1,118-foot-long flat-plate fish screen, intake channel, 2,500 cfs capacity pumping plant and discharge conduit to divert water from the Sacramento River into the Tehama-Colusa and Corning canals. In 2011, the dam gates were permanently placed in the open position for free migration of fish while ensuring continued water deliveries by way of the Red Bluff Pumping Plant.

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.

A.3.4 CVP Shasta and Sacramento River Divisions Operations

A.3.4.1 *Flood Control*

Flood control objectives for Shasta Lake require that releases be restricted to quantities that would not cause downstream flows or stages to exceed specified levels. These include a flow of 79,000 cfs at the tailwater of Keswick Dam, and a stage of 39.2 feet in the Sacramento River at Bend Bridge gauging station, which corresponds to a flow of approximately 100,000 cfs.

Flood control operations are based on regulating criteria developed by the USACE pursuant to the provisions of the Flood Control Act of 1944. Maximum flood space reservation is 1.3 MAF, with variable storage space requirements based on an inflow parameter. Flood control operation at Shasta Lake requires forecasting runoff conditions into Shasta Lake and runoff conditions of unregulated creek systems downstream from Keswick Dam as far in advance as possible. A critical element of upper Sacramento River flood operations is the local runoff entering the Sacramento River between Keswick Dam and Bend Bridge.

The unregulated creeks (major creek systems are Cottonwood Creek, Cow Creek, and Battle Creek) in this reach of the Sacramento River can be very sensitive to a large rainfall event and produce high rates of runoff into the Sacramento River in short time periods. During large rainfall and flooding events, the local runoff between Keswick Dam and Bend Bridge can exceed 100,000 cfs.

The travel time required for release changes at Keswick Dam to affect Bend Bridge flows is approximately 8 to 10 hours. If the total flow at Bend Bridge is projected to exceed 100,000 cfs, the release from Keswick Dam is decreased to maintain Bend Bridge flow below 100,000 cfs. As the flow at Bend Bridge is projected to recede, the Keswick Dam release is increased to evacuate water stored in the flood control space at Shasta Lake. Changes to Keswick Dam releases are scheduled to minimize rapid fluctuations in the flow at Bend Bridge.

The flood control criteria for Keswick releases specify that releases should not be increased more than 15,000 cfs or decreased more than 4,000 cfs in any 2-hour period. The restriction on the rate of decrease is intended to prevent sloughing of saturated downstream channel embankments caused by rapid reductions in river stage. In rare instances, the rate of decrease may have to be accelerated to avoid exceeding critical flood stages downstream.

A.3.4.2 *Fish and Wildlife Requirements in the Sacramento River*

Historical Perspective

Reclamation operates the Shasta, Sacramento River, and Trinity River divisions of the CVP to meet (to the extent possible) the provisions of SWRCB Order 90-5. An April 5, 1960, MOA between Reclamation and CDFW originally established flow objectives in the Sacramento River for the protection and preservation of fish and wildlife resources.

The agreement provided for minimum releases into the natural channel of the Sacramento River at Keswick Dam for normal and critically dry years (Table A.3-3). Since October 1981, Keswick Dam has operated based on a minimum release of 3,250 cfs for normal years from September 1 through the end of February, in accordance with an agreement between Reclamation and CDFW. This release schedule was included in SWRCB Order 90-05, which maintains a minimum release of 3,250 cfs at Keswick Dam and

Red Bluff Pumping Plant from September through the end of February in all water years except critically dry years.

Dedication of (b)(2) water on the Sacramento River provided instream flows below Keswick Dam greater than those that would have occurred under pre-CVPIA conditions, e.g. the fish and wildlife requirements specified in SWRCB Order 90-5 and the temperature criteria formalized in the 1993 NMFS winter-run Chinook Salmon BO as the base. Instream flow objectives from October 1 to April 15 (typically April 15 is when water temperature objectives for winter-run Chinook Salmon become the determining factor) were usually selected to minimize dewatering of redds and provide suitable habitat for salmon spawning, incubation, rearing, and migration.

Table A.3-3. Minimum Flow Requirements and Objectives (cfs) on the Sacramento River below Keswick Dam

Period	MOA	Water Rights 90-5	MOA and Water Rights 90-5
Water Year Type	Normal	Normal	Critically Dry
January 1–February 28(29)	2,600	3,250	2,000
March 1–March 31	2,300	2,300	2,300
April 1–April 30	2,300	2,300	2,300
May 1–August 31	2,300	2,300	2,300
September 1–September 30	3,900	3,250	2,800
October 1–November 30	3,900	3,250	2,800
December 1–December 31	2,600	3,250	2,000

The 1960 MOA between Reclamation and CDFW provides that releases from Keswick Dam (from September 1 through December 31) are made with minimum water level fluctuation or change to protect salmon to the extent compatible with other operations requirements.

Reclamation usually attempts to reduce releases from Keswick Dam to the minimum fishery requirement by October 15 each year and to minimize changes in Keswick releases between October 15 and December 31. Releases may be increased during this period to meet downstream needs such as higher outflows in the Delta to meet water quality requirements, or to meet flood control requirements. Releases from Keswick Dam may be reduced when downstream tributary inflows increase to a level that would meet flow needs. Reclamation attempts to establish a base flow that minimizes release fluctuations to reduce impacts to fisheries and bank erosion from October through December.

The Connelly-Areias-Chandler Rice Straw Burning Reduction Act of 1991 changed agricultural water diversion practices along the Sacramento River and has affected Keswick Dam release rates in the fall. This program is generally known as the Rice Straw Decomposition and Waterfowl Habitat Program. Prior to this change, the preferred method of clearing fields of rice stubble was to systematically burn it. Today, rice field burning has been phased out due to air quality concerns and has been replaced in some areas by a program of rice field flooding that decomposes rice stubble and provides additional waterfowl habitat. The result has been an increase in water demand to flood rice fields in October and November, which has increased the need for higher Keswick releases in all but the wettest of fall months.

A.3.4.3 *Minimum Flow for Navigation as Measured at Wilkins Slough*

Historical commerce on the Sacramento River resulted in a CVP authorization to maintain minimum flows of 5,000 cfs at Chico Landing to support navigation in accordance with references to Sacramento River Division operations in the River and Harbors Act of 1935 and the Rivers and Harbors Act of 1937. Currently, there is no commercial traffic between Sacramento and Chico Landing, and USACE has not dredged this reach to preserve channel depths since 1972. However, long-time water users diverting from the river have set their pump intakes just below this level and cannot easily divert when lower river elevations occur with lower flows. Therefore, the CVP is operated to meet the navigation flow requirement of 5,000 cfs to Wilkins Slough, (gauging station on the Sacramento River), under all but the most critical water supply conditions, to facilitate pumping and use of screened diversions.

At flows below 5,000 cfs at Wilkins Slough, diverters have reported increased pump cavitation as well as greater pumping head requirements. Diverters are able to operate for extended periods at flows as low as 4,000 cfs at Wilkins Slough, but pumping operations become severely affected and some pumps become inoperable at flows lower than this. Flows may drop as low as 3,500 cfs for short periods while changes are made in Keswick releases to reach target levels at Wilkins Slough.

A.3.4.4 *Water Temperature Operations in the Upper Sacramento River*

Water temperature on the Sacramento River system is influenced by several factors, including the relative water temperatures and ratios of releases from Shasta Dam and from the Spring Creek Power Plant. The temperature of water released from Shasta Dam and the Spring Creek Power Plant is a function of the reservoir temperature profiles at the discharge points at Shasta and Whiskeytown, the depths from which releases are made, the seasonal management of the deep cold water reserves, ambient seasonal air temperatures and other climatic conditions, tributary accretions and water temperatures, and residence time in Keswick, Whiskeytown and Lewiston Reservoirs, and in the Sacramento River. Water temperature in the upper Sacramento River is governed by current water rights permit requirements.

In 1990 and 1991, SWRCB issued Water Rights Orders 90-05 and 91-01 modifying Reclamation’s water rights for the Sacramento River. The orders stated that Reclamation shall operate Keswick and Shasta Dams and the Spring Creek Power Plant to meet a daily average water temperature of 56°F as far downstream in the Sacramento River as practicable during periods when higher temperature would be harmful to fisheries. The optimal control point is the Red Bluff Pumping Plant.

Under the orders, the water temperature compliance point may be modified when the objective cannot be met at Red Bluff Pumping Plant. In addition, SWRCB Order 90-05 modified the minimum flow requirements initially established in the 1960 MOA for the Sacramento River below Keswick Dam. The water right orders also recommended the construction of a Shasta Temperature Control Device (TCD) to improve the management of the limited cold-water resources.

Pursuant to SWRCB Orders 90-05 and 91-01, Reclamation configured and implemented the Sacramento-Trinity Water Quality Monitoring Network to monitor temperature and other parameters at key locations in the Sacramento and Trinity Rivers. SWRCB orders also required Reclamation to establish the SRTTG to formulate, monitor, and coordinate temperature control plans for the upper Sacramento and Trinity Rivers. This group consists of representatives from Reclamation, SWRCB, NMFS, USFWS, CDFW, Western, DWR, and the Hoopa Valley Indian Tribe.

Each year, with finite cold-water resources and competing demands usually an issue, the SRTTG devise operation plans with the flexibility to provide the best protection consistent with the CVP’s temperature control capabilities and considering the annual needs and seasonal spawning distribution monitoring information for winter-run and fall-run Chinook Salmon. In every year since SWRCB issued the orders, those plans have included modifying the Red Bluff Pumping Plant compliance point to make best use of the cold-water resources based on the location of spawning Chinook Salmon. These modifications occurred in 2012. Reports are submitted periodically to SWRCB over the temperature control season defining our temperature operation plans. SWRCB has overall authority to determine if the plan is sufficient to meet water right permit requirements.

A.3.4.5 *Shasta Temperature Control Device*

Construction of the TCD at Shasta Dam was completed in 1997. This device is designed for greater flexibility in managing the cold-water reserves in Shasta Lake while enabling hydroelectric power generation to occur and to improve salmon habitat conditions in the upper Sacramento River. The TCD is also designed to enable selective release of water from varying lake levels through the power plant in order to manage and maintain adequate water temperatures in the Sacramento River downstream of Keswick Dam.

Prior to construction of the Shasta TCD, Reclamation released water from Shasta Dam's low-level river outlets to alleviate high water temperatures during critical periods of the spawning and incubation life stages of the winter-run Chinook Salmon stock. The release of water through the low-level river outlets was a major facet of Reclamation's efforts to control upper Sacramento River temperatures from 1987 through 1996. Releases through the low-level outlets bypass the power plant and result in a loss of hydroelectric generation at the Shasta Power Plant.

The seasonal operation of the TCD is generally as follows: during mid-winter and early spring the highest possible elevation gates are utilized to draw from the upper portions of the lake to conserve deeper colder resources. During late spring and summer, the operators begin the seasonal progression of opening deeper gates as Shasta Lake elevation decreases and cold-water resources are utilized. In late summer and fall, the TCD side gates are opened to utilize the remaining cold-water resource below the Shasta Power Plant elevation in Shasta Lake.

The seasonal progression of the Shasta TCD operation is designed to maximize the conservation of cold water resources deep in Shasta Lake, until the time the resource is of greatest management value for fishery management purposes. Recent operational experience with the Shasta TCD has demonstrated significant operational flexibility improvement for cold water conservation and upper Sacramento River water temperature and fishery habitat management purposes. Recent operational experience has also demonstrated the Shasta TCD has significant leaks that are inherent to TCD design. Also, operational uncertainties cumulatively impair the seasonal performance of the Shasta TCD to a greater degree than was anticipated in previous analysis and modeling used to describe long-term Shasta TCD benefits.

A.3.4.6 *Current Status*

A.3.4.6.1 Spring Pulse Flows

Under the Core Water Operation, Reclamation would not release spring pulse flows unless the projected May 1 Shasta Reservoir storage is greater than 4 MAF. If Shasta Reservoir total storage on May 1 is projected to be greater than 4 MAF, Reclamation would make a Spring pulse release as long as the release would not cause Reclamation to drop into a lower Tier of the Shasta summer temperature management or interfere with the ability to meet other anticipated demands on the reservoir.

A.3.4.6.2 Cold Water Pool Management

The closer Shasta Reservoir is to full by the end of May, the greater the likelihood of being able to meet the Winter Run Chinook salmon temperature control criteria throughout the entire temperature control season. If Shasta Reservoir storage is high enough to use the Shasta TCD upper shutters by the end of May, Reclamation can maximize the cold water pool potential. Storage of 3.66 MAF allows water to pass through the upper gates of the Shasta TCD, but historical relationships suggest that a storage of 4 MAF on May 1st generally provides enough storage to continue operating through the upper gates and develop a sufficient cold water pool to meet 53.5°F on the Sacramento River above Clear Creek (at the CCR gaging station) for winter-run Chinook salmon spawning and egg incubation. Figure 4-2 provides an approximate rule of thumb for the relationship between temperature compliance, total storage in Shasta Reservoir and cold water pool in Shasta Reservoir.

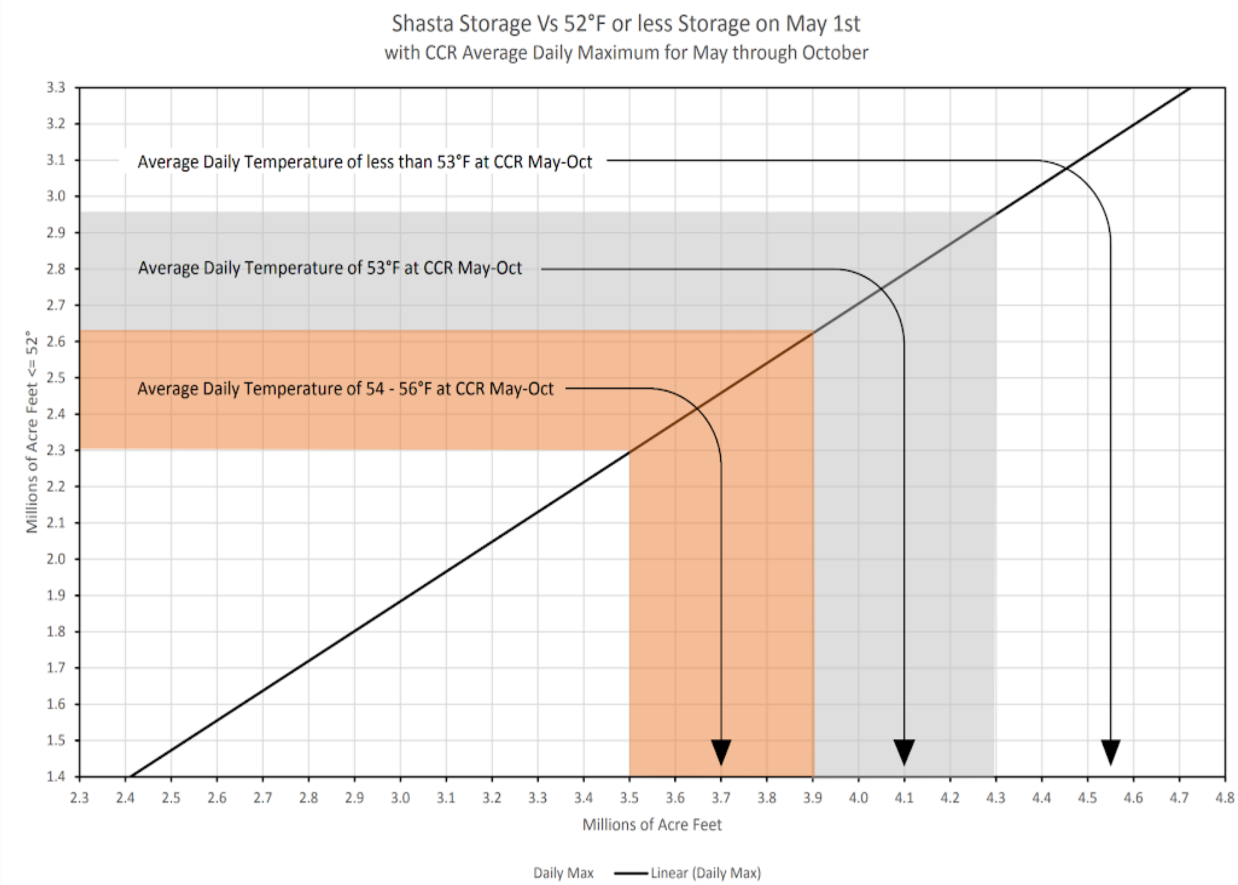


Figure 4-2. Relationship between Temperature Compliance, Total Storage in Shasta Reservoir, and Cold Water Pool in Shasta Reservoir

A.3.4.6.3 Summer Cold Water Pool Management

Reclamation proposes to operate the TCD at Shasta Dam to continue providing temperature management in accordance with CVPIA 3406(b)(6) while minimizing impacts to power generation. Cold water pool is defined as the volume of water in Shasta Reservoir that is less than 52°F, which Reclamation would determine based on monthly (or more frequent) reservoir temperature profiles. The Sacramento River above Clear Creek (CCR) gage is a surrogate for the downstream extent of most winter-run Chinook salmon redds. Temperature management would start after May 15, or when the monitoring working group determines, based on real-time information, that winter-run Chinook salmon have spawned, whichever is later. Temperature management would end October 31, or when the monitoring working group determines based on real-time monitoring that 95% of Winter-run Chinook salmon eggs have hatched, and aelvin have emerged, whichever is earlier.

Reclamation proposes to address cold water management utilizing a tiered strategy that allows for strategically selected temperature objectives, based on projected total storage and cold water pool, meteorology, Delta conditions, and habitat suitability for incoming fish population size and location. The tiered strategy recognizes that cold water is a scarce resource that can be managed to achieve desired water temperatures for fisheries objectives. Figure 4-3 below shows examples of water temperatures at CCR under the four tiers. The proposed tiers are described below, along with storage levels that are likely to provide for cold water management within the tier. Actual operations will depend upon the available cold water and modeling. In any given year, cold water pool and storage could result in Reclamation switching between tiers within the year if needed to optimally use the cold water pool.

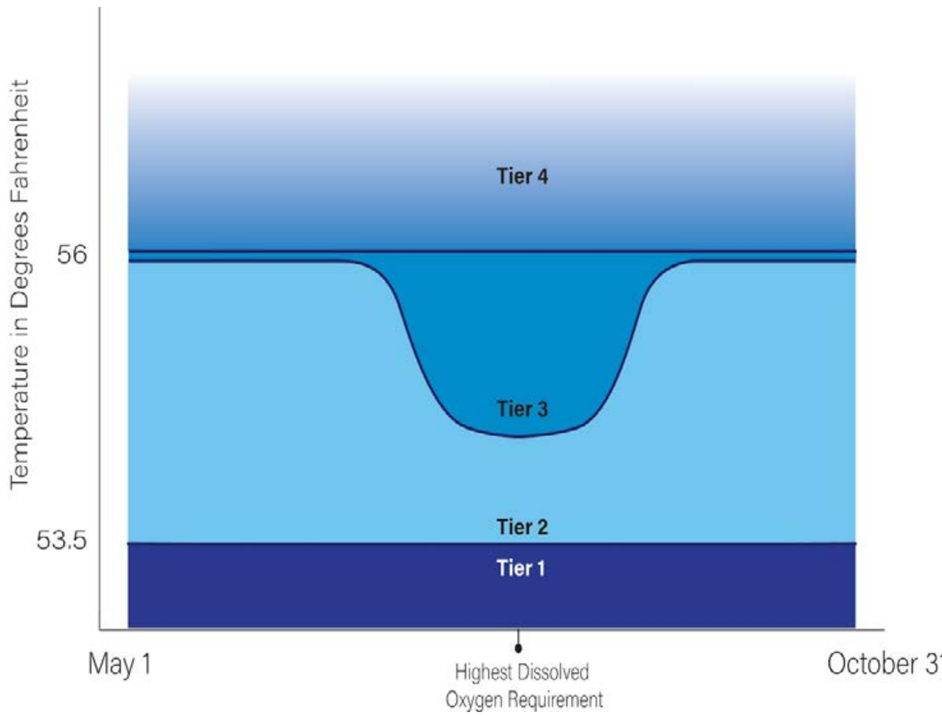


Figure 4-3. Tiered Temperature Management Strategy

- **Tier 1**. In years when Reclamation determines that cold water pool is sufficient (e.g. more than 2.8 MAF of cold water pool in Shasta Reservoir at the beginning of May or modeling suggests that a daily average temperature of 53.5 °F at CCR can be maintained from May 15 to October 31), Reclamation proposes to operate to a daily average temperature of 53.5 °F at the CCR gaging station to minimize temperature dependent mortality.
- **Tier 2.** In years when cold water pool is insufficient to allow Tier 1 above (e.g. less than 2.8 MAF of cold water pool in Shasta Reservoir at the beginning of May or modeling suggests that the 53.5 °F at CCR cannot be maintained from May 15 to October 31), Reclamation would

optimize use of cold water for Winter-run Chinook salmon eggs based on life-stage specific requirements, reducing the duration of time of operating to 53.5 degree target temperatures. Water temperatures at CCR would vary based on real-time monitoring of redd timing and lifestage-specific temperature dependent mortality models, e.g. Anderson (2017). The time period of 53.5 °F at CCR would be centered around the projected time period when the Winter-run eggs have the highest dissolved oxygen requirement (37 - 67 days post fertilization). At 2.79 MAF of cold water pool, Reclamation would operate to 53.5 °F from 37 days after the first observed redd to 67 days after the last observed redd, as long as this is earlier than October 31. The duration of the 53.5°F protection will decrease in proportion to the available cold water pool on May 1. Reclamation will determine this time period by running different temperature scenarios through the latest egg mortality model(s) and real-time monitoring of redds. Reclamation would operate to daily average temperatures at CCR during the temperature management season outside of the stage-specific critical window no warmer than 56 °F.

- **Tier 3.** When Reclamation determines that life-stage-specific temperature targets cannot be met per (2) above (e.g. less than 2.3 MAF of cold water pool in Shasta Reservoir at the beginning of May or modeling suggests that maintaining 53.5 °F at CCR would have higher mortality than a warmer temperature), Reclamation proposes to utilize cold water pool releases to maximize winter-run Chinook salmon redd survival by increasing the coldest water temperature target (see Figure 4-3 below). At the highest storage levels in Tier 3, the targeted temperature at CCR will be daily average 53.5 °F and as storage decreases would warm in the life-stage-specific critical period up to 56 °F. Reclamation would increase the temperature while minimizing adverse effects to the greatest extent possible, as determined by the latest egg mortality models, real-time monitoring, and expected and current water availability. This tier would be in effect until Reclamation could no longer meet 56 °F at CCR at which point Reclamation would shift to tier 4. See Appendix B – Sub-Alternatives and Components for additional details.
- **Tier 4**. If there is less than 2.5 MAF of total storage (note the use of "total" storage as opposed to the "cold water pool" used in the previous criteria) in Shasta Reservoir at the beginning of May, or if Reclamation cannot meet 56°F at CCR, Reclamation will attempt to operate to a less than optimal temperature target and period that is determined in real-time with technical assistance from NMFS and USFWS. Reclamation will explore improved coordination of downstream diversions, and the potential for demand shifting. In addition, Reclamation proposes to implement intervention measures (e.g., increasing hatchery intake and trap and haul, as described below).

At the March forecast (mid-March), if the forecasted Shasta Reservoir total storage is projected to be below 2.5 MAF at the end of May, Reclamation would initiate discussions with USFWS and NMFS on potential intervention measures should this low storage condition continue into April and May, as described in Tier 4. Reclamation proposes to perform the first temperature model run in April after the DWR Bulletin 120 has been received and the operations forecast completed. This is the first month that a temperature model run is feasible based on temperature profiles. Prior to April, there is insufficient stratification in Shasta Reservoir to allow a temperature model to provide meaningful results. The April temperature model scenario is used to develop an initial temperature plan for submittal to the SWRCB. This temperature plan may be updated as Reclamation has improved data on reservoir storage and cold water pool via the reservoir profiles at the end of May, and throughout the temperature control season. Figure 4-4 provides a decision tree explaining the decision points for Shasta Reservoir temperature management.

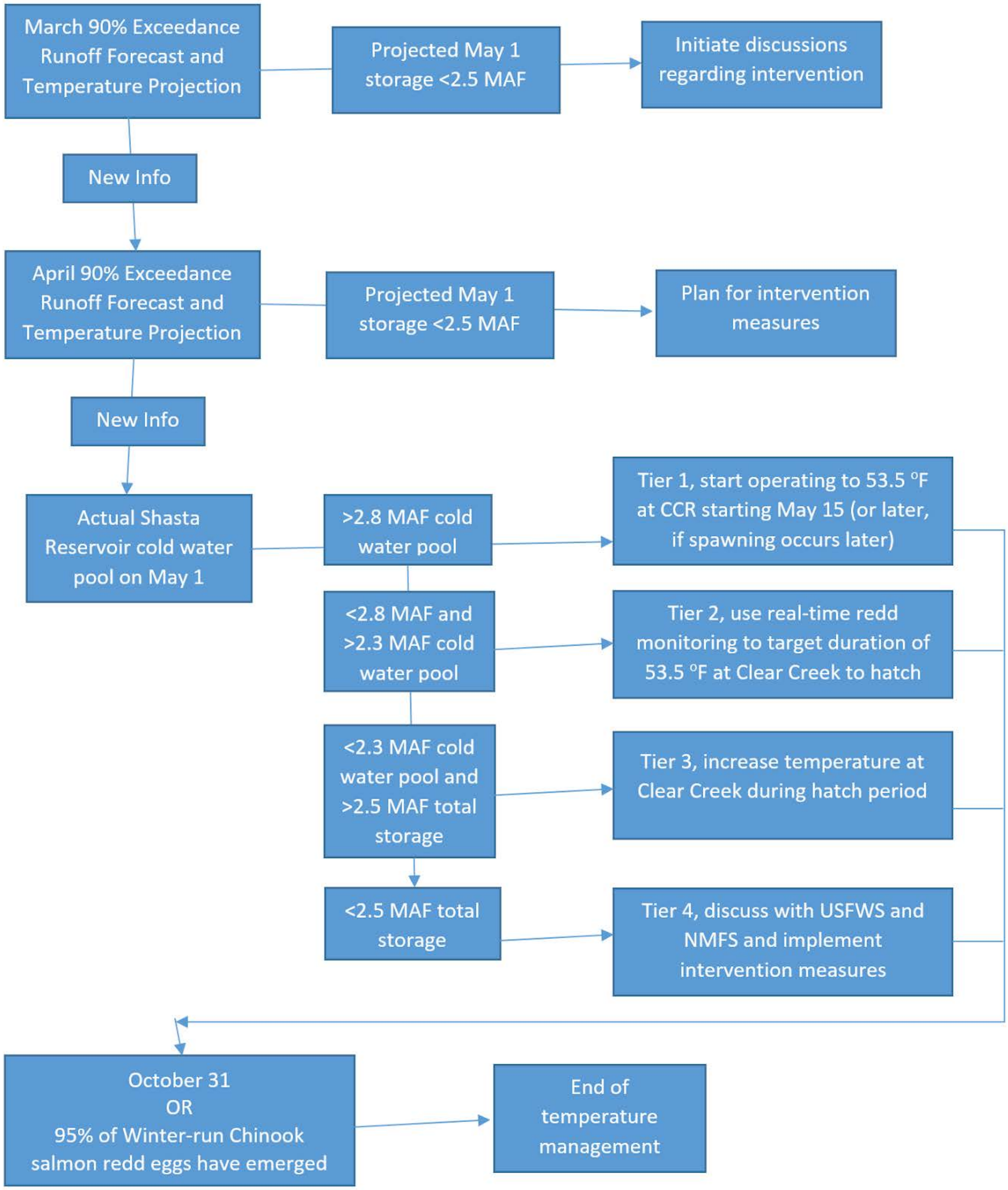


Figure 4-4. Decision Tree for Shasta Reservoir Temperature Management

Reclamation intends to provide temperature profile measurements for Shasta, Whiskeytown, and Trinity Reservoirs as shown in Table 4-10.

Table 4-10. Temperature Profile Measurements for Shasta, Whiskeytown, and Trinity Reservoirs

Reservoir	Every Month	Every Two Weeks	Every Week	Comment
Shasta	01/01 – 03/01 12/1 – 12/31	03/01 – 05/01 11/15 – 12/01	05/01 – 11/15	25 ft intervals for “Every Month”, otherwise 5 ft intervals
Whiskeytown	01/01 – 12/31			25 ft intervals
Trinity	01/01 – 12/31			25 ft intervals

Reclamation proposes to provide a draft temperature management plan to the SRTTG in April for their review and comment, consistent with WRO 90-5. Reclamation’s proposed April temperature management plan will describe which of the 4 tiers Reclamation projects for that year’s summer temperature management season, along with a temperature modeling scenario and the operations forecast. The SWRCB has overall authority to determine if the plan is sufficient to meet water right permit requirements.

A.3.4.7 *Fall and Winter Refill and Redd Maintenance*

Reclamation proposes to rebuild storage and cold water pool for the subsequent year. Maintaining releases to keep late spawning winter-run Chinook salmon redds underwater may drawdown storage necessary for temperature management in a subsequent year. Reclamation will minimize effects with a risk analysis of the remaining winter-run Chinook salmon redds, the probability of sufficient cold water in a subsequent year, and conservative distribution and timing of subsequent winter-run Chinook salmon redds. If maintaining flows puts the subsequent year class at a 10% or less risk, Reclamation will reduce releases to rebuild storage.

Demands by the National Wildlife Refuges, upstream CVP contractors, and the Sacramento River Settlement Contractors in October result in Keswick Dam releases that are generally not maintained throughout the winter due to needs to store water for beneficial uses the following year. These releases result in some early fall Chinook redds being dewatered at winter base flows. Targets for winter base flows (December 1 through the end of February) from Keswick would be set in October and would be based on the previous months’ Shasta Reservoir end-of-September (EOS) storage. These targets would be set based on EOS storage and the current hydrology. Base flows would be set based on historic performance to accomplish improved refill capabilities for Shasta Reservoir to build cold water pool for the following year. Table 4-11 shows examples of possible Keswick Releases based on Shasta Reservoir storage condition; these would be refined through future modeling efforts as part of the seasonal operations planning.

Table 4-11. Keswick Dam Release Schedule for EOS Storage

Keswick Release (cfs)	Shasta End of September Storage
3,250 cfs	≤ 2.2 MAF
4,000 cfs	≤ 2.8 MAF
4,500	≤ 3.2
5,000 cfs	> 3.2 MAF

A.3.4.8 *Anderson-Cottonwood Irrigation District Diversion Dam*

Anderson Cottonwood Irrigation District (ACID) holds senior water rights and has diverted into the ACID Canal for irrigation along the west side of the Sacramento River between Redding and Cottonwood since 1916. The United States and ACID signed a contract providing for Project water service and agreement on diversion of water. ACID diverts to its main canal (on the right bank of the river) from a diversion dam located in Redding about 5 miles downstream from Keswick Dam.

Close coordination between Reclamation and ACID is required for regulation of river flows to ensure safe operation of ACID's diversion dam during the irrigation season. The irrigation season for ACID runs from April through October. Keswick release rate decreases required for the ACID operations are limited to 15 percent in a 24-hour period and 2.5 percent in any one hour. Therefore, advance notification is important when scheduling decreases to allow for the installation or removal of the ACID diversion dam.

A.3.4.9 *Tehama-Colusa Canal Authority Operations*

The intake for the Tehama-Colusa Canal and the Corning Canal is located on the Sacramento River approximately 2 miles southeast of Red Bluff. Water is diverted through fish passage facilities along the Sacramento River and lifted by a 2,500 cfs pumping plant into a settling basin for continued conveyance in the Tehama-Colusa Canal and the Corning Canal. Reclamation operates the pumping plant in accordance with BOs issued by USFWS and NMFS specifically for the Red Bluff Pumping Plant.

The Tehama-Colusa Canal is a lined canal extending from the settling basin 111 miles south from the Red Bluff Pumping Plant and provides irrigation service on the west side of the Sacramento Valley in Tehama, Glenn, Colusa, and northern Yolo counties. Construction of the Tehama-Colusa Canal began in 1965, and it was completed in 1980.

The Corning Pumping Plant lifts water approximately 56 feet from the screened portion of the settling basin into the unlined, 21-mile-long Corning Canal. The Corning Canal was completed in 1959, to provide water to the CVP contractors in Tehama County that could not be served by gravity from the Tehama-Colusa Canal. The Tehama-Colusa Canal Authority (TCCA) operates both the Tehama-Colusa and Corning canals.

A.3.5 Feather River Watershed

The Feather River, with a drainage area of 3,607 square miles on the east side of the Sacramento Valley, is the largest tributary to the Sacramento River below Shasta Dam (Reclamation 1997, DWR 2007a). The

Feather River enters the Sacramento River from the east at Verona. The total flow is provided by the Feather River and tributaries, which include the Yuba and Bear rivers.

A.3.5.1 *Lower Yuba River*

The Yuba River watershed extends over 1,339 square miles in the Sierra Nevada. The Yuba River is a major tributary to the Feather River, and historically has contributed over 40 percent of the lower Feather River flows (Reclamation 1997). The major reservoir in the watershed is the 970-TAF New Bullards Bar Reservoir that is owned and operated by the Yuba County Water Agency to provide flood control, water storage, and hydroelectric generation (Yuba County Water Agency [YCWA] 2012). The Yuba River watershed also includes over 400 TAF additional storage in reservoirs located upstream of New Bullards Bar Reservoir.

Water is diverted from New Bullards Bar Reservoir through the Colgate Tunnel and Powerhouse and discharged into the Yuba River. The 70-TAF Englebright Lake is formed by the Harry L. Englebright Dam downstream of New Bullards Dam. Englebright Lake was constructed by the California Debris Commission to trap and store sediment from historical hydraulic mining sites in the upper watershed and provide recreation and hydroelectric generation opportunities (USACE 2013). Following decommissioning of the California Debris Commission in 1986, administration of Englebright Dam and Lake was assumed by the USACE (USACE 2012, 2013, 2014). Major water diversions from the Yuba River occur 12.5 miles downstream of Englebright Dam at Daguerre Point Dam. Water transfers have occurred between Yuba County Water Agency and other water agencies, including CVP and SWP water users, since 2008 under the Lower Yuba River Accord (Lower Yuba River Accord, River Management Team [LYRARMT] 2013).

A.3.5.2 *Oroville Complex*

DWR holds contracts with 29 public agencies in Northern, Central, and Southern California for water supplies from the SWP. Water stored in the Lake Oroville facilities, along with excess water available in the Delta, is captured in the Delta and conveyed through several facilities to SWP water contractors.

The SWP is operated to provide flood control, meet Delta requirements and provide water for agricultural, M&I, recreational, and environmental purposes. Water is stored in Lake Oroville and released to serve three Feather River area water contractors and two water contractors served from the NBA, and 24 SWP contractors in the SWP service areas in the south San Francisco Bay Area, San Joaquin Valley, and Southern California. In addition to exporting portions of water released from Lake Oroville, the Clifton Court/Banks Pumping Plant complex diverts natural surplus flow available in the Delta. Water exported at Banks PP is conveyed into storage at San Luis Reservoir or is delivered directly to SWP member agencies south of the Delta via the California Aqueduct and its associated facilities.

A.3.5.2.1 Facilities

Oroville Dam and its related facilities comprise a multipurpose complex. The reservoir stores winter and spring runoff, which is released into the Feather River to meet the Project's needs, Delta requirements, and fish and wildlife protection. The Oroville Complex also provides power generation (including pumpback operations) flood control storage, and recreation opportunities.

The Oroville Project creates a lake with a maximum surface area of 15,810 acres, has a total storage capacity of 3,538 TAF, and is fed by the North, Middle, and South forks of the Feather River. Average annual unimpaired runoff into the lake is about 4.5 MAF. Historical water storage volumes and water storage elevations for Lake Oroville for Water Years 2001 through 2018 are presented on Figures A.3-14 and A.3-15 (DWR 2018t, 2018u).

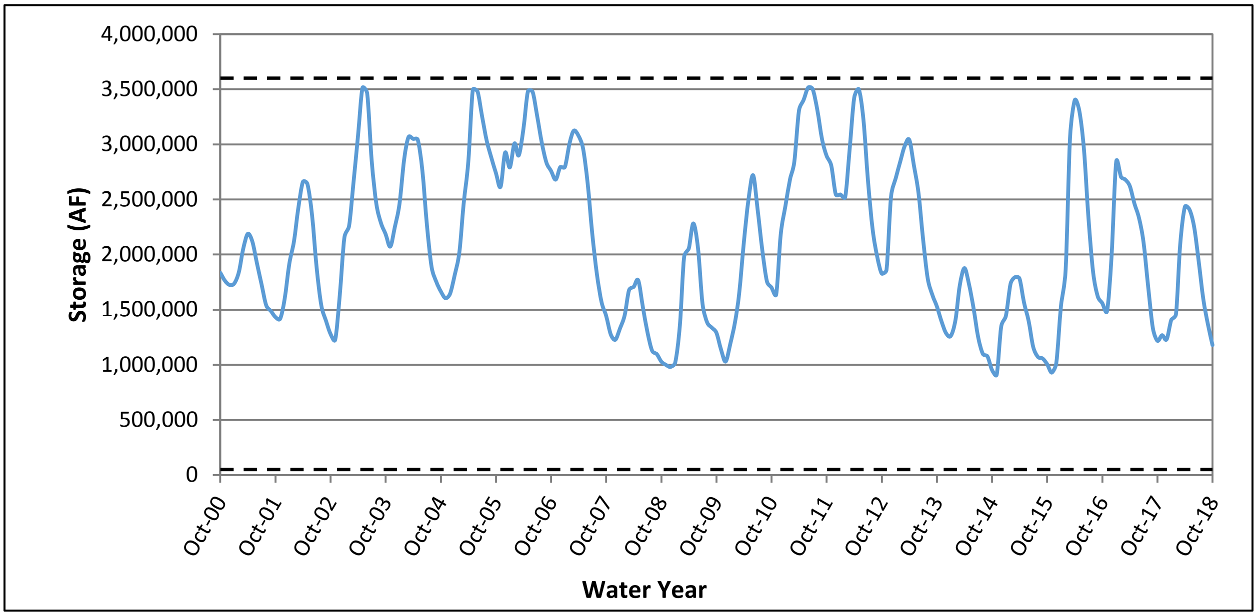


Figure A.3-14. Lake Oroville Storage

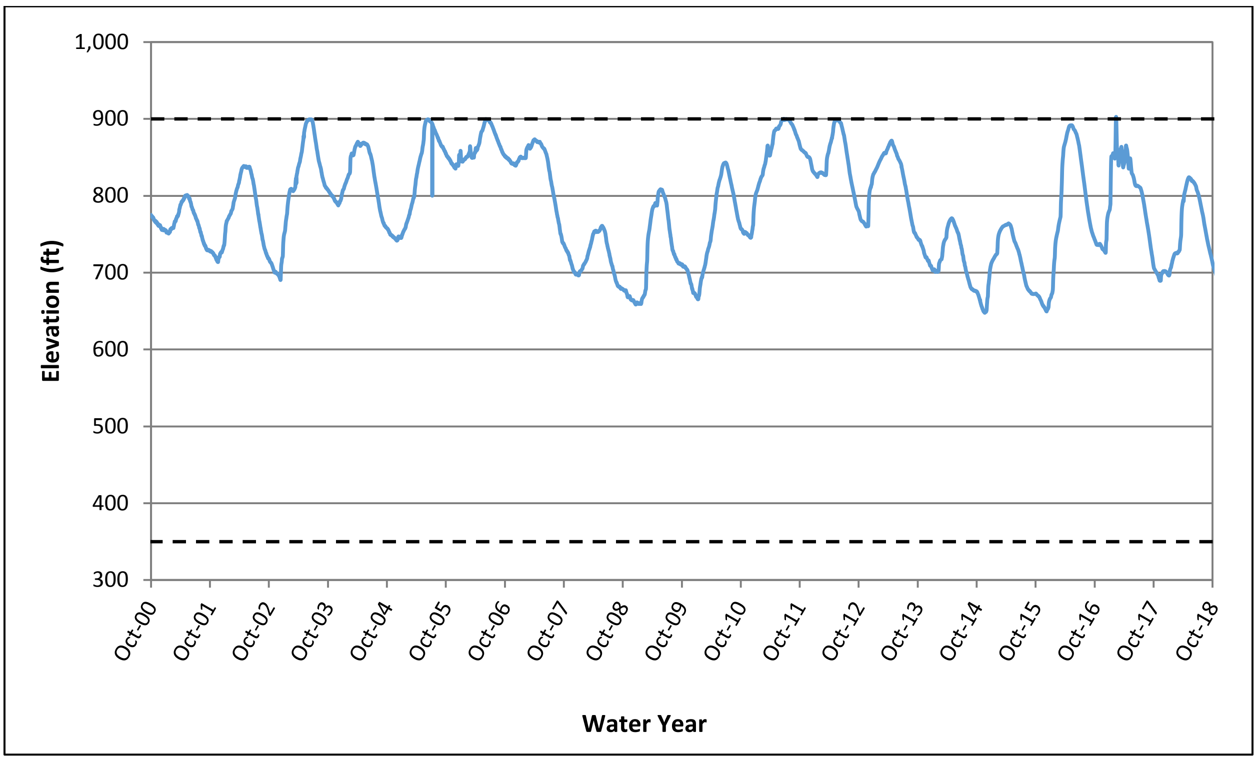


Figure A.3-15. Lake Oroville Elevation

A maximum of 16,950 cfs can be released through the Edward Hyatt Power Plant, located underground near the left abutment of Oroville Dam. Three of the six units are conventional generators driven by vertical-shaft, Francis-type turbines. The other three are motor-generators coupled to Francis-type, reversible pump turbines. The latter units allow pumped storage operations. The intake structure has an overflow type shutter system that determines the level from which water is drawn.

Approximately 4 miles downstream of Oroville Dam and Edward Hyatt Power Plant is the Thermalito Diversion Dam. Thermalito Diversion Dam consists of a 625-foot-long, concrete gravity section with a regulated ogee spillway that releases water to the low flow channel of the Feather River. On the right abutment is the Thermalito Power Canal regulating headwork structure. Water storage volumes and water storage elevations for Thermalito Reservoir for Water Years 2001 through 2018 are presented on Figures A.3-16 and A.3-17 (DWR 2018v, 2018w).

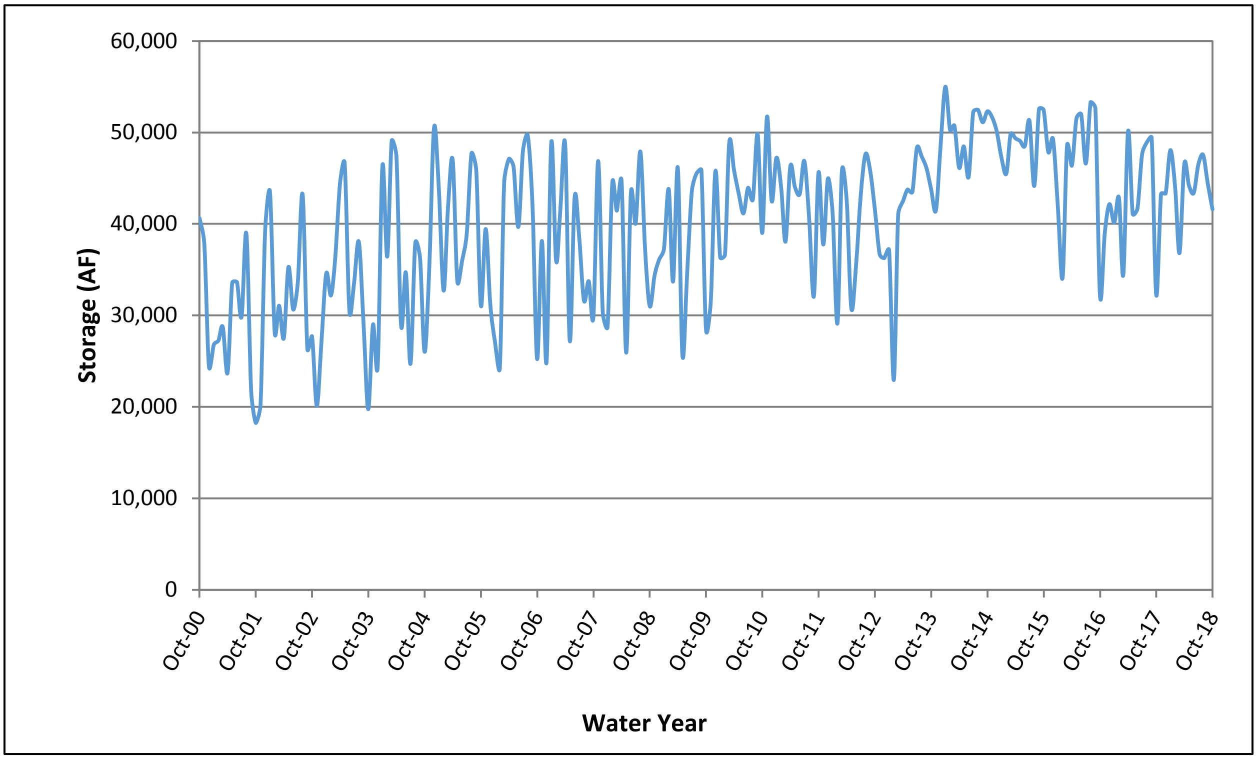


Figure A.3-16. Thermalito Reservoir Storage

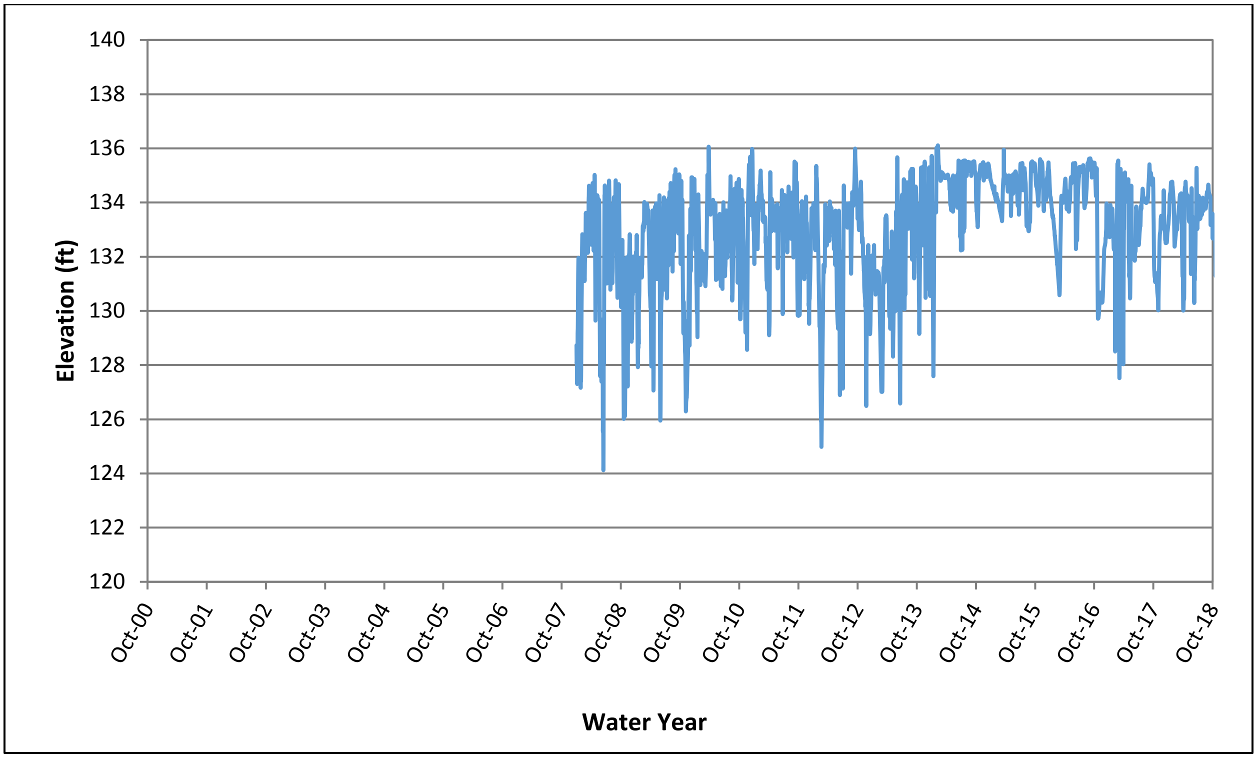


Figure A.3-17. Thermalito Reservoir Elevation

The purpose of the diversion dam is to divert water into the 2-mile long Thermalito Power Canal that conveys water in either direction and creates a tailwater pool (Thermalito Diversion Pool) for Edward Hyatt Power Plant. The Thermalito Diversion Pool acts as a forebay when Hyatt is pumping water back into Lake Oroville. On the left abutment is the Thermalito Diversion Dam Power Plant, with a capacity of 615 cfs that releases water to the low-flow section of the Feather River.

Thermalito Power Canal hydraulically links the Thermalito Diversion Pool to the Thermalito Forebay (11.768 TAF), which is the off-stream regulating reservoir for Thermalito Power Plant.

Thermalito Power Plant is a generating-pumping plant operated in tandem with the Edward Hyatt Power Plant. Energy prices and availability have historically been the two main factors that determine if pumpback operations are desirable for economic benefits. Pumpback operations typically occurred during off-peak hours when energy prices are lower. However, due to recent changes in the energy market (i.e. solar power contributions) and a desire to reduce operational stress on aging infrastructure, pumpback operations have been very infrequent in recent history. The Oroville Thermalito Complex has a capacity of approximately 17,000 cfs through the power plants. Water is returned to the Feather River via the Thermalito Afterbay river outlet.

Five agricultural districts divert water directly from the Thermalito Afterbay under the terms of water right settlement agreement with DWR. The diversion facilities replace the historic river diversion used by the local districts prior to the construction of the Thermalito Complex. The total capacity of afterbay diversions during peak demands is 4,050 cfs.

Feather River mean daily flows from Water Years 2001 through 2018 are presented in Figure A.3-18 (DWR 2018x).

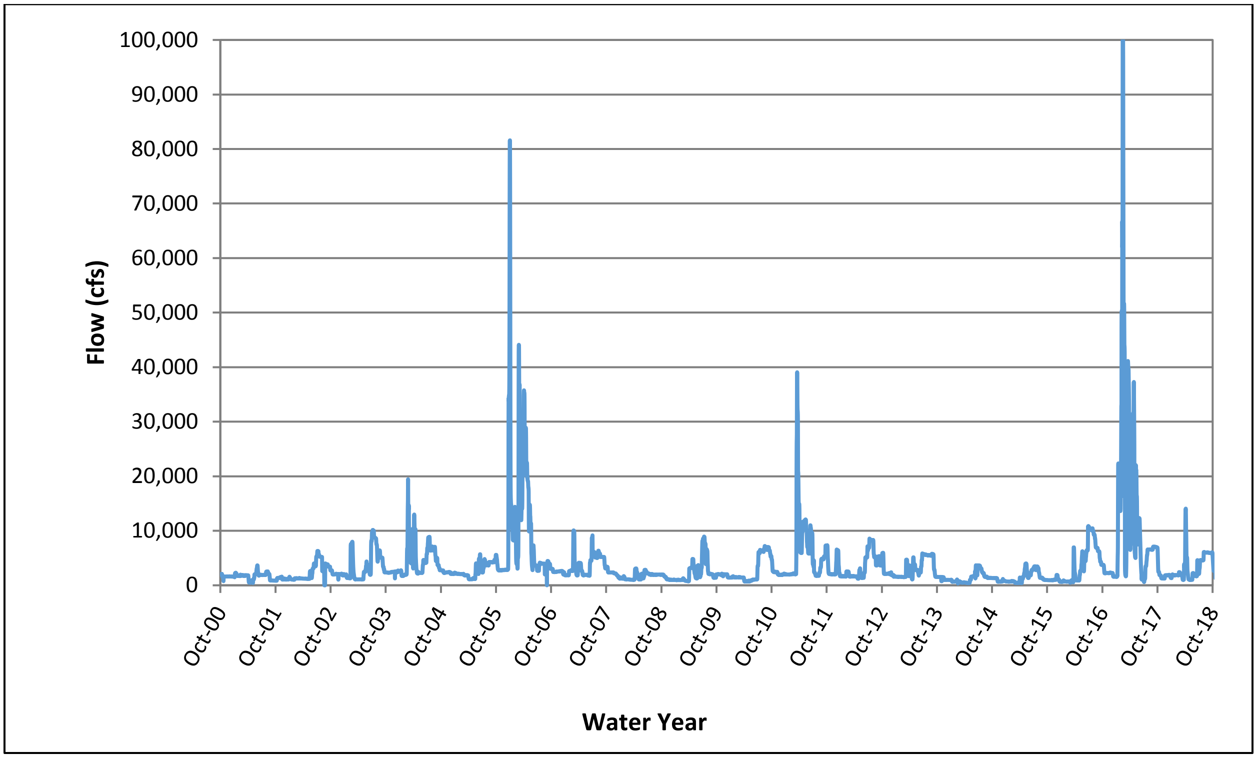


Figure A.3-18. Feather River Near Gridley

The Feather River Fish Hatchery (FRFH) provides mitigation for the construction of Oroville Dam, rears Chinook Salmon and steelhead and is operated by CDFW. Both indirect and direct take resulting from FRFH operations will be authorized through Section 4(d) of the Endangered Species Act through NMFS-approved Hatchery and Genetic Management Plans (HGMPs). DWR and CDFW are jointly preparing HGMPs for the spring and fall-run Chinook Salmon and steelhead production programs at the Feather River Fish Hatchery.

A.3.5.2.2 Flow Requirements

DWR maintains a minimum flow of 600 cfs within the Feather River LFC as required by the 1983 CDFW Agreement (except during flood events when minimum flows are governed by USACE's Water Control Manual and under certain other conditions as described in the 1984 FERC order). Downstream of the Thermalito Afterbay Outlet, in the high flow channel (HFC), per the license and the 1983 CDFW Agreement, minimum releases for flows in the Feather River are 1,000 cfs from April through September and 1,700 cfs from October through March, when the April-to-July unimpaired runoff in the Feather River is greater than 55 percent of normal. When the April-to-July unimpaired runoff is less than 55 percent of normal, the minimum flow requirements are 1,000 cfs from March to September and 1,200 cfs from October to February. The 1983 CDFW Agreement also states that if the April 1 runoff forecast in a given year indicates that the reservoir level would be drawn down to 733 feet, water releases for fish may be reduced, but not by more than 25 percent.

In addition, according to the 1983 Agreement, during the period of October 15 to November 30, if the average highest 1-hour flow of combined releases exceeds 2,500 cfs, then the minimum flow must be no lower than 500 cfs less than that flow through the following March 31 (with the exception of flood management, accidents, or maintenance.) In practice, flows are maintained below 2,500 cfs from October 15 to November 30 to prevent spawning in the overbank areas.

A.3.5.2.2.1 Flow Change Rates

Maximum allowable ramp-down release requirements are intended to prevent rapid reductions in water levels that could potentially cause dewatering and stranding of juvenile salmonids and other aquatic organisms. Ramp-down release requirements to the LFC during periods outside of flood management operations, and to the extent controllable during flood management operations, are shown in Table A.3-6.

Table A.3-6. Lower Feather River Ramping Rates

Releases to the Feather River Low Flow Channel (cfs)	Rate of Decrease (cfs)
5,000 to 3,501	1,000 per 24 hours
3,500 to 2,501	500 per 24 hours
2,500 to 600	300 per 24 hours

Source: National Marine Fisheries Service 2004.

A.3.5.2.3 Water Temperature Requirements

The temperature of the water released from Oroville Dam is in accordance with the temperature requirements for the FRFH, under the August 1983 CDFW Agreement titled Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish and Wildlife, and the 2004 NMFS Biological Opinion for Robinson Riffle, while also conserving the cold-water pool in Lake Oroville.

Water is withdrawn from Lake Oroville at depths that provide sufficiently cold water to meet the FRFH and Robinson Riffle temperature targets. The reservoir depth from which water is released initially determines the river temperatures, but atmospheric conditions, which fluctuate from day to day, influence downstream river temperatures. In order to conserve the cold-water pool during dry years, DWR strives to meet the Robinson Riffle temperatures by increasing releases to the low flow channel (LFC) rather than releasing colder water.

DWR has taken various other temperature management actions to achieve the water temperature requirements, including curtailing pumpback operations, removing shutters at the intakes of the Hyatt Pumping-Generating Plant, releasing flow through the river valves (for FRFH only), and increasing flows at the Thermalito Diversion Dam to the LFC (for Robinson Riffle only).

DWR plans to manage its cold-water storage and its intake shutters to avoid the need for flows through the river valve in order to meet its temperature obligations. Other than local diversions, outflow from the Oroville Project is released to the Feather River at the LFC and Thermalito Afterbay.

A.3.5.2.3.1 Temperature Requirements for Robinson Riffle

The 2004 NMFS Biological Opinion for Robinson Riffle requires DWR to provide water temperatures at Robinson Riffle (RR) at or lower than 65 degrees Fahrenheit (maximum allowable daily average) from June 1 through September 30. There is no RR requirement from October 1 through May 30.

A.3.5.2.3.2 Temperature Requirements for FRFH

The 1983 Agreement requires DWR to provide suitable Feather River water temperatures for salmon on a year-round basis. Current FRFH intake water temperatures, as required by the 1983 CDFW and DWR Agreement are shown in Table A.3-7.

Table A.3-7. Feather River Fish Hatchery Temperature Requirements

Period of Year	Temperature (°F)
April 1–May 15	51 (±4°F Allowed)
May 16–May 31	55 (±4°F Allowed)
June 1–June 15	56 (±4°F Allowed)
June 16–August 15	60 (±4°F Allowed)
August 16–August 31	58 (±4°F Allowed)
September 1–September 30	52 (±4°F Allowed)
October 1–November 30	51 (±4°F Allowed)
December 1–March 31	No greater than 55

A.3.5.2.4 Flood Control

Flood control operations at Oroville Dam are conducted in accordance with the requirements set forth by USACE. The Federal Government shared the expense of Oroville Dam, which provides up to 750 TAF of flood control space. For the 2018/2019 flood season, variable flood management storage based on dry and wet ground conditions will be used. Flood control storage ranges from 412,000 acre-feet (elevation 872.8 feet) to 920,000 acre-feet (elevation 835.5 feet) through February as dictated by the enhanced Flood Control Diagram (FCD) shown in Figure A.3-19. Elevations taper up to the 1970 WCM elevations at the end of March, and then the refill period starts.

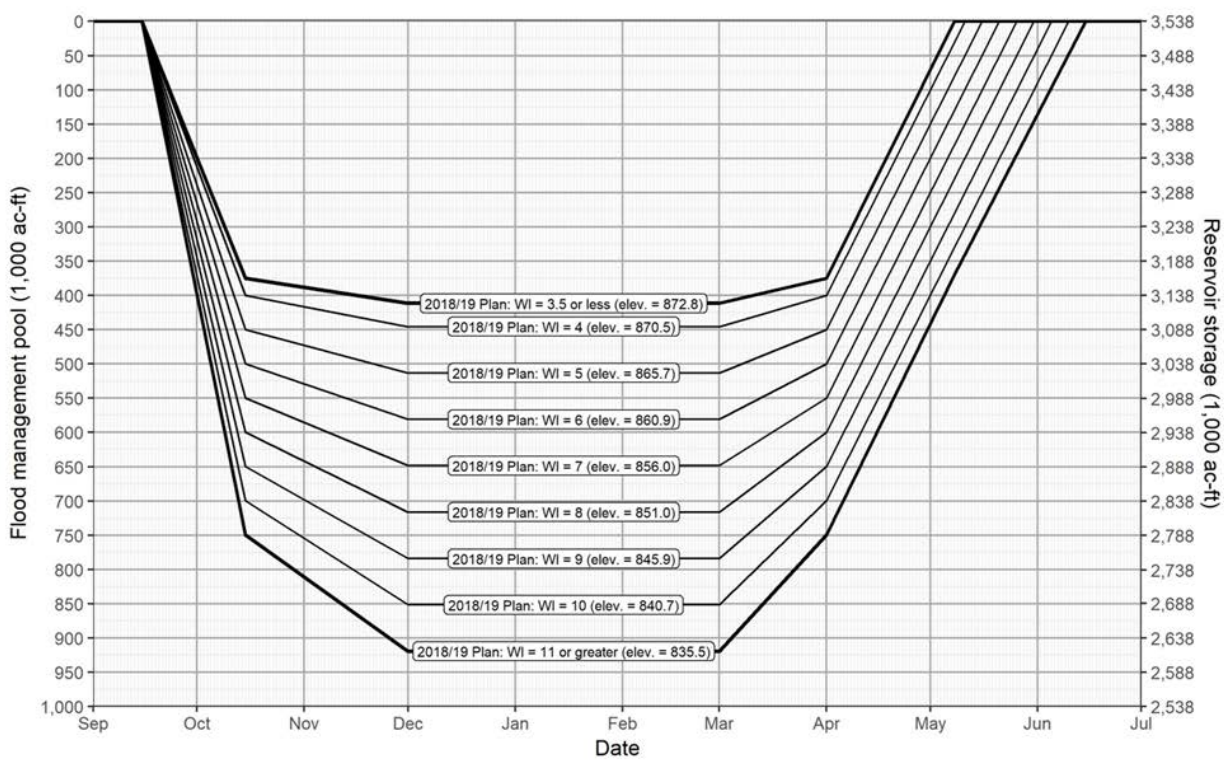


Figure A.3-19. Oroville Dam Flood Control Diagram

The spillway is located on the right abutment of the dam and has two separate elements: a controlled gated outlet and an emergency uncontrolled spillway. The gated control structure releases water to a concrete-lined chute that extends to the river. The uncontrolled emergency spill flows over a recently completed concrete apron.

A.3.5.2.5 Federal Energy Regulatory Commission Relicensing of the Oroville Project

The original FERC license to operate the Oroville Project expired in January 2007. Since 2007, annual license renewals have been issued, requiring DWR to operate to the original FERC license conditions. The new FERC license has not yet been adopted by the Commission. Until a new license for the Oroville Project is issued by FERC, DWR will continue to operate the Oroville facilities in accordance with the current (original) license conditions.

A.3.6 Yolo Bypass

Flows from the Sacramento River, Feather River, Sutter Bypass, and Natomas Cross Canal join upstream of 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 in the Yolo Bypass that increased the volume of flow by more than 300 to 900 percent (Frantzich 2014).

Mean daily flows into the Yolo Bypass at Fremont Weir are presented on Figure A.3-20 (2018y). Between 2002 and 2018, flows have entered the Yolo Bypass at Fremont Weir during 19 periods, including:

- January 2002 – spill continued for 7 days with flows up to 30,000 cfs
- January 2003 – spill continued for 6 days with flows up to 22,000 cfs
- May 2003 – spill continued for 1 day with flows up to 100 cfs
- January 2004 – spill continued for 3 days with flows up to 3,000 cfs
- February 2004 – spill continued for 20 days with flows up to 79,000 cfs
- May 2005 – spill continued for 4 days with flows up to 35,000 cfs
- January/February 2006 (2 events) – spill continued for a total of 37 days with flows up to 205,000 cfs
- March/April/May 2006 – spill continued for 65 days with flows up to 96,000 cfs
- January 2010 – spill continued for 4 days with flows up to 5,000 cfs
- December 2010 – spill continued for 4 days with flows up to 9,000 cfs

- March/April 2011 – spill continued for 24 days with flows up to 85,000 cfs
- December 2012 – spill continued for 5 days with flows up to 26,000 cfs
- March 2016 – spill continued for 10 days, with flows up to 62,000 cfs
- December 2016 – spill continued for 4 days, with flows up to 27,000 cfs
- January 2017 – spill continued for 62 days, with flows up to 180,000 cfs
- March 2017 – spill continued for 12 days, with flows up to 177,000 cfs
- April/May 2017 – spill continued for 25 days, with flows up to 41,000 cfs
- April 2018 – spill continued for 3 days with flows up to 16,000 cfs

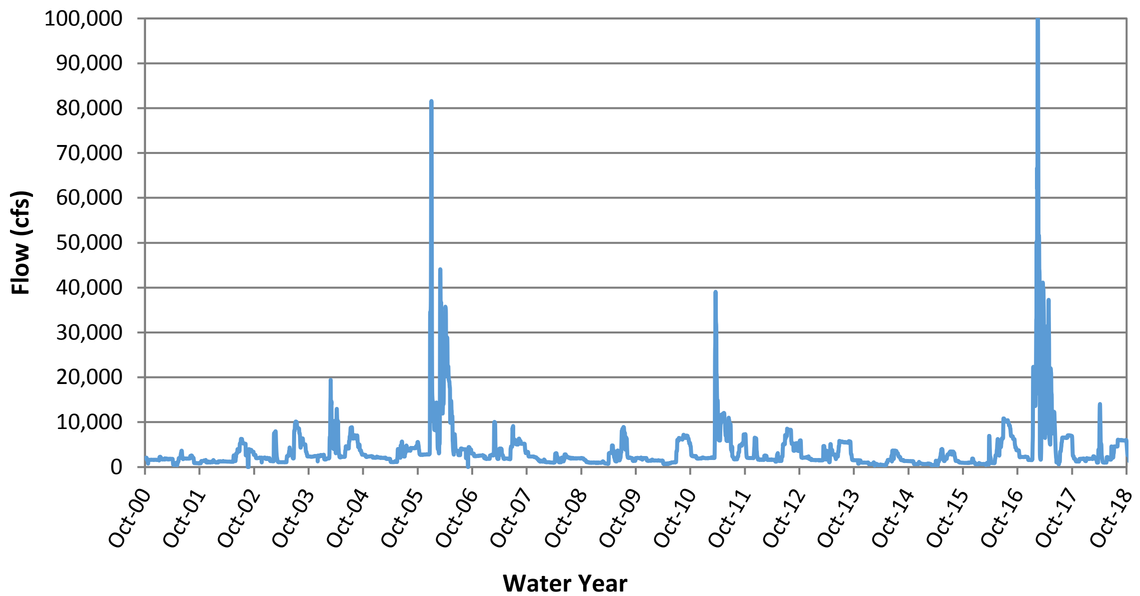


Figure A.3-20. Yolo Bypass over Fremont Weir

Reclamation is currently working on the Yolo Bypass Fish Passage Improvement Project.

A.3.7 American River from Folsom Lake to Sacramento River

The American River watershed extends over 1,895 square miles and contributes approximately 15 percent of the flow in the lower Sacramento River.

A.3.7.1 *Facilities*

The American River Division includes facilities that provide storage and conveyance of water on the American River for flood control, fish and wildlife protection, recreation, protection of the Delta from intrusion of saline ocean water, irrigation and M&I water supplies, and hydroelectric power generation. Initially authorized features of the American River Division included Folsom Dam, Lake, and Power Plant; Nimbus Dam and Power Plant, and Lake Natoma.

A.3.7.1.1 Upper American River Basin

Although Folsom Reservoir is the main storage and flood control reservoir on the American River, numerous other small non-federal reservoirs in the upper basin provide hydroelectric generation and water supply. None of the upstream reservoirs have any specific flood control responsibilities but PCWA and SMUFD reservoirs are considered to provide flood storage space when they have it. The total upstream reservoir storage above Folsom Reservoir is approximately 820 TAF. Ninety percent of this upstream storage is contained by five reservoirs: French Meadows (136 TAF); Hell Hole (208 TAF); Loon Lake (76 TAF); Union Valley (271 TAF); and Ice House (46 TAF). Reclamation has agreements with the operators of some of these reservoirs to coordinate operations for releases.

French Meadows and Hell Hole reservoirs, located on the Middle Fork of the American River, are owned and operated by the Placer County Water Agency (PCWA). The PCWA provides wholesale water to agricultural and urban areas within Placer County. For urban areas, PCWA operates water treatment plants and sells both wholesale raw water and treated water to municipalities that provide retail delivery to their customers. The cities of Rocklin and Lincoln receive water from PCWA, Loon Lake, and Union Valley and Ice House reservoirs on the South Fork of the American River, are all operated by the Sacramento Municipal Utilities District (SMUD) for hydropower purposes.

A.3.7.1.2 Folsom Dam and Reservoir

Reclamation's Folsom Reservoir, the largest reservoir in the American River watershed, has a capacity of 967 TAF. Folsom Dam, located approximately 30 miles upstream from the confluence with the Sacramento River, is operated as a major component of the CVP. The facility serves water to M&I users in Placer and Sacramento counties.

Table A.3-8 provides Reclamation's annual water deliveries for the period 2000 through 2010 in the American River Division. The totals reveal an increasing trend in water deliveries over that period. For this EIS under the No Action Alternative, the American River Division water demands are modeled assuming that water users can utilize their full contract/agreement values with average annual deliveries of about 800 TAF per year. The American River contractors are not currently using this volume, but it is anticipated that due to fast growth and new water agreements, the actual usage (as projected by their Urban Water Management Plans) could increase to about 650 to 800 TAF/year over the next 10 years, depending upon growth rates and implementation of water demand reduction measures.

Table A.3-8. Annual Water Deliveries- American River Division

Year	Water Delivery (TAF)*
2000	174
2001	223
2002	221
2003	270
2004	266
2005	297
2006	280
2007	113
2008	233
2009	260
2010	125

Year	Water Delivery (TAF)*
2011	269
2012	279

Notes:
* Annual water delivery data has been enhanced and the annual totals include CVP contracts, water rights (including water rights for the City of Sacramento), and other deliveries (e.g. Folsom South Canal losses)
TAF = thousand acre-feet

A.3.7.1.3 Nimbus Dam and Lake Natoma

Nimbus Dam creates Lake Natoma, a forebay built to re-regulate flows of 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. Water storage volumes and water storage elevations for Folsom Lake and Lake Natoma for Water Years 2001 through 2018 are presented on Figures A.3-21 through A.3-24 (DWR 2018z, 2018aa, 2018ab, 2018ac). Mean daily flows in American River at Fair Oaks, downstream of Nimbus Dam are presented in Figure A.3-25 (DWR 2018ad).

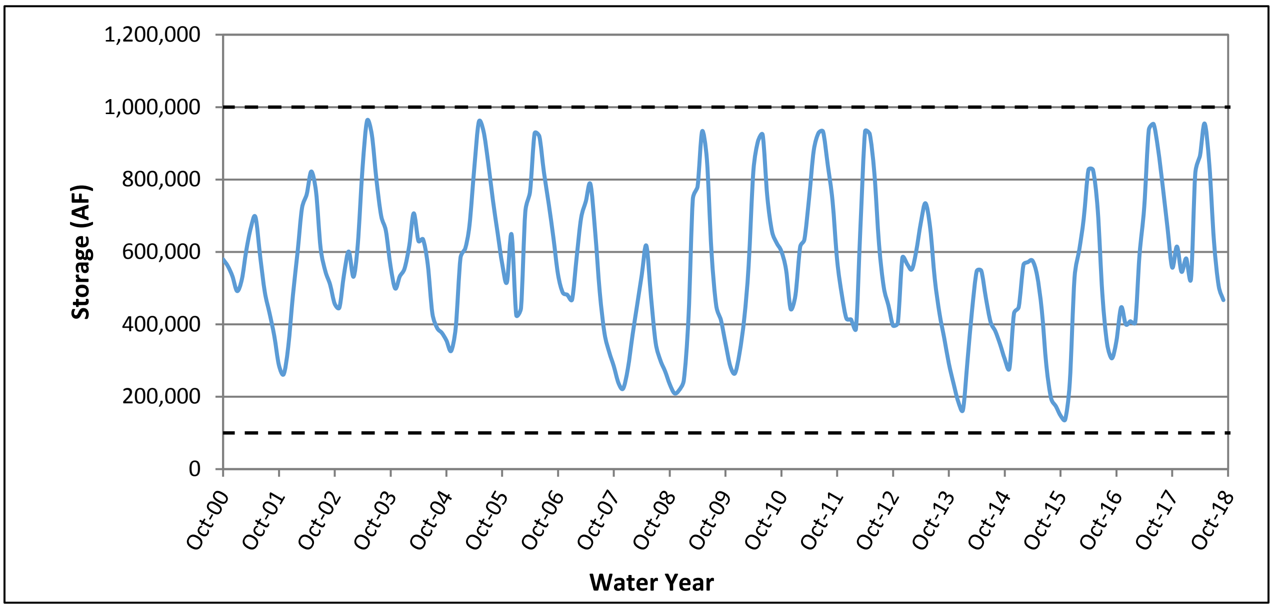


Figure A.3-21. Folsom Lake Storage

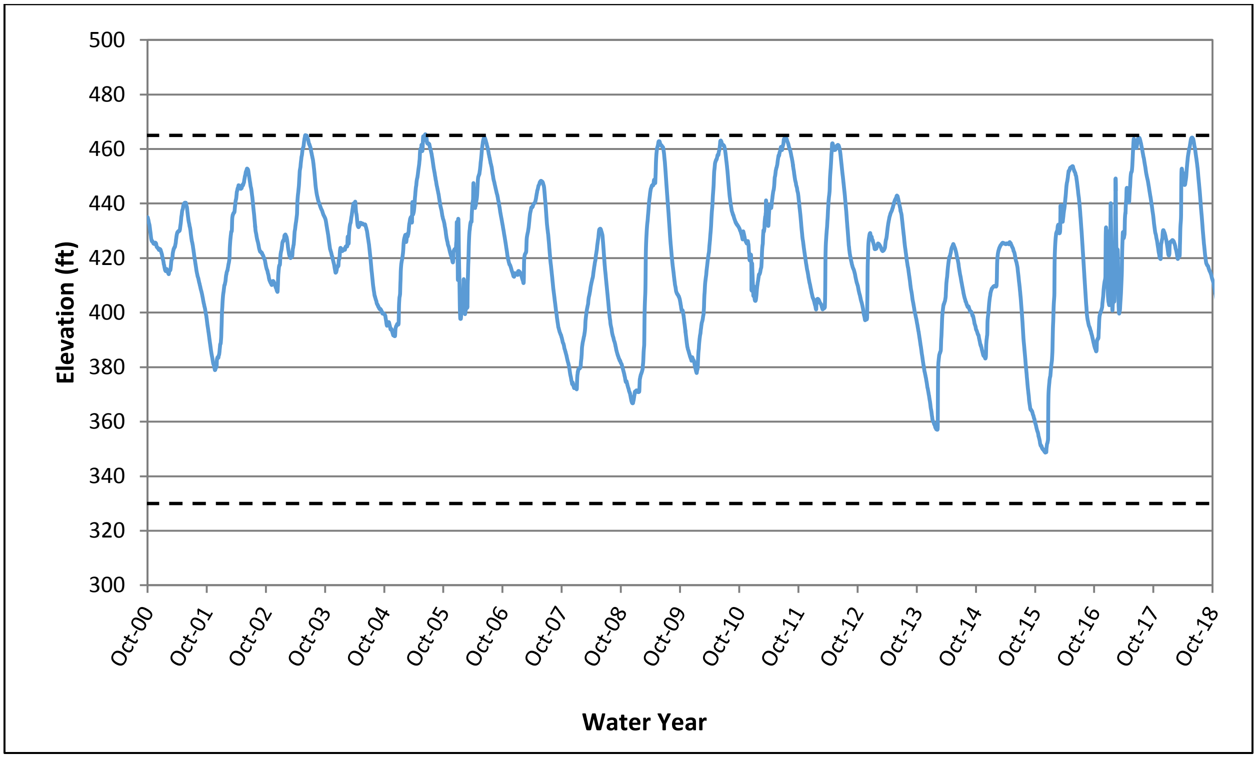


Figure A.3-22. Folsom Lake Elevation

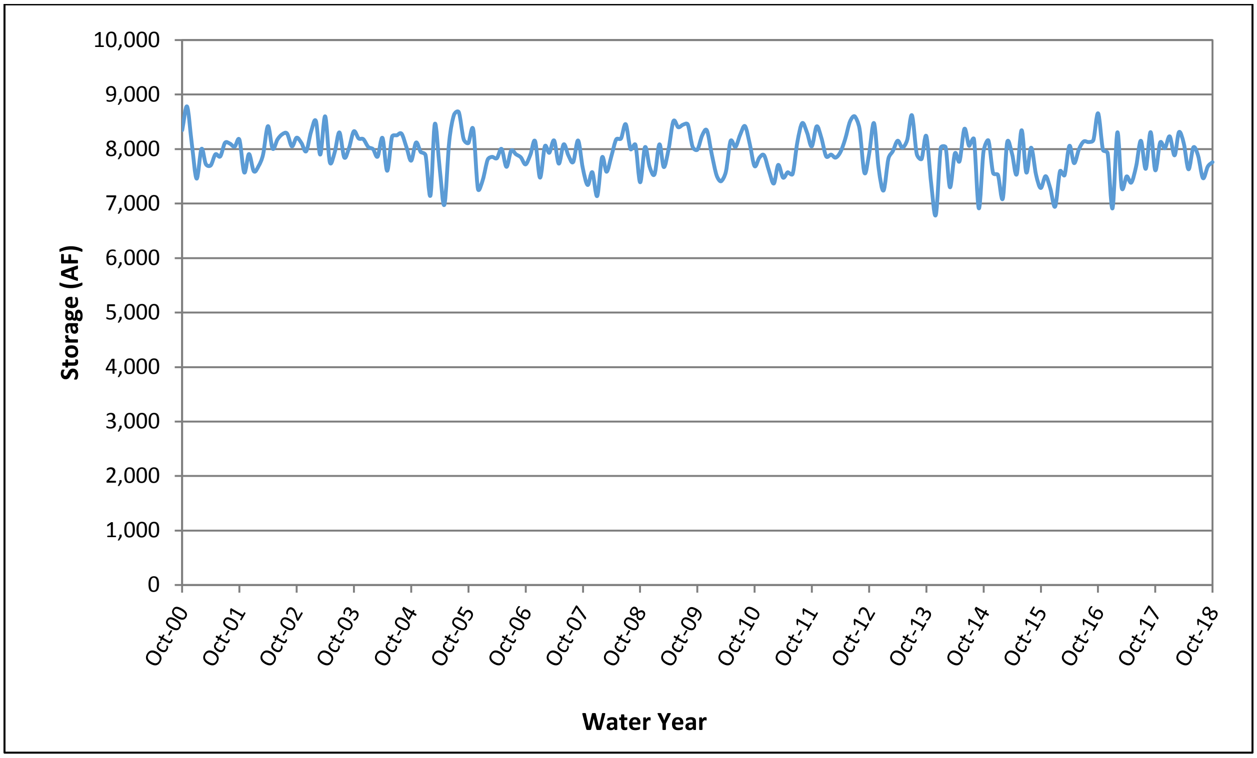


Figure A.3-23. Lake Natoma Storage

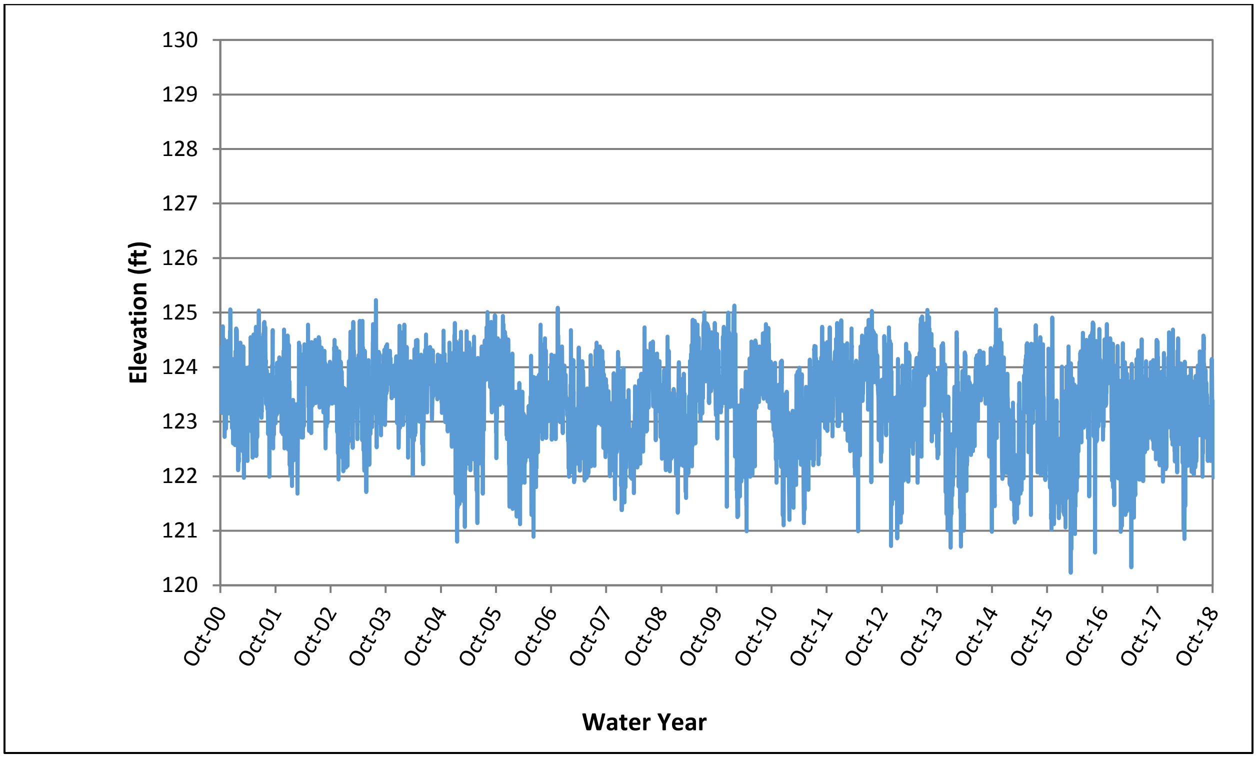


Figure A.3-24. Lake Natoma Elevation

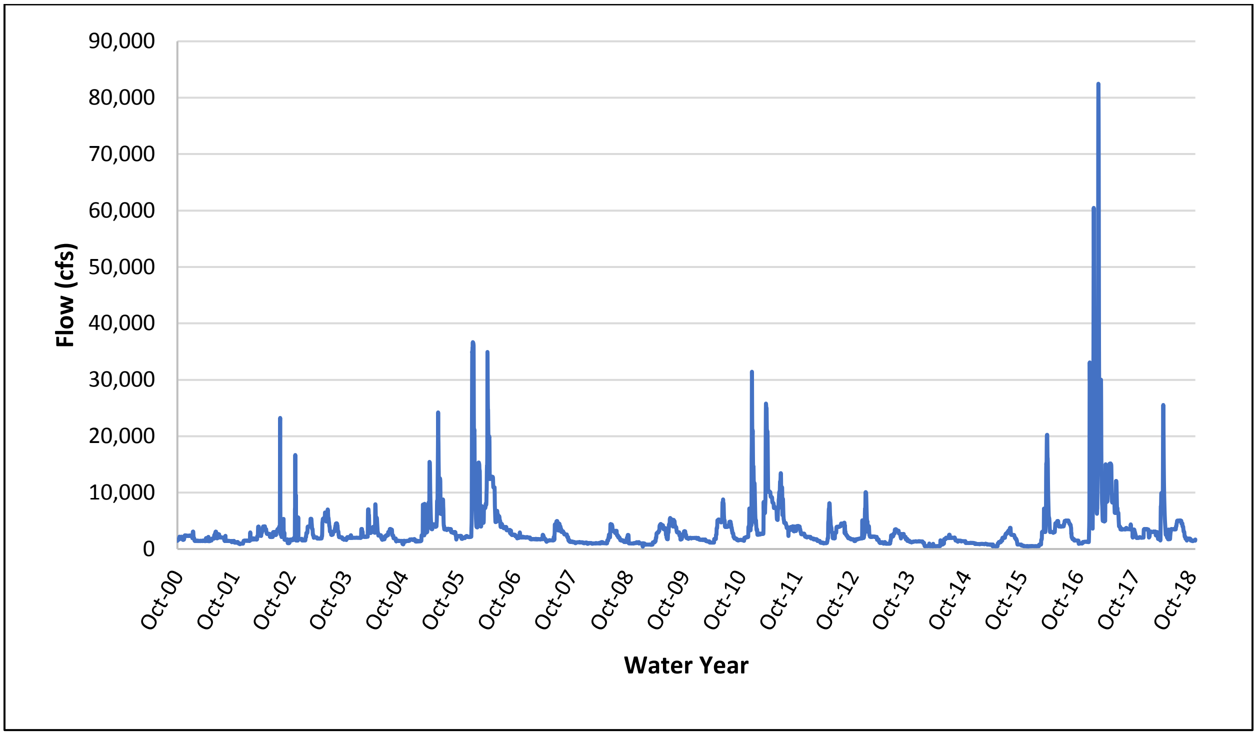


Figure A.3-25. American River at Fair Oaks

A.3.7.1.4 Diversion Management

The American River Operations Group (ARG) is a public forum consisting of Reclamation, fisheries agencies, and other interested parties. Since 1996 the group has provided input on a number of operational issues and has served as a discussion forum for topics such as adaptively managing releases, including flow fluctuation and stability, and managing water temperatures in the Lower American River to meet the needs of salmon and steelhead.

Water is diverted to municipal and industrial water users, including water rights holders, upstream of Folsom Dam, from the Folsom South Canal, and from the American River downstream of Folsom Dam. During recent critically dry years it was feared that water elevations in Folsom Lake would become too low for adequate operation of diversion facilities; as a precaution Reclamation provided temporary barges with intake and conveyance facilities to divert water from the lake to the adjacent water users. To date the barges have not been necessary to provide water conveyance.

A.3.7.2 *Operations in the Lower American River*

Releases to the lower American River are governed by multiple factors. Minimum releases are set based on the Flow Management Study (FMS) Minimum River Release (MRR). Releases above the MRR can be required for many reasons; instream temperature control, releases to help meet delta outflow or salinity requirements, flood control releases and export needs. Recent mean daily flows in the American River are presented on Figure XX (DWR 2013ak).

A.3.7.2.1 Flood Control

A.3.7.2.1.1 Historical Perspective

Flood control requirements and regulating criteria for October 1 through May 31 are specified by the USACE and described in the Folsom Dam and Lake, American River, California Water Control Manual (U.S. Army Corps of Engineers 1987). Flood control objectives for the Folsom unit require that the dam and lake be operated to:

- Protect the City of Sacramento and other areas within the Lower American River floodplain against reasonable probable rain floods.
- Control flows in the American River downstream from Folsom Dam to existing channel capacities, insofar as practicable, and reduce flooding along the lower Sacramento River and in the Delta in conjunction with other CVP Projects.
- Provide the maximum amount of water conservation storage without impairing the flood control functions of the reservoir.
- Provide the maximum amount of power practicable and be consistent with required flood control operations and the conservation functions of the reservoir.

From June 1 through September 30, no flood control storage restrictions exist. From October 1 through November 16 and from April 20 through May 31, reserving storage capacity for flood control is a function of the date only, with full flood reservation capacity required from November 17 through February 7. Beginning February 8 and continuing through April 20, flood reservation capacity is a function of both date and current hydrologic conditions in the basin.

If the inflow into Folsom Reservoir causes the water elevation to encroach into the capacity reserved for flood control, releases from Nimbus Dam are increased. Flood control regulations prescribe the following releases when water is stored within the flood control reservation space.

- Maximum inflow (after the storage entered into the flood control reservation space) of as much as 115,000 cfs, but not less than 20,000 cfs, when inflows are increasing.
- Releases would not be increased more than 15,000 cfs or decreased more than 10,000 cfs during any two-hour period.
- Flood control requirements override other operational considerations in the fall and winter period. Consequently, short-term changes in river releases may occur.

Since 1996, Reclamation has operated according to modified flood control criteria, which reserve 400 to 670 TAF of flood control space in Folsom Reservoir in combination with empty reservoir space in Hell Hole, Union Valley, and French Meadows, to be treated as if it were available in Folsom Reservoir. This flood control plan, which provides additional protection for the Lower American River, is implemented through an agreement between Reclamation and SAFCA. The terms of the agreement allow some of the empty reservoir space in Hell Hole, Union Valley, and French Meadows to be treated as if it were available in Folsom Reservoir.

Following significant flood events in February 1986 and January 1997, the lower American River flooding issues were analyzed; and revised flood operations criteria were developed by the Sacramento Area Flood Control Agency (SAFCA). The SAFCA release criteria are generally equivalent to the USACE plan, except the SAFCA diagram may prescribe flood releases earlier than the USACE plan. The SAFCA diagram also relies on Folsom Dam outlet capacity to make the earlier flood releases. The outlet capacity at Folsom Dam is currently limited to 32,000 cfs based on lake elevation. However, in general the SAFCA plan diagram provides greater flood protection than the existing USACE plan for communities in the American River floodplain.

Required flood control space under the SAFCA diagram begins to decrease on March 1. Between March 1 and April 20, the rate of filling is a function of the date and available upstream space. As of April 21, the required flood reservation is about 225 TAF. From April 21 to June 1, the required flood reservation is a function of the date only, with Folsom Reservoir storage permitted to fill completely on June 1.

A.3.7.3 *Current Status*

Reclamation and USACE constructed an auxiliary spillway under the Joint Federal Project, at Folsom Dam in accordance with the recommendations of the Water Control Manual Update (Reoperation Study). The USACE is also implementing increased system capabilities provided by the authorized features of the Common Features Project to strengthen the American River levees to convey up to 160,000 cfs and completion of the authorized Folsom Dam Mini-Raise Project. The spillway work is complete and the facility has been transferred to Reclamation for operation and maintenance. This spillway allows Reclamation to release higher flows for flood control purposes while the reservoir storage is lower than we were previously able to do. This should help reduce peak releases from moderate events by allowing us to release earlier in the event thus preventing reservoir storage from encroaching significantly into the flood control pool.

USACE (and Reclamation as the National Environmental Policy Act [NEPA] cooperating agency) has completed a Folsom Dam Reoperation Study to develop, evaluate, and recommend changes to the flood control operations of the Folsom Dam project that would further the goal of reduced flood risk for the Sacramento area. Operational changes may be necessary to fully realize the flood risk reduction benefits of the additional operational capabilities created by completion of the Joint Federal Project, and the increased system capabilities provided by the implemented and authorized features of the Common Features Project (a project being carried out by USACE and designed to strengthen the American River levees so they can safely pass a flow of 160,000 cfs); and those anticipated to be provided by completion of the authorized Folsom Dam MiniRaise Project. The Folsom Dam Reoperation Study considers improved forcasts from the National Weather Service. USACE, in cooperation with Reclamation (and DWR as the California Environmental Quality Act [CEQA] lead and SAFCA as the local partner), is consulting with USFWS and NMFS relative to any changes to American River and/or system-wide CVP operations that may result.

The new Water Control Manual (WCM) utilizes forecasted inflow as the criteria for determining flood control releases. There are criteria for total forecasted inflow on a 5 day out, 3 day out, 2 day out, and 1 day out basis. This is a first of its kind flood control diagram. Historically the flood control diagrams were based on current storage and current inflows to the reservoir, with a resulting action specified. Our new manual looks ahead five days and considers the forecasted inflow volume for the total of those five days. If that volume exceeds a threshold, a flood control release is specified. This is being termed a “blue sky release” because the release may occur before rainfall begins. The concept is to pre-emptively draw the reservoir down in anticipation of high inflows, thus providing space to store the rain event when it arrives. This will allow Reclamation to pass higher precipitation events with lower peak releases which relieves stress on the downstream levees and provides a higher level of flood protection to downstream areas.

The WCM is complete, the USFWS and NMFS are currently providing biological reviews of the WCM. At this time, Reclamation is operating to the new WCM under a temporary one year order from the USACE.

Additional information related to the flood control criteria for Folsom Dam operations is included by reference to documents prepared by the USACE and SAFCA.

A.3.7.3.1 American River Flows to Meet Delta Salinity Requirements

Folsom Reservoir is also operated by Reclamation to release water to help meet Delta salinity and flow objectives established to improve fisheries conditions. Weather conditions combined with tidal action and local accretions from runoff and return flows can quickly affect Delta salinity conditions and require increases in Delta inflow to maintain salinity standards, as described below. In accordance with Federal and state regulatory requirements, the CVP and SWP are frequently required to release water from upstream reservoirs to maintain Delta water quality. Because Folsom Lake is located closer to the Delta than Lake Oroville and Shasta Lake, if the need for salinity control is immediate, releases may be made first from Folsom Reservoir. As water from the other reservoirs arrives in the Delta, Folsom Reservoir releases can be reduced. In general however, as the CVP is operated as an integrated project, releases to meet downstream needs are sourced from multiple locations, e.g. both Shasta Reservoir and Folsom Reservoir, and SWP contributions from Lake Oroville. Water released from Lake Oroville and Shasta Lake generally reaches the Delta in approximately three and five days, respectively. Travel time is taken into consideration when release decisions are made as part of operating as an integrated project.

A.3.7.3.2 Fish and Wildlife Requirements in the Lower American River

A.3.7.3.2.1 Flow Requirements

The minimum allowable flows in the Lower American River are defined by SWRCB Water Right Decision 893 (D-893), which states that, in the interest of fish conservation, releases should not ordinarily fall below 250 cfs between January 1 and September 15 or below 500 cfs at other times. D-893 minimum flows are rarely the controlling objective of CVP operations at Nimbus Dam. Nimbus Dam releases are nearly always controlled during significant portions of a water year by either flood control requirements or are coordinated with other CVP and SWP releases to meet downstream SWRCB WQCP requirements and CVP water supply objectives. Power regulation and management needs occasionally control Nimbus Dam releases. Nimbus Dam releases are expected to exceed the D-893 minimum flows in all but the driest of conditions.

In July 2006, Reclamation, the Sacramento Area Water Forum and other stakeholders completed a draft technical report establishing a flow and temperature regime intended to improve conditions for fish in the lower American River (i.e., the Lower American River Flow Management Standard [FMS]). Minimum flow requirements during October, November, and December are primarily intended to address fall-run Chinook Salmon spawning, and flow requirements during January and February address fall-run Chinook Salmon egg incubation and steelhead spawning. From March through May, minimum flow requirements are primarily intended to facilitate steelhead spawning and egg incubation, as well as juvenile rearing and downstream movement of fall-run Chinook Salmon and steelhead. The June through September flows are designed to address over-summer rearing by juvenile steelhead, although this period partially overlaps with adult fall-run Chinook Salmon immigration. Reclamation began operating to the FMS immediately thereafter.

Reclamation proposes to meet water rights, contracts and agreements that are both specific to the American River Division as well as those that apply to the entire CVP, including the Delta Division. For lower American River flows (below Nimbus Dam), Reclamation proposes to adopt the minimum flow schedule and approach proposed by the Water Forum in 2017. Flows range from 500 to 2000 cfs based on time of year and annual hydrology. The flow schedule is intended to improve cold-water pool and habitat conditions for steelhead and fall-run Chinook Salmon. Specific flows are determined using an index intended to define the current and recent hydrology. Although Reclamation has assumed the index proposed by the Water Forum in 2017 for the purposes of modeling and analysis within this biological assessment, Reclamation intends to continue discussions with the Water Forum to ensure the index used for implementation is appropriate to meet the intended objectives under continuously changing hydrology.

Reclamation proposes to work together with the American River Stakeholders to define an appropriate amount of storage in Folsom Reservoir that represents the lower bound for typical forecasting processes at the end of calendar year (the "planning minimum"). The objective of the planning minimum is to preserve storage to protect against future drought conditions and to facilitate the development of the cold water pool when possible. This planning minimum will be a single value (or potentially a series of values for different hydrologic year types) to be used for each year’s forecasting process into the future. The objective of incorporating the planning minimum into the forecasting process is to provide releases of salmonid-suitable temperatures to the lower American River and reliable deliveries (using the existing water supply intakes and conveyance systems) to American River water agencies that are dependent on deliveries or releases from Folsom Reservoir. This planning minimum is expected to be initially defined in 2019; however, it will be continuously evaluated between Reclamation and the Water Forum throughout implementation.

Reclamation expects infrequent scenarios where the forecasted storage may fall below the “planning minimum” due to a variety of circumstances and causes. In those instances, Reclamation and the American River stakeholders will develop a list of potential off-ramp actions that may be taken to either improve forecasted storage or decrease demand on Folsom Reservoir. In its forecasting process for guiding seasonal operations, Reclamation will plan to maintain or exceed the planning minimum at the end of the calendar year. When Reclamation estimates, using the forecasting process, that it would not be able to maintain Folsom Reservoir storage at the end-of-December “planning minimum” for that year type (such as in extreme hydrologic conditions) or unexpected events cause the storage level to be at risk, American River Division contractors would coordinate with Reclamation to identify and implement appropriate actions to improve forecasted storage conditions, and the American River stakeholders would work together to educate the public on the actions that have been agreed upon and implemented and the reasons and basis for them. If potential changes to Folsom Dam operations would have impacts on other aspects of the CVP and SWP or the entire integrated system, Reclamation will meet and discuss these potential changes and impacts with water contractors. Reclamation would ramp down to the revised minimum flows from Folsom Reservoir as soon as possible in the fall and maintain these flows, where possible.

As part of implementing the 2017 Flow Management Standard, Reclamation proposes redd dewatering protective adjustments to limit potential redd dewatering due to reductions in the minimum release during the January through May period. Redd dewatering protective adjustments should limit the amount of dewatering due to a reduction of the minimum release, not the actual river release, and, as such, would not always minimize dewatering impacts to the same extent. Reclamation proposes to not reduce flows more than 500 cfs/day and not more than 100 cfs per hour except if necessary for flood control operations. Reclamation will minimize releases above 4000 cfs during sensitive life stages (e.g, eggs, incubation, rearing) of salmonids and steelhead to the extent feasible.

To the extent practicable, Reclamation proposes to accommodate requests for spring pulse flows by re-shaping previously planned releases; however, these requests will not be accommodated in times when they may compromise temperature operations later in the year. Reclamation proposes to follow the 2017 Flow Management Standard, which includes a pulse flow event at some time during the period extending from March 15 to April 15 by supplementing normal operational releases from Folsom Dam under certain conditions when no such flow event has occurred between the preceding February 1 and March 1 time frame. This spring pulse flow provides a juvenile salmonid emigration cue before relatively low flow conditions and associated unsuitable thermal conditions later in the spring, and downstream in the lower Sacramento River.

A.3.7.3.2.2 Water Temperature Requirements

The current objectives for water temperatures in the Lower American River address the needs for steelhead incubation and rearing during the late spring and summer, and for fall–run Chinook Salmon spawning and incubation starting in late October or early November.

Water temperature control operations in the Lower American River are affected by many factors and operational tradeoffs. These include available cold-water resources, Nimbus release schedules, annual hydrology, Folsom power penstock shutter management flexibility, Folsom Dam Urban Water Supply TCD management, and Nimbus Hatchery considerations. Shutter and TCD management provide the majority of operational flexibility used to control downstream temperatures.

Selective withdrawal capability on the Folsom Dam Urban Water Supply Pipeline (also known as the M&I TCD) became operational in 2003. A telescoping control gate allows for selective withdrawal of water to provide additional flexibility to conserve cold water for downstream use. The TCD is operated during the summer months and delivers water that is slightly warmer than that which could be used to meet downstream requirements, but not so warm as to cause significant treatment issues.

During the late 1960s, Reclamation designed a modification to the trashrack structures to provide selective withdrawal capability at Folsom Dam through the Folsom Power Plant.

The steel trashracks are now equipped with three groups of shutters that allow operators to pull water from various elevations, which are different temperatures when the lake is stratified. The shutters can be different at different locations on each of the three penstocks, allowing operators to blend water at different temperatures to meet downstream requirements.

Only in wetter hydrologic conditions is the volume of cold water sufficient to meet the majority of the water temperature objectives. Therefore, significant operations tradeoffs and flexibilities are part of an annual planning process for coordinating an operation strategy that realistically manages the limited cold-water resources available.

Reclamation proposes to prepare a draft Temperature Management Plan by May 1 for the summer through fall temperature management season using the best available (as determined by Reclamation) decision support tools. The information provided by the Operations Forecast will be used in the development of the Temperature Plan. The draft plan will contain: (1) forecasts of hydrology and storage; and (2) a modeling run or runs, using these forecasts, demonstrating what temperature compliance schedule can be attained. Reclamation will use an iterative approach, varying shutter configurations, with the objective to attain the best possible temperature schedule for the compliance point at Watt Avenue Bridge. The draft plan will be shared with the American River Group (ARG) before finalization, and may be updated monthly based on system conditions.

Reclamation proposes to manage the Folsom/Nimbus Dam complex and the water temperature control shutters at Folsom Dam to maintain a daily average water temperature of 65°F (or other temperature as determined by the temperature modeling) or lower at Watt Avenue Bridge from May 15 through October 31, to provide suitable conditions for juvenile steelhead rearing in the lower American River. If the temperature is exceeded for three consecutive days, Reclamation will notify NMFS and outline steps being taken to bring the water temperature back into compliance. During the May 15 to October 31 period, if the Temperature Plan defined temperature requirement cannot be met because of limited cold water availability in Folsom Reservoir, then the target daily average water temperature at Watt Avenue may be increased incrementally (i.e., no more than one degree Fahrenheit every 12 hours) to as high as 68°F. The priority for use of the lowest water temperature control shutters at Folsom Dam shall be to achieve the water temperature requirement for listed species (i.e., steelhead), and thereafter may also be used to provide cold water for fall-run Chinook salmon spawning.

A.3.7.3.2.3 Hatchery Concerns

Reclamation owned Nimbus Fish Hatchery, located just downstream of Nimbus Dam, is a mitigation facility that produces Chinook Salmon and Steelhead. A fish diversion weir at the hatchery blocks Chinook Salmon from continuing upstream and guides them to the hatchery fish ladder entrance. Installing the weir requires flows to be lowered for less than a week in early to mid-September. The hatchery also has water temperature concerns, especially June through September. Reclamation considers the Nimbus Fish Hatchery needs when balancing the cold-water pool for fish spawning in the river during fall.

A.3.7.3.2.4 Delta Needs

Folsom Reservoir can be operated to release water to meet Delta water quality and flow objectives to improve fisheries conditions, including releases for salinity objectives. When Delta needs require an increase upstream reservoir releases, then Folsom Reservoir often releases first because the released water would reach the Delta (in about one day) before flows released from other CVP and SWP reservoirs would get there. Lake Oroville water releases require about 3 days to reach the Delta, while water released from Shasta Lake requires 5 days to travel from Keswick Reservoir to the Delta. As water from the other reservoirs arrives in the Delta, Folsom Reservoir releases can be adjusted downward. . It should be noted that Folsom Reservoir does not always release first for anticipated Delta needs. The CVP is operated as in integrated project, and releases from Shasta and Folsom are coordinated with releases from Oroville for the SWP contribution to meeting Delta standards. Many factors are considered when making a determination of which reservoir to release from first. Current storage, current releases, temperature control objectives, cold water pool volume in all reservoirs, COA balance, and anticipated future demands are all considered when determining which reservoir(s) to release from, and how much to release from each reservoir.

The real-time implementation of flow objectives and meeting SWRCB D-1641 Delta standards with the limited water resources of the Lower American River requires a significant coordination effort to manage the cold-water resources at Folsom Dam and Reservoir. Reclamation consults with USFWS, NMFS, and CDFW through ARG when these types of difficult decisions are needed.

A.3.7.3.2.5 Water Delivery Requirements

American River allocations to contractors and water settlement contractors is a function of storage in Folsom Reservoir and projected inflow for the water year. Default allocation is 100 percent, unless forecasted end of September storage is so low that the system would not be support that allocation. During the recent drought period, many M & I contractors on the American River were allocated what is referred to as Health and Safety allocations, this is a minimal amount that will maintain all essential functions, with rationing imposed.

A.4 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, along 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 from 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 westward 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 Rage 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 also contribute substantial flows into the San Joaquin Valley and affect operations of CVP and SWP water users and operations.

A.4.1 San Joaquin River

The San Joaquin River flows 100 miles from Friant Dam to the Delta. Flows in the upper San Joaquin River are regulated by the CVP Friant Dam which forms Millerton Lake. Flows downstream of Friant Dam are influenced by flows from tributary rivers and streams, as described below; including CVP operations of New Melones Reservoir on the Stanislaus River.

A.4.1.1 *Millerton Lake*

Friant Dam is a concrete gravity structure located on the San Joaquin River, 25 miles northeast of Fresno where the San Joaquin River exits the Sierra foothills and enters the valley. Several reservoirs in the upper portion of the San Joaquin River watershed, including Mammoth Pool and Shaver Lake, affect the inflow to Millerton Lake.Millerton Lake provides flood control capacity on the San Joaquin River, provides downstream releases to meet senior water rights requirements above Mendota Pool, and provides conservation storage as well as diversion into Madera and Friant-Kern Canals.

Millerton Lake has a volume of 524 TAF, a surface area of 4,905 acres, and an elevation of 580.6 feet above msl (NAVD 1988) (elevation 580.6) at top of active storage (Reclamation 2008). The flood pool elevation is 587.6 while the maximum observed water surface elevation was 583, experienced during the January 1997 flood. Recent water storage volumes and elevations for Water Years 2001 through 2018 in Millerton Lake are presented on Figures A.4-1 through A.4-2 (DWR 2018ae, 2018af). Outflow from Millerton Lake for these Water Years is presented in Figure A.4-3 (DWR 2018ag).

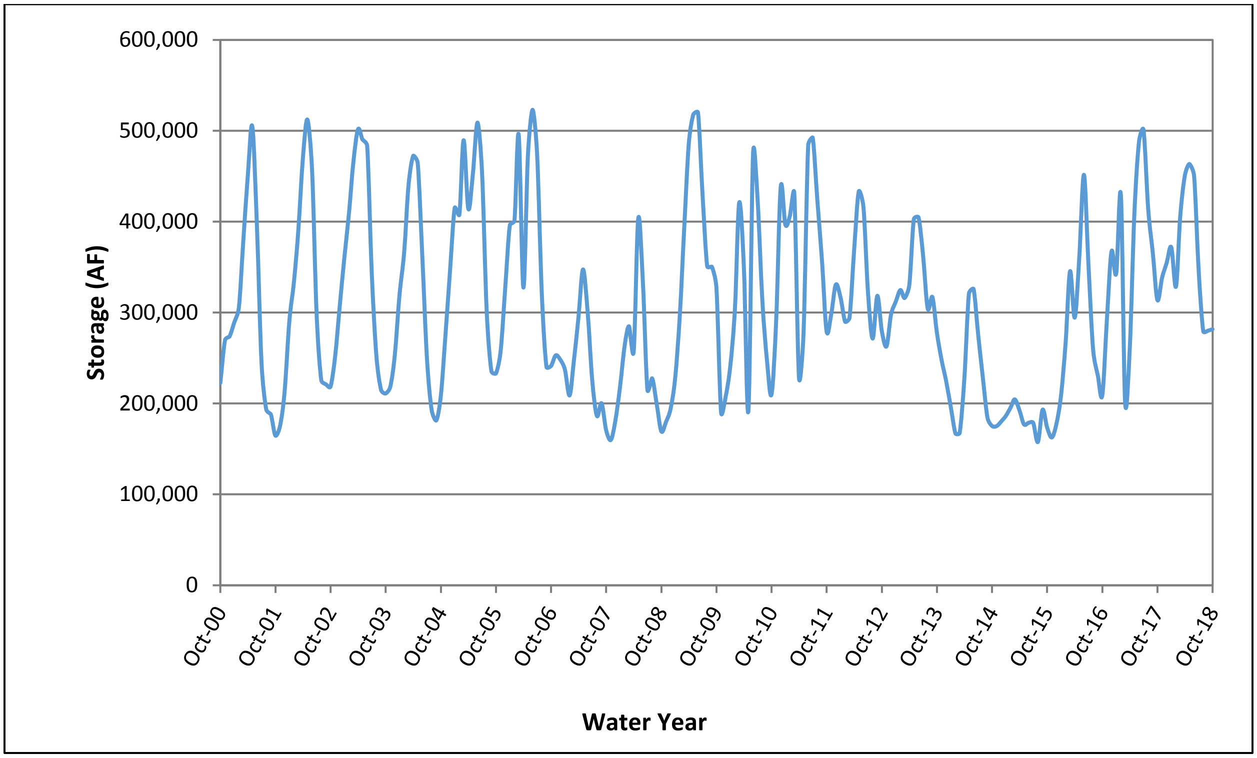


Figure A.4-1. Millerton Lake Storage

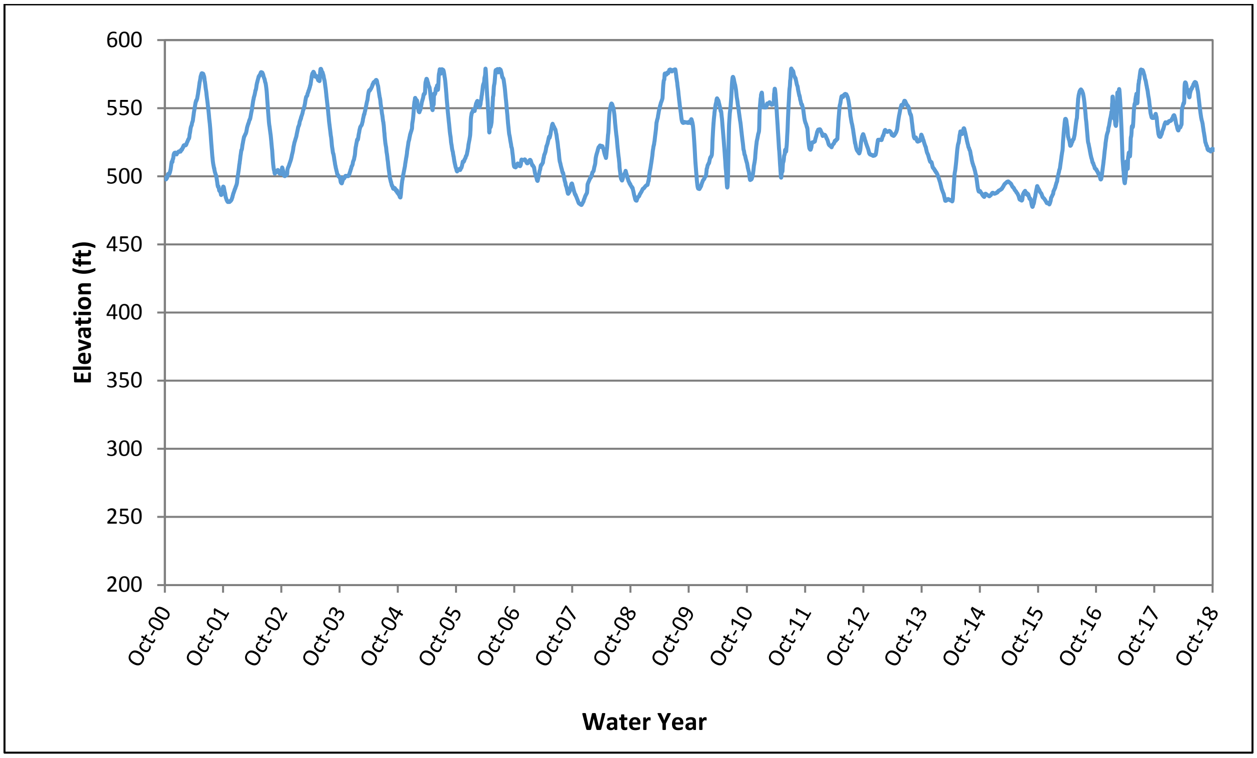


Figure A.4-2. Millerton Lake Elevation

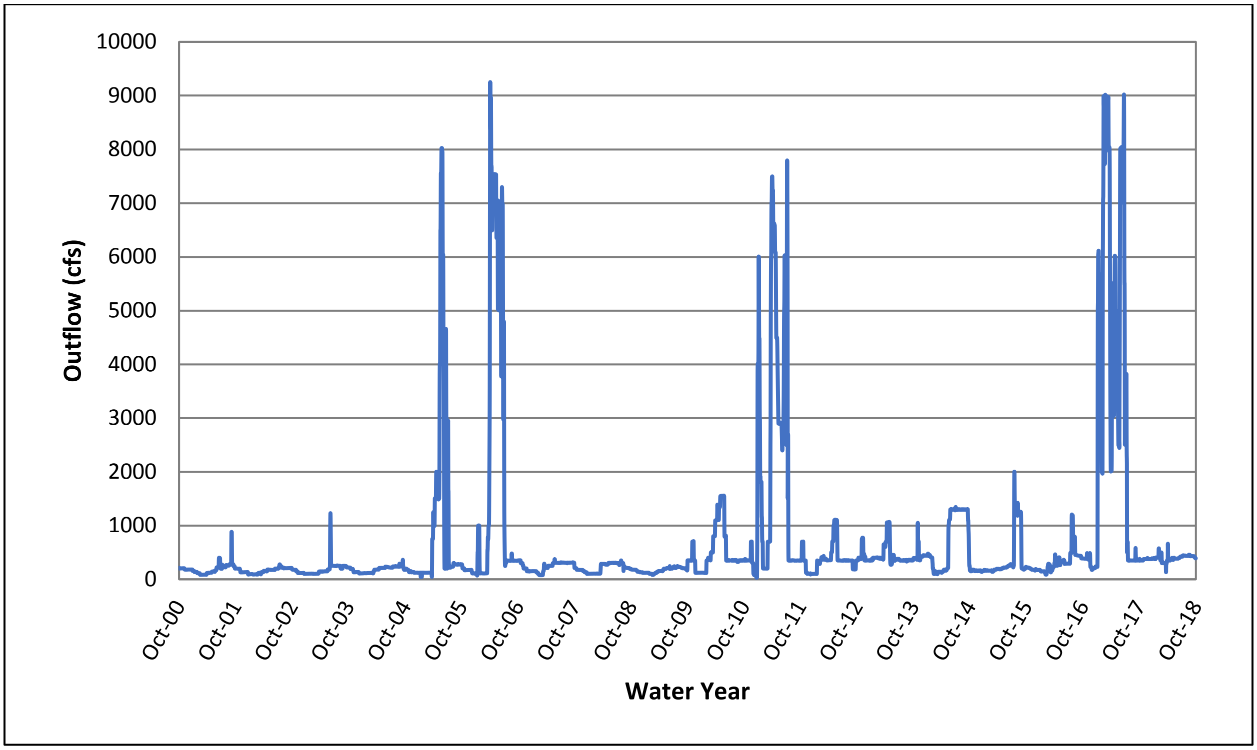


Figure A.4-3. Millerton Lake Outflow

The minimum operating storage of Millerton Lake is 130 TAF, resulting in active available conservation storage of about 390 TAF. The minimum operating storage allows for diversion from dam outlets to the Friant-Kern canal (elevation 466.6), Madera canal (elevation 448.6), and the San Joaquin River (elevation 382.6). The reservoir has three small dikes to close low areas along the reservoir rim, one of which is located in the Millerton Lake SRA. Millerton Road, a two-lane paved secondary highway, passes over these dikes.

Friant Dam is the principal flood damage reduction facility on the San Joaquin River and is operated to maintain combined releases to the San Joaquin River at or below a flow objective of 8,000 cfs. Several flood events in the past few decades have resulted in flows greater than 8,000 cfs downstream from Friant Dam and, in some cases, flood damages resulted. Flood control storage space in Millerton Lake is based on a complex formula, which considers storage in upstream reservoirs, forecasted snowmelt, and time of year. Flood management releases occur approximately once every 3 years and are managed based on downstream channel design capacity to the extent possible.

A.4.1.2 *San Joaquin River Restoration Program: Friant Dam to Confluence of Merced River*

In 2006, parties to NRDC, et al., v. Rodgers, et al., executed a stipulation of settlement that called for a comprehensive long-term effort to restore flows to the San Joaquin River from Friant Dam to the confluence of the Merced River and a self-sustaining Chinook Salmon fishery while reducing or avoiding adverse water supply impacts. The SJRRP implements the settlement consistent with the San Joaquin River Restoration Settlement Act in Public Law 111-11. The USFWS issued a Programmatic BO for the implementation of the SJRRP on August 21, 2012 and NMFS issued a Programmatic BO on September 18, 2012 for SJRRP flow releases of up to 1,660 cfs from Millerton Lake into the San Joaquin River. The settlement-required flow targets for releases from Millerton Lake include six water year types for releases depending upon available water supply as measures of inflow to Millerton Lake. The Millerton Lake releases include the flexibility to reshape and retime releases forwards or backwards by 4 weeks during the spring and fall pulse periods. Flood flows may potentially occur and meet or exceed the Settlement flow targets. If flood flows meet the settlement flow targets, then Reclamation would not release additional water from Millerton Lake. The San Joaquin River channel downstream of Friant Dam currently lacks the capacity to convey flows to the Merced River and releases are limited accordingly.

The San Joaquin River Restoration Program Restoration Area includes five distinct reaches of the San Joaquin River and portions of the flood management system (Figure XX.39): Reach 1: Friant Dam to Gravelly Ford, Reach 2: Gravelly Ford to Mendota Dam, Reach 3: Mendota Dam to Sack Dam, Reach 4: Sack Dam to Eastside Bypass Confluence, Reach 5: Eastside Bypass Confluence to Merced River, and Chowchilla, Eastside, and Mariposa Flood Bypasses. San Joaquin River flows from Water Years 2001 through 2018 at Gravelly Ford, near Dos Palos, near Washington Road, at Bifurcation Structiore, at Freemont Ford Bridge are presented in Figures A.4-4 through A.4-9 (DWR 2018ah, 2018ai, 2018aj; Reclamation 2018a, 2018b).

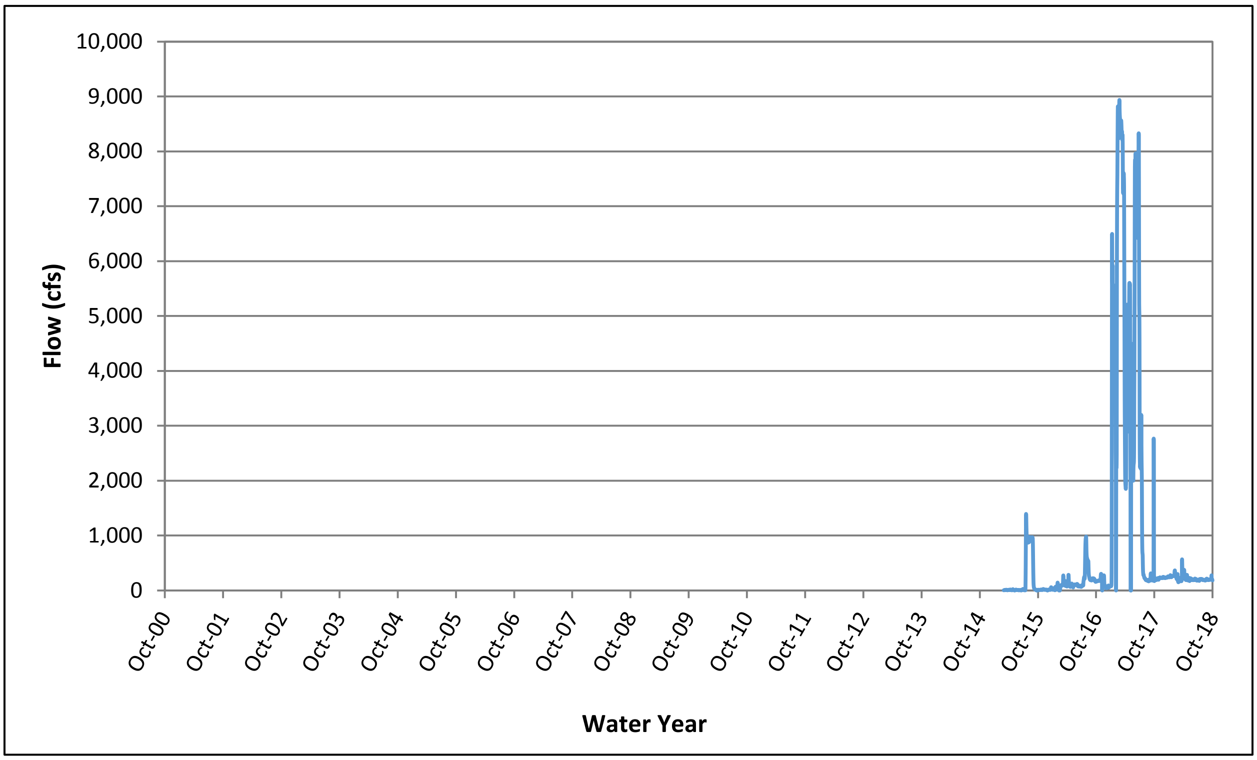


Figure A.4-4. San Joaquin River at Gravelly Ford

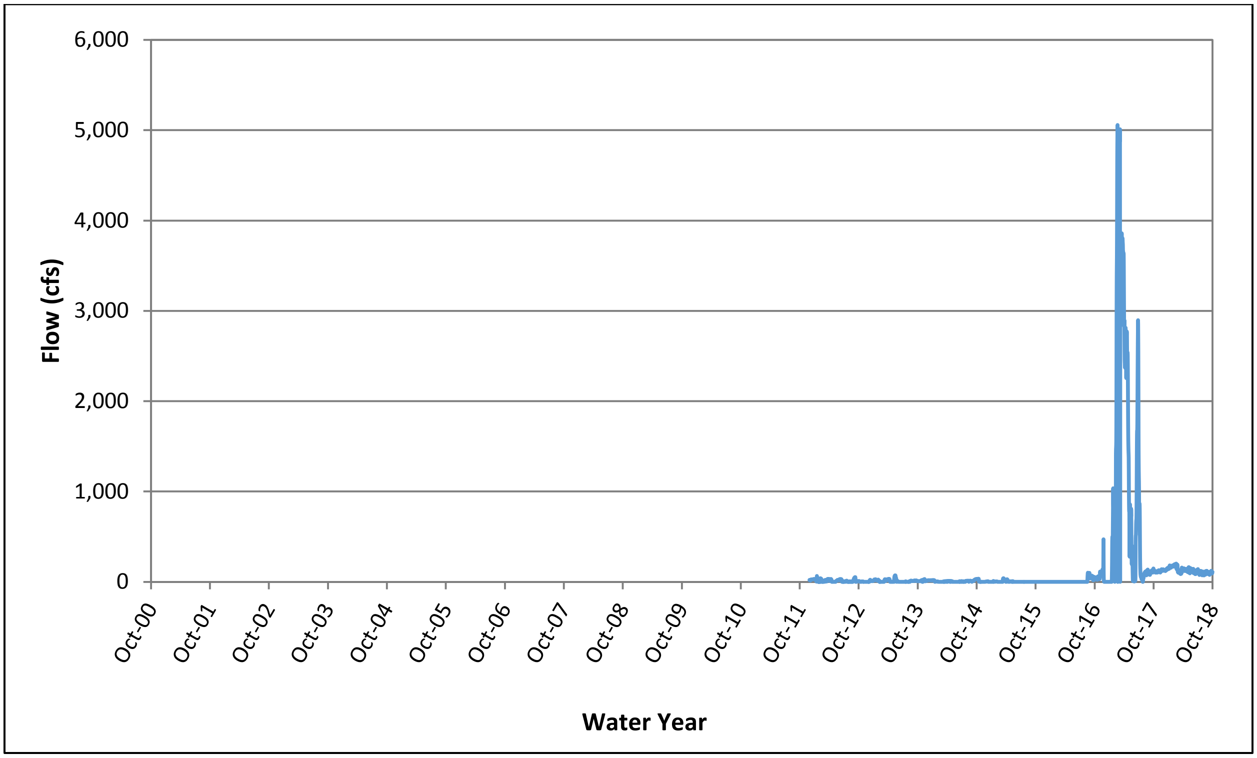


Figure A.4-5. San Joaquin River Near Dos Palos

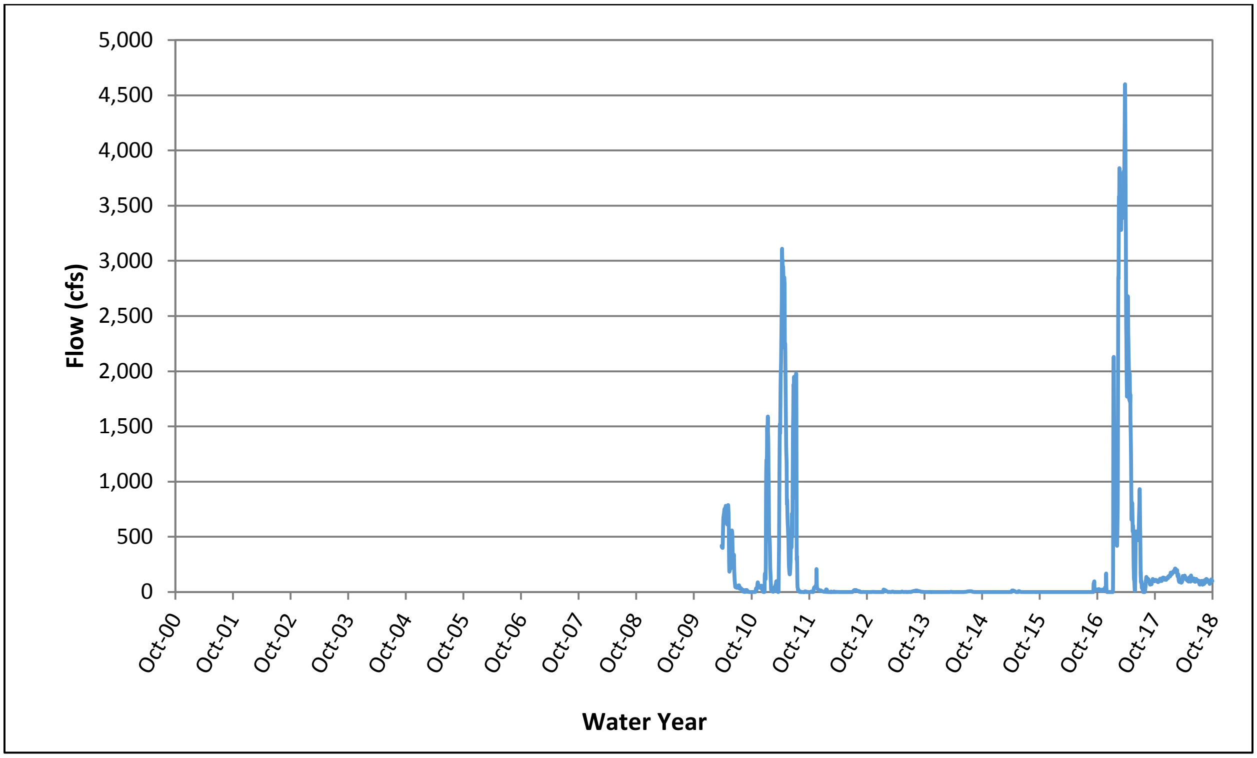


Figure A.4-6. San Joaquin River near Washington Rd (source: Reclamation QAQC Database)

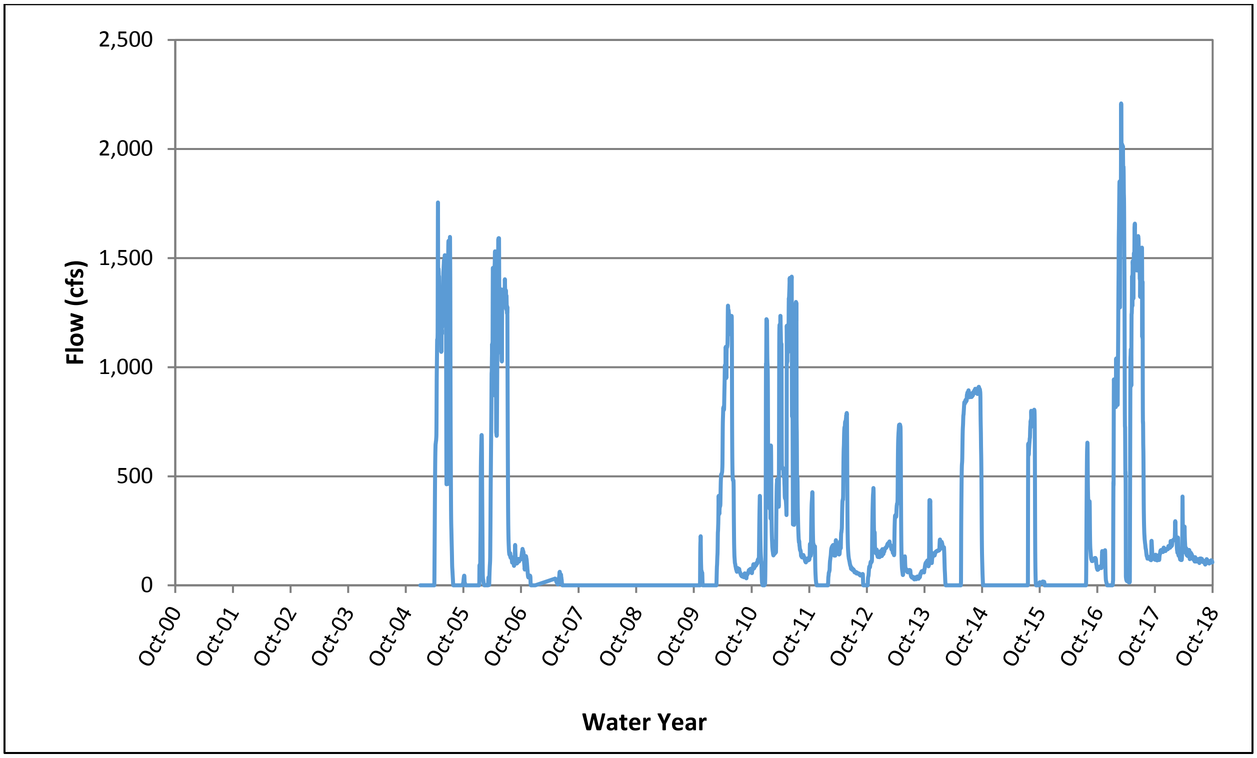


Figure A.4-7. San Joaquin River at Bifurcation Structure (source: Reclamation QAQC Database)

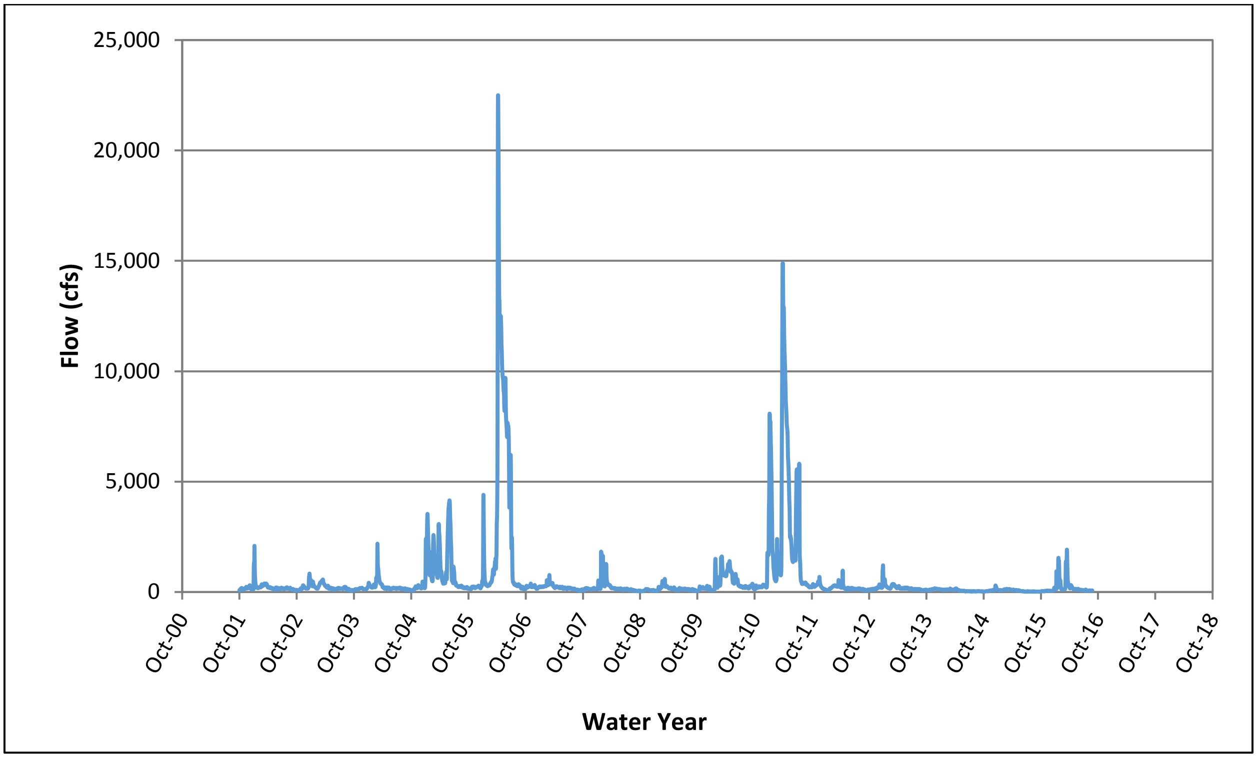


Figure A.4-8. San Joaquin River at Freemont Ford Bridge (source: Reclamation QAQC Database)

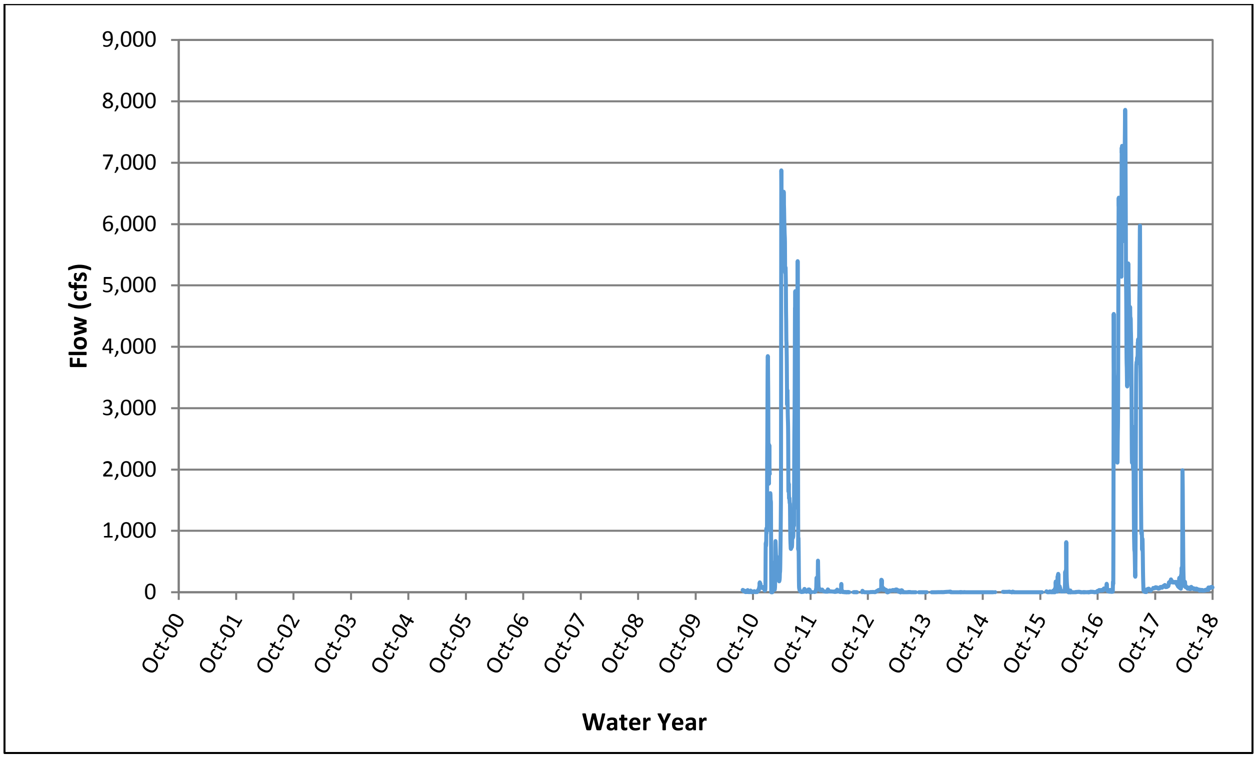


Figure A.4-9. Eastside Bypass Below Mariposa Bypass

A.4.1.2.1 Reach 1 – Friant Dam to Gravelly Ford

Reach 1 conveys continuous flows approximately 39 miles through an incised, gravel-bedded channel to Gravelly Ford, forming part of the boundary between Fresno and Madera counties. Releases are made at Friant Dam to comply with Holding Contract requirements along Reach 1. Streamflow of at least 5 cfs is maintained past the last diversion near Gravelly Ford, with no requirements for streamflow into Reach 2. Reach 1 is the only reach in the Restoration Area with exposed gravel and a river gradient suitable for Chinook salmon spawning. Extensive gravel mining in Reach 1A and the upper portion of Reach 1B has left many pits, some connected to the river, within the historical floodplain. An average of 117,000 acre-feet of water per year is released from Friant Dam into Reach 1 for riparian water users. Reach 1 is subdivided into two subreaches, 1A and 1B, at SR 99.

The objective release from Friant Dam into Reach 1 is 8,000 cfs. Reach 1 of the San Joaquin River is hydraulically connected to 190 acres of sand and aggregate mining pits, with an additional 1,170 acres of pits in the surrounding floodplain (McBain and Trush 2002). These pits can attenuate flow and increase evaporation through ponding. There are no storage facilities in Reach 1. Ten major road crossings in this reach can affect flow stage (McBain and Trush 2002). Agricultural return flows in Reach 1 are minor but have reached up to 300 cfs on occasion (EPA 2007). Stormwater runoff from the Fresno Metropolitan Area is managed by the Fresno Metropolitan Flood Control District. All but five of the District’s 161 drainage basins route stormwater to retention and detention facilities, limiting the urban surface runoff into Reach 1.

Reach 1A. Flows within Reach 1A are predominantly influenced by releases from Friant Dam, along with diversions and seepage losses. Mining pits in Reach 1 are primarily located in Reach 1A. Eighty-four water diversions are located along this reach, not all of which are active on a regular basis. Cottonwood Creek and Little Dry Creek, two intermittent streams, join the San Joaquin River in Reach 1A.

Cottonwood Creek, draining 35.6 square miles, flows in from the north near the base of Friant Dam. Little Dry Creek, draining 57.9 square miles, joins the San Joaquin River from the south approximately 8 miles downstream from Friant Dam. Flows in Little Dry Creek can be augmented from the Big Dry Creek flood control reservoir (McBain and Trush 2002). Flows from these two creeks must be included in the 8,000 cfs Reach 1A capacity limits when determining releases from Friant Dam.

Since 1949, Reclamation has made average annual releases of approximately 117 TAF from Friant Dam to the San Joaquin River to comply with Holding Contract requirements upstream from Gravelly Ford. Additional river flows occur during years when releases are made to the San Joaquin River for flood management purposes or for the San Joaquin River Restoration Program.

Reach 1B. Flows within Reach 1B are predominantly influenced by inflow from Reach 1A, diversions and seepage losses. Fifteen water diversions are located along this reach, not all of which are active on a regular basis.

A.4.1.2.2 Reach 2 – Gravelly Ford to Mendota Dam

Reach 2 marks the end of the incised channel and is a meandering channel of low gradient. Reach 2 meanders approximately 24 miles across the sandy alluvial fan of the San Joaquin River between Gravelly Ford and Mendota Dam and is subdivided into two subreaches, 2A and 2B, at the Chowchilla Bypass Bifurcation Structure. Reach 2 is typically dry; flows reach the Mendota Pool from Reach 2B or from the Fresno Slough only during periods of flood management releases. Flood flows in the San Joaquin and/or Kings rivers occurred at the Mendota Pool in 1997, 2001, 2005, 2006, 2011, and 2017. Additionally, flows released by the San Joaquin River Restoration Program have at times been recaptured in Mendota Pool due to downstream capacity constraints. At all other times, the DMC is the primary source of water to the Mendota Pool. The Mendota Pool provides no long-term storage for water supply operations or flood management. Reach 2 ends at Mendota Dam, and the Mendota Pool backwater extends up a portion of this subreach. The Mendota Pool delivers water to the San Joaquin River Exchange Contractors Water Authority, other CVP contractors, wildlife refuges and management areas, and State water authorities.

Reach 2A. Reach 2A is typified by the accumulation of sand caused in part by backwater effects of the Chowchilla Bypass Bifurcation Structure and by a lower gradient relative to Reach 1. Reach 2A has a design channel capacity of 8,000 cfs to accommodate controlled releases from Friant Dam. Under steady-state conditions (i.e., losses are calculated under extended periods of steady flow), flow does not reach the Chowchilla Bypass Bifurcation Structure when discharge at Gravelly Ford is less than 75 cfs (McBain and Trush 2002). Agricultural return flows within this reach are minor. Ten water diversions are located along this reach. Reach 2A has also been subject to local sand mining, although this has not caused the extensive channel degradation seen in Reach 1.

Reach 2B. Reach 2B is a sandy channel extending into the Mendota Pool. The design conveyance capacity of this reach is 2,500 cfs, but significant seepage has been observed at flows above 1,300 cfs (RMC 2007). The Mendota Pool Bypass and Reach 2B Project will expand the channel capacity of this reach. Agricultural return flows within this reach are minor. Reach 2B ends at Mendota Dam, and Mendota Pool backwater extends up a portion of this reach. Twenty-nine water diversions are located along this reach. One major road crossing in this reach can affect flow stage. The DMC typically conveys 2,500 to 3,000 cfs to the Mendota Pool during the irrigation season.

Mendota Dam. Mendota Dam, built in 1917, is owned and operated by the Central California ID. Mendota Dam is a flashboard and buttress dam 23 feet high and 485 feet long; the crest elevation is 168.5 17 feet. The Dam is located at the confluence of the San Joaquin River and Fresno Slough, serves as a forebay for diversions to the Main and Outside canals, and is the termination of the Delta-Mendota Canal, which conveys CVP water from the Delta. Fresno Slough connects the Kings River to the San Joaquin River and delivers water to the south from Mendota Pool during irrigation season and delivers water to the Mendota Pool and San Joaquin River from the Kings River when the Kings River is flooding. The 50-TAF Mendota Pool is a small reservoir, with approximately 8,500 acre-feet of storage, created by the 23-foot-high Mendota Dam (Reclamation 2004). The Mendota Pool does not provide any appreciable flood storage. The water surface elevation in the pool is maintained by a set of gates and flashboards that are manually opened/removed in advance of high-flow conditions. This process lowers the water level in the pool for passing high flows to reduce seepage impacts to adjacent lands but prevents diversions on Fresno Slough from the Delta-Mendota Canal and San Joaquin River flows. A fish ladder exists at Mendota Dam, but has been inoperable for the last several decades. The Mendota Pool Bypass and Reach 2B Project will provide fish passage around Mendota Pool.

Cyclically, the Mendota Pool fills with sediment during infrequent high-flow releases from Friant Dam. During times of high flows, some unknown portion of this sediment is able to flush and route downstream when flashboards have been pulled, restoring much of the Mendota Pool storage capacity. If the flashboards are not pulled before a high-flow event from either the San Joaquin River or Fresno Slough, the increased water surface elevations cause seepage problems on upstream and adjacent properties. Recent mean daily flows in the San Joaquin River at Mendota are presented on Figure A.4-10 (DWR 2018al).

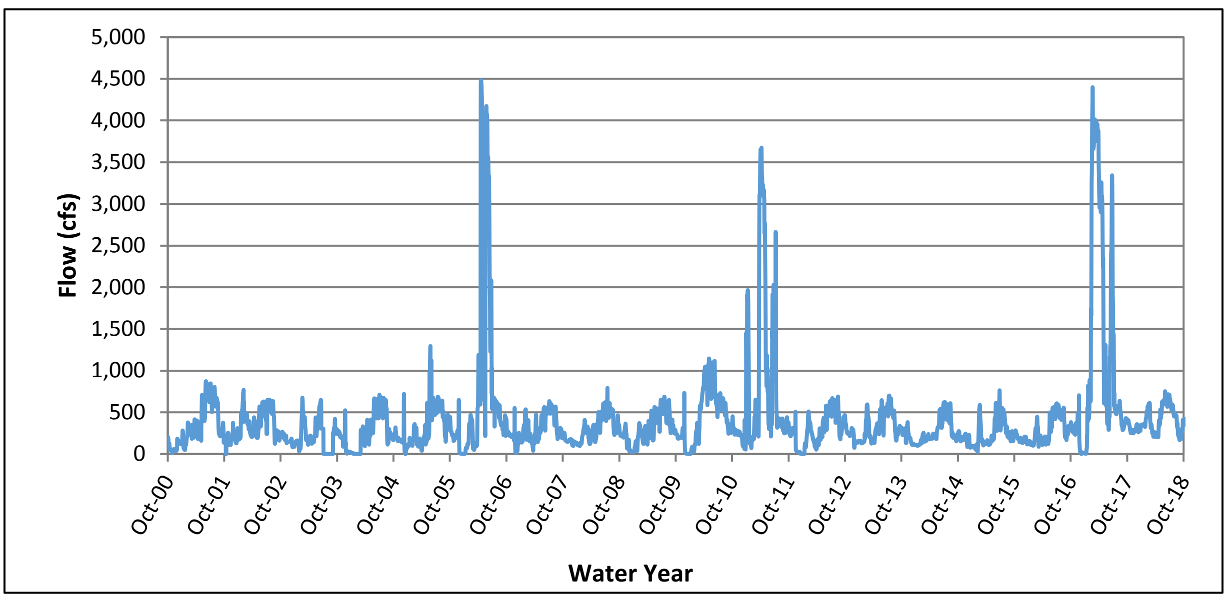


Figure A.4-10. San Joaquin River Near Mendota

A.4.1.2.3 Reach 3 – Mendota Dam to Sack Dam

Reach 3 begins at Mendota Dam and extends approximately 23 miles downstream to Sack Dam. Reach 3 conveys flows of up to 800 cfs from the Mendota Pool for diversion to the Arroyo Canal at Sack Dam, maintaining flow year-round in a meandering channel with a sandy bed. The Fresno Slough and Mendota Pool convey flood flows from the Kings River to this reach. Irrigation canals bound this reach for most of its length. In some portions, lands within the floodway are actively used for agricultural production and are protected by local or interior levees.

Reach 3 flows 23 miles along a sandy channel from Mendota Dam to Sack Dam. The design capacity of Reach 3 is 4,500 cfs; however, anecdotal evidence suggests that seepage and associated flooding may begin at sustained flows above 800 cfs (RMC 2007). The San Joaquin River Restoration Program is actively pursuing seepage easements and projects in this reach. Significant bed lowering has been measured within Reach 3; however, the extent of this lowering that is due to subsidence from groundwater overdraft, or to human-induced sediment and hydrology modification within the channel, is unknown (McBain and Trush 2002). Flows within this reach predominantly consist of water conveyed from the Delta by the DMC and released from the Mendota Pool for diversion.

Sack Dam is a 5-foot-high concrete and wood diversion structure delivering water to the Arroyo Canal on the west side of the river (RMC, 2003). No operational storage for water supply exists within this reach. The Arroyo Canal and Sack Dam Fish Passage Project of the San Joaquin River Restoration Program will screen Arroyo Canal and provide for fish passage over the site of Sack Dam. Flows of 500 to 600 cfs are typically released from the Mendota Pool for downstream diversions at Sack Dam. Flows greater than required for diversions (such as during flood events) spill over Sack Dam into the San Joaquin River downstream into Reach 4A. Seven water diversions are located in this reach. One major road crossing in this reach can affect flow stage.

A.4.1.2.4 Reach 4 – Sack Dam to Eastside Bypass Confluence

Reach 4 runs approximately 46 miles from Sack Dam to the confluence of the Eastside Bypass. Historically, flows within much of this reach were predominantly agricultural return flows, and large sections of this reach were dry. Since 2016, Restoration Flows have re-wet Reach 4A and Restoration Flows are maintained at low levels year-round.

Reach 4 is subdivided into three subreaches: 4A, 4B1, and 4B2. 4A begins at Sack Dam and extends to the Sand Slough Control Structure; 4B1 extends from the Sand Slough Control Structure to the Mariposa Bypass confluence; and 4B2 begins at the confluence of the Mariposa Bypass and extends to the confluence of the Eastside Bypass. The Sand Slough Control Structure controls the flow split between the mainstem San Joaquin River and Eastside Bypass. A headgate is also present at the entrance to Reach 4B1 of the San Joaquin River. Reach 4 subreaches have different characteristics and design capacities, as discussed below.

Reach 4A. The design channel capacity in this reach is approximately 4,500, beginning at Sack Dam and extending to the Sand Slough Control Structure. The channel below Sack Dam has flow during the agricultural season (agricultural return flows) and during upstream flood releases, in addition to Restoration Flows. Four water diversions are located along this reach. This subreach has experienced bed lowering similar to that discussed for Reach 3.

Reach 4B1. This reach has a design capacity of 1,500 cfs, and the Sand Slough Control Structure is designed to maintain this design discharge; although current operations recommend discharge past the control structure to be 300 to 400 cfs because of reduced capacity in the channel. Thus, actual operations keep the gates of the San Joaquin River headgates closed, diverting all flow from Reach 4B1 to the Eastside Bypass (McBain and Trush 2002). Reach 4B1, therefore, is dry until downstream agricultural return flows contribute to its baseflow, although this flow is often pumped and reused for irrigation.

Reach 4B2. The design channel capacity of Reach 4B2 is 10,000 cfs. The channel carries tributary and flood flows from the Mariposa Bypass. No operational storage for water supply exists within this reach. Two water diversions are located along this reach.

A.4.1.2.5 Reach 5 – Eastside Bypass Confluence to Merced River

Reach 5 of the San Joaquin River extends approximately 18 miles from the confluence of the Eastside Bypass downstream to the Merced River confluence. The design capacity of Reach 5 is 26,000 cfs; no significant capacity constraints have been identified in this reach. Reach 5 receives flow from Reach 4B2 and the Eastside Bypass. Agricultural and wildlife management area return flows also enter Reach 5 via Mud and Salt sloughs, which drain the west side of the San Joaquin Valley. Three major road crossings within this reach can affect flow stage. San Joaquin River Flood Control Project levees confine Reach 5. West bank levees end at Salt Slough while the east bank levees continue to the Merced River confluence. There are four water diversions in this reach.

A.4.1.2.6 Flood Bypasses – Chowchilla, Eastside, and Mariposa

The State constructed the San Joaquin River Flood Control Project which includes flood damage reduction structures and facilities within the Restoration Area. Construction of the original State system was initiated in 1959 and completed in 1966. These improvements were coordinated with the Federal Government to ensure the effectiveness of the Federal portion of the project. The bypass system consists primarily of man-made channels (Eastside, Chowchilla, and Mariposa bypasses), which divert and carry flood flows from the San Joaquin River at Gravelly Ford, along with inflows from the Kings River and other tributaries, downstream to the mainstem just above Merced River. The system consists of about 193 miles of levees, several control structures, and other appurtenant facilities, and about 80 miles of surfacing on existing levees. Operations and maintenance (O&M) of the completed State upstream bypass features of the project are accomplished by the LSJLD. The flood damage reduction structures and facilities within the Restoration Area are described below.

The Chowchilla, Eastside, and Mariposa bypasses convey flood flows from the San Joaquin and Kings rivers. Tributaries to the Chowchilla Bypass include the Fresno River and Berenda Slough. The Chowchilla Bypass extends to the confluence of Ash Slough, which marks the beginning of the Eastside Bypass. Eastside Bypass Reach 1 extends from Ash Slough to the Sand Slough Bypass confluence and receives flows from the Chowchilla River. Eastside Bypass Reach 2 extends from the Sand Slough Bypass confluence to the head of the Mariposa Bypass. Eastside Bypass Reach 3 extends from the head of the Mariposa Bypass to the head of Reach 5 and receives flows from Deadman, Owens, and Bear creeks. The Mariposa Bypass extends from the Mariposa Bypass Bifurcation Structure to the head of Reach 4B2. A drop structure is located near the downstream end of the Mariposa Bypass that dissipates energy from flows before flows enter the mainstem San Joaquin River.

Chowchilla Bypass and Bypass Bifurcation Structure. As a component of the Lower San Joaquin River and Tributaries Project, the Chowchilla Bypass begins at the Chowchilla Bypass Bifurcation Structure in the San Joaquin River and runs northwest, parallel to the San Joaquin River, to the confluence of the Fresno River, where the Chowchilla Bypass ends and becomes the Eastside Bypass. The design channel capacity of the Chowchilla Bypass is 5,500 cfs. The bypass is constructed in highly permeable soils, and much of the initial flood flows infiltrate and recharge groundwater. The Chowchilla Bypass Bifurcation Structure is a gated structure that controls the proportion of flood flows between the Chowchilla Bypass and Reach 2B of the San Joaquin River. The Chowchilla Bypass Bifurcation Structure is operated to keep flows in Reach 2B at a level less than 2,500 cfs because of channel capacity limitations, though significant seepage has been observed at flows above 1,300 cfs (RMC 2007), and the

Mendota Pool Bypass and Reach 2B Project will increase the capacity of Reach 2B. Historically, releases from the Chowchilla Bypass Bifurcation Structure to Reach 2B were limited to the 1,300 cfs capacity of Reach 2B, or to flows that would not exceed the capacity of Reaches 3 and 4A when combined with Kings River flood flows and irrigation delivery flows from Mendota Pool.

Eastside Bypass and Control Structure. The Eastside Bypass extends from the confluence of the Fresno River and the Chowchilla Bypass to its confluence with the San Joaquin River at the head of Reach 5. The Eastside Bypass is subdivided into three reaches. Eastside Bypass Reach 1 gradually increases in design channel capacity from 10,000 cfs to 17,000 cfs as it receives flows from the Fresno River, Berenda Slough, and Ash Slough, and ends at the downstream end of the Sand Slough Bypass, where it intercepts flows from the Chowchilla River. Eastside Bypass Reach 2, with a design channel capacity of 16,500 cfs, extends from the Sand Slough Bypass confluence to the Mariposa Bypass Bifurcation Structure at the head of the Mariposa Bypass and the Eastside Bypass Control Structure. Eastside Bypass Reach 3, with a design channel capacity of 13,500 cfs at the Eastside Bypass Control Structure, and a design channel capacity of 18,500 cfs at its confluence with Bear Creek, extends from the Eastside Bypass Control Structure to the head of Reach 5 of the San Joaquin River, and receives flows from Deadman, Owens, and Bear creeks. The gated Eastside Bypass Control Structure works in coordination with the Mariposa Bypass Bifurcation Structure to direct flows to either Eastside Bypass Reach 3 or to the Mariposa Bypass. The channel capacities described above are design capacities; current capacities may be reduced due to subsidence of Eastside Bypass levees. Eastside Bypass Reach 3 ultimately joins with Bear Creek to return flows to the San Joaquin River.

Sand Slough Control Structure/San Joaquin River Headgates. The Sand Slough Control Structure, located in the short connection between the San Joaquin River at mile post 168.5 and the Eastside Bypass between Eastside Bypass Reaches 1 and 2, is an uncontrolled weir working on coordination with the San Joaquin River Headgates to control the flow split between the mainstem San Joaquin River and the Eastside Bypass. The Sand Slough Control Structure diverts flows from the San Joaquin River to the Eastside Bypass, and the San Joaquin River Headgates control the timing and quantity of flows entering Reach 4A of the San Joaquin River into Reach 4B1. The operating rule for the control structure and headgates is to divert the first 50 cfs of San Joaquin River flow to Sand Slough, and then equally divide flow in excess of 50 cfs to Sand Slough and Reach 4B1. Historical operations have kept the headgates closed for many years, diverting all flood flows to Sand Slough (RMC 2007).

Mariposa Bypass and Bypass Bifurcation Structure. The Mariposa Bypass Bifurcation Structure controls the proportion of flood and Restoration flows that continue down the Eastside Bypass or return the San Joaquin River through the Mariposa Bypass to Reach 4B2. The Mariposa Bypass delivers flow back into the San Joaquin River from the Eastside Bypass at the head of Reach 4B2. Of 14 bays on the Mariposa Bypass Bifurcation Structure, eight are gated. The operating rule for the Mariposa Bypass is to divert all flows to the San Joaquin River when flows in the Eastside Bypass above the Mariposa Bypass are less than 8,500 cfs, with flows greater than 8,500 cfs remaining in the Eastside Bypass, eventually discharging back into the San Joaquin River at the Bear Creek Confluence at the end of Reach 4B2 of the San Joaquin River. Eastside Bypass below Mariposa Bypass flows are presented in Figure A.4-9 (DWR 2018ak).

However, actual operations have deviated from this rule, flows of up to 2,000 cfs to 3,000 cfs have historically remained in the Eastside Bypass, and approximately one-quarter to one-third of the additional flows are released to the Mariposa Bypass (McBain and Trush 2002). Flood flows not diverted to the San Joaquin River via the Mariposa Bypass continue down the Eastside Bypass and are returned to the San Joaquin River via Bravel Slough and Bear Creek. Restoration Flows continue down the Eastside Bypass.

Bravel Slough reenters the San Joaquin River at mile post 136 and is the ending point of the bypass system.

A.4.1.3 *San Joaquin River from Merced River to the Delta*

Flows in the San Joaquin River below the Merced River confluence to the Delta are controlled in large part by releases from reservoirs, located on the tributary systems, to satisfy contract deliveries and instream flow requirements, as well as operational agreements such as D-1641. Recent mean daily flows in the San Joaquin River at Vernalis (located at the southeastern boundary of the Delta) are presented on Figure A.4-11 (DWR 2018am).

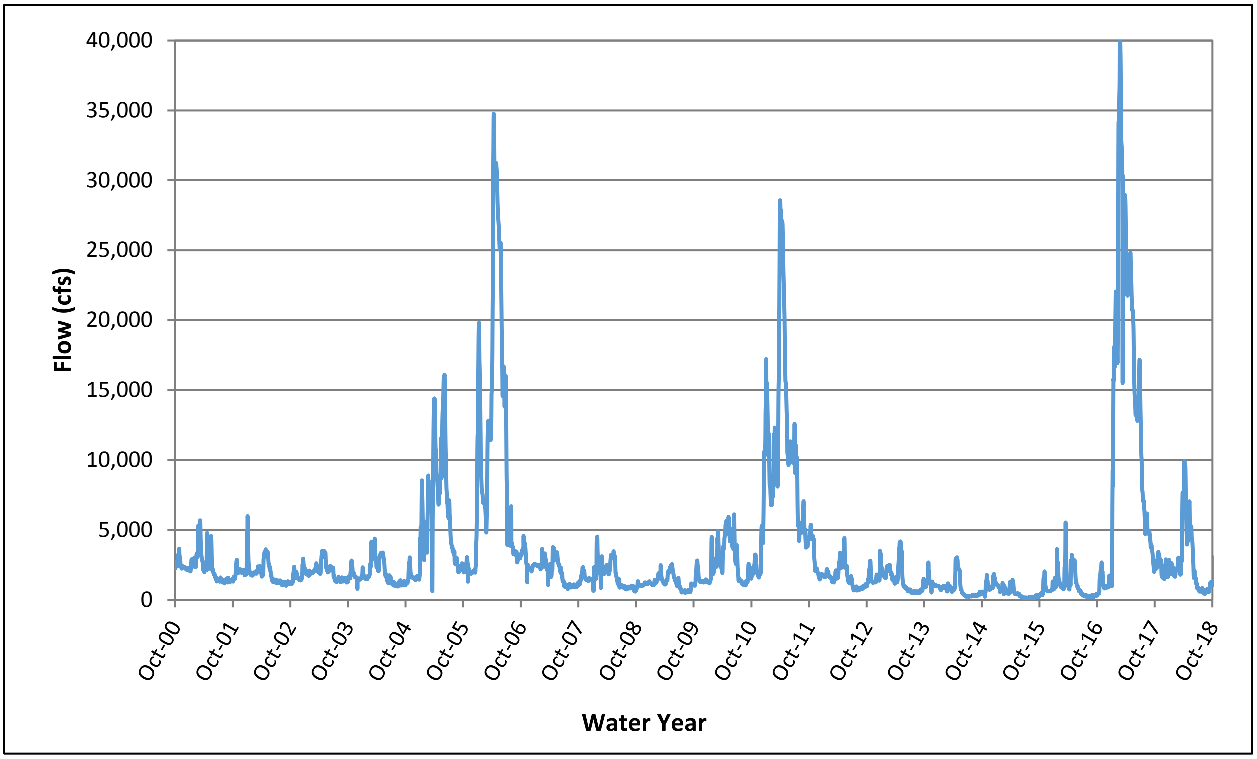


Figure A.4-11. San Joaquin River at Vernalis

A.4.1.3.1 Merced River

The Merced River flows west out of the Sierra Nevada to its confluence with the San Joaquin River at the end of Reach 5. Merced River stream flows are regulated primarily by New Exchequer and McSwain dams, which form Lake McClure and Lake McSwain, respectively. The Crocker-Hoffman Diversion Dam is located downstream from New Exchequer and McSwain dams. Lake McClure is a water supply, hydropower, and flood control reservoir and Lake McSwain is a regulating reservoir approximately 6 miles downstream from Lake McClure. Both reservoirs are owned and operated by the Merced ID. Minimum flow standards were established in 1964 (Project No. 2179) by a FERC license and, in addition, the Davis-Grunsky Contract No. D-GGR17 between Merced ID and DWR. During high-flow events, a portion of Merced River flows are conveyed to the San Joaquin River through Merced Slough.

A.4.1.3.2 Tuolumne River

The Tuolumne River enters the San Joaquin River downstream from the Merced River. The largest reservoir on the Tuolumne River is New Don Pedro Lake, owned and operated by the Turlock Irrigation District and Modesto Irrigation District for water supply, hydropower, and flood control purposes. La Grange Reservoir below New Don Pedro Lake is also jointly owned by the two irrigation districts and is operated as a diversion dam. The 1995 New Don Pedro Settlement Agreement contains instream flow requirements on the Tuolumne River for the anadromous fishery downstream from the project (FERC 2009).

The Stanislaus River and associated facilities and operations are described below.

A.4.2 Stanislaus River and the East Side Division

The East Side Division encompasses portions of the Stanislaus and San Joaquin River Systems and includes New Melones Dam, Tulloch Dam, Goodwin Dam, and smaller Diversion Dams and associated Reservoirs.

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.

A.4.2.1 *Early Water Development*

Agricultural water supply development in the Stanislaus River watershed began in the 1850s and has significantly altered the basin's hydrologic conditions. Prior to 1856, the San Joaquin Water Company constructed a diversion dam on the Stanislaus River immediately downstream of the present-day location of Tulloch Dam and used the diversion dam to distribute water for irrigation and other uses in the Knights Ferry Area. Beginning in 1856, a series of water and power companies constructed several water supply and power facilities in the Stanislaus River watershed.

The San Joaquin Water Company was sold to the Tulloch family in the late 1800s, and in 1910, Oakdale Irrigation District (OID) and South San Joaquin Irrigation District (SSJID) bought the Tulloch water rights and physical distribution system. In 1913, OID and SSJID jointly constructed Goodwin Diversion Dam, an 80-foot tall double concrete arch dam, to divert Stanislaus River water (up to 1,816.6 cfs daily) into their respective canals for distribution into their respective service areas for irrigation. Despite its height, Goodwin Diversion Dam is a re-operating reservoir, not a storage reservoir, because a full reservoir is needed to allow diversion to these canals.

To address their lack of storage, OID and SSJID joined with The Pacific Gas and Electric Company (PG&E) in 1925 to construct the Melones Dam and Powerhouse (110 TAF capacity) approximately 12.3 river miles upstream of the Goodwin Diversion Dam. Water released from Melones was diverted at Goodwin Diversion Dam for delivery into OID and SSJID's distribution systems.

In 1955, OID and SSJID agreed to construct three new facilities, including the Donnells Dam and Reservoir (64,500 TAF capacity) and Beardsley Dam and Reservoir (97.5 TAF capacity) upstream of Melones Dam, and the Tulloch Dam and Reservoir (54.663 TAF capacity), downstream of Melones Dam. Construction of the three facilities, collectively referred to as the Tri-Dam Project, was completed in 1957 and the facilities became operational in 1958. As part of the construction of the Tri-Dam project, Goodwin Diversion Dam was raised to create an afterbay to regulate discharge from Tulloch. From 1985–1990, the Calaveras County Water District constructed the North Fork Stanislaus Hydroelectric Project, which included the construction of New Spicer Reservoir (189 TAF capacity) in 1989. This was a joint development project by Northern California Power Agency (NCPA) and Calaveras County Water District. Calaveras County Water District is the licensee and NCPA is the project operator.

Twenty ungauged tributaries contribute flow to the lower portion of the Stanislaus River below Goodwin Dam. These streams provide intermittent flows, occurring primarily during the months of November through April. Agricultural return flows, as well as operational spills from irrigation canals receiving water from both the Stanislaus and Tuolumne Rivers, enter the lower portion of the Stanislaus River. In addition, a portion of the flow in the lower reach of the Stanislaus River originates from groundwater accretions. There are also approximately 48 TAF of annual riparian water rights in the Stanislaus River downstream of Goodwin Dam.

A.4.2.2 *Federal Water Development*

In the Flood Control Act of December 1944, Congress authorized construction of a dam to replace Melones Dam to help alleviate serious flooding problems along the Stanislaus and Lower San Joaquin Rivers. In the Flood Control Act of October 1962, Congress reauthorized the project, and expanded it to be a multipurpose facility to be built by USACE and operated by the Secretary of the Interior as the New Melones Unit of the Eastside Division of the CVP. Dam and reservoir construction began in 1966 and, after being halted from 1972 to 1974, was completed by USACE in 1978, with a storage capacity of 2.4 MAF.

In 1972, Reclamation applied for the assignment of two state-filed water rights and two new water rights for the New Melones Project. These applications were protested by several parties and mostly resolved through protest settlement agreements. In 1973, SWRCB Decision 1422 (D-1422) initially approved less than 600 TAF in storage for power, senior water rights, water quality, and fish and wildlife protection and enhancement, citing a lack of demonstrated demand and protection of upstream recreation as a reason not to grant consumptive use rights for new demands without further demonstration of a demand for this water.

To demonstrate the consumptive use demands, in 1980 Reclamation produced a Stanislaus River Water Allocation and an EIS for the proposed water allocation of the New Melones Unit. The documents describe preferred and alternative boundaries of the Stanislaus River Basin, the anticipated project yield for 2020 conditions, the current and anticipated future needs of such basin, the determination of an available “interim” supply until the full buildup of in-basin needs, and an anticipated “firm yield” once full in-basin demand was established. The ROD described that New Melones Reservoir would generate a water supply yield of 230 TAF in 2000, and 180 TAF in 2020; assuming maximum annual releases of 70 TAF for water quality and 98 TAF for downstream fishery. For the interim supply, 85 TAF would be available in the year 2000, diminishing to zero at full in-basin demand. For the firm supply, the Secretary determined that there would be 49 TAF available in 2020 after in-basin demands were met. In 1983, Reclamation entered into a long-term water service contract with Central San Joaquin Water Conservation District for 49 TAF of firm supply and an interim supply of 31 TAF, and a long-term water service contract totaling 75 TAF of interim water with Stockton East Water District (SEWD). Reclamation then successfully applied to have D-1422 amended to allow up to full storage for demonstrated power and consumptive use demands in the same year, and New Melones briefly filled to its capacity of 2.4 MAF for the first time.

In 1984, Reclamation applied for the assignment of the direct diversion portion of one of the state water right filings, to be able to serve contracts water at times when New Melones is filling. The application was again protested, with protests largely settled through protest settlement agreements. The direct diversion right was granted in D-1616 in 1988. D-1616 continued water quality requirements and included a new fish and wildlife protest settlement agreement. A later revision added a requirement to study downstream steelhead/trout needs.

In 1995 and in 2000, water rights decisions related to updates of the San Francisco Bay/Sacramento–San Joaquin River Delta Water Quality Control Plan (WQCP) added flow requirements at Vernalis and partial responsibility for interior Delta water quality to CVP water rights.

A.4.2.3 *Reservoir Operations*

The operating criteria for New Melones Reservoir are constrained by water rights requirements, flood control operations, contractual obligations, and federal requirements under the Federal Endangered Species Act (ESA) and CVPIA. Reclamation must operate New Melones Reservoir to meet senior water rights and in-basin demands. Senior water rights are defined for both current and future upstream water right holders in accordance with the SWRCB Decision 1422 (D-1422) and Decision 1616 (D-1616); through protest settlement agreements with Tuolumne and Calaveras Counties; and for current downstream water right holders and riparian rights whose priorities are either senior to Reclamation or senior to appropriative rights in general, respectively. Reclamation also is required to make full contract amounts available to Stockton East Water District and Central San Joaquin Water Conservation District except for when contractual shortage provisions apply.

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).

Below Goodwin Dam, the lower Stanislaus River flows approximately 40 miles to the confluence with the San Joaquin River. Agricultural return flows and operational spills from irrigation canals also enter the lower Stanislaus River.

Reservoir storage varies in accordance with upstream hydrology and downstream water demands and instream flow requirements. Recent water storage volumes and elevations for Water Years 2001 through 2018 in New Melones and Goodwin reservoirs are presented on Figures A.4-12 through A.4-15 (2018an, 2018ao, 2018ap, 2018aq). Recent mean daily flows in the Stanislaus River downstream of Goodwin Dam are presented on Figure A.4-16 (DWR 2018ar).

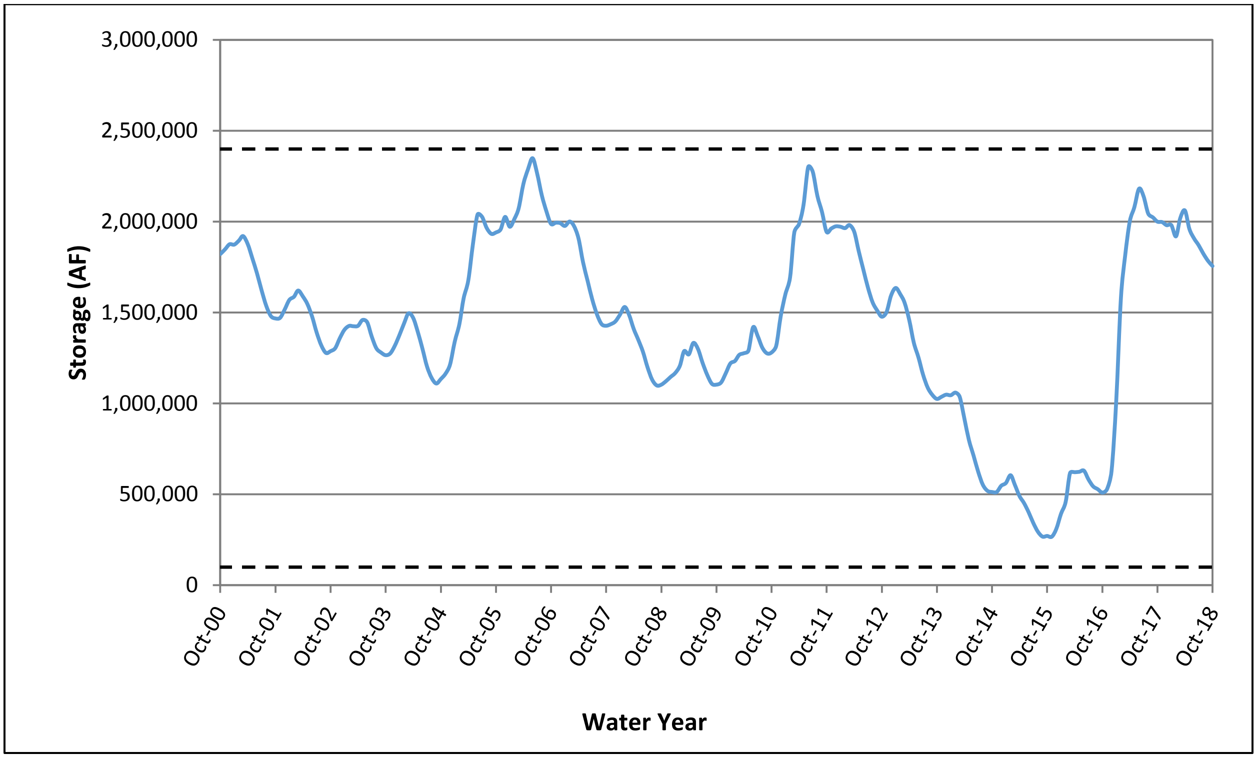


Figure A.4-12. New Melones Reservoir Storage

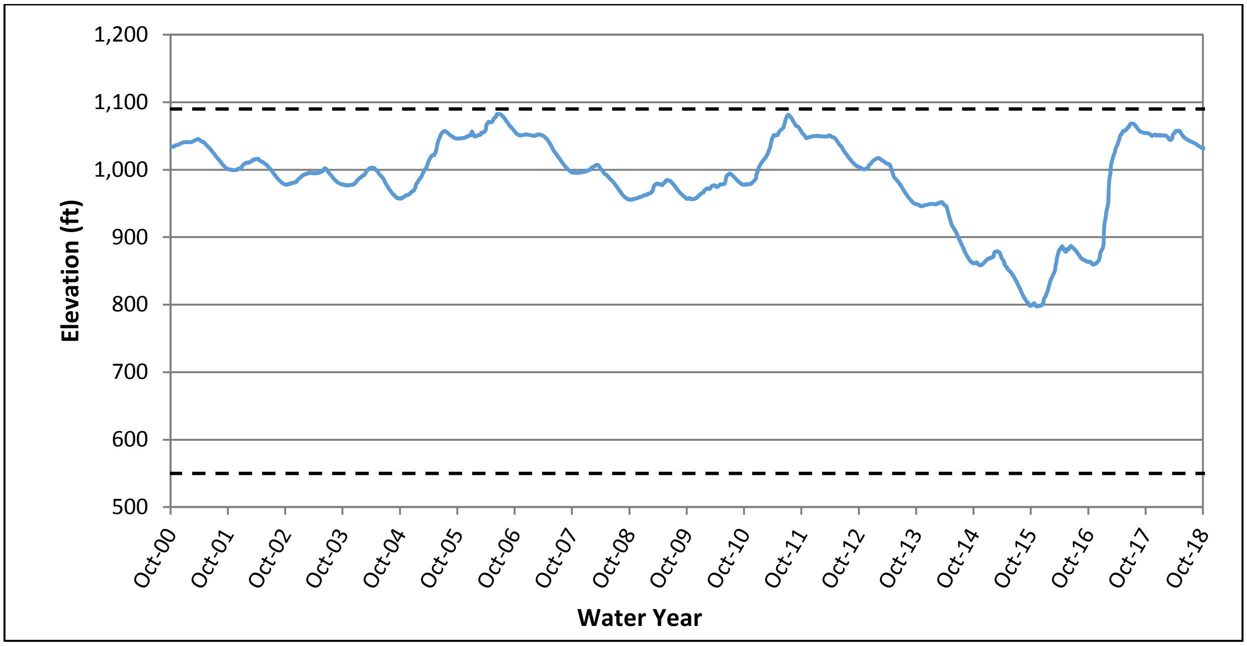


Figure A.4-13. New Melones Reservoir Elevation

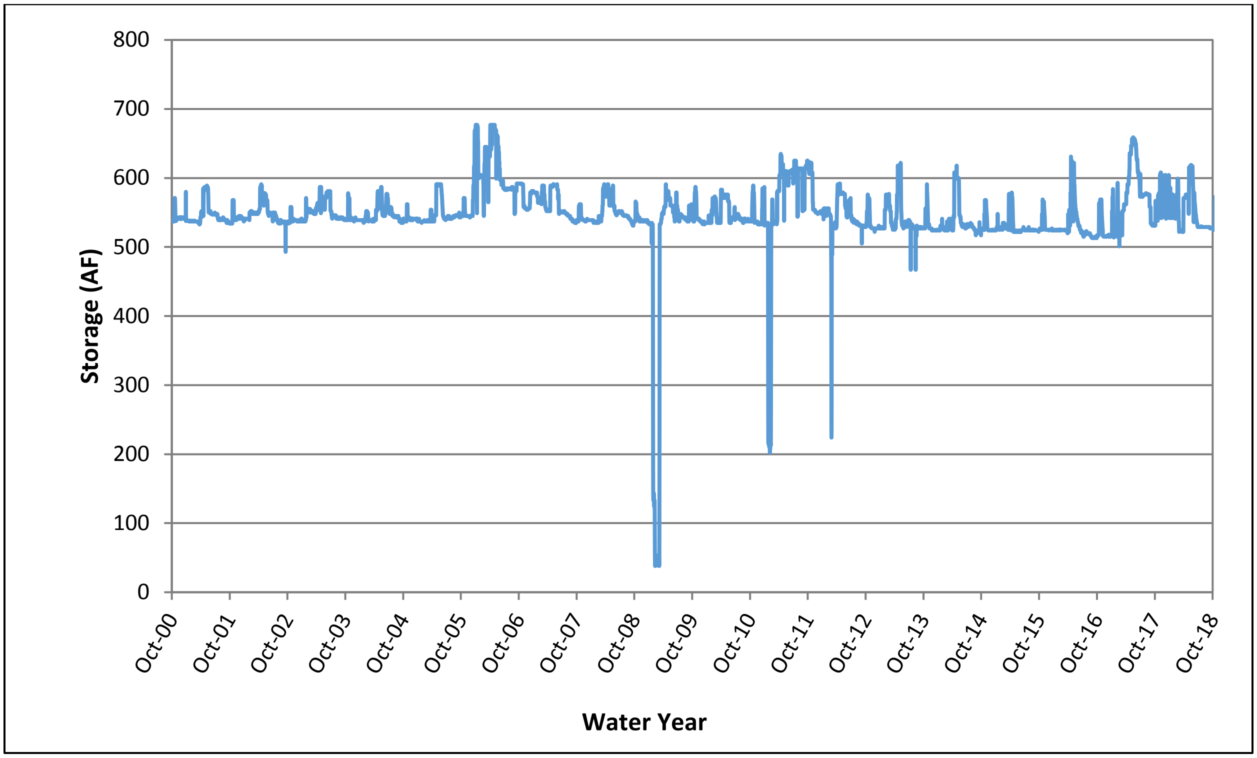


Figure A.4-14. Goodwin Reservoir Storage

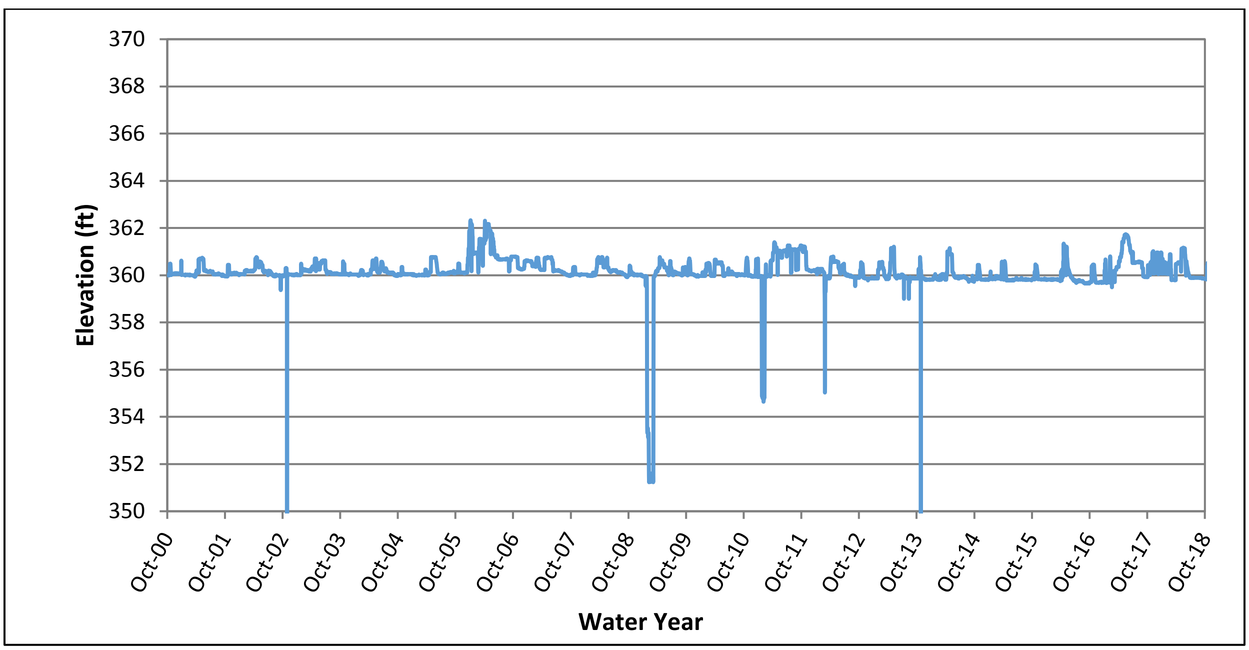


Figure A.4-15. Goodwin Reservoir Elevation

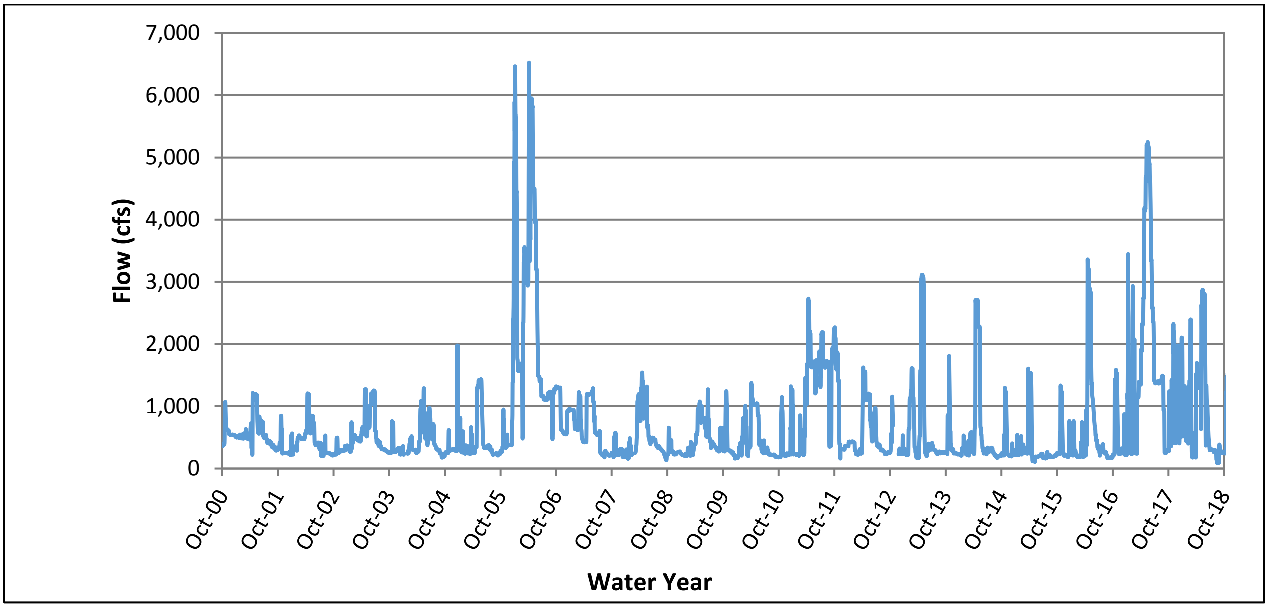


Figure A.4-16. Stanislaus River at Orange Blossom Bridge

A.4.2.3.1 Flood Control

The New Melones Reservoir flood control operation is coordinated with the operation of Tulloch Reservoir. The flood control objective is to maintain flood flows at the Orange Blossom Bridge at less than 8,000 cfs. When possible, however, releases from Tulloch Dam are maintained at levels that would not result in long-term downstream flows in excess of 1,500 cfs because of the past reported potential for seepage in agricultural lands adjoining the river associated with flows above this level. Up to 450 TAF of the 2.4 MAF storage volume in New Melones Reservoir is dedicated for flood control and 10 TAF of Tulloch Reservoir storage is set aside for flood control. Based upon the flood control diagrams prepared by USACE, part or all of the dedicated flood control storage may be used for conservation storage (storing allocated, excess waters), depending on the time of year and the current flood hazard.

A.4.2.3.2 Water Rights Requirements

The operating criteria for New Melones Reservoir are constrained by water rights requirements, flood control operations, contractual obligations, and federal requirements under the ESA and CVPIA.

Terms and conditions of Reclamation's water rights define the limitations within which Reclamation can directly divert water or divert water to storage, after senior water rights and in-basin demands are met. Senior water rights are both current and future upstream water right holders (whose priority is reserved in D-1422 and D-1616 and through protest settlement agreements with Tuolumne and Calaveras Counties), and current downstream water right holders and riparian rights (whose priorities are either senior to Reclamation or senior to appropriative rights in general, respectively). In-basin, instream demands include water quality and flow in the lower Stanislaus River and in part in the lower San Joaquin River and Delta (in that the Stanislaus River contributes to these systems). Downstream demands are first met, to the degree possible, by bypassing natural inflow through New Melones Reservoir. When natural flow is insufficient, stored water is released to meet demands specified either through calculated riparian demand, downstream instream objectives, or protest settlement agreements. Whenever possible, multiple demands are met with the same flow.

A.4.2.3.3 Senior Water Rights: Protest Settlement Agreements

Reclamation's application for assignment of state water right filings in the early 1970s was protested by future in-basin users, senior water rights holders, and the CDFW. To resolve the senior water rights' protest, Reclamation entered into a 1972 Agreement and Stipulation with OID, and SSJID. The 1972 Agreement and Stipulation specifies that it satisfies the yield for consumptive purposes of the OID and SSJID water rights on the Stanislaus River, through the provision of up to a maximum of 654 TAF per year of either natural inflow to New Melones Reservoir or water stored in New Melones for diversion at Goodwin Dam for direct use by OID and SSJID and for storage in Woodward Reservoir (36 TAF capacity).

In 1988, following a year of low inflow to New Melones Reservoir, the Agreement and Stipulation among Reclamation, OID, and SSJID was renegotiated, resulting in an agreement that depended less on actual inflow and more on Reclamation's storage in New Melones, in order to provide a more reliable, albeit slightly smaller maximum, supply. The 1988 agreement commits Reclamation to provide water in accordance with a formula based on inflow and storage of up to 600 TAF each year for diversion at Goodwin Dam by OID and SSJID to meet their demands. The 1988 Agreement and Stipulation created a "conservation account" in which the difference between the entitled quantity and the actual quantity diverted by OID and SSJID in a year may be carried over for use in subsequent years, depending on storage/flood control conditions in New Melones. This conservation account has a maximum volume of 200 TAF, and withdrawals are constrained by criteria in the agreement.

A.4.2.3.4 In-Basin Requirements

A.4.2.3.4.1 Lower Stanislaus River

Based on a protest settlement agreement between Reclamation and CDFW, SWRCB D-1422 required Reclamation to bypass or release 98 TAF of water per year (69 TAF in critical years) through New Melones Reservoir to the Stanislaus River on a distribution pattern to be specified each year by CDFW for fish and wildlife purposes. Based on a second protest settlement agreement in 1987, SWRCB D-1616 as amended required increased releases from New Melones to enhance fishery resources for an interim period, during which habitat requirements were to be better defined and a study of Chinook Salmon fisheries on the Stanislaus River would be completed.

During the study period, releases for instream flows were to range from 98.3 to 302.1 TAF per year. The exact quantity to be released each year was to be determined based on a formulation involving storage, projected inflows, projected water supply, water quality demands, projected CVP contractor demands, and target carryover storage. Because of dry hydrologic conditions during the 1987 to 1992 drought period, the ability to provide increased releases was limited. USFWS published the results of a 1993 study, which recommended a minimum instream flow on the Stanislaus River of 155.7 TAF per year for spawning and rearing (Aceituno 1993).

The study period is near completion with all but one study (outlined in the 1987 agreement) completed at the time of this document. Reclamation is proposing a new plan of operations. This new plan is explained below and will replace the former CDFW and D-1641 downstream release requirements and satisfy ESA obligations.

Reclamation's New Melones water rights require that water be bypassed through or released from New Melones Reservoir to maintain applicable dissolved oxygen (DO) standards to protect the salmon fishery in the Stanislaus River. The 2004 San Joaquin Basin 5C Plan (Central Valley Regional Water Quality

Control Board) designates the lower Stanislaus River with cold water and spawning beneficial uses, which have a general water quality objective of no less than 7 mg/L DO. This objective is therefore applied through the water rights to the Stanislaus River near Ripon.

A.4.2.3.4.2 Lower San Joaquin River

SWRCB D-1641 conditioned CVP water rights to meet flow requirements on the San Joaquin River at Vernalis from February to June to the extent possible. During this timeline, there is an additional 30-day period from April 15 through May 15 when export restrictions are required. These flows are summarized in Table A.4-1.

Table A.4-1. San Joaquin Base Flows-Vernalis

Water Year Class	February–June Flow (cfs)*
Critical	710–1,140
Dry	1,420–2,280
Below Normal	1,420–2,280
Above Normal	2,130–3,420
Wet	2,130–3,420

*The higher flow required when X2 is required to be at or west of Chipps Island.

SWRCB D-1422 required Reclamation to operate New Melones to maintain average monthly levels of 500 parts per million (ppm) total dissolved solids (TDS) in the San Joaquin River at Vernalis as it enters the Delta. SWRCB D-1641 modified the water quality objectives at Vernalis to include the irrigation and non-irrigation season objectives contained in the 1995 WQCP: average monthly electric conductivity (EC) of 0.7 milliSiemens per centimeter (mS/cm) during the months of April through August and 1.0 mS/cm during the months of September through March.

A.4.2.3.5 Water Temperature Requirements

Water temperatures in the lower Stanislaus River are affected by many factors and operational tradeoffs. These include available cold-water resources in New Melones reservoir, Goodwin release rates for fishery flow management, ambient air conditions, and residence time in Tulloch Reservoir, as affected by local irrigation demand

A.4.2.3.6 Fish and Wildlife Requirements on the Stanislaus River

Reclamation proposes to operate New Melones Reservoir (as measured at Goodwin Dam) in accordance with a Stepped Release Plan (SRP) that varies by hydrologic condition/water year type as shown in Table 4-15.

Table 4-15. New Melones SRP Annual Releases by Water Year Type

Water Year Class	Annual Release (TAF)
Critical	184.3
Dry	233.3
Below Normal	344.6
Above Normal	344.6
Wet	476.3

The New Melones SRP will be implemented similarly to current operations under the 2009 biological opinion with a default daily hydrograph, and the ability to shape monthly and seasonal flow volumes to meet specific biological objectives. The default daily hydrograph is the same as prescribed under current operations for Critical, Dry, and Below Normal water year types. The difference occurs in Above Normal and Wet years, where the minimum requirement for larger releases is reduced from current operations to promote storage for potential future droughts and preserve cold water pool. When compared to minimum daily flows from Appendix 2-E of the 2009 biological opinion (2-E), the daily hydrograph for the New Melones SRP is identical for Critical, Dry, and Below Normal year types; Above Normal and Wet year types follow daily hydrographs for Below Normal and Above Normal year types from 2-E, respectively. The complete daily hydrograph for the New Melones SRP is available in Appendix C - New Melones Stepped Release Plan Daily Hydrographs for Critical, Dry, Below Normal, Above Normal and Wet Year Types.

For the New Melones SRP, Reclamation proposes to classify water year types using the San Joaquin Valley “60-20-20” Water Year Hydrologic Classification (60-20-20) developed for D-1641 implementation[1]. Previous operating plans for New Melones Reservoir relied on the New Melones Index (NMI) to determine water year type, calculated by summing end of February storage and forecasted inflow through September. Because the reservoir can store more than twice its average inflow, the NMI resulted in a water year type determination that was more closely tied to storage rather than hydrology. Changing from the NMI to 60-20-20 is expected to provide operations that better represent current hydrology and correlate closer to water year types for other nearby tributaries.

Reclamation proposes to convene the Stanislaus Watershed Team (successor to the Stanislaus Operating Group), consisting of agency representatives and local stakeholders having direct interest on the Stanislaus River, at least monthly to share operational information and improve technical dialogue on the implementation of the New Melones SRP. The Stanislaus Watershed Team will also provide input on the shaping and timing of monthly or seasonal flow volumes to optimize biological benefits.

During the summer, Reclamation is required to maintain applicable dissolved oxygen standards on the lower Stanislaus River for species protection. Reclamation currently operates to a 7.0 mg/L dissolved oxygen requirement at Ripon from June 1 to September 30. Reclamation proposes to move the compliance location to Orange Blossom Bridge, where the species are primarily located at that time of year.

A.5 Delta and Suisun Marsh

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

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).

Water quality in the Delta is highly variable and strongly influenced by inflows from the rivers and by seawater intrusion into the western and central portions of the Delta during periods of low outflow that may be affected by high volumes of export pumping. The concentrations of salts and other materials in the Delta are affected by river inflows, tidal flows, agricultural diversions, drainage flows, wastewater discharges, water exports, cooling water intakes and discharges, and groundwater accretions. Seawater intrusion into the Delta is dependent on tidal conditions, inflows to the Delta, and Delta channel geometry. Delta channels are typically less than 30 feet deep, unless dredged, and vary in width from less than 100 feet to more than 1 mile. Although some channels are edged with riparian and aquatic vegetation, steep mud or rip-rap covered levees border most channels. To enhance flow and aid in levee maintenance, vegetation is often removed from the channel margins. The tidal currents carry large volumes of seawater back and forth through the San Francisco Bay-Delta Estuary with the tidal cycle. The mixing zone of salt and fresh water can shift 2 to 6 miles daily depending on the tides and may reach far into the Delta during periods of low inflow.

The CVP’s Delta Division consists of the CVP facilities in and south of the Sacramento-San Joaquin Rivers Delta, including the Delta Cross Channel (DCC), the Contra Costa Canal and Pumping Plants, Contra Loma Dam, Martinez Dam, the C.W. “Bill” Jones Pumping Plant (JPP) (formerly Tracy Pumping Plant), the Tracy Fish Collection Facility (TFCF), the Delta Mendota Canal (DMC), and Delta-Mendota Canal/California Aqueduct Intertie. Collectively these facilities are used to divert, convey and store water for irrigation, M&I, and fish and wildlife uses in the San Joaquin Valley, Santa Clara Valley, Contra Costa County, and San Benito County.

Salinity objectives adopted by the SWRCB were established to protect beneficial uses, including agricultural and municipal water supplies, and fisheries. The CVP and SWP facilities are operated to comply with the requirements that would protect the Delta water quality; operational requirements affect the hydrology in the Delta.

Hydrological conditions in the Delta and Suisun Marsh 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 and the SWP Banks Pumping Plant. Structures that change flows in Delta channels include the Delta Cross Channel, the Suisun Marsh Salinity Control Gates, 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 that are listed as threatened or endangered species under ESA in accordance with the SWRCB D-1641, 2008 USFWS BO, and the 2009 NMFS BO. The diversion patterns are implemented to maintain the ratio of exports at the Banks and Jones Pumping Plants to the Delta inflow (known as the E:I ratio); to maintain the ratio of San Joaquin River inflow to exports at the Banks and Jones Pumping Plants (known as the San Joaquin River I:E ratio); and to limit net reverse flow in Old and Middle rivers (known as the OMR criteria). Operations of the Jones and Banks pumping plants are affected by downstream CVP and SWP water demands and reservoir operations in San Luis Reservoir that is jointly used by the CVP and SWP.

To meet the Delta water quality requirements and water rights requirements of users located upstream of the Delta, the CVP and SWP are operated in a coordinated manner in accordance with Coordinated Operation Agreement (COA), as described in the following section.

A.5.1 Delta Cross Channel

The Delta Cross Channel (DCC) is a gated diversion channel in the Sacramento River near Walnut Grove and Snodgrass Slough. When the gates are open, water flows from the Sacramento River through the cross channel to channels of the lower Mokelumne and San Joaquin Rivers toward the interior Delta. The DCC operation improves water quality in the interior Delta by improving circulation patterns of good quality water from the Sacramento River towards Delta diversion facilities.

Reclamation operates the DCC in the open position to (1) improve the movement of water from the Sacramento River to the export facilities at the Banks and Jones Pumping Plants, (2) improve water quality in the southern Delta, and (3) reduce salt water intrusion rates in the western Delta. During the late fall, winter, and spring, the gates are often periodically closed to protect out migrating salmonids from entering the interior Delta. In addition, whenever flows in the Sacramento River at Sacramento reach 20,000 to 25,000 cfs (on a sustained basis) the gates are closed to reduce potential scouring and flooding that might occur in the channels on the downstream side of the gates.

Flow rates through the gates are determined by Sacramento River stage and are not affected by export rates in the south Delta. The DCC also serves as a link between the Mokelumne River and the Sacramento River for small crafts and is used extensively by recreational boaters and fishermen whenever it is open. The SWRCB D-1641 requires closure of the DCC gates for fisheries protection as follows.

- From November through January, the DCC may be closed for up to 45 days for fishery protection purposes.
- From February 1 through May 20, the gates are closed for fishery protection purposes.
- The gates may also be closed for 14 days for fishery protection purposes during the May 21 through June 15 period.

A.5.1.1 *Delta Cross Channel Operations*

Flow rates through the gates are determined by Sacramento River stage and are not affected by export rates in the south Delta. The DCC also serves as a link between the Mokelumne River and the Sacramento River for small crafts and is used extensively by recreational boaters and fishermen whenever it is open.

Because alternative routes around the DCC are quite long, Reclamation tries to provide adequate notice of DCC closures, so boaters may plan for the longer excursion.

Reclamation proposes to operate the DCC gates to reduce juvenile salmonid entrainment risk beyond actions described in D-1641, consistent with Delta water quality requirements in D-1641. From October 1 to November 30, if the Knights Landing Catch Index or Sacramento Catch Index are greater than three fish per day Reclamation proposes to operate in accordance with Table A.5-1, below, to determine whether to close the DCC gates and for how long. From December 1 to May 20, the DCC gates will be closed, unless Reclamation determines that water quality can avoid D-1641 exceedances by opening the DCC gates for up to 5 days for up to 2 events within this period. If there is a conflict between water quality and species in December / January due to drought, Reclamation and DWR propose to coordinate with USFWS and NMFS. From May 21 to June 15, Reclamation will close the DCC gates for 14 days during this period, consistent with D-1641. Reclamation proposes to evaluate in accordance with Table A.5-1, below. Reclamation and DWR's risk assessment will consider the Knights Landing rotary screw trap, Delta juvenile fish monitoring program (Sacramento trawl, beach seines), Rio Vista flow standards, acoustic telemetered fish monitoring information as well as DSM2 modeling informed with recent hydrology, salinity, and tidal data. Reclamation will evaluate this information to determine if fish responses may be altered by DCC operations. If the risk assessment determines that survival, route entrainment, or behavior change to create a new adverse effect not considered under this Proposed Action, Reclamation will not open the DCC.

Table A.5-1. Proposed DCC Operations

Date	Action Triggers	Action Responses
October 1 – November 30	Water Quality criteria per D-1641 are met and either Knights Landing Catch Index or Sacramento Catch Index is greater than 5 fish per day	Within 48 hours, close the DCC gates and keep closed until the catch index is less than 3 fish per day at both the Knights Landing and Sacramento monitoring sites.
	Water Quality criteria per D-1641 are met, neither Knights Landing Catch Index or the Sacramento Catch Index are greater than 3 fish per day but less than or equal to 5 fish per day	Within 48 hours of trigger, DCC gates are closed. Gates will remain closed for 3 days.
	Water quality criteria per D-1641 are met, real-time hydrodynamic and water quality modeling 1 shows water quality concern level targets are not exceeded during 28 day period following DCC closure and there is no observed deterioration of interior Delta water quality.	Within 48 hours of start of LMR attraction flow release, close the DCC gates for up to 10 days (dependent upon continuity of favorable water quality conditions).
	Water quality criteria per D-1641 are met, real-time hydrodynamic and water quality modeling 1 shows water quality concern level targets are not exceeded during 14 day period following DCC closure and there is no observed deterioration of interior Delta water quality.	Within 48 hours of start of LMR attraction flow release, close the DCC gates for up to 5 days (dependent upon continuity of favorable water quality conditions).
	Water quality criteria per D-1641 are met, real-time hydrodynamic and water quality modeling shows water quality concern level targets are exceeded during 14 day period following DCC closure.	No closure of DCC gates

Date	Action Triggers	Action Responses
	The KLCI or SCI triggers are met but water quality criteria are not met per D-1641 criteria	Salmonids Monitoring Team reviews monitoring data and provides data to Reclamation, Reclamation does a risk assessment.

[1] Real time hydrodynamic and water quality modeling will occur within 7 days of the DCC closure.

Table A.5-2. Water Quality Concern Level Targets

Water Quality Concern Level Targets (Water Quality Model simulated 14-day average Electrical Conductivity)
Jersey Point – 1800 umhos/cm
Bethel Island – 1000 umhos/cm
Holland Cut – 800 umhos/cm
Bacon Island – 700 umhos/cm

A.5.2 Temporary Agricultural Barriers

DWR initiated the South Delta Temporary Barrier Project (TBP) in 1991. Currently, the Department of Water Resources (DWR) has permits extending the TBP through 2022. The TBP Biological Opinions (BO) issued in 2018 by United States Fish Wildlife Service and the National Marine Fisheries Service to the United States Army Corps of Engineers (USACE) are mandatory requirements of the 5-year 404 permit for construction and removal of the barriers. USACE issued separate permits for both the agricultural barriers and the Head of Old River (HOR) barrier that run through 2022. The California Department of Fish and Wildlife Service (CDFW) issued two permits; the Incidental Take Permit and the Streambed Alteration Agreement, providing coverage through 2021, and finally, the 401 Water Quality Certification from the Regional Water Quality Control Board provides coverage through 2022.

The project consists of four rock barriers across south Delta channels. In various combinations, these barriers improve water levels for agricultural diversions and conditions for San Joaquin River origin salmonids in the south Delta. The existing TBP consists of the seasonal installation and the removal of temporary rock barriers at the following locations:

- Middle River near the Victoria Canal, about 0.5 miles south of the confluence of Middle River, Trapper Slough, and North Canal.
- Old River near Tracy, about 0.5 miles east of the DMC intake.
- Grant Line Canal near Tracy Boulevard Bridge, about 400 feet east of Tracy Boulevard Bridge.
- HOR at the confluence of Old River and San Joaquin River.

The temporary barriers on Middle River (MR), Old River near Tracy (ORT), and the Grant Line Canal (GLC) are referred to as the agricultural barriers (ag barriers) which are flow control facilities designed to improve water levels and circulation for agricultural diversions and are in place during the irrigation season. The installation of the ag barriers is coordinated with the installation of the spring HOR barrier that is authorized by the Central Valley Project Improvement Act because of its benefits to salmon. Reclamation proposes not to install the HOR barrier as part of this proposed action. If the spring HOR barrier is installed, installation of the ag barriers can begin as early as March 1, the same starting day of the HOR barrier, but the ag barriers must be closed before the closing of the HOR barrier to protect south Delta agricultural diverters from water level impacts associated with reduced flows from the San Joaquin River into Old River. The MR and ORT barriers must be closed before the closing of the HOR barrier; however, the GLC barrier is only partially closed due to the presence of the Delta smelt in the area during the spring. Prior to requesting permission to fully close GLC, a need for full closure must be demonstrated through documented water level complaints. In late May to early June, the USFWS upon evaluating the status of the Delta smelt, will typically grant permission to close the GLC barrier. Table A.5-3 provides the detailed barrier installation schedule requirements.

Table A.5-3. Agricultural barrier installation and operation schedule, for years when the spring HOR barrier is not installed

	MR	ORT	GLC
May 1	Installation may begin.	Installation may begin.	Installation may begin.
May 15 to May 31	Full operation and closure may occur if: • the need for MR full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data shall be provided to the DFG, NMFS and USFWS one week in advance of closing the flapgates).	Full operation and closure may occur if: • the need for ORT full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data shall be provided to the DFG, NMFS and USFWS one week in advance of closing the flapgates).	Full operation and closure may occur if: the need for GLC full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data shall be provided to the DFG, NMFS and USFWS two weeks in advance of closing the flapgates and center sections of the barrier). AND: the incidental take concern level for delta smelt at the SWP/CVP facilities has not been reached. If the incidental take concern limit is reached at the SWP/CVP facilities and if reductions in project exports are determined to be inadequate to protect delta smelt, the DFG, NMFS and USFWS may require the flap gates to be tied in the open position and the center section to be removed.
June 1 to November 30	Full operation and closure may occur. Barrier elevation can be raised from 3.3 feet NAVD to 4.3 feet NAVD with DFG and USFWS approval.	Full operation and closure may occur.	Full operation and closure may occur. If the incidental take concern limit is reached at the SWP/CVP facilities and if reductions in project exports are determined to be inadequate to protect delta smelt, the DFG, NMFS and USFWS may require the flap gates to be tied in the open position and the center section to be removed.
September 15	Barrier must be notched to allow passage of adult salmon.	Barrier must be notched to allow passage of adult salmon.	Barrier must have enough flashboards removed to allow passage of adult salmon.
November 30	Barrier must be completely removed.	Barrier must be completely removed.	Barrier must be completely removed.

Any rock barrier operating on or after September 15 must be notched by September 15. The ag barriers must be notched to allow for the passage of adult salmon. At the GLC barrier, flashboards would be removed at the southern end of the barrier to form a notch. Installation and operation of the barriers are summarized in Table A.5-3.

In addition to allowing construction and removal of the barriers, the permits also give DWR coverage for scientific studies that may take endangered fish species. According to NMFS and USFWS BO requirements, actions for each upcoming year—including barrier type, timing, and any scientific studies planned—must be submitted to the USACE by October 1 of each year. USACE requires NMFS and USFWS to append the actions for the upcoming year to the current BOs.

In 2009 and 2010, an experimental non-physical barrier was installed in lieu of the HOR spring rock barrier with the intention of deterring out-migrating juvenile salmonids from entering Old River. This experimental barrier is a patented technology using sound and light as a deterrent. Although high flows prohibited installation of the non-physical barrier in 2011, a without-barrier study of predator behavior was conducted. In 2012, a rock barrier with eight culverts was installed in the spring. The rock barrier with eight culverts is expected to be installed each spring unless installation is prevented by high flows in the San Joaquin River, or if new studies conclude the spring HOR barrier does not provide salmonid protections previously assumed.

To improve water circulation and quality, DWR coordinated with the South Delta Water Agency and Reclamation in 2007 to manually tie open the culvert flap gates at the Old River near Tracy barrier to improve water circulation and untie them when water levels fell unacceptably. This operation is expected to continue in subsequent years as needed to improve water quality. In addition, DWR consulted with USACE and received USFWS and NMFS approval to raise the Middle River weir height by 1 foot. The weir height can be raised during the summer irrigation season only after the Delta smelt concerns have passed. The requested modification was approved late in the 2010 irrigation season. The weir height has been raised every year since 2010 except in 2011 and 2017 due to high flow conditions in the south Delta. Upon notification and analysis of effects, current environmental permits allow for changes in the type and numbers of culverts through the barrier as well as weir elevations.

In the absence of permanent operable gates to replace the rock barriers, the TBP will continue to be planned and permitted. Computer model forecasts, real-time monitoring, and coordination with local, state, federal agencies, and stakeholders will help determine if the temporary rock barriers operations need to be modified during the transition period.

A.5.2.1 *Conservation Strategies and Mitigation Measures*

DWR has complied with the various measures and conditions required by regulatory agencies under past and current permits to avoid, minimize, and compensate for the TBP impacts. An ongoing monitoring plan is implemented each year that the barriers are installed, and an annual monitoring report is prepared to summarize the activities. The monitoring elements include fisheries monitoring, water quality analysis, salmon smolt survival investigations, barrier effects on SWP and CVP entrainment, Swainson's Hawk monitoring, water elevation, water quality sampling, and hydrodynamic modeling.

The 2008 NMFS BO for the TBP requires a fishery monitoring program using biotelemetry techniques to examine the movements and survival of juvenile salmon and juvenile steelhead through the channels of the south Delta. Further the NMFS Biological Opinion for the long terms operations of the CVP and SWP required an evaluation of salmonid smolt survival and predation prior to requesting consultation for permanent operable gates. Information gained as part of the 2009 pilot study was used to develop the full-scale study that started in 2010. 2011 was the third and final year of the mandated studies. The study has been finalized and will be submitted to NMFS in late 2018. Additional studies of predatory fish behavior at the Head of Old River began in 2011 as required by CDFW. Studies continued and included a multi-year study lead by NMFS that looked at the predator and prey interactions on the San Joaquin River near the Head of Old River. The study showed that predatory fish removals did not significantly improve salmon out-migration survival in the stretch of the San Joaquin River between the Head of Old River and Stockton.

The current CDFW incidental take permit provides California Endangered Species coverage through 2021 and requires that all impacts on California Endangered Species be fully mitigated. This permit requires mitigation for all shallow water habitat impacts and required the purchase of 2.49 acres of shallow water habitat credits. TBP purchased a total of 3.0 acres from Liberty Island Holdings I, LLC for salmonid/smelt restoration conservation credits to satisfy anticipated mitigation requirements. The TBP has been mitigating for impacts over many years and in addition to numerous habitat bank credit purchases, DWR operates fish screens to offset TBP impacts at Sherman Island.

A.5.3 Delta Water Diversions

Water diversions in the Delta include the CVP Jones Pumping Plant, the SWP Banks Pumping Plant, the CVP Contra Costa Canal Pumping Plant at Rock Slough, the SWP Barker Slough Pumping Plant for the North Bay Aqueduct, Contra Costa Water District intakes on Mallard Slough, Old River, and Victoria Canal, and over 1,800 municipal and agricultural diversions for in-Delta use (DWR 2010b). Also included are the City of Stockton Municipal Area (COSMA) intake and the Freeport intake.

Delta channels have been modified to allow transport of Delta inflow to the diversions throughout the Delta, including the CVP and SWP south Delta intakes, and to reduce the effects of pumping on the direction of flows and salinity intrusion within the Delta. The conveyance of water from the Sacramento River southward through the Delta to the CVP and SWP south Delta intakes is aided by the Delta Cross Channel (DCC), a constructed, gated channel that conveys water from the Sacramento River to the Mokelumne River.

A.5.3.1 *Diversion Facilities*

A.5.3.1.1 SWP North Bay Aqueduct – Barker Slough Intake

The Barker Slough Pumping Plant (BSPP) diverts water from Barker Slough into the NBA for delivery to the Solano County Water Agency (SCWA) and the Napa County Flood Control and Water Conservation District (Napa County FC&WCD) (NBA water contractors).

The NBA intake is located approximately 10 miles from the main stem Sacramento River at the end of Barker Slough. Water quality in Barker Slough becomes degraded during winter and spring rainfall events. The Barker Slough drainage basin is characterized by grazing lands, erodible soils, and urban uses. Rainfall runoff can include elevated levels of coliform bacteria, organic matter, turbidity, and pollutants. The water is costly to treat to meet drinking water standards.

A.5.3.1.2 Clifton Court Forebay

CCF is a 31 TAF reservoir located in the southwestern edge of the Delta, about 10 miles northwest of the city of Tracy. CCF provides storage to allow off-peak pumping of water exported through Banks Pumping Plant, moderates the effect of the pumps on the fluctuation of flow and stage in adjacent Delta channels, and collects sediment before it enters the California Aqueduct. Diversions from Old River into CCF are regulated by five radial gates.

A.5.3.1.2.1 Clifton Court Forebay Aquatic Weed and Algal Bloom Control Program

Aquatic weeds dominate CCF from late spring through fall. Surveys of the aquatic plant community in CCF show aquatic weeds were present in 91% of the forebay's surface area in 2014 compared to only 38% in 2006. In 2006, the aquatic weed community was dominated by *Egeria densa*. The results of a 2014 survey showed a mixed assemblage of mostly submersed plants dominated by Southern naiad (*Najas guadalupensis*), sago pondweed (*Potamogeton pectinalus*), American pondweed (P*otamogeton nodosus*), and curly-leaf pondweed (*Potamogeton crispus*). *P. crispus* was determined by CDFW to be a major invader in the Sacramento-San Joaquin Delta (CDFW 2015, and *P. crispus* and *E. densa* are targeted for control by DPR-DBW under the Submersed Aquatic Vegetation Control Program (CDPR 2018).

Excessive growth of submerged aquatic weeds in CCF can cause severe head loss and pump cavitation at Banks Pumping Plant when the stems of rooted plants break free, combine into "mats," and accumulate on the primary and secondary trashracks. This mass of uprooted and fragmented vegetation essentially forms a watertight plug at the trashracks and vertical louver array. The resulting blockage necessitates a reduction in the water pumping rate to prevent potential equipment damage through pump cavitation. Cavitation creates excessive wear and deterioration of the pump impeller blades. Excessive floating weed mats also block the passage of fish into the Skinner Fish Facility, thereby reducing the efficiency of fish salvage operations. Therefore, controlling aquatic vegetation will improve salvage efficiency and decrease debris management issues, both of which in turn will promote salmonid survival.

Mechanical methods are implemented to manually remove aquatic weeds. A debris boom and an automated weed rake system continuously remove weeds entrained on the trashracks. During high weed load periods in late summer and fall when the plants senesce and fragment, boat-mounted harvesters are operated on an as-needed basis to remove aquatic weeds in the Forebay and the intake channel upstream of the trashracks and louvers. The objective is to decrease the weed load on the trashracks and to improve flows in the channel. Effectiveness is limited due to the sheer volume of aquatic weeds and the limited capacity and speed of the harvesters. Harvesting rate for a typical machine ranges from 0.5 to 1.5 acres per hour or 4 to 12 acres per day. Actual harvest rates may be lower due to travel time to off-loading site, unsafe field conditions such as high winds, and equipment maintenance.

In addition, dense stands of aquatic weeds provide cover for unwanted predators that may prey on listed species within CCF. Submerged aquatic vegetation (SAV) has been linked with piscivorous fish densities since the mid-1990s (Grimaldo and Hymanson 1999). Thick stands of aquatic vegetation can create favorable habitat conditions for nonnative fish species that do well in warm, clear, slow-moving water (Nobriga et al. 2005; Ferrari et al. 2014; and Durand et al. 2016). These stands harbor invasive sunfish, including largemouth bass, bluegill, redear sunfish, and warmouth commonly found in CCF. Nobriga et al. (2007) concluded that restoration projects in the Delta need to discourage SAV because largemouth bass were observed to have a high per capita predatory influence and have become established primarily where SAV has proliferated. Furthermore, Ferrari et al. (2014) suggest that SAV and largemouth bass have the potential to interact synergistically to the detriment of native fish species. This information suggests that reducing SAV in CCF may reduce predation and subsequently reduce pre-screen loss of salmonids.

Aquatic weed assemblages change from year to year in the CCF from predominantly *Egeria densa* to one dominated by curly-leaf pondweed, sago pondweed, and southern naiad. Depending upon the aquatic weed assemblage, DWR applies either copper-based herbicides to control *E. densa* or Aquathol K, an endothall-based aquatic herbicide, to control pondweed species. Treatment areas are typically about 900 acres, and no more than 50% of the 2,180 total surface acres.

Harmful algal blooms (HAB) in CCF are of concern as they degrade drinking water quality through the production of cyanotoxins that are harmful to both humans and wildlife and produce compounds that impart an unpleasant taste and odor to drinking water. The frequency of occurrence of HAB's is increasing world-wide, including in California and the Sacramento-San Joaquin Delta. There are many species of HAB-forming cyanobacteria present in the Delta and CCF, including Microcystis, Aphanizomenon, Dolichospermum, Planktothrix, Cuspidothrix, and Cylindrospermum that can produce cyantoxins including microcystins, cylindrospermopsin, anatoxin-a and saxitoxin.

One HAB-forming cyanobacterium of concern is Microcystis spp. Microcystis produces cyanotoxins, including the liver toxin microcystin, that can cause skin rashes, gastrointestinal distress, liver failure, and even death in humans, dogs and wildlife. Microcystis was first described in 1999 in the San Francisco Estuary (Lehman et al. 2013). Since its initial observation, Microcystis blooms have occurred every year in the Delta, typically starting in July and ending in October. Recent drought conditions caused enhanced Microcystis blooms in Delta waterways that lasted into December (Lehman et al. 2017). Blooms originate in the San Joaquin River and expand throughout most of the Delta and past the confluence of the Sacramento-San Joaquin rivers.

Some key abiotic drivers of Microcystis blooms are flow, water temperature, salinity, and nutrient concentrations. Microcystis blooms start when average daily water temperatures exceed 18°C and proliferate in aquatic environments when water temperatures are greater than 25°C. Toward the end of autumn, Microcystis blooms die off when water temperatures average below 15°C in the freshwater interior Delta. Therefore, changes in the timing and during of temperature ranges may influence Microcystis bloom in the Delta.

In 2015, the U.S. Environmental Protection Agency (EPA) published non-regulatory 10-day finished drinking water advisory levels for microcystins and cylindrospermopsin. These are established health-based advisory levels for concentrations at or below which adverse human health effects are not anticipated to occur over a 10-day exposure period (EPA 2015). In addition, EPA listed cyanotoxins including microcystin-LR, cylindrospermopsin, and anatoxin–a on the Contaminant Candidate Lists (CCL), which identify contaminants that may need regulation under the Safe Drinking Water Act. In 2016, the State Water Resources Control Board provided updated voluntary guidance on HABs in recreational waters and published recreational health advisory levels for microcystins, anatoxin-a, and cylindrospermopsin (California Cyanobacteria and Harmful Algal Blooms Network 2010).

DWR first began monitoring for cyanotoxins in the SWP in 2006 and began issuing recreational advisories in 2015. The SWP monitoring locations include the CCF inlet and Banks Pumping Plant, which pumps water from CCF into Bethany Reservoir and the California Aqueduct. Monitoring is typically conducted during the "algal bloom season" of April through October. A HAB within CCF may necessitate the application of an algaecide to halt the production of cyanotoxins and protect downstream drinking water sourcewaters.

Attached benthic cyanobacteria blooms have occurred in CCF that produce compounds that cause unpleasant tastes and odors to finished drinking water. The highest biomass of taste- and odor-producing cyanobacteria was present in the nearshore areas but not limited to shallow benthic zone. Geosmin and 2-methylisoborneol (MIB) are natural byproducts of algal chlorophyll production. The finished drinking water secondary maximum contaminant level (MCL) for taste and odor compounds is 10 ng/L of geosmin and 5 ng/L of MIB. Historically, copper sulfate was applied to the nearshore areas of CCF when results of solid phase microextraction analysis exceed the control tolerances (MIB < 5 ng/L and geosmin < 10 ng/L) (DWR 2013). Application areas varied considerably in past years based on the distribution of the benthic algal bloom in CCF.

Aquatic weed and algae treatments would occur on an as-needed basis dependent upon the level of vegetation biomass, the cyanotoxin concentration from the HAB, or concentration of taste and odor compounds. It is not possible to predict future CCF conditions with climate change. However, the frequency of aquatic herbicide applications to control aquatic weeds is not expected to occur more than twice per year, as demonstrated by the history of past applications. Aquatic herbicides are ideally applied early in the growing season when plants are susceptible to them during rapid growth and formation of plant tissues; or later in the season, when plants are mobilizing energy stores from their leaves towards their roots for overwintering senescence. The frequency of algaecide applications to control HABs is not expected to occur more than once every few years, as indicated by monitoring data and demonstrated by the history of past applications.

DWR receives Clean Water Act pollutant discharge coverage under the National Pollutant Discharge Elimination System (NPDES) Permit No. CAG990005 (General Permit) issued by SWRCB for application of aquatic pesticides to the SWP's aqueducts, forebays, and reservoirs. SWRCB functions as the USEPA's non-federal representative for implementation of the Clean Water Act in California.

A Mitigated Negative Declaration was prepared by DWR to comply with CEQA requirements associated with regulatory requirements established by SWRCB. DWR, a public entity, was granted a Section 5.3 Exception by SWRCB (Water Quality Order 2004-0009-DWQ). Under the exception, DWR is not required to meet the copper limitation in receiving waters defined in DWR's Aquatic Pesticide Application Plan as occurring on an as-needed basis during the year, after other options have been exhausted.

To effectively treat a dynamic aquatic weed assemblage and harmful algal blooms, multiple aquatic herbicide compounds are required to control aquatic weeds and algal blooms in CCF. The preferred products are:

- Aquathol K, an endothall-based aquatic herbicide, that is effective on pondweeds;
- copper-based compounds that are effective on *E. densa* and cyanobacteria and green algae. The copper-based aquatic herbicides include copper sulfate pentahydrate and chelated copper herbicides; and
- peroxygen-based algaecides (e.g., PAK 27) that are effective on cyanobacteria.

A.5.3.1.2.1.1 <u>Aquathol K</u>

The dipotassium salt of endothall is used for control of aquatic weeds and is the active ingredient in Aquathol® K (liquid formulation). Aquathol K is a widely used herbicide to control submerged weeds in lakes and ponds, and the short residual contact time (12-48 hours) makes it effective in both still and slow-moving water. Aquathol K is effective on many weeds, including hydrilla, milfoil, and curly-leafpondweed, and begins working on contact to break down cell structure and inhibit protein synthesis. Without the ability to grow, the weed dies. Full kill takes place in 1 to 2 weeks. As weeds die, they sink to the bottom and decompose. Aquathol K is not effective at controlling *E. densa*.

Aquathol K is registered for use in California and has effectively controlled pondweeds and southern naiad in CCF and in other lakes. Endothall has low acute and chronic toxicity effects to fish. The LC_{50} for salmonids is 20-40 times greater than the maximum concentration allowed to treat aquatic weeds. The EPA maximum concentration allowed for Aquathol K is 5 parts per million (ppm). A recent study (Courter *et al.* 2012) of the effect of *Cascade*® (same endothall formulation as Aquathol K) on salmon and steelhead smolts showed no sublethal effects until exposed to 9-12 ppm, that is, 2-3 times greater than the 5ppm maximum concentration allowed by the EPA. In the study, steelhead and salmon smolts showed no statistical difference in mean survival between the control group and treatment groups, however, steelhead showed slightly lower survival after 9 days at 9-12 ppm. Based on the studies with salmonids, Aquathol K applied at or below the EPA maximum allowable concentration of 5 ppm poses a low to no toxicity risk to salmon, steelhead and other fish.

When aquatic plant survey results indicate that pondweeds are the dominant species in CCF,

Aquathol K will be selected due to its effectiveness in controlling these species. Aquathol K will be applied according to the label instructions, with a target concentration dependent upon plant biomass, water volume, and forebay depth. The target concentration of treatments is 2 to 3 ppm, which is well below the concentration of 9-12 ppm where sublethal effects have been observed (Courter *et al*. 2012). DWR monitors herbicide concentration levels during and after treatment to ensure levels do not exceed the Aquathol K application limit of 5 ppm. No more than 50% of the surface area of CCF will be treated at one time.

A.5.3.1.2.1.2 Copper-based Aquatic Herbicides and Algaecides

Copper herbicides and algaecides include chelated copper products and copper sulfate pentahydrate crystals. When aquatic plant survey results indicate that *E. densa* is the dominant species, copper-based compounds will be selected due to their effectiveness in controlling this species. *E. densa* is not affected by application of Aquathol K. Copper-based algaecides are effective at controlling algal blooms (cyanobacteria) that produce cyanotoxins or taste and odor compounds.

Copper herbicides and algaecides will be applied in a manner consistent with the label instructions, with a target concentration dependent upon target species and biomass, water volume and the depth of the forebay. Applications of copper herbicides are applied at a concentration of 1 ppm. Applications for algal control are applied at a concentration of 0.2 to 1 ppm. DWR monitors herbicide concentration levels during and after treatment to ensure levels do not exceed the application limit of 1 ppm. No more than 50% of the surface area of CCF will be treated at one time.

A.5.3.1.2.1.3 Peroxygen-Based Algaecides

PAK 27 algaecide active ingredient is sodium carbonate peroxyhydrate. An oxidation reaction occurs immediately upon contact with the water destroying algal cell membranes and chlorophyll. There is no contact or holding time requirement, as the oxidation reaction occurs immediately and the byproducts are hydrogen peroxide and oxygen. There are no fishing, drinking, swimming, or irrigation restrictions following use of this product. PAK 27 has NSF/ANSI Standard 60 Certification for use in drinking water supplies at maximum-labeled rates and is certified for organic use by the Organic Materials Reviews Institute (OMRI).

PAK 27 will be applied in a manner consistent with the label instructions, with permissible concentrations in the range of 0.3 to 10.2 ppm hydrogen peroxide. No more than 50% of the surface area of CCF will be treated at one time.

A.5.3.1.2.1.4 Operational Procedures during Treatment for Applications of Aquathol K and Copper-based Products

Proposed operational procedures to minimize impacts to listed species during aquatic herbicide and algaecide applications in CCF are dependent upon the active ingredient compound to be applied, the required contact time, and the anticipated impacts.

Operational procedures for Aquathol K and copper applications include:

- Apply aquatic pesticides, as needed, after temperatures within CCF are above 25°C or after June 28 and prior to the activation of Delta smelt and salmonid protective measures following the first flush rainfall event in Fall/Winter.
- Apply aquatic pesticides within CCF during periods of activated Delta smelt and salmonid protective measures if the following conditions are met:
  - The herbicide application begins after the radial gates have been closed for 24 hours or after the period of predicted delta smelt and salmonid survival within CCF has been exceeded, and
  - The radial gates remain closed for 24 hours after the completion of the application, or
  - The applied herbicide is PAK 27. There are no anticipated impacts on fish with the use of PAK 27 during or following treatment.
- Monitor the salvage of listed fish at the Skinner Fish Protection Facility prior to the application of the aquatic herbicides and algaecides in CCF.
- Close the radial intake gates at the entrance to CCF prior to the application of herbicides to allow fish to move out of the proposed treatment areas and towards the salvage facility and to prevent any possibility of aquatic herbicide diffusing into the Delta.
- For Aquathol K and copper compounds, the radial gates will remain closed for 12 to 24 hours after treatment to allow for the recommended duration of contact time between the aquatic herbicide or algaecide and the treated vegetation or cyanobacteria in the forebay. (Contact time is dependent upon herbicide type, applied concentration, and weed assemblage). Radial gates would be reopened after a minimum of 24 hours.
- For peroxide-based algaecides, the radial gates may reopen immediately after the treatment as the required contact time is less than 1 minute and there is no residual by-product.
- Application would be made by a licensed applicator under the supervision of a California Certified Pest Control Advisor.
- Aquatic herbicides and algaecides would be applied by boat, starting at the shore and moving systematically farther offshore in its application.
- Application would be to the smallest area possible that provides relief to SWP operations or water quality.
- Monitoring of copper and endothall concentration in the water column will occur during and after application. No monitoring of copper or endothall concentrations in the sediment or detritus is proposed.
- No aerial spray applications will occur during rain or within 48 hours of forecasted precipitation.
- A spill prevention plan will be implemented in the event of an accidental spill.

Aquatic weed and algae treatments would occur on an as-needed basis. The timing of application is an avoidance measure and is based on the life history of Chinook salmon and steelhead in the Central Valley's Delta region and of Delta smelt. Migrations of juvenile winter-run Chinook salmon and spring-run Chinook salmon primarily occur outside of the summer period in the Delta. Central Valley (CV) steelhead have a low probability of being in the South Delta during late June when temperatures exceed 25 C through the first rainfall flush event, which can occur as late at December in some years (Grimaldo 2009). Delta smelt are not expected to be in CCF during this time period. Delta smelt are not likely to survive when temperatures reach a daily average of 25°C, and they are not expected to occur in the Delta prior to the first flush event. Therefore, the likelihood of herbicide exposure to Chinook salmon, CV steelhead, and Delta smelt during the proposed herbicide treatment timeframe in CCF is low.

Additional protective measures will be implemented to prevent or minimize adverse effects from herbicide applications. As described above, applications of aquatic herbicides and algaecides will be contained within CCF. The radial intake gates to CCF will be closed prior to, during, and following the application. The radial gates will remain closed during the recommended minimum contact time based on herbicide type, application rate, and aquatic weed assemblage. Additionally, prior to aquatic herbicide applications following gate closures, the water is drawn down in the CCF via the Banks Pumping Plant. This drawdown helps facilitate the movement of fish in the CCF towards the fish diversion screens and into the fish protection facility, and it lowers the water level in the CCF to decrease the total amount of herbicide that would need to be applied, per volume of water.

A.5.3.1.2.1.5 Operational Procedures during Treatment for Applications of Aquathol K and Copper-based Products

Proposed operational procedures to minimize impacts to listed species during peroxide-base algaecide applications in CCF are dependent upon the active ingredient compound to be applied, the required contact time, and the anticipated impacts.

Operational procedures for peroxide-based algaecide (e.g. PAK 27) applications include:

- Apply aquatic pesticide, as needed, year-round.
- Monitor the salvage of listed fish at the Skinner Fish Protection Facility prior to the application in CCF.
- Close the radial intake gates at the entrance to CCF prior to application to prevent any possibility of aquatic herbicide diffusing into the Delta.
- The radial gates may reopen immediately after treatment as the required contact time is less than 1 minute and there are no residual by-products of concern.
- Application would be made by a licensed applicator under the supervision of a California Certified Pest Control Advisor.
- The algaecide would be applied by boat, starting at the shore and moving systematically farther offshore in its application.
- Application would be to the smallest area possible that provides relief to SWP operations or water quality.
- No monitoring of peroxide (PAK 27) concentration in the water column will occur during and after application as the reaction is immediate and there is no residual. Dissolved oxygen concentration will be measured immediately following application within and adjacent to the treatment zone.

- No applications will occur during rain or within 48 hours of forecasted precipitation.
- A spill prevention plan will be implemented in the event of an accidental spill.

Additional protective measures will be implemented to prevent or minimize adverse effects from herbicide applications. As described above, applications of peroxide-based algaecides will be contained within CCF. The radial intake gates to CCF will be closed prior to, during, and following the application. The radial gates will remain closed during the recommended minimum contact time.

A.5.3.1.2.2 Clifton Court Forebay Predation Studies

DWR has conducted the following studies on predation at Clifton Court Forebay:

- Clifton Court Forebay Predation Study Project Report (DWR 2010a)
- 2013 CCF Predation Study Annual Progress Report (DWR 2015b)
- 2014 CCF Predation Study Annual Progress Report (DWR 2016a)
- 2015 CCF Predation Study Annual Progress Report (DWR 2017a)
- 2016 CCF Predation Study Annual Progress Report (DWR 2018as)
- Quantification of Pre-Screen Loss of Juvenile Steelhead in Clifton Court Forebay (DWR 2009)
- 2007-2008 Fish Release Site Predation Study (“CHTR Element 2”) Report
- 2016 CCF Predator Reduction Electrofishing Study Annual Report (DWR 2016b)
- 2017 CCF Predator Reduction Electrofishing Study Annual Report (DWR 2017b)
- 2018 CCF Predator Reduction Electrofishing Study Annual Report (DWR 2018at)

A.5.3.1.2.3 Proposed Measures to Reduce Mortality of ESA-Listed Fish Species

DWR plans to continue implementation of projects to reduce mortality of ESA listed fish species in response to the National Marine Fisheries Service (NMFS) letter dated April 9, 2015, requiring that the California Department of Water Resources (DWR) immediately implement interim measures to improve predator control until an acceptable alternative can be implemented. These interim measures that could be implemented include: (a) electro-shocking and relocating predators; (b) controlling aquatic weeds; (c) developing a fishing incentives or reward program for predators; and (d) operational changes when listed species are present.

DWR recently completed work at the Curtis Landing Fish Release Site, the Fish Science Building and Warehouse, and two new fish release sites as part of its ongoing efforts to improve the survival of ESA listed and other Delta fish species.

A.5.3.1.3 <u>SWP John E. Skinner Delta Fish Protective Facility</u>

The John E. Skinner Delta Fish Protective Facility is located west of the CCF, 2 miles upstream of the Banks Pumping Plant. The Skinner Fish Facility screens fish away from the pumps that lift water into the California Aqueduct. Large fish and debris are directed away from the facility by a 388-foot long trash boom. Smaller fish are diverted from the intake channel into bypasses by a series of metal louvers, while the main flow of water continues through the louvers and towards the pumps. These fish pass through a secondary system of screens and pipes into seven holding tanks, where a subsample is counted and recorded. The salvaged fish are then returned to the Delta in oxygenated tank trucks.

A.5.3.1.4 SWP Harvey O. Banks Pumping Plant

The Harvey O. Banks (Banks) Pumping Plant is in the south Delta, about 8 miles northwest of Tracy and marks the beginning of the California Aqueduct. The plant provides the initial lift of water 244 feet into the California Aqueduct by means of 11 pumps, including two rated at 375 cfs capacity, five at 1,130 cfs capacity, and four at 1,067 cfs capacity. Even though the installed capacity of Banks Pumping Plant is 10,670 cfs, the maximum conveyance capacity of the California Aqueduct limits the pumping rate to 10,300 cfs.

Permits issued by the USACE regulate the rate of diversion of water into CCF for pumping at Banks. 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.

A.5.3.1.4.1 Diversion Increase During July, August, and September

During the months of July, August, and September, the maximum allowable daily diversion rate into CCF was increased from 13,870 acre-feet to 14,860 acre-feet and 3-day average diversions from 13,250 acre-feet to 14,240 acre-feet (500 cfs per day equals 990 acre-feet per day). The increase in diversions was originally permitted in 2000 and was recently extended through 2020. The purpose of this diversion increase into CCF for use by the SWP is to recover export reductions made due to actions taken to benefit fisheries resources. The increased diversion rate does not result in any increase in water supply deliveries above those that would occur in the absence of the increased diversion rate. This increased diversion over the 3-month period could result in an amount not to exceed 90 TAF each year.

Variations to hydrologic conditions coupled with regulatory requirements may limit the ability of the SWP to fully utilize the proposed increased diversion rate. Also, facility capabilities may limit the ability of the SWP to fully utilize the increased diversion rate.

Implementation of this action is contingent on meeting the following conditions:

- The increased diversion rate would not result in greater annual SWP water supply allocations than would occur in the absence of the increased diversion rate. Water pumped due to the increased capacity would only be used to offset reduced diversions that occurred or would occur because of ESA or other, similar protective actions taken to benefit fisheries.
- Use of the increased diversion rate would be in accordance with all terms and conditions of existing BOs governing SWP operations.
- All three temporary agricultural barriers (Middle River, Old River near Tracy and Grant Line Canal) must be in place and operating when SWP diversions are increased.
- Prior to the start of, or during any time when the SWP has increased its diversion rate between July 1 and September 30, if the combined salvage of listed fish species reaches a level of concern, the Data Assessment Team (DAT) will convene to assess the need to modify the planned increase in SWP diversion rates. If DAT does not concur with the continued use of the increased SWP diversion rate, then the issue will be elevated to the Water Operations Management Team (WOMT). The WOMT will consider the DAT assessment as to whether the use of the SWP increased diversion rate should continue or be suspended. If the WOMT is unable to reach agreement on the operation, the relevant fish regulatory agency will determine whether the 500cfs increased diversion is or continues to be implemented.

A.5.3.1.5 CVP Jones Pumping Plant and Tracy Fish Collection Facility

The CVP's Jones Pumping Plant, located about 5 miles north of Tracy, has six available pumps. The Jones Pumping Plant has a physical capacity of approximately 5,200 cfs and sits at the end of an earth-lined intake channel about 2.5 miles long. Because of limited capacity in the Delta Mendota Canal, the facilities in which water pumped at Jones flows, the current, maximum pumping capacity at Jones is approximately 4,600 cfs. That capacity is available when Reclamation accesses the Delta-Mendota Canal/California Aqueduct Intertie (described under Joint Project Facilities), Jones Pumping Plant can be operated to its permitted capacity of 4600 cfs.

The TFCF is located in the south-west portion of the Delta at the head of the intake channel for the Jones Pumping Plant. The TFCF uses behavioral barriers consisting of primary louvers and four rotating traveling screens aligned in a single row 7 degrees to the flow of the water, to guide entrained fish into holding tanks before transport by truck to release sites at the confluence of the Delta. The TFCF was designed to handle smaller fish (<200 millimeters [mm]) that would have difficulty fighting the strong pumping plant induced flows since the intake is essentially open to the Delta and also impacted by tidal action.

The primary louvers are located in the primary channel just downstream of the trashrack structure. The traveling water screen is located in the secondary channel. The louvers allow water to pass through onto the pumping plant but the openings between the slats are tight enough and angled against the flow of water so as to prevent most fish from passing between them and to, instead, enable the fish to enter one of four bypass entrances along the louver arrays.

Approximately 52 different species of fish are entrained into the TFCF each year; however, the total numbers are significantly different for the various species salvaged. Also, it is difficult, if not impossible, to determine exactly how many safely make it all the way to the collection tanks, to be transported back to the Delta. Hauling trucks, used to transport salvaged fish to release sites, inject oxygen and contain an eight parts per thousand salt solution to reduce stress.

When south Delta hydraulic conditions allow, and within the original design criteria for the TFCF, the louvers are operated based on the Biological Opinion objectives of achieving water approach velocities: for striped bass velocities of approximately 1 foot per second (ft/s) from May 15 through October 31, and for salmon velocities of approximately 3 feet per second (ft/s) from November 1 through May 14.

Fish passing through the facility are sampled at intervals of 30 minutes every 2 hours year round. Fish observed during sampling intervals are identified by species, measured to fork length, examined for marks or tags, and placed in the collection facilities for transport by tanker truck to the release sites in the North Delta away from the pumps. In addition, TFCF personnel monitor for the presence of spent female Delta Smelt in anticipation of expanding the salvage operations to include sub-20 millimeter (mm) larval Delta Smelt detection.

TFCF personnel monitor for the presence of spent female Delta Smelt by euthanizing all adult Delta Smelt that are collected in the 30-minute fish count, determine the gender and the gonadal or sexual maturation stage of the Delta Smelt, and determining if the eggs have reached Stage IV, the stage when eggs are ready for release (0.9-10 mm in diameter and easily stripped). Stages V (i.e. post-vitellogenic stage) and VI (i.e. post-ovulatory or "spent" stage) are expected soon after Stage IV observation. Stages are determined and reported real-time when a biologist is present or the following morning after smelt detection and collection. Stage or gonad maturation is determined using egg stage descriptions from Mager (1996).

Larval smelt sampling at the TFCF commences once a trigger is met (detection of a spent female at CVP/SWP being one of three triggers). Fish count screen with a 2.4 mm mesh size opening is replaced with one that has a mesh size of 0.5 mm in order to retain larval fish. Sampling is done 4 times a day (04:00, 10:00, 16:00, 22:00) and all larval smelt are identified to species and reported the day after collection.

CDFW is leading studies of fish survival during the collection, handling, transportation, and release process, examining Delta Smelt injury, stress, survival, and predation. Thus far it has presented initial findings at various interagency meetings (Interagency Ecological Program [IEP], Central Valley Fish Facilities Review Team, and American Fisheries Society) showing relatively high survival and low injury. DWR has concurrently been conducting focused studies examining the release phase of the salvage process including a study examining predation at the point of release and a study examining injury and survival of Delta Smelt and Chinook Salmon through the release pipe. Based on these studies, improvements to release operations and/or facilities, including improving fishing opportunities in Clifton Court Forebay (CCF) to reduce populations of predator fish, are being implemented.

CDFW and USFWS evaluated pre-screen loss and facility/louver efficiency for juvenile and adult Delta Smelt at the Skinner Fish Facility of the SWP. DWR also conducted pre-screen loss and facility efficiency studies for steelhead.

A.5.3.1.6 Contra Costa Water District Facilities

CCWD diverts water from the Delta for irrigation and M&I uses under its CVP contract, under its own water right permits and license issued by the SWRCB, and under East Contra Costa Irrigation District's pre-1914 water right. CCWD's water system includes the Mallard Slough, Rock Slough, Old River, and Middle River (on Victoria Canal) intakes; the Contra Costa Canal and shortcut pipeline; and the Los Vaqueros Reservoir. The Rock Slough Intake facilities, the Contra Costa Canal, and the shortcut pipeline are owned by Reclamation, and operated and maintained by CCWD under contract with Reclamation. Reclamation completed construction of a fish screen at the Rock Slough Intake in 2011. Mallard Slough Intake, Old River Intake, Middle River Intake, and Los Vaqueros Reservoir are owned and operated by CCWD.

The Mallard Slough Intake is located at the southern end of a 3,000-foot-long channel running south from Suisun Bay, near Mallard Slough (across from Chipps Island). The Mallard Slough Pump Station was refurbished in 2002, which included constructing a positive barrier fish screen at this intake. The Mallard Slough Intake can pump up to 39.3 cfs. CCWD's water right license and permit (License No. 10514 and Permit No. 19856) authorize diversions of up to 26,780 acre-feet per year at Mallard Slough. However, this intake is not used when salinity is high at this location. Pumping at the Mallard Slough Intake since 1993 has on average accounted for about 3 percent of CCWD's total diversions. Water diverted at the Mallard Slough Intake reduces CCWD's diversion of CVP water at its other intakes.

The Rock Slough Intake is located about four miles southeast of Oakley. Water is pumped west from Rock Slough through a positive barrier fish screen into the Contra Costa Canal using Pumping Plants #1 through #4. The fish screen at this intake was designed in accordance with the CVPIA and the 1993 USFWS BO for the Los Vaqueros Project to reduce take of fish through entrainment at the Rock Slough Intake. The Contra Costa Canal is 48 miles long. CCWD's Contra Costa Canal Replacement Project replaces the 4-mile long, earth-lined portion of the Contra Costa Canal between the Rock Slough Fish Screen and Pumping Plant #1 with a buried 10'-diameter concrete pipe. The remaining 44 miles of the Contra Costa Canal after Pumping Plant #1 are concrete-lined. The earth-lined portion of the Contra Costa Canal is subject to water quality degradation due to seepage into the canal from saline groundwater in the area, as well as seepage losses where the groundwater table is lower than canal water levels. Replacing the open channel with a buried pipe also eliminates evaporative losses. Removal of the open water facility also improves public safety, system security, and flood control, which are needed in light of the developing and planned urbanization in the vicinity. As of late 2018, approximately 3 miles of the earth-lined portion of the Canal has been replaced (from Pumping Plant #1 to the east) and the flood isolation structure near the fish screen has also been completed. Pumping Plant #1 has a permitted capacity to pump up to 350 cfs into the Canal. Diversions at Rock Slough Intake are typically taken under CVP contract or under East Contra Costa Irrigation District's pre-1914 water right. CCWD diverts approximately 30 percent to 50 percent of its total annual supply through the Rock Slough Intake, depending upon water quality in a given year.

Construction of the Old River Intake was completed in 1997 as a part of the Los Vaqueros Project. The Old River Intake is located on Old River near State Route 4. The intake has a positive-barrier fish screen and a pumping capacity of 250 cfs and can pump water via pipeline either to the Contra Costa Canal or to Los Vaqueros Reservoir. Diversions at Old River to the Contra Costa Canal are typically taken under CVP contract or under local water rights. Pumping to storage in Los Vaqueros Reservoir is limited to 200 cfs by the terms of the Los Vaqueros Project BOs and by the SWRCB water right decision for the Los Vaqueros Project (D-1629). Diversions to storage in Los Vaqueros Reservoir are typically taken under CVP contract or under CCWD's Los Vaqueros water right permit (Permit 20749). The CCWD's water diversions that are not made at Rock Slough are diverted at the Middle River and Old River intakes, as determined primarily by the CCWD water quality goals described below.

In 2010, CCWD completed construction of the Middle River Intake (formerly referred to as the Alternative Intake Project) on Victoria Canal. The Middle River Intake has a capacity of 250 cfs capacity, with positive-barrier fish screens and a conveyance pipeline to CCWD's conveyance facilities near its Old River Intake. Similar to the Old River Intake, the Middle River Intake can be used either to pump to the Contra Costa Canal or to fill the Los Vaqueros Reservoir. Diversions to the Contra Costa Canal are typically taken under CVP contract, while diversions to storage in the Los Vaqueros Reservoir can be taken either under CVP contract or under CCWD's Los Vaqueros water right (Permit 20749).

CCWD operates its intake facilities to meet its delivered water quality goals and to protect listed species. The choice of which intake to use at any given time is based in large part upon salinity at the intakes, consistent with fish protection requirements in the BOs for the Middle River Intake and the Los Vaqueros Project. The Middle River Intake was built as a project to improve the water quality delivered to the CCWD service area, and does not increase CCWD's average annual diversions from the Delta. However, it can alter the timing and pattern of CCWD's diversions, because Middle River Intake salinity tends to be lower in the late summer and fall than salinity at CCWD's other intakes. This allows CCWD to decrease winter and spring diversions while still meeting water quality goals in the summer and fall through use of the new intake.

Los Vaqueros Reservoir is an off-stream reservoir in the Kellogg Creek watershed to the west of the Delta. Originally constructed as a 100 TAF reservoir in 1997 as part of the Los Vaqueros Project, the facility is used to improve delivered water quality and emergency storage reliability for CCWD's customers. Los Vaqueros Reservoir is filled with Delta water from either the Old River Intake or the Middle River Intake, when salinity in the Delta is low. When Delta salinity is high, typically in the fall months, CCWD releases low salinity water from Los Vaqueros Reservoir to blend with direct diversions from its Delta intakes to meet CCWD water quality goals. Releases from Los Vaqueros Reservoir are conveyed to the Contra Costa Canal via a pipeline. Water released from Los Vaqueros Reservoir does not re-enter Delta channels.

In 2012, Los Vaqueros Reservoir was expanded from 100 TAF to a total storage capacity of 160 TAF to provide additional water quality and water supply reliability benefits and maintain the initial functions of the reservoir. With the expanded reservoir, CCWD's average annual diversions from the Delta remain the same as they were with the 100 TAF reservoir. A feasibility study is ongoing to evaluate whether an additional expansion of this reservoir to 275 TAF is in the federal interest.

CCWD diverts approximately 127 TAF per year in total. Approximately 110 TAF is CVP contract supply. In winter and spring months when the Delta is relatively fresh (generally January through July), deliveries to the CCWD service area are made by direct diversion from the Delta. In addition, when salinity is low enough, Los Vaqueros Reservoir is filled at a rate of up to 200 cfs from the Old River Intake and Middle River Intake. The BOs for the Los Vaqueros Project, CCWD's Incidental Take Permit issued by CDFW, and SWRCB D-1629 include fisheries protection measures consisting of a 75-day period during which CCWD does not fill Los Vaqueros Reservoir (no-fill period) and a concurrent 30-day period during which CCWD halts all diversions from the Delta (no-diversion period), provided that Los Vaqueros Reservoir storage is above emergency levels. During the no-diversion period, CCWD customer demand is met by releases from Los Vaqueros Reservoir. The default dates for the no-fill and no-diversion periods are March 15 through May 31 and April 1 through April 30, respectively. USFWS, NMFS, and CDFW can change these dates to best protect the subject species. CCWD coordinates the filling of Los Vaqueros Reservoir with Reclamation and DWR to avoid water supply impacts on other CVP and SWP customers.

In addition to the 75-day no-fill period and the concurrent no-diversion 30-day period, CCWD operates to an additional term in the Incidental Take Permit issued by CDFW that provides for an additional no-fill period of up to 15 days. Under this term, CCWD shall not divert water to storage in Los Vaqueros Reservoir for 15 days from February 14 through February 28, provided that reservoir storage is at or above 90 TAF on February 1. If reservoir storage is at or above 80 TAF on February 1, but below 90 TAF, CCWD shall not divert water to storage in Los Vaqueros Reservoir for 10 days from February 19 through February 28. If reservoir storage is at or above 70 TAF on February 1, but below 80 TAF, CCWD shall not divert water to storage in Los Vaqueros Reservoir for 5 days from February 24 through February 28. These dates can be changed to better protect Delta fish species, at the direction of CDFW.

CCWD's operation of the diversion, storage, and conveyance facilities to divert water under CCWD's water rights meets the permitting requirements of the ESA through BOs issued by USFWS and NMFS that are specific to the CCWD system. The NMFS BO issued on March 18, 1993 and USFWS BO issued on September 9, 1993 address the operation of the Los Vaqueros Project, including the Los Vaqueros Reservoir and the Mallard Slough, Rock Slough, and Old River intakes. NMFS BO 2005/00122 issued on July 13, 2007, and USFWS BO issued on April 27, 2007 and amended on May 16, 2007, address the Middle River Intake operations. Concurrence that CCWD's operations consistent with expansion of Los Vaqueros Reservoir to 160 TAF are not likely to adversely affect listed Delta fish species was provided by NMFS on October 15, 2010 and USFWS on November 1, 2010. Biological opinions for operation and maintenance of the Rock Slough Fish Screen were issued by NMFS on June 29, 2017 and USFWS on November 2, 2017.

A.5.3.1.7 Delta Mendota Canal, San Luis Unit, and California Aqueduct Intertie

A.5.3.1.7.1 Water Demands

Water provided to the DMC and San Luis Unit primarily meet demands from three types of contractors: CVP water service contractors (including both agricultural (AG) and municipal and industrial (M&I),

exchange contractors, and wildlife refuge contractors. Distinct relationships exist between Reclamation and each of these three groups.

Exchange contractors “exchanged” their senior rights to water in the San Joaquin River for a CVP water supply generally provided from the Delta. Reclamation’s first obligation for the water supply from the Delta is to provide water to meet the 840 TAF per annum Exchange Contract obligation, with a maximum reduction under the Shasta critical year criteria to an annual water supply of 650 TAF.

South of Delta CVP agricultural water service contractors also receive their supply from the Delta, but their supplies are subject to the availability of CVP water supplies that can be developed after senior obligations are met. The CVP also contracts with refuges to provide water supplies to specific managed lands for wildlife purposes. These contracts are reduced under Shasta critical year criteria up to 25 percent.

The CVP also contracts with refuges to provide water supplies to specific managed lands for wildlife purposes. These contracts are also subject to the availability of CVP water supplies, but may be reduced under Shasta critical year criteria, up to 25 percent.

To achieve the best operation of the CVP, it is necessary to combine the contractual demands of these three types of contractors to achieve an overall pattern of requests for water. In most years, sufficient supplies are not available to meet all water demands because of reductions in CVP water supplies primarily due to restrictions placed on Delta pumping. In some dry or critically dry years, water deliveries are limited because there is insufficient storage in northern CVP reservoirs to meet all instream fishery objectives, including water temperatures, and to make additional water deliveries via the Jones Pumping Plant. Scheduling of water demands and the releases of water supplies from the northern CVP to meet those demands, is a CVP operational objective that is intertwined with Trinity, Sacramento, and American River operations.

A.5.3.1.7.2 Delta-Mendota Canal/California Aqueduct Intertie

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. The DMC/California Aqueduct Intertie can be used under one of the following three different scenarios:

- Up to 467 cfs may be pumped from the DMC to the California Aqueduct to ease DMC conveyance constraints related to Jones Pumping Plant capacity limitations.
- Up to 467 cfs may be pumped from the DMC to the California Aqueduct to minimize impacts on water deliveries due to temporary restrictions in flow or water levels on the lower DMC (south of the Intertie) or the upper California Aqueduct (north of the Intertie) for system maintenance or due to an emergency shutdown.
- Up to 900 cfs may be conveyed from the California Aqueduct to the DMC using gravity flow to minimize impacts on water deliveries due to temporary restrictions in flow or water levels on the lower California Aqueduct (downstream of the Intertie) or the upper DMC (upstream of the Intertie) for system maintenance or for an emergency shutdown.

A.5.3.1.7.3 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. Water storage volumes and water storage elevations for San Luis Reservoir for Water Years 2001 through 2018 are presented on Figures A.5-1 and A.5-2 (DWR 2018au, 2018av).

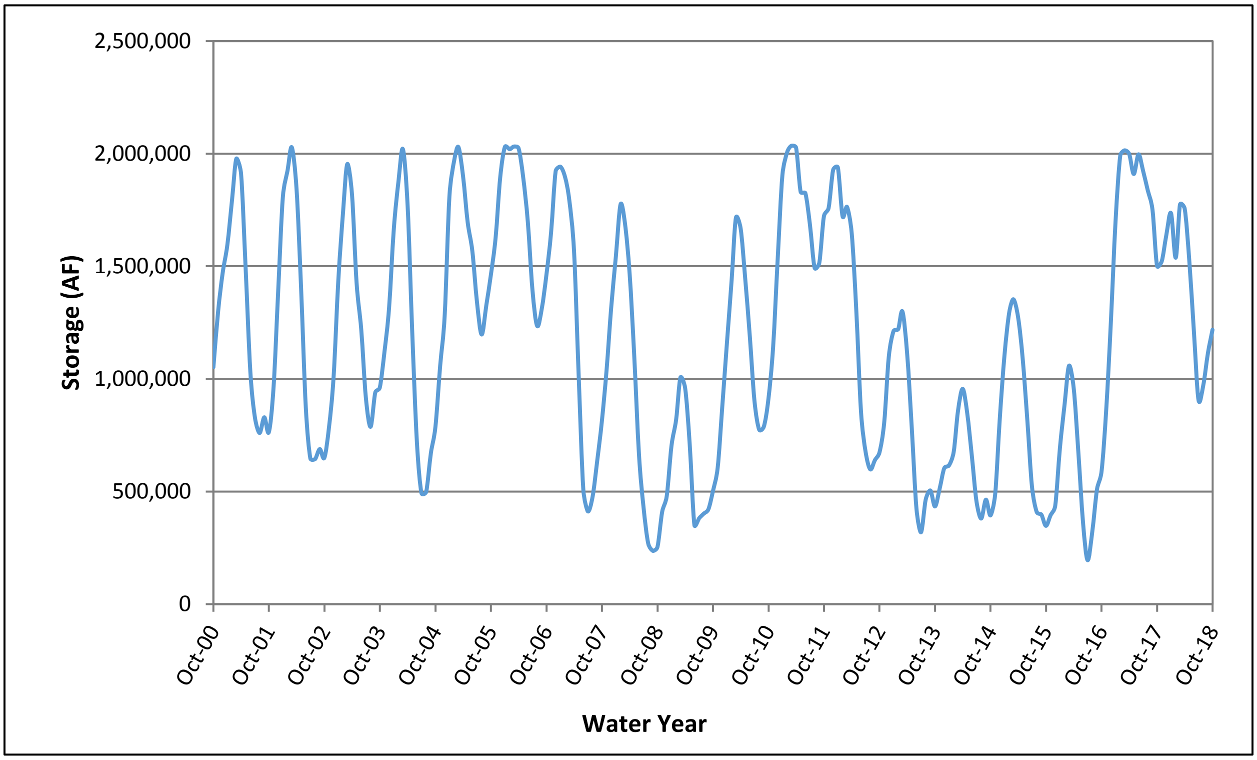


Figure A.5-1. San Luis Reservoir Storage

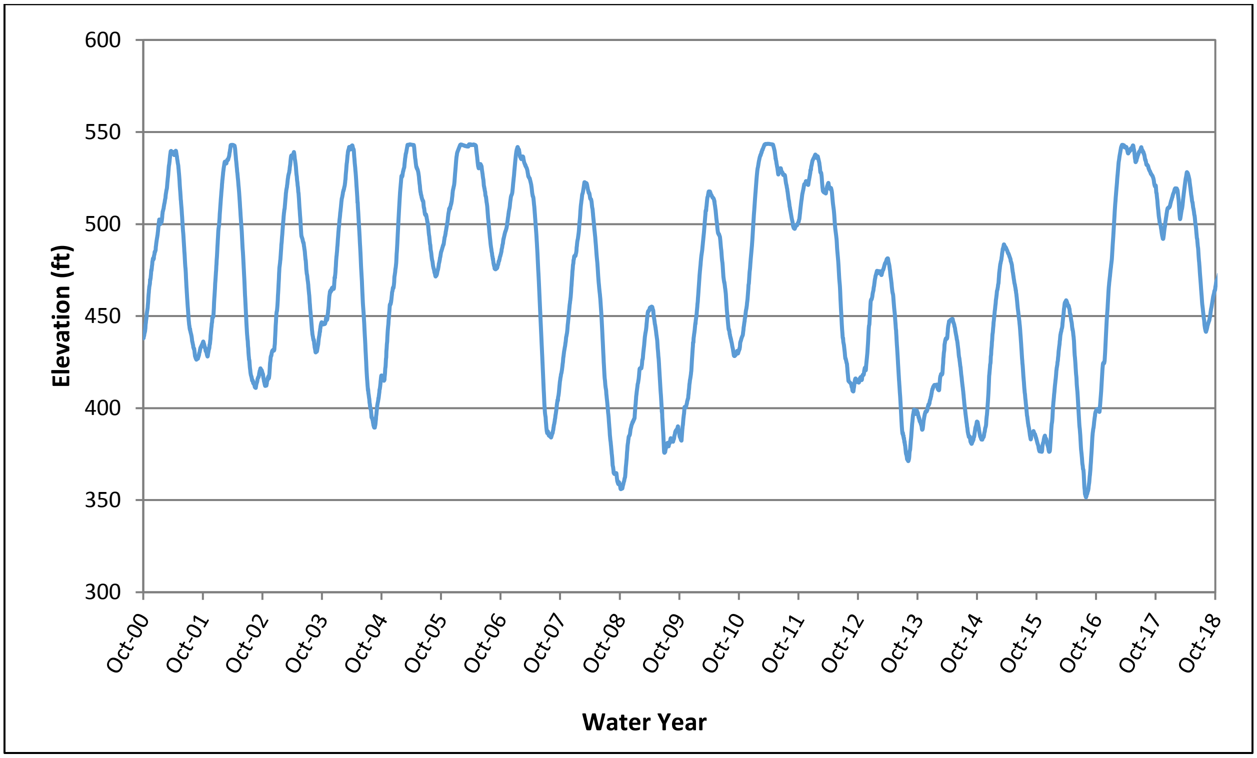


Figure A.5-2. San Luis Reservoir Elevation

The San Luis Complex consists of the following:

- O'Neill Pumping-Generating Plant (CVP facility)
- William R. Gianelli Pumping-Generating Plant (joint CVP and SWP facility)
- San Luis Canal (joint CVP and SWP facility)
- Dos Amigos Pumping Plant (joint CVP and SWP facility)
- Coalinga Canal (CVP facility)
- Pleasant Valley Pumping Plant (CVP facility)
- Los Banos and Little Panoche Detention Dams and Reservoirs (joint CVP and SWP facilities)

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.

When all SWP demands are met, including diversion to storage facilities south of the Delta and Table A demands, and the Delta is in excess conditions, DWR would use available excess pumping capacity at Banks Pumping Plant to make excess water supplies, called Article 21 water under the long-term SWP water supply contracts, available to the SWP Contractors. Article 21 of the SWP water contracts describes the conditions under which water can be delivered in addition to the amounts specified in Table A of the contracts.

Unlike Table A water, which is an allocated annual SWP supply made available for scheduled delivery throughout the year, Article 21 water is an interruptible water supply made available only when certain conditions exist. However, while not a dependable supply, Article 21 water is an important part of the total SWP supplies provided to the SWP contractors. As with all SWP water, Article 21 water is pumped consistent with the existing terms and conditions of SWP water rights permits and is pumped from the Delta under the same environmental, regulatory, and operational constraints that apply to all SWP operations.

Article 21 water is only available as long as the required conditions exist as determined by DWR. As Article 21 deliveries are in addition to scheduled Table A deliveries, this supply is delivered to SWP contractors that can, on relatively short notice, put it to beneficial use. SWP contractors have used Article 21 water to meet needs such as additional short-term irrigation demands, replenishment of local groundwater basins, short-term substitution of local supplies and storage in local surface reservoirs for later use by the requesting SWP contractor, all of which provide SWP contractors with opportunities for better water management through more efficient coordination with their local water supplies. Allocated Article 21 water to a SWP contractor cannot be transferred.

Article 21 water is typically offered to SWP contractors on a short-term (daily or weekly) basis when all of the following conditions exist: the SWP share of San Luis Reservoir is physically full, or projected to be physically full; other SWP reservoirs south of the Delta are at their storage targets or the SWP conveyance capacity to fill these reservoirs is maximized; the Delta is in excess condition; current Table A and SWP operational demands are being fully met; and Banks Pumping Plant has export capacity beyond that which is needed to meet all Table A and other SWP operational demands. The increment of available unused Banks Pumping Plant capacity is offered as the Article 21 delivery capacity. SWP contractors then indicate their desired rate of delivery of Article 21 water. DWR allocates the available Article 21 water in proportion to the requesting SWP contractors annual Table A amounts if requests exceed the amount offered. Deliveries can be discontinued at any time when SWP operations change. In the modeling for Article 21, deliveries are only made in months when the SWP share of San Luis Reservoir is full. In actual operations, Article 21 may be offered a short period in advance of actual filling.

By April or May, demands from both agricultural and M&I SWP Contractors usually exceed the pumping rate at Banks Pumping Plant, and releases from San Luis Reservoir to the SWP facilities are needed to supplement the Delta pumping at Banks Pumping Plant to meet SWP contractor demands for Table A water.

A.5.3.2 *Regulatory Limitations on Operations of Delta Water Diversions*

Operations of the CVP and SWP are implemented in accordance with SWRCB water rights and water quality decisions, including SWRCB D-1641, and the 2008 USFWS BO and 2009 NMFS BO.

A.5.3.2.1 Decision 1641

The SWRCB adopted the 1995 Bay-Delta Plan on May 22, 1995, which became the basis of SWRCB D-1641 (adopted on December 29, 1999 and revised on March 15, 2000). The SWRCB D-1641 amended certain terms and conditions of the SWP and CVP water rights to include 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 the CVP and SWP under SWRCB D-1641. The requirements in SWRCB D-1641 address the standards for fish and wildlife protection, water supply water quality, and Suisun Marsh salinity. These objectives include specific Delta outflow requirements throughout the year, specific export limits in the spring, and export limits based on a percentage of estuary inflow throughout the year. The water quality objectives are designed to protect agricultural, municipal and industrial, and fishery uses, and vary throughout the year and by water year type. The new export to inflow ratio limited exports to 35% of total Delta inflow from February through June. The 35% E/I from February to June required in D-1641 was a significant change from D-1485. This spring requirement reduced the availability of "unstored" flow for export and storage in San Luis Reservoir. February to June became an unreliable season for conveying water across the Delta. Spring X2 reduced the "unstored flow" availability by dedicating a significant block of water to Delta outflow/salinity goals. The “spring X2” Delta outflow is specified from February through June to maintain freshwater and estuarine conditions in the western Delta to protect aquatic life. The criteria require operations of the CVP and SWP upstream reservoir releases and Delta exports in a manner that maintains a salinity objective at an “X2” location. X2 refers to the horizontal distance from the Golden Gate Bridge up the axis of the Delta estuary to where tidally averaged near-bottom salinity concentration of 2 parts of salt in 1,000 parts of water occurs; the X2 standard was established to improve shallow water estuarine habitat in the months of February through June and relates to the extent of salinity movement into the Delta (DWR, Reclamation, USFWS and NMFS 2013). The location of X2 is important to both aquatic life and water supply beneficial uses.

The Delta outflow and salinity goals under D-1641 requires reservoir releases at times. The effect of D-1641 shifted the export season to the summer, and the CVP and SWP entered the fall with lower reservoir levels and less need for flood releases in the fall and winter. COA was not updated to address how the D-1641 operational requirements may change the sharing agreement and it also was not updated to define an approach to share the D-1641 export restrictions.

A Vernalis flow and salinity requirement was imposed for the San Joaquin Basin. D-1641 imposed a salinity standards for the San Joaquin Basin and also included requirements at Vernalis for both base flows and a large spring pulse flow, however it did not address how the requirement would be shared between the three major San Joaquin tributaries. In order to avoid protests and the need to immediately revise D-1641 to assign responsibility, the parties entered into the San Joaquin River Agreement (SJRA), which included flow commitments from all three tributaries, funding commitments, transfers and voluntary demand reductions. The agreement ended in 2009 but was extended to 2012. During the timeframe of this agreement, the parties expected the State Board to modify the San Joaquin River requirements and assign appropriate responsibility. Despite Reclamation extending the term of the SJRA to 2012, the SWRCB took no action and the SJRA expired. Absent the SJRA, responsibility for the Vernalis requirements were solely attached to the Reclamation water rights permits on the Stanislaus River for operating New Melones Dam and Reservoir, and it is the State Board’s position that this requires approximately 300–700 TAF of storage releases from New Melones Reservoir each year (SWRCB, 1999, Figure V-6). Reclamation’s view is that the Board’s position lacks a rational basis and conflicts with Reclamation’s long-term obligations under federal law.

Mean daily Delta outflow flows for Water Years 2001 through 2018 are presented on Figure A.5-3 (DWR 2018aw). Mean daily flows for Water Years 2001 through 2018 are presented on Figures A.5-4 through A.5-9 for diversions at Jones, Banks, Barker Slough, and Contra Costa Canal pumping plants; and Contra Costa Water District intakes at Old River and Middle River (DWR 2018ax, 2018ay, 2018az, 2018ba, 2018bb, 2018bc).

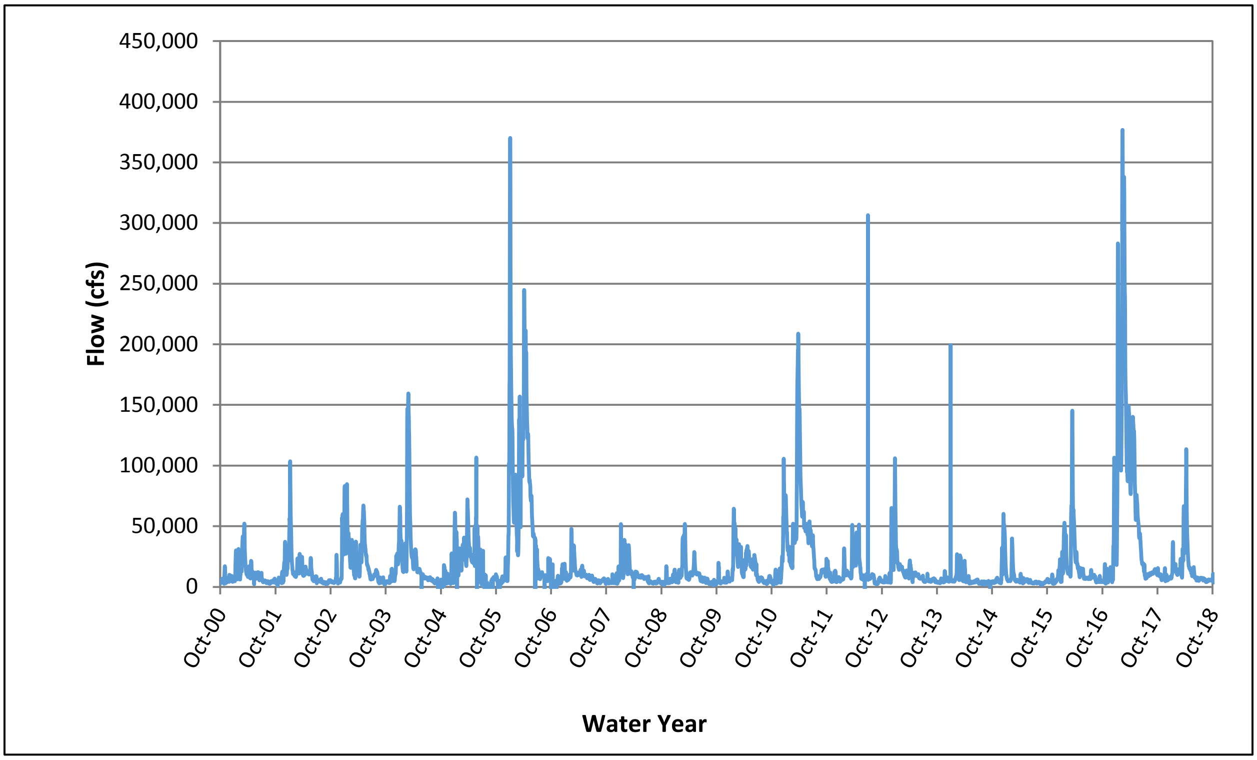


Figure A.5-3. Delta Outflow

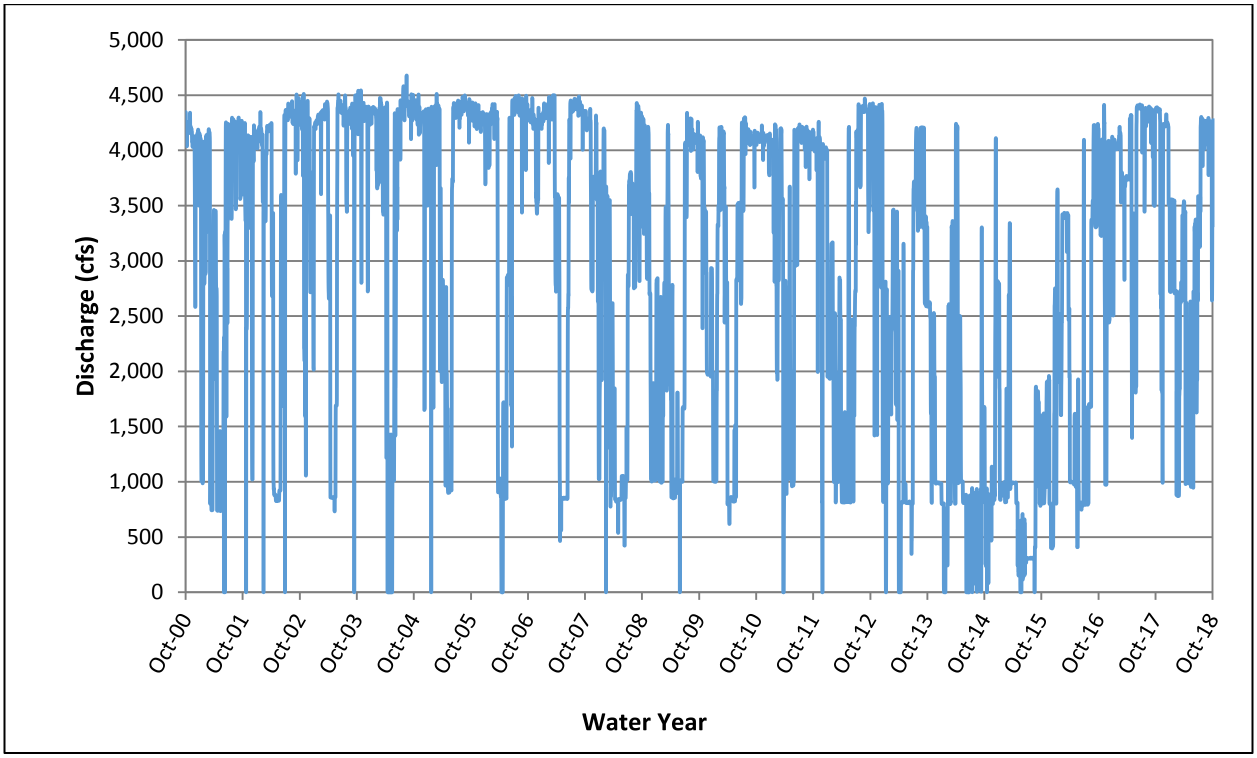


Figure A.5-4. Jones Pumping Plant

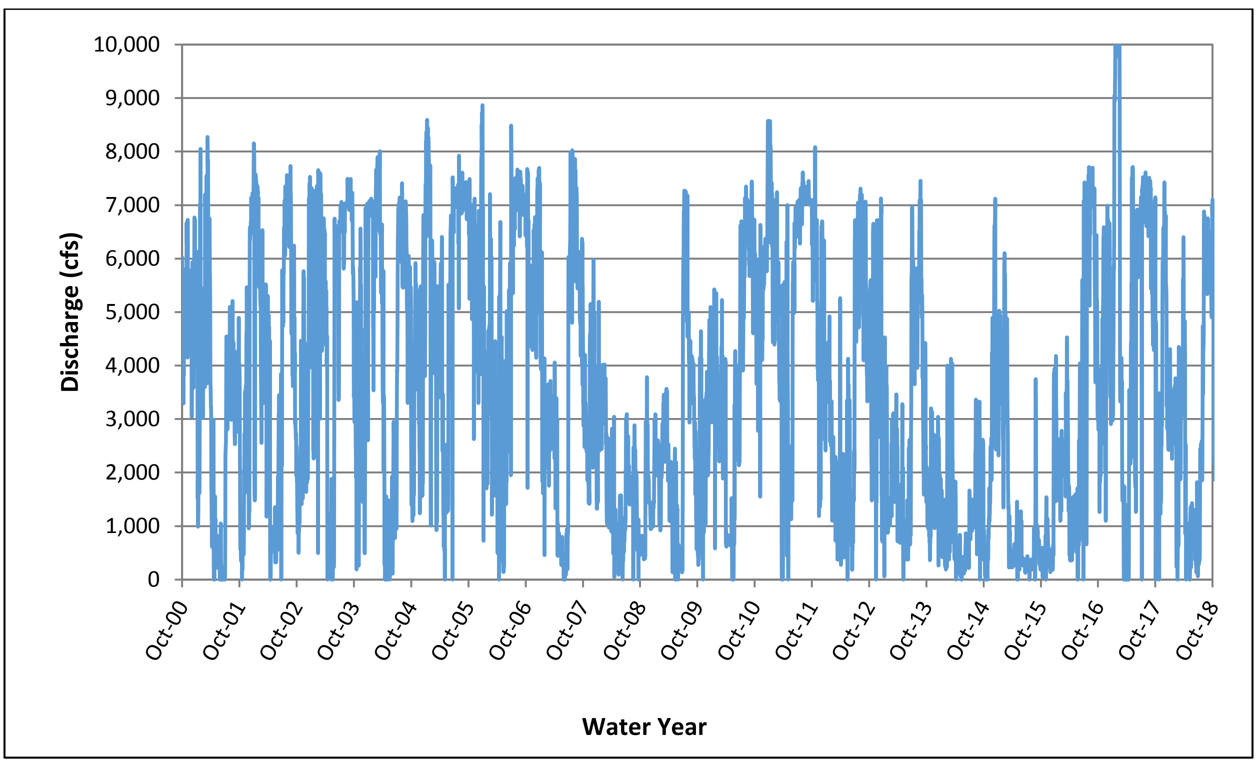


Figure A.5-5. Bank Pumping Plant

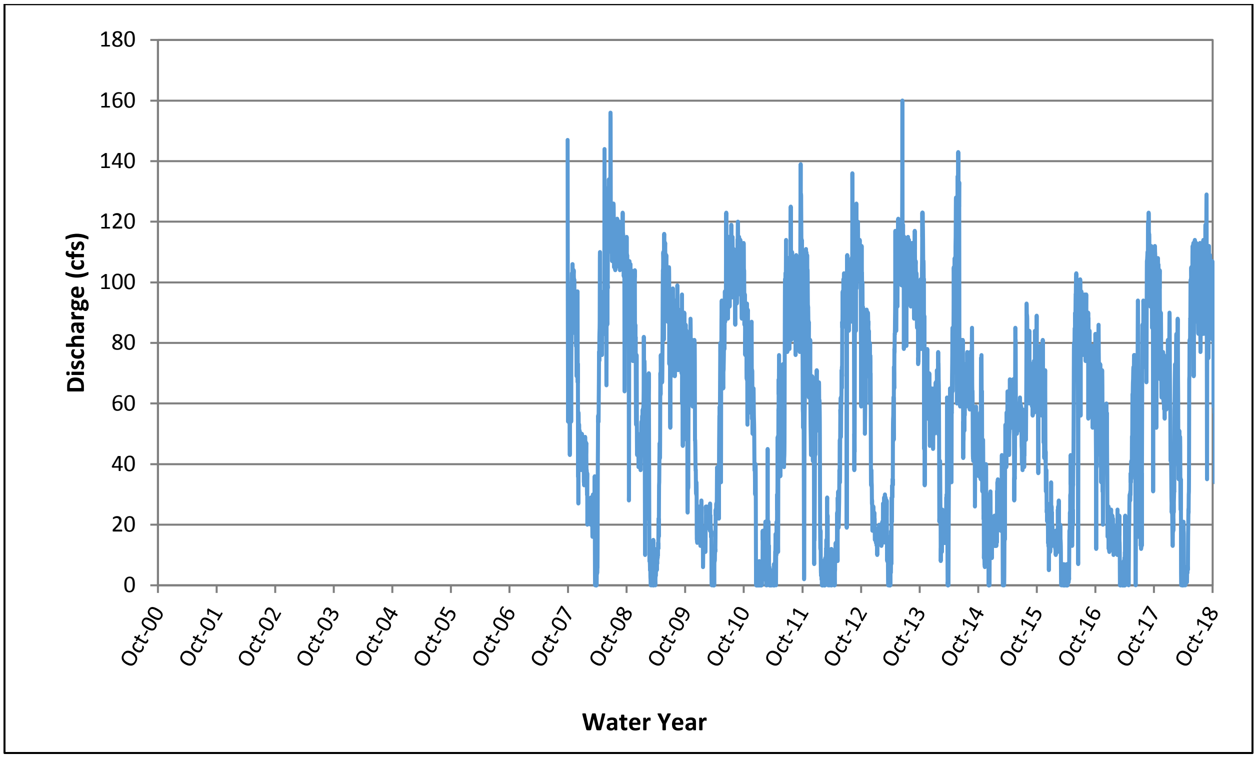


Figure A.5-6. Barker Slough Pumping Plant

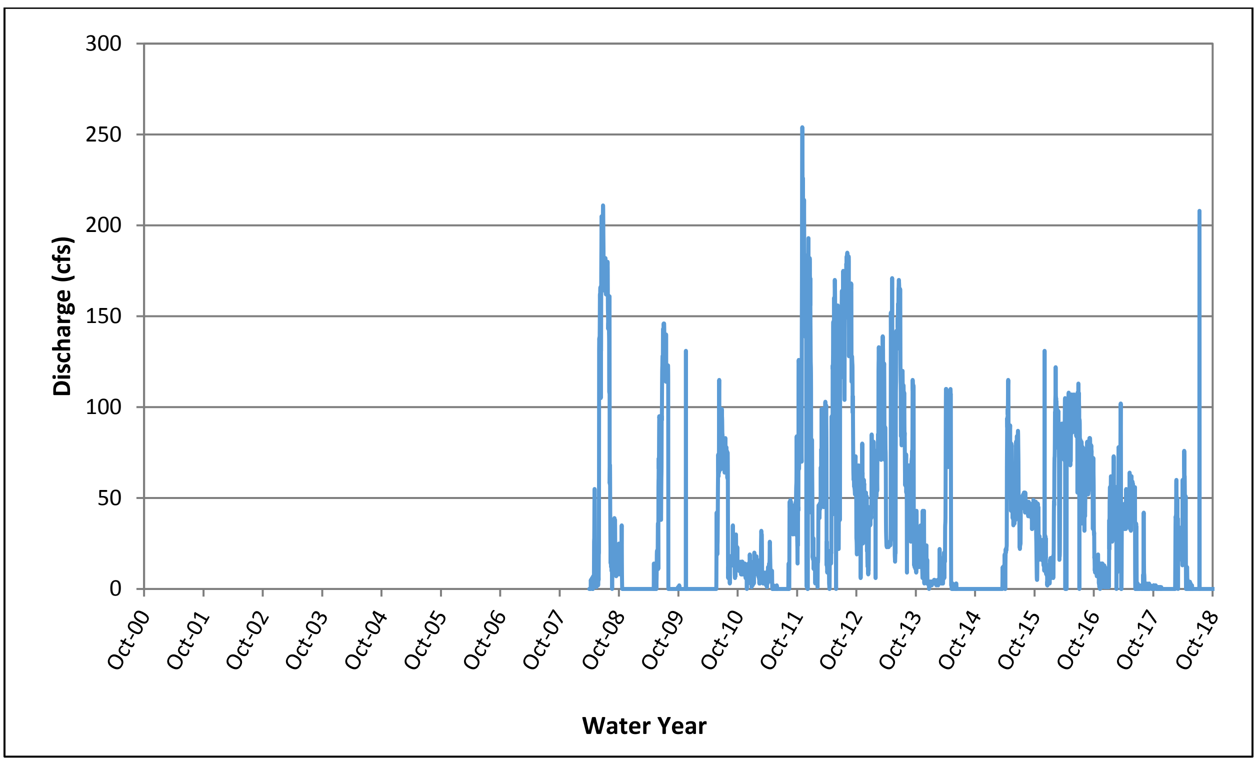


Figure A.5-7. Contra Costa Canal Rock Slough Intake

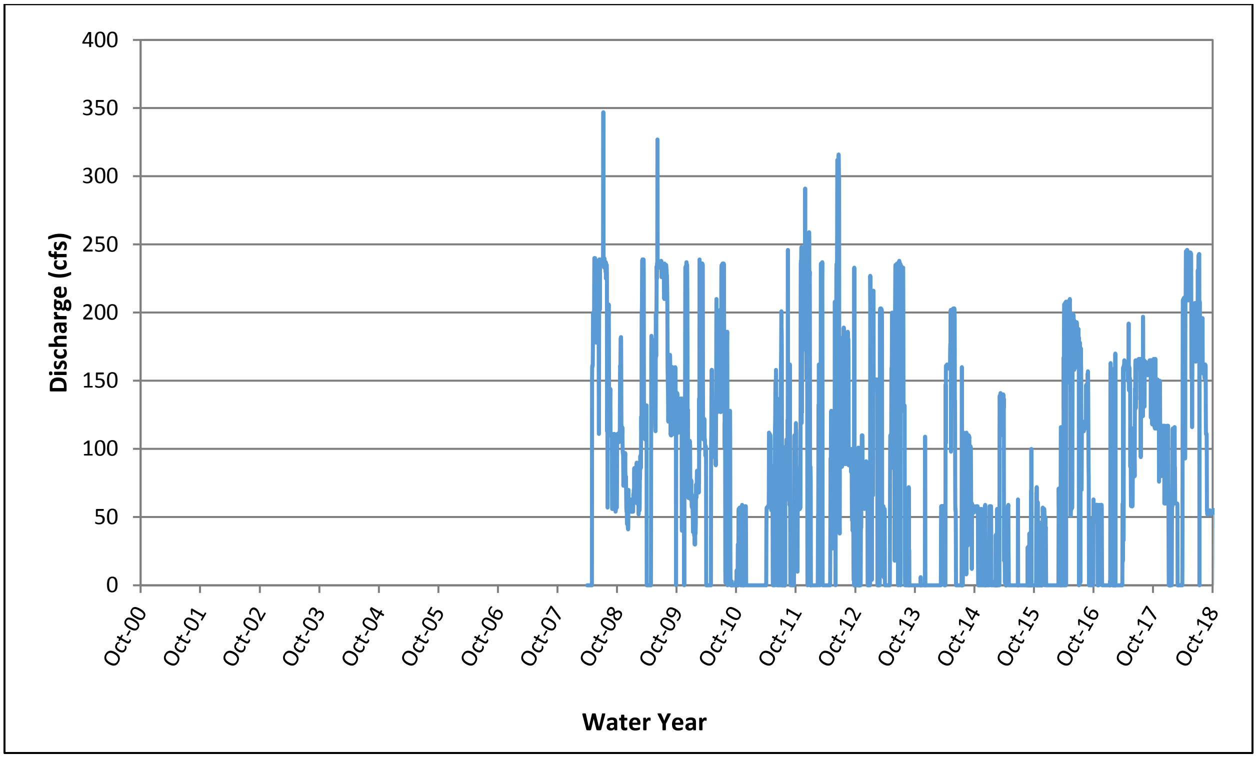


Figure A.5-8. Contra Costa WD Old River Intake

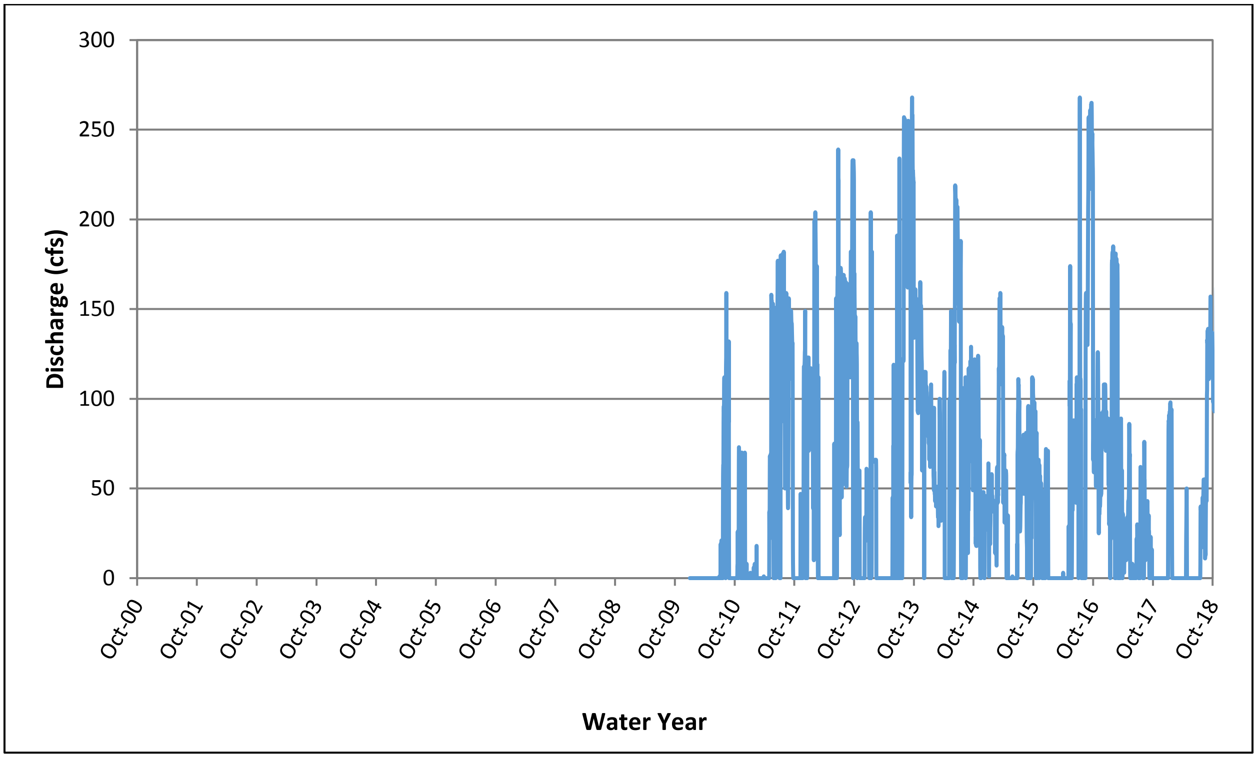


Figure A.5-9. Contra Costa WD Middle River Intake

A.5.3.2.2 Joint Point of Diversion

SWRCB D-1641 authorized the SWP and CVP to jointly use both Jones and Banks pumping plants in the southern Delta, with conditional limitations and required response coordination plans (referred to as Joint Point of Diversion [JPOD]). Use of JPOD is based on staged implementation and conditional requirements for each stage of implementation. The stages of JPOD in SWRCB D-1641 are:

- Stage 1—for water service to a group of CVP water service contractors (Cross Valley contractors, San Joaquin Valley National Cemetery and Musco Family Olive Company), and to recover export reductions implemented to benefit fish;
- Stage 2—for any purpose authorized under the current CVP and SWP water right permits; and
- Stage 3—for any purpose authorized, up to the physical capacity of the diversion facilities.

In general, JPOD capabilities are used to accomplish four basic CVP and SWP objectives:

- When wintertime excess pumping capacity becomes available during Delta excess conditions and total CVP and SWP San Luis storage is not projected to fill before the spring pulse flow period, the Project with the deficit in San Luis storage may elect to pursue the use of JPOD capabilities;
- When summertime pumping capacity is available at Banks Pumping Plant and CVP reservoir conditions can support additional releases, the CVP may elect to use JPOD capabilities to enhance annual CVP south of Delta water supplies;
- When summertime pumping capacity is available at Banks or Jones Pumping Plant to facilitate water transfers, JPOD may be used to further facilitate the water transfer; and
- During certain coordinated CVP and SWP operation scenarios for fishery entrainment management, JPOD may be used to shift CVP and SWP exports to the facility with the least fishery entrainment impact while minimizing export at the facility with the most fishery entrainment impact.

Each stage of JPOD has regulatory terms and conditions that must be satisfied in order to implement JPOD. All stages require a response plan to ensure water elevations in the southern Delta will not be lowered to the injury of local riparian water users (Water Level Response Plan); and a response plan to ensure the water quality in the southern and central Delta will not be significantly degraded through operations of the JPOD to the injury of water users in the southern and central Delta. Stage 2 has an additional requirement to complete an operations plan that will protect fish and wildlife and other legal users of water (Fisheries Response Plan). Stage 3 has an additional requirement to protect water levels in the southern Delta. All JPOD diversions under excess conditions in the Delta are junior to CCWD water right permits for the Los Vaqueros Project and must have an X2 location west of certain compliance locations consistent with the 1993 Los Vaqueros BO for Delta smelt.

A.5.3.2.3 Old and Middle River Reverse Flow Management

Reclamation and DWR propose to operate the CVP and SWP in a manner that maximizes exports while minimizing entrainment of fish. Net flow Old and Middle River Net Flows (OMR) provides a surrogate indicator for how exports at Banks and Jones Pumping Plants, San Joaquin River inflow, influence hydrodynamics in the south Delta. OMR flow for Water Years 2001 through 2018 is presented in Figure A.5-10 (USGS 2018a, 2018b).

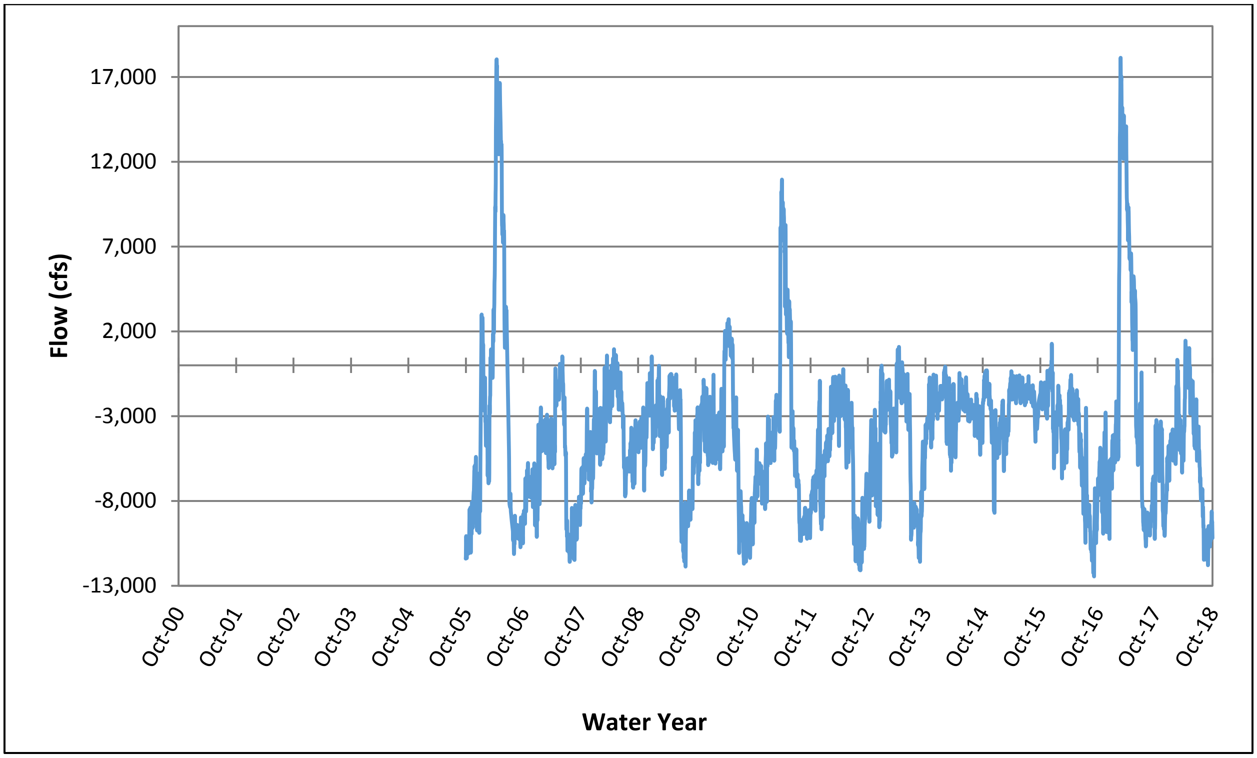


Figure A.5-10. OMR Flow (CFS) (source: USGS)

Reclamation and DWR propose to operate the CVP and SWP in a manner that maximizes exports while minimizing entrainment of fish and protecting critical habitat. Net flow in Old and Middle River (OMR) provides a surrogate indicator for how export pumping at Banks and Jones Pumping Plants influence hydrodynamics in the south Delta. The management of OMR, in combination with other environmental variables, can minimize or avoid the entrainment of fish in the South Delta and at CVP and SWP salvage facilities. Reclamation and DWR propose to maximize exports by incorporating real-time monitoring of fish distribution, turbidity, temperature, hydrodynamic models, and entrainment models into the decision support for the management of OMR to focus protections for fish when necessary and provide flexibility where possible, consistent with the WIIN Act Sections 4002 and 4003, as described below. Estimates of species distribution will be described by multi-agency Delta-focused technical teams. Reclamation and DWR will make a change to exports within 3 days of the trigger when monitoring, modeling, and criteria indicate protection for fish is necessary.

- Reclamation and DWR propose to operate to an OMR index computed using an equation. An OMR index allows for short-term operational planning and real-time adjustments.
- OMR Management: From the onset of OMR management to the end, Reclamation and DWR will operate to an OMR index no more negative than a 14-day moving average of -5,000 cfs unless a storm event occurs (see below for storm-related OMR flexibility). Grimaldo et al (2017) indicate that -5,000 cfs is an inflection point in OMR for fish entrainment. OMR could be more positive than -5000 cfs if additional real-time OMR restrictions are triggered as described below.
- Onset of OMR Management: Reclamation and DWR shall start OMR management when one or more of the following conditions have occurred:
    - o Integrated Early Winter Pulse Protection: When the 3-day average turbidity is 12 NTU or greater at Old River at Bacon Island (OBI), Prisoner's Point (PPT), and Victoria Canal (VCU) after December 1, Reclamation and DWR propose to operate to -2,000 cfs of the 14-

day average OMR index for 14 days. This action does not apply if triggered in January or later.

- o Salmonids: After January 1, if more than 5% of any one or more salmonid species (wild young-of-year Winter-run, wild young-of-year Spring-run, or wild central valley steelhead) are estimated to be present in the Delta as determined by their appropriate monitoring working group based on available real-time data, historical information and modeling.

- Additional Real-Time OMR Restrictions: Reclamation and DWR shall manage to a more positive OMR based on the following conditions:
  - o Turbidity Bridge Avoidance: Reclamation and DWR propose to operate to avoid a turbidity bridge (defined as 12 NTU at OBI, Middle River at Holt (HLT), and PPT). If a turbidity bridge occurs (72 hour average turbidity is 12 NTU or greater at OBI, Holland Cut near Bethel Island (HOL), and PPT, and/or other predictors of a turbidity bridge), Reclamation and DWR propose to operate to an 5-day average OMR index of -2000 cfs until the turbidity bridge dissipates (3-day average drops below 12 NTU at the 3 stations). If Reclamation and DWR determine that turbidity measured at the aforementioned sites is triggered by a wind event in Franks Tract and the channels immediately adjacent to Franks Tract, Reclamation and DWR would not modify the controlling OMR. This action terminates when water temperature reaches 12°C based on a three station daily mean at Mossdale, Antioch, and Rio Vista, or when Delta Smelt spawning starts (indicated by spent females or presence of larva in the Spring Kodiak Trawl, EDSM or at Jones or Banks Pumping Plants).
  - o Larval and Juvenile Delta Smelt: When Q-West is negative and larval or juvenile smelt are within the entrainment zone of the pumps based on real-time sampling, Reclamation and/or DWR propose to run hydrodynamic models informed by the EDSM, 20 mm or other relevant survey data to estimate the percentage of larval and juvenile smelt that could be entrained, and operate to avoid no greater than 10% loss of modeled larval and juvenile cohort Delta Smelt. (Typically this would come into effect beginning the middle of March.)
  - o Wild Central Valley Steelhead Protection: Reclamation and DWR would operate to OMR of -2,500 cfs for 5 days whenever natural-origin steelhead loss trigger between the onset of OMR management for steelhead (more than 5% of steelhead are present in the Delta) and May 31 exceeds 10 steelhead per TAF. The timing of this action is intended to provide protections to San Joaquin origin Central Valley steelhead, but the loss-density trigger is based on loss of all steelhead since there is currently no protocol to distinguish San Joaquin-basin and Sacramento-basin steelhead in salvage. Reclamation would use the current loss equation for steelhead or surrogate.
  - o Salvage or Loss Thresholds: Reclamation and DWR propose a cumulative annual loss threshold equal to 1% of the abundance estimate based on EDSM for adult Delta Smelt; 1% of the winter-run Chinook salmon JPE (genetically confirmed or 2% based on length at date); 1% of the spring-run Chinook salmon JPE (or 0.5% of spring-run surrogates); 3,000 juvenile Central Valley steelhead, and 100 juvenile green sturgeon. Reclamation and DWR propose to operate as follows:
- Reclamation and DWR may operate to a more positive OMR when the daily salvage loss indicates that continued OMR of -5,000 cfs may exceed the cumulative salvage loss thresholds as described below.
- Restrict OMR to a 14-day moving average OMR index of -3,500 cfs when a species-specific cumulative salvage or loss threshold exceeds 50 percent of the threshold. The OMR restriction to -3,500 cfs will persist until the species-specific offramp is met.

- Restrict OMR to a 14-day moving average OMR index of -2,500 cfs (or more positive if determined by Reclamation) when cumulative salvage or loss threshold for any of the above species exceeds 75 percent of the threshold. The OMR restriction to -2,500 cfs will persist until the species-specific offramp is met.
- Species specific OMR restrictions will end when the individual species-specific off ramp from "End of OMR management criteria", below, are met.
- Storm-Related OMR Flexibility: If Reclamation and DWR are not implementing additional real-time OMR restrictions, consistent with other applicable legal requirements, Reclamation and DWR may operate to a more negative OMR up to a maximum (otherwise-permitted) export rate at Banks and Jones Pumping Plants of 14,900 cfs (which could result in a range of OMR values) to capture peak flows during storm-related events. Reclamation and DWR will continue to monitor fish in real-time and will operate in accordance with "Additional Real-time OMR Restrictions," above.
- End of OMR Management: OMR criteria may control operations until June 30, or when both of the following have occurred, whichever is earlier:
    - Delta Smelt—when the daily mean water temperature at Clifton Court Forebay reaches 25° C for 3 consecutive days.
    - Salmonids—when more than 95 percent of salmonids have migrated past Chipps Island, as determined by their monitoring working group, OR after daily average water temperatures at Mossdale exceed 72°F for 7 days during June (the 7 days do not have to be consecutive).

Figure 4-5 shows OMR management in a decision tree.

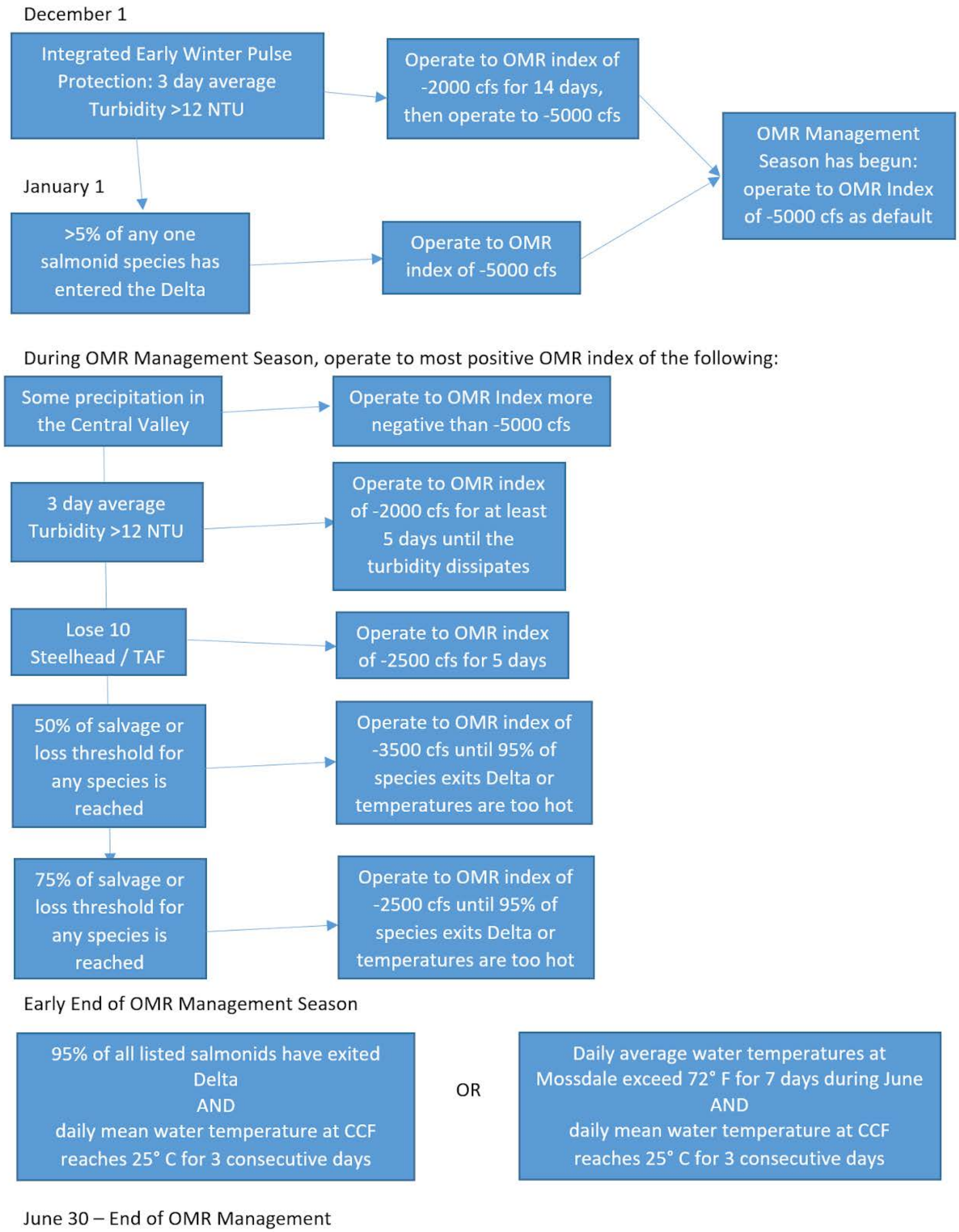


Figure 4-5. Decision Tree for Old and Middle River Reverse Flow Management

A.5.3.2.4 Delta Smelt Habitat

In addition to the October through May operation to meet Suisun water quality standards, Reclamation and DWR propose operating the Suisun Marsh Salinity Control Gates (SMSCG) on the tidal cycle to meet the physical and biological features of Delta Smelt critical habitat in below-normal and above-normal Sacramento Valley Index year types in June through September for 60 days, based on data gathered over time to allow for assessment of the action. Slater and Baxter (2014) posit that food is limited for Delta Smelt in August and September. Reclamation and DWR would increase tidal operations of the SMSCG to direct more fresh water in Suisun Marsh, which is intended to reduce salinities in Suisun Marsh, increase food, and improve habitat conditions for Delta Smelt in the region. This would be combined with Roaring River Distribution System management for food production; flushing fresh water through the Roaring River Distribution System to increase the low salinity habitat in Grizzly and Honker Bays. Reclamation and DWR will continue to meet existing D-1641 salinity requirements in the Delta and Suisun Marsh.

A.5.3.2.5 Water Transfers

Both projects propose to transfer project and non-project water supplies through CVP and SWP facilities. Water transfers would occur through various methods, including, but not limited to, groundwater substitution, release from storage, and cropland idling, and would include individual and multi-year transfers. Water transfers would occur from July through November in volumes up to those described in Table A.5-4.

Table A.5-4. Maximum Transfer Amounts, by Water Year Type

Water Year Type	Maximum Transfer Amount
Critical	Up to 600 Thousand Acre-Feet
Dry (following Critical)	Up to 600 Thousand Acre-Feet
Dry (following Dry)	Up to 600 Thousand Acre-Feet
All other years	Up to 360 Thousand Acre-Feet

As part of this proposed action, Reclamation and DWR will provide a transfer window from July 1 through November 30. Allowing fall transfers is expected to have water supply benefits and may provide flexibility to improve Sacramento River temperature operations, such as occurred during the 2014-2015 drought conditions. Real-time operations may restrict transfers within the transfer window so that Reclamation and DWR can meet other authorized project purposes, i.e. when pumping capacity is needed for CVP or SWP water.

A.5.3.2.6 Coordinated Operation Agreement

The CVP and SWP are operated in a coordinated manner in accordance with Public Law 99-546 (October 27, 1986), directing the Secretary to execute the COA. The CVP and SWP are also operated under the SWRCB decisions and water right orders related to the CVP's and SWP's 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 are permitted by SWRCB to store water, divert water and re-divert CVP and SWP water that has been stored in upstream reservoirs. 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. The CVP's and SWP's water rights are conditioned by the SWRCB to protect the beneficial uses of water within the watersheds.

As conditions of the water right permits and licenses, SWRCB requires the CVP and SWP to meet specific water quality objectives within the Delta. Reclamation and DWR coordinate operation of the CVP and SWP, pursuant to the COA, to meet these and other operating requirements. The COA is an agreement between the Federal government and the State of California for the coordinated operation of the CVP and SWP. The agreement suspended a 1960 agreement and superseded annual coordination agreements that had been implemented following construction of the SWP.

A.5.3.2.7 Obligations for In-Basin Uses

In-basin uses are defined in the COA as legal uses of water in the Sacramento Basin, including the water required under the SWRCB D-1485.

Balanced water conditions are defined in the COA as periods when it is mutually agreed that releases from upstream reservoirs plus unregulated flows approximately equals the water supply needed to meet Sacramento Valley in-basin uses plus exports. Excess water conditions are periods when it is mutually agreed that releases from upstream reservoirs plus unregulated flow exceed Sacramento Valley in-basin uses plus exports.

During excess water conditions, sufficient water is available to meet all beneficial needs, and the CVP and SWP are not required to make additional releases. In excess water conditions, water accounting is not required and some of the excess water is available to CVP water contractors, SWP water contractors, and users located upstream of the Delta. However, during balanced water conditions, CVP and SWP share the responsibility in meeting in-basin uses.

Each party's responsibility for making available storage withdrawals to meet Sacramento Valley inbasin use of storage withdrawals shall be determined by multiplying the total Sacramento Valley inbasin use of storage withdrawals by the following percentages, as shown in Table A.5-5.

Table A.5-5. Responsibility for Making Available Storage Withdrawals, by Water Year Type

Water Year Type*	United States	State of California
Wet	80%	20%
Above Normal	80%	20%
Below Normal	75%	25%
Dry	65%	35%
Critical	60%	40%

*Water year types will be determined by the Sacramento Valley 40-30-30 index.

The water year classifications described in this Article 6(c) shall be based on the Sacramento Valley 40—30—30 Index as most recently published through the Department of Water Resources Bulletin 120. In a Dry or Critical Year following two Dry or Critical Years, the United States and State will meet to discuss additional changes to the percentage sharing of responsibility to meet inbasin use.

- Sharing of Applicable Export Capacity When Exports are Constrained

  During periods when exports are constrained by non-discretionary requirements imposed on the Central Valley Project and the State Water Project South Delta exports by any federal or state agency, and the Delta is in balanced water conditions, the Projects will share the total export capacity with Reclamation pumping up to 65% of the allowable total exports and DWR pumping the remaining capacity, but no less than 35%.

When restrictions are in place and the Delta is in excess water conditions, the Projects will share the available capacity with Reclamation pumping 60% and DWR pumping 40% of available water.

- CVP use of Banks Pumping Plant

  DWR will transport up to 195,000 acre-feet of Central Valley Project water through the California Aqueduct Reaches 1, 2A, and 2B no later than November 30 of each year by direct diversion or by rediversion of stored Central Valley Project water at times those diversions do not adversely affect the State Water Project purposes or do not conflict with State Water Project contract provisions. The State will provide available capacity at the Harvey O. Banks Pumping Plant (“Banks”) to the Central Valley Project to divert or redivert 195,000 acre-feet when the diversion capacity at the south Delta intake to Clifton Court Forebay is in excess of 7,180 cubic feet per second during the July 1 through September 30, except when the Delta is in Excess Water Conditions during July 1 through September 30, the diversion capacity at the south Delta intake to Clifton Court Forebay in excess of 7,180 cubic feet per second shall be shared equally by the State and the United States. This Article does not alter the Cross-Valley Canal contractors’ priority to pumping at the Harvey O. Banks Pumping Plant, as now stated in Revised Water Rights Decision 1641 (March 15, 2000).

- Periodic review (article 14(b)(2) on page 24)

  Prior to December 31 of the fifth full year following execution of the revised COA, and before December 31 of each fifth year thereafter, or within 365 days of the implementation of new or revised requirements imposed jointly on Central Valley Project and State Water Project operations by any federal or state agency, or prior to initiation of operation of a new or significantly modified facility of the United States or the State or more frequently if so requested by either party, the United States and the State jointly shall review the operations of both projects. The parties shall (1) compare the relative success which each party has had in meeting its objectives, (2) review operation studies supporting this agreement, including, but not limited to, the assumptions contained therein, and (3) assess the influence of the factors and procedures of Article 6 in meeting each partys future objectives.

A.5.3.2.8 **Accounting and Coordination of Operations**

Reclamation and DWR coordinate on a daily basis to determine target Delta outflow for water quality, reservoir release levels necessary to meet in-basin demands, schedules for joint use of the San Luis Unit facilities, and for the use of each other’s facilities for pumping and wheeling. During balanced water conditions, daily water accounting is maintained for the CVP and SWP obligations. This accounting allows for flexibility in operations and avoids the necessity of daily changes in reservoir releases that originate several days’ travel time from the Delta.

The accounting language of the COA provides the mechanism for determining the responsibility of each project for Delta outflow influenced standards; however, real-time operations dictate actions. For example, conditions in the Delta can change rapidly. Weather conditions combined with tidal action can quickly affect Delta salinity conditions, and therefore, the Delta outflow required to maintain standards. If, in this circumstance, it is decided the reasonable course of action is to increase upstream reservoir releases, then the response may be to increase Folsom Reservoir releases first because the released water will reach the Delta before flows released from other CVP and SWP reservoirs. Lake Oroville water releases require about three days to reach the Delta, while water released from Shasta Lake requires five days to travel from Keswick Reservoir to the Delta. As water from the other reservoirs arrives in the Delta, Folsom Reservoir releases can be adjusted downward. Any imbalance in meeting each project's initial shared obligation would be captured by the COA accounting.

Reservoir release changes are one means of adjusting to changing in-basin conditions. Increasing or decreasing project exports can also immediately achieve changes to Delta outflow. As with changes in reservoir releases, imbalances in meeting the CVP and SWP initial shared obligations are captured by the COA accounting.

The duration of balanced water conditions varies from year to year. Some very wet years have had no periods of balanced conditions, while very dry years may have had long continuous periods of balanced conditions, and still other years may have had several periods of balanced conditions interspersed with excess water conditions.

A.5.4 Joint Facilities in Suisun Marsh

Since the early 1970s, the California Legislature, SWRCB, Reclamation, CDFW, Suisun Resource Conservation District (SRCD), DWR, and other agencies have worked to preserve beneficial uses of Suisun Marsh in mitigation for perceived impacts of reduced Delta outflow on the salinity regime. Early on, salinity standards were set by SWRCB to protect alkali bulrush production, a primary waterfowl plant food. The most recent standard under SWRCB D-1641 acknowledges that multiple beneficial uses deserve protection.

A contractual agreement among DWR, Reclamation, CDFW, and SRCD contains provisions for DWR and Reclamation to mitigate the effects on Suisun Marsh channel water salinity from SWP and CVP operations and other upstream diversions. The Suisun Marsh Preservation Agreement (SMPA) requires DWR and Reclamation to meet salinity standards, sets a timeline for implementing the Plan of Protection, and delineates monitoring and mitigation requirements. In addition to the contractual agreement, SWRCB D-1485 codified salinity standards in 1978, which have been carried forward to SWRCB D-1641.

There are two primary physical mechanisms for meeting salinity standards set forth in SWRCB D-1641 and the SMPA: (1) the implementation and operation of physical facilities in the Marsh; and (2) management of Delta outflow (i.e., facility operations are driven largely by salinity levels upstream of Montezuma Slough and salinity levels are highly sensitive to Delta outflow). Physical facilities, described below, have been operating since the early 1980s and have proven to be a highly reliable method for meeting standards.

A.5.4.1 *Suisun Marsh Salinity Control Gates*

The Suisun Marsh Salinity Control Gates (Gates), which aid in reducing salinity throughout the Suisun Marsh, are in the eastern portion of Montezuma Slough approximately 3 miles north of Collinsville. The Gates are one of the four facilities that began operating in November 1988 and were included in the SMPA. The Gates are a structure that consists of three radial gates, removable flashboards, and a boat lock that span the 465-foot width of Montezuma Slough. The gates control salinity by restricting the flow of higher salinity water from Grizzly Bay into Montezuma Slough during incoming tides and retaining lower salinity Sacramento River water from the previous ebb tide. Operation of the gates in this fashion lowers salinity in Suisun Marsh channels and results in a net movement of water from east to west.

The USACE permit for operating the SMSCG requires that it be operated between October and May only when needed to meet Suisun Marsh salinity standards. Historically, the gate has been operated as early as

October 1, while in some years (e.g. 1996) the gate was not operated at all. Currently, the Gates begin tidally-operating in early October, depending on salinity, and may continue through the end of May. This period is referred to as the control season. During the control season, the radial gates are lowered during the flood tides and opened during the ebb tides (i.e., tidally operated), flashboards are installed, and the boat lock is operated as-needed for passing vessels. Outside of the control season, the radial gates remain open (allowing unrestricted tidal flow), the flashboards are removed, and the operation of the boat lock is not needed.

In addition to the October through May operation to meet Suisun water quality standards, Reclamation and DWR propose operating the Suisun Marsh Salinity Control Gates (SMSCG) on the tidal cycle to meet the physical and biological features of Delta Smelt critical habitat in below-normal and above-normal Sacramento Valley Index year types in June through September for no more than 60 days as part of the adaptive management framework, based on data gathered over time to allow for assessment of the action. Slater and Baxter (2014) posit that food is limited for Delta Smelt in August and September. Reclamation and DWR would increase tidal operations of the SMSCG to direct more fresh water in Suisun Marsh, which is intended to reduce salinities in Suisun Marsh, increase food, and improve habitat conditions for Delta Smelt in the region. This would be combined with Roaring River Distribution System management for food production; flushing fresh water through the Roaring River Distribution System to increase the low salinity habitat in Grizzly and Honker Bays. Reclamation and DWR will continue to meet existing D-1641 salinity requirements in the Delta and Suisun Marsh. Reclamation and DWR would implement monitoring of physical factors to evaluate this action as part of the adaptive management plan.

Montezuma Slough runs in a semicircular route from the Sacramento River–San Joaquin River confluence downstream to Grizzly Bay. During flood tide, flow typically goes from west to east depending upon the magnitude of Delta outflow, where the flow from Grizzly Bay is dominant. By convention, this flow direction is considered to be negative. At high tide, a slack water condition typically occurs, and the flow slows to zero. Then, as ebb tide begins, flow goes from east to west, where the flow from the Delta is dominant. This flow direction is considered positive. At low tide, a slack water conditions once again occurs, with the flow slowing to zero.

The process then repeats. The Gates control salinity by allowing tidal flow from the Sacramento River into Montezuma Slough during ebb (outgoing) tides but restricting the tidal flow from Montezuma Slough during flood (incoming) tides. The Gates cause a net inflow (approximately 2,500 cubic feet per second) of low salinity Sacramento River water into Montezuma Slough. When sensors detect a velocity of -+0.1 feet per second (fps) the Gates automatically close. Some higher saline water from Grizzly Bay does enter Montezuma Slough, but far less than if the Gates were open. As the flood tide proceeds, a stage differential builds between both sides of the Gates, with the higher stage occurring on the western side. The highest differential occurs at high tide. As the ebb tide proceeds, the stage on the eastern side of the Gates becomes dominant. When the sensors read that the eastern side is 0.3 feet higher than the western side, the Gates are opened, allowing the less saline Delta outflow to flow into Montezuma Slough. This ‘freshwater pumping’ operation is effective only between September and May (depending on hydrology and when ebb flows have a lower volumetric flow rate) and when flashboards are in place. Currently, the gates are operated approximately 10-20 days a year in September and October as needed to meet water quality objectives for managed wetlands in the Marsh.

The Department coordinated fish passage studies in 1993, 1994, 1998, 1999, 2001, 2002, 2003, and 2004. Migrating adult fall-run Chinook Salmon were tagged and tracked by telemetry in the vicinity of the SMSCG to assess potential measures to increase the salmon passage rate and decrease salmon passage time through the gates. Results in 2001, 2003, and 2004 indicate that leaving the boat lock open during the Control Season when the flashboards are in place at the SMSCG and the radial gates are tidally operated provides a nearly equivalent fish passage to the outside of the control season configuration when the flashboards are out, and the radial gates are open. This approach minimizes delay and blockage of adult Sacramento River winter-run Chinook Salmon, Central Valley spring-run Chinook Salmon, and Central Valley Steelhead migrating upstream during the Control Season while the SMSCG is operating. However, the boat lock gates may be closed temporarily to stabilize flows to facilitate safe passage of watercraft through the facility.

Operation of the gates for salinity control is currently determined by salinities at monitoring stations throughout Suisun Marsh, to meet salinity targets, set by the State Water Resources Control Board in Water Right Decision 1641 (D-1641). If salinity is expected to exceed targets, DWR operates the Gates until salinity is sufficiently lowered. If salinities are low relative to the standards, the Gates remain in the open position. Reclamation and DWR proposes to hold the boat lock portion of the structure in an open position at all times during SMSCG operation to allow opportunities for fish passage during all phases of the tidal cycle.

A.5.4.2 *Roaring River Distribution System*

The Roaring River Distribution System (RRDS) is located in the southeastern Suisun Marsh and was constructed by the DWR and Reclamation in 1979 to mitigate for the effects on Marsh channel water salinity caused by Central Valley Project and State Water Project operations. The distribution system is used to convey less saline water from Montezuma Slough to managed 5,000 acres of private and 3,000 acres of CDFW managed wetlands on Simmons, Hammond, Van Sickle, Wheeler, and Grizzly Islands.

Salinity control is mandated by State Water Resources Control Board (SWRCB), Suisun Marsh Protection Plan (BCDC 1976), Plan of Protection for Suisun Marsh (DWR 1984) and associated Environmental Impact Report, and in response to D-1485, Order 7, superseded by D-1641. DWR and Reclamation are required under the Suisun Marsh Preservation Agreement (Reclamation et al. 1987) to operate and maintain the RRDS to provide lower salinity water to adjacent State and private landowners in the Marsh.

Diversions from Montezuma Slough typically occur from August through June. Water is diverted from RRDS to the managed wetlands and circulated. The water is drained from the managed wetlands in spring, taking with it salts from the soil.

The RRDS includes an intake structure from Montezuma Slough consisting of eight 60-inch culverts with flap gates and slide gates. Managed wetlands north and south of the RRDS receive water, as needed, through publicly and privately-owned turnouts on the system. Between 1981 and 1982 fish screens were placed over the intake according to California Department of Fish and Wildlife (CDFW) standards. After the listing of Delta Smelt, RRDS diversion rates have been controlled to maintain an average approach velocity below 0.7 ft/s at the intake fish screen. The intake discharges to the 40-acre Hammond Island pond at the southeast corner of CDFW property. Motorized slide gates in Montezuma Slough and flap gates in the pond control flows through the culverts into the pond. A manually operated flap gate and flashboard riser are located at the confluence of Roaring River and Montezuma Slough to allow drainage back into Montezuma Slough for controlling water levels in the distribution system and for flood protection. DWR owns and operates this drain gate to ensure the Roaring River levees are not compromised during extremely high tides. Approximately 8 miles of channel run from Hammond Island pond to the western edge of Simmons Island. Several turnouts along RRDS are operated and maintained by the DFW and adjacent private landowners.

DWR conducts routine maintenance of the system, primarily maintaining the levee roads and fish screens. RRDS, like other levees in the marsh, have experienced subsidence.

A.5.4.3 *Morrow Island Distribution System*

The Morrow Island Distribution System (MIDS) was constructed in 1979 and 1980 in the southwestern Suisun Marsh as part of the Initial Facilities in the Plan of Protection for the Suisun Marsh. The contractual requirement for Reclamation and DWR is to provide water to the ownerships so that lands may be managed according to approved local management plans. The system was constructed primarily to channel drainage water from the adjacent managed wetlands for discharge into Suisun Slough and Grizzly Bay. This approach increases circulation and reduces salinity in Goodyear Slough.

The MIDS is used year-round, but most intensively from September through June. When managed wetlands are filling and circulating, water is tidally diverted from Goodyear Slough just south of Pierce Harbor through three 48-inch culverts. Drainage water from Morrow Island is discharged into Grizzly Bay by way of the C-Line Outfall (two 36-inch culverts) and into the mouth of Suisun Slough by way of the M-Line Outfall (three 48-inch culverts), rather than back into Goodyear Slough. This helps prevent increases in salinity due to drainage water discharges into Goodyear Slough. The M-Line ditch is approximately 1.6 miles long and the C-Line ditch is approximately 0.8 miles long.

Reclamation and DWR operate the Goodyear Slough Outfall to improve water circulation in the marsh. This structure consists of four 48-inch diameter culverts with flap gates designed to drain water from the southern end of Goodyear Slough into Suisun Bay. On flood tides, the gates reduce the amount of tidal inflow into Goodyear Slough.

A.5.4.4 *Suisun Marsh Wildlife Habitat Management, Preservation, and Restoration Plan*

The Suisun Marsh Habitat Management, Preservation, and Restoration Plan (SMP) was developed by the Suisun Principal Agencies including USFWS, Reclamation, CDFW, DWR, NMFS, and Suisun Resource Conservation. The SMP is a 30-year comprehensive plan designed to address the various conflicts regarding use of Marsh resources, with the focus on achieving an acceptable multi-stakeholder approach. The plan balances the benefits of tidal wetland restoration with other habitat uses in the Marsh by evaluating alternatives that provide a politically acceptable change in Marshwide land uses, such as salt marsh harvest mouse habitat, managed wetlands, public use, and upland habitat. The SMP is intended to address the full range of issues in the Marsh, which are linked geographically, ecologically, and ideologically. The objectives of the SMP are to:

1. Implement the CALFED Ecosystem Restoration Program Plan (ERPP) restoration target for the Suisun Marsh ecoregion of 5,000 to 7,000 acres of tidal marsh and protection and enhancement of 40,000 to 50,000 acres of managed wetlands;
2. Maintain the heritage of waterfowl hunting and other recreational opportunities and increase the surrounding communities' awareness of the ecological values of Suisun Marsh;
3. Maintain and improve the Suisun Marsh levee system integrity to protect property, infrastructure, and wildlife habitats from catastrophic flooding; and
4. Protect and, where possible improve, water quality for beneficial uses in Suisun Marsh, including estuarine, spawning, and migrating habitat uses for fish species as well as recreational uses and associated wildlife habitat.

In June of 2013, the USFWS issued a BO (File Number: 08ESMF00-2012-F-0602-2) to the Bureau of Reclamation that addresses the effects of the SMP on the endangered threatened along with their designated critical habitat. The SMP BO analyses both a project-level plan for managed wetlands and a programmatic action for tidal restoration. Tidal wetland restoration helps achieve the restoration goals established for the Marsh by the CALFED ERP Plan, San Francisco Bay Area Wetlands Ecosystem Goals Project, and the USFWS's Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California for the Suisun Bay Area Recovery Unit. The BO details requirements for proposed tidal marsh restoration projects that maybe appended to the BO.

A.5.5 CVP and SWP Conveyance Facilities Downstream of San Luis Reservoir

Water is released from the San Luis Reservoir into the lower portion the California Aqueduct that extends to Lake Perris in Riverside County and delivers water to the San Joaquin Valley, Central Coast, and southern California. The first reach of the California Aqueduct, the San Luis Canal, 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.

Near Kettleman City, water is diverted into the SWP Coastal Branch Aqueduct to serves agricultural areas west of the California Aqueduct and communities in San Luis Obispo and Santa Barbara counties.

The California Aqueduct continues 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.

The East Branch conveys water through the Tehachapi East Afterbay, Alamo Powerplant, Pearblossom Pumping Plant, and Mojave Siphon Powerplant into Silverwood Lake in the San Bernardino Mountains, which stores 73,000 acre-feet of water. From Silverwood Lake, water flows through the San Bernardino Tunnel into Devil Canyon Powerplant to Lake Perris. Lake Perris, located near the City of Riverside, provides up to 131,500 acre-feet of storage, and serves as a regulatory and emergency water supply facility for the East Branch. The Phase I of the East Branch Extension was completed in 2003 and conveys water to San Gorgonio Pass Water Agency and the eastern portion of the San Bernardino Valley Municipal Water District.

The West Branch conveys water through Oso Pumping Plant, Quail Lake, Lower Quail Canal, and William E. Warne Powerplant into Pyramid Lake in Los Angeles County. Water from Pyramid Lake is conveyed through the Angeles Tunnel, Castaic Powerplant, Elderberry Forebay, and Castaic Lake. Castaic Lake, located north of the City of Santa Clarita, provides 324,000 acre-feet of storage, and is a regulatory and emergency water supply facility for the West Branch. The Castaic Powerplant is owned and operated by the Los Angeles Department of Water and Power.

A.5.6 Non-CVP and SWP Reservoirs that Store CVP and SWP Water

The CVP and SWP water is delivered to water agencies. Some of those water agencies store the water in regional and local reservoirs. These reservoirs frequently store non-CVP and SWP water supplies, including local runoff or water diverted under separate water rights or contracts. The capacities of these reservoirs are listed in Tables A.1-5, A.1-6, and A.1-7.

In the San Francisco Bay Area Region, CVP water is stored in the Contra Costa Water District Los Vaqueros Reservoir and the East Bay Municipal Utility District Upper San Leandro, San Pablo, Briones, and Lafayette reservoirs and Lake Chabot. The Los Vaqueros Reservoir, as previously described, also stores water diverted from the Delta under separate water rights. The East Bay Municipal Utility District reservoirs primarily store water diverted under water rights on the Mokelumne River.

In the Central Coast Region, a portion of the SWP water supply diverted in the Coastal Branch can be stored in Cachuma Lake for use by southern Santa Barbara County communities. Cachuma Lake is a facility owned and operated by Reclamation in Santa Barbara County as part of the Cachuma Project (not the CVP).

In the Southern California Region, SWP water is stored in the Metropolitan Water District of Southern California's Diamond Valley Lake and Lake Skinner; United Water Conservation District's Lake Piru; City of Escondido's Dixon Lake; City of San Diego's San Vicente, El Capitan, Lower Otay, Hodges, and Murray reservoirs; Helix Water District's Lake Jennings; Sweetwater Authority's Sweetwater Reservoir; and San Diego County Water Authority's Olivenhain Reservoir. There are future plans to expand local and regional water surface water storage.

A.5.7 Water Supplies Used by Central Valley Project and State Water Project Water Users

The CVP and SWP water supplies are the only water supplies available to some water users, many of the CVP Sacramento River Settlement Contractors, communities near Redding (Centerville, Clear Creek, and Shasta community services districts; Shasta County Water Agency), communities in the San Joaquin Valley (cities of Avenal, Coalinga, and Huron), and some communities served by the Antelope Valley-East Kern Water Agency. Other CVP and SWP water users rely upon other surface water supplies and groundwater. However, when the CVP and SWP water supplies are limited due to climate conditions and hydrology, the other surface water supplies are also limited.

Several CVP and SWP water users also rely upon other imported water supplies, including water from Solano Project (used by the Solano County Water Agency), San Francisco Public Utilities Commission (used by portions of the service areas of Alameda County Water District, Santa Clara Valley Water District, and Zone 7 Water Agency), and the Colorado River (used by portions of the service area of the Metropolitan Water District of Southern California and Coachella Valley Water District). These surface water supplies are also subject to reductions due to hydrologic conditions. In the case of water users that rely upon Colorado River water supplies, Delta water is used to dilute the salts and trace elements (e.g., selenium) in the Colorado River water in addition to providing direct water supplies (Reclamation 2012).

In response to recent reductions in CVP and SWP water supply reliability, water agencies have been improving regional and local water supply reliability through enhanced water conservation efforts, wastewater effluent and stormwater recycling, construction of surface water and groundwater storage facilities, and construction of desalination treatment plants for brackish water sources and ocean water sources. In addition, many agencies have constructed conveyance facilities to allow sharing of water supplies between communities, including the recent Bay Area Regional Water Supply Reliability project that provided conveyance opportunities between several CVP and SWP water users in the San Francisco Bay Area Region.

Water conservation is an integral part of water management in the study area. Water use efficiency programs and initiatives reduce the need for more expensive water supplies by facilitating the efficient use of existing water supplies. For example, a cost-effective component of many water plans is to reduce water use through educational tools that include commercial and residential guidance for water efficient landscapes, water use calculators for agricultural and municipal users, and conservation websites. All of these efforts are implemented to meet the statewide goals to reduce municipal per capita water use by 20 percent by 2020 and to optimize agricultural water use efficiency.

Water transfers also are an integral part of water management. Historically, water transfers primarily were in-basin transfers (e.g., Sacramento Valley water seller to Sacramento Valley water user) (Reclamation 2013b; DWR, Reclamation, USFWS and NMFS 2013). However, between 2001 and 2012, water transfers from the Sacramento Valley to the areas located south of the Delta of up to 298,806 acre-feet occurred (not including water transfers under the Environmental Water Account Program in the early 2000s) (DWR, Reclamation, USFWS and NMFS 2013). These transfers occurred in drier years. In the 2012 and 2013, the following types of water transfers occurred (DWR and Reclamation 2014).

Until recently, most of the water transfers extended for one or two years. In 2008, one of the first long-term water transfer agreements was approved by the SWRCB for the Lower Yuba River Accord. The plan was designed to protect and enhance fisheries resources in the Lower Yuba River, increase local water supply reliability, provide DWR with increased operational flexibility for protection of Delta fisheries resources, and provide added dry-year water supplies to CVP and SWP water users. In 2013, Reclamation approved an overall program for a 25-year period (2014 to 2038) to transfer up to 150,000 acre-feet per year of water from the San Joaquin River Exchange Contractors Water Authority to DOI for refuge water supplies or CVP and SWP water users (Reclamation 2013b). Reclamation is currently planning a long-term water transfer program between water sellers in the Sacramento Valley and water users located in the San Francisco Bay Area and south of the Delta (Reclamation 2014b).

A.6 References

CALFED. 2004. Environmental Water Program Pilot Flow Augmentation Project: Concept Proposal for Flow Acquisition on Lower Clear Creek. August.

CCSF (City and County of San Francisco). 2009. *Draft Environmental Impact Report, San Francisco Public Utilities Commission, Calaveras Dam Replacement Project*. October 6.

City of San Diego. 2014a. Reservoirs: Barrett Reservoir. Site accessed September 17, 2014. http://www.sandiego.gov/water/recreation/reservoirs/barrett/index.shtml.

City of San Diego. 2014b. Reservoirs: Sutherland Reservoir. Site accessed September 17, 2014. http://www.sandiego.gov/water/recreation/reservoirs/sutherland.shtml.

City of San Diego. 2014c. Reservoirs: El Capitan Reservoir. Site accessed September 17, 2014. http://www.sandiego.gov/water/recreation/reservoirs/elcapitan.shtml.

City of San Diego. 2014d. Reservoirs: Morena Reservoir. Site accessed September 17, 2014. http://www.sandiego.gov/water/recreation/reservoirs/morena.shtml.

DOI (U.S. Department of the Interior). 2000. *U.S. Department of the Interior Record of Decision Trinity River Mainstem Fishery Restoration Final Environmental Impact Statement/Environmental Impact Report December 2000*. December.

DOI (U.S. Department of the Interior). 2014. *Trinity River Division Authorization's 50,000 acre-foot Proviso and the 1959 Contract between the Bureau of Reclamation and Humboldt County, from Solicitor to Secretary of the Department of the Interior*. December 23.

DOI and DFG (Department of the Interior and California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2012. *Klamath Facilities Removal Final Environmental Impact Statement/Environmental Impact Report*. December. Drought Monitor. 2015. Site accessed October 29, 2015. http://droughtmonitor.unl.edu/MapsAndData/Data Tables.Aspx

DWR (California Department of Water Resources). 1957. Bulletin Number 3 California Water Plan.

DWR (California Department of Water Resources). 1984. The Potential for Rehabilitating Salmonid Habitat in Clear Creek, Shasta County. June.

DWR (California Department of Water Resources). 1986. Clear Creek Fishery Study. March.

DWR (California Department of Water Resources). 1994. California Water Plan Update Volume 1. Bulletin 160 93. October.

DWR (California Department of Water Resources). 2007a. Draft Environmental Impact Report Oroville Facilities Relicensing—FERC Project No. 2100. May.

DWR (California Department of Water Resources). 2009. Quantification of Pre-Screen Loss of Juvenile Steelhead in Clifton Court Forebay. March 2009.

DWR (California Department of Water Resources). 2010a. Release Site Predation Study. May 2010.

DWR (California Department of Water Resources). 2010b. The State Water Project Delivery Reliability Report 2009. August.

DWR (California Department of Water Resources). 2012. The State Water Project, Final Delivery Reliability Report, 2011. June.

DWR (California Department of Water Resources). 2013a. California Water Plan Update 2013 – Public Review Draft.

DWR (California Department of Water Resources). 2013b. North-of-the-Delta Offstream Storage Preliminary Administrative Draft Environmental Impact Report. December.

DWR (California Department of Water Resources). 2014b. Division of Safety of Dams, Listing of Dams. Site accessed September 3, 2014. http://www.water.ca.gov/damsafety/damlisting/.

DWR (California Department of Water Resources). 2014c. California Data Exchange Center, Reservoir Information, Sorted by Dam Name. Site accessed September 16, 2014. http://cdec.water.ca.gov/misc/resinfo.html.

DWR (California Department of Water Resources). 2014e. Notice to State Water Project Contractors, 2014 State Water Project Allocation Scheduling Revision. May 30.

DWR (California Department of Water Resources). 2015a. Clifton Court Forebay Predation Study. September 2015.

DWR (California Department of Water Resources). 2015b. Clifton Court Forebay Predation Study: 2013 Annual Progress Report. September 2015.

DWR (California Department of Water Resources). 2016a. Clifton Court Forebay Predation Study: 2014 Annual Progress Report. August 2016.

DWR (California Department of Water Resources). 2016b. Clifton Court Forebay Predator Reduction: Electrofishing Annual Report 2016. December 2016.

DWR (California Department of Water Resources). 2017a. Clifton Court Forebay Predation Study: 2015 Annual Progress Report. September 2017

DWR (California Department of Water Resources). 2017b. Clifton Court Forebay Predator Reduction: Electrofishing Annual Report 2017. December 2017.

DWR (California Department of Water Resources). 2018a. California Data Exchange Center: Trinity Lake, Monthly Reservoir Storage. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018b. California Data Exchange Center: Trinity Lake, Daily Reservoir Elevation. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018c. California Data Exchange Center: Lewiston, Monthly Reservoir Storage. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018d. California Data Exchange Center: Lewiston, Daily Reservoir Elevation. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018e. California Data Exchange Center: Trinity River at Douglas City, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018f. California Data Exchange Center: Klamath River at Klamath, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018g. California Data Exchange Center: Whiskeytown Dam, Monthly Reservoir Storage. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018h. California Data Exchange Center: Whiskeytown Dam, Daily Reservoir Elevation. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018i. California Data Exchange Center: Clear Creek near Igo, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018j. California Data Exchange Center: Shasta Dam, Monthly Reservoir Storage. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018k. California Data Exchange Center: Shasta Dam, Daily Reservoir Elevation. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018l. California Data Exchange Center: Keswick Reservoir, Monthly Reservoir Storage. Site accessed October 17, 2013. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018m. California Data Exchange Center: Keswick Reservoir, Daily Reservoir Elevation. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018n. California Data Exchange Center: Sacramento River at Bend Bridge, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018o. California Data Exchange Center: Sacramento River at Vina Bridge – Main Ch, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018p. California Data Exchange Center: Sacramento River at Hamilton City – Main Ch, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018q. California Data Exchange Center: Sacramento River Below Wilkins Slough, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018r. California Data Exchange Center: Sacramento River at Verona, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018s. California Data Exchange Center: Sacramento River at Freeport, Daily Flows. Site accessed December 2018 http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018t. California Data Exchange Center: Oroville Dam, Monthly Reservoir Storage. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018u. California Data Exchange Center: Oroville Dam, Daily Reservoir Elevation. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018v. California Data Exchange Center: Thermalito, Monthly Reservoir Storage. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018w. California Data Exchange Center: Thermalito, Daily Reservoir Elevation. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018x. California Data Exchange Center: Feather River near Gridley, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018y. California Data Exchange Center: Sacramento River at Fremont Weir (Crest 33.5’), Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018z. California Data Exchange Center: Folsom Lake, Monthly Reservoir Storage. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018aa. California Data Exchange Center: Folsom Lake, Daily Reservoir Elevation. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018ab. California Data Exchange Center: Lake Natoma (Nimbus Dam), Monthly Reservoir Storage. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018ac. California Data Exchange Center: Lake Natoma (Nimbus Dam), Daily Reservoir Elevation. Site accessed December 2018 http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018ad. California Data Exchange Center: American River at Fair Oaks, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018ae. California Data Exchange Center: Millerton Lake, Monthly Reservoir Storage. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018af. California Data Exchange Center: Millerton Lake, Daily Reservoir Elevation. Site accessed December 2018 http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018ag. California Data Exchange Center: Millerton Lake, Daily Reservoir Outflows. Site accessed December 2018 http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018ah. California Data Exchange Center: San Joaquin River at Gravelly Ford, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018ai. California Data Exchange Center: San Joaquin River Near Dos Palos, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018aj. California Data Exchange Center: San Joaquin River Near Washington Road, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018ak. California Data Exchange Center: Eastside Bypass Below Mariposa Bypass, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018al. California Data Exchange Center: San Joaquin River Near Mendota, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018am. California Data Exchange Center: San Joaquin River near Vernalis, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018an. California Data Exchange Center: New Melones Reservoir, Monthly Reservoir Storage. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018ao. California Data Exchange Center: New Melones Reservoir, Daily Reservoir Elevation. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018ap. California Data Exchange Center: Goodwin Dam, Daily Reservoir Storage. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018aq. California Data Exchange Center: Goodwin Dam, Daily Reservoir Elevation. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018ar. California Data Exchange Center: Stanislaus River at Orange Blossom Bridge, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018as. Clifton Court Forebay Predation Study: 2016 Annual Progress Report. January 2018.

DWR (California Department of Water Resources). 2018at. Clifton Court Forebay Predator Reduction: Electrofishing Annual Report 2018. December 2018.

DWR (California Department of Water Resources). 2018au. California Data Exchange Center: San Luis Reservoir, Monthly Reservoir Storage. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018av. California Data Exchange Center: San Luis Reservoir, Daily Reservoir Elevation. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018aw. California Data Exchange Center: Delta Outflow, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018ax. California Data Exchange Center: Jones Pumping Plant, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018ay. California Data Exchange Center: Harvey O Banks Pumping Plant, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018az. California Data Exchange Center: Barker Slough Pumping Plant, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018ba. California Data Exchange Center: CCWD Rock Slough PP Near Brentwood, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018bb. California Data Exchange Center: CCWD Old River PP Near Discovery Bay, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR (California Department of Water Resources). 2018bc. California Data Exchange Center: CCWD Middle River PP on Victoria Canal, Daily Flows. Site accessed December 2018. http://cdec.water.ca.gov/dynamicapp/selectQuery?station_id=&sensor_num=&dur_code=D&start_date=&end_date.

DWR and Reclamation (California Department of Water Resources and Bureau of Reclamation). 2014. Draft Technical Information for Preparing Water Transfer Proposals (Water Transfer White Paper), Information for Parties Preparing Proposals for Water Transfers Requiring Department of Water Resources or Bureau of Reclamation Approval. November. EBMUD (East Bay Municipal Utility District). 2011. Urban Water Management Plan 2010. June.

Federal Energy Regulatory Commission (FERC). 2009. 1995 New Don Pedro FERC Settlement Agreement. Available: <http://www.ferc.gov/docs-filing/elibrary.asp>.

Frantzich, J. 2014. Yolo Bypass as a Source of Delta Phytoplankton: Not Just a Legend of the Fall? Presented at the Interagency Ecological Program 2014 Annual Workshop, Friday February 28, 2014. Site accessed May 19, 2015. http://www.water.ca.gov/aes/staff/frantzich.cfm.

LYRARMT (Lower Yuba River Accord, River Management Team). 2013. Interim Monitoring & Evaluation Report. April 8.

McBain and Trush, Inc. (eds.). 2002. San Joaquin River Restoration Study Background Report. Prepared for Friant Water Users Authority, Lindsay California, and Natural Resources Defense Council, San Francisco, California.

NCRWQCB et al. (California North Coast Regional Water Quality Control Board and Bureau of Reclamation). 2009. Channel Rehabilitation and Sediment Management for Remaining Phase 1 and Phase 2 Sites, Draft Master Environmental Impact Report and Environmental Assessment. June.

PFMC (Pacific Fishery Management Council). 2015. Pacific Fishery Management Council Meeting. November.

Reclamation (Bureau of Reclamation). 1994. San Felipe Division, The Central Valley Project.

Reclamation (Bureau of Reclamation). 1997. Draft Central Valley Project Improvement Act – Programmatic Environmental Impact Statement/Report. September.

Reclamation (Bureau of Reclamation). 2004. Mendota Pool 10-Year Exchange Agreements, Final Environmental Impact Statement.

Reclamation (Bureau of Reclamation). 2009a. Whiskeytown Dam Hydraulics and Hydrology. June 4. Site accessed January 26, 2015 http://www.usbr.gov/projects/Facility.jsp?fac_Name=Whiskeytown+Dam&groupName=Hydraulics+26+Hydrology.

Reclamation (Bureau of Reclamation). 2010a. New Melones Lake Area, Final Resource Management Plan and Environmental Impact Statement. February.

Reclamation (Bureau of Reclamation). 2011a. Updated Information Pertaining to the 2008 Biological Opinion for Coordinated Long-Term Operation of the Central Valley Project (CVP) and State Water Project (SWP). Letter from Susan M. Fry, Reclamation Bay-Delta Office Manager to Michael A. Chotkowski, U.S. Fish and Wildlife Service Field Supervisor. August 26.

Reclamation (Bureau of Reclamation). 2011b. Shasta/Trinity River Division Project, Project Data. April 2011. Site accessed January 26, 2015 http://www.usbr.gov/projects/Project.jsp?proj_Name=Shasta/Trinity River Division Project&pageType=ProjectDataPage.

Reclamation (Bureau of Reclamation). 2012. Colorado River Basin Water Supply and Demand Study. December.

Reclamation (Bureau of Reclamation). 2013a. Shasta Lake Water Resources Investigation Draft Environmental Impact Statement. June.

Reclamation (Bureau of Reclamation). 2013b. Record of Decision, Water Transfer Program for the San Joaquin River Exchange Contractors Water Authority, 2014-2038. July 30.

Reclamation (Bureau of Reclamation). 2014a. Orland Project. Site accessed September 14, 2014. http://www.usbr.gov/projects/Project.jsp?proj_Name=Orland+Project.

Reclamation (Bureau of Reclamation). 2014b. San Luis Unit Project. Site accessed September 13, 2014. http://www.usbr.gov/projects/Project.jsp?proj_Name=San Luis Unit Project.

Reclamation (Bureau of Reclamation). 2014c. Cachuma Project. Site accessed September 14, 2014. http://www.usbr.gov/projects/Project.jsp?proj_Name=Cachuma+Project.

Reclamation (Bureau of Reclamation). 2014d. Shasta/Trinity River Division Project. Site accessed September 14, 2014. http://www.usbr.gov/projects/Project.jsp?proj_Name=Shasta/Trinity River Division Project.

Reclamation (Bureau of Reclamation). 2014e. Spring Creek Debris Dam and Powerplant. Site accessed September 19, 2014. http://www.usbr.gov/mp/headlines/2014/June/Photo_of_the_Week6-16-14.pdf.

Reclamation (Bureau of Reclamation). 2015. Central Valley Project Summary of Water Supply Allocations (1977 to 2015). Site accessed October 29, 2015. http://www.usbr.gov/mp/cvo

Reclamation and DWR (Bureau of Reclamation, and California Department of Water Resources). 2011. San Joaquin River Restoration Program Environmental Impact Statement/Report.

Reclamation (Bureau of Reclamation). 2018a. Historical Archive and Reports System QA/QC Database. San Joaquin River at Bifurcation, Daily Flow.

Reclamation (Bureau of Reclamation). 2018b. Historical Archive and Reports System QA/QC Database. San Joaquin River at Freemont Ford Bridge, Daily Flow.

Reclamation et al. (Bureau of Reclamation, U.S. Army Corps of Engineers, California Reclamation Board, Sacramento Area Flood Control Agency). 2006. Folsom Dam Safety and Flood Damage Reduction Draft Environmental Impact Statement/Environmental Impact Report. December.

Reclamation and DWR (Bureau of Reclamation, and California Department of Water Resources). 2014a. CVP and SWP Drought Contingency Plan, October 15, 2014 through January 15, 2015, Balancing Multiple Needs in Fall 2014. October 15.

Reclamation and DWR (Bureau of Reclamation, and California Department of Water Resources). 2014b. Interagency 2015 Drought Strategy for the Central Valley Project and State Water Project, Working Draft. December 11.

Reclamation and DWR (Bureau of Reclamation, and California Department of Water Resources). 2015a. Central Valley Project and State Water Project Drought Contingency Plan, January 15, 2015 – September 30, 2015. January 15.

San Joaquin River Resource Management Coalition (RMC). 2003. Upper San Joaquin River Conceptual Restoration Phase 1 Planning Document. August.

San Joaquin River Resources Management Coalition (RMC). 2007. Final Appraisal Report: San Joaquin River Settlement Agreement and Legislation, prepared for San Joaquin River Resource Management Coalition. September.

SCVWD (Santa Clara Valley Water District). 2012a. 2011 Urban Water Management Plan 2010. May.

SDCWA and USACE (San Diego County Water Authority and U.S. Army Corps of Engineers). 2008. Final Environmental Impact Report/Environmental Impact Statement for the Carryover Storage and San Vicente Dam Raise Project. April.

SJRRP (San Joaquin River Restoration Program). 2011a. Draft Program Environmental Impact Statement/Environmental Impact Report. April.

SWRCB (State Water Resources Control Board). 2009a. In the Matter of Petitions for Reconsideration of Water Quality Certification for the Re-Operation of Pyramid Dam for the California Aqueduct Hydroelectric Project Federal Energy Regulatory Commission Project No. 2426. August 4

SWRCB (State Water Resources Control Board). 2009b. Water Recycling Funding Program (WRFP). Site accessed October 29, 2015. http://www.waterboards.ca.gov/water_issues/programs/grants_loans/water_recycling/muirec.shtml

SWRCB (State Water Resources Control Board). 2012. Public Draft, Substitute Environmental Document in Support of Potential Changes to the Water Quality Control Plan for the San Francisco Bay-Sacramento/San Joaquin Delta Estuary: San Joaquin River Flows and Southern Delta Water Quality. December.

TRRP (Trinity River Restoration Program, including Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Forest Service, Hoopa Valley Tribe, Yurok Tribe, California Department of Water Resources, California Department of Fish and Wildlife, and Trinity County). 2014. Typical Releases. Site accessed September 4, 2014. http://www.trrp.net/restore/flows/typical/.

USACE (U.S. Army Corps of Engineers). 2012. Biological Assessment for the U.S. Army Corps of Engineers Ongoing Operation and Maintenance of Englebright Dam and Reservoir, and Daguerre Point Dam on the Yuba River. January.

USACE (U.S. Army Corps of Engineers). 2013. Biological Assessment for the U.S. Army Corps of Engineers Ongoing Operation and Maintenance of Englebright Dam and Reservoir on the Yuba River. October.

USACE (U.S. Army Corps of Engineers). 2014. Recreation at Englebright Lake. Site accessed May 19, 2014. http://www.spk.usace.army.mil/Locations/SacramentoDistrictParks/EnglebrightLake.aspx.

U.S. Environmental Protection Agency (EPA). 2007. Tulare Lake Basin Hydrology and Hydrography: A Summary of the Movement of Water and Aquatic Species. April 2007.USEPA. See U.S. Environmental Protection Agency

USFWS et al. (U.S. Fish and Wildlife Service, Bureau of Reclamation, Hoopa Valley Tribe, and Trinity County). 1999. Trinity River Mainstem Fishery Restoration Environmental Impact Statement/Report. October.

USGS (U.S. Geological Survey). 2018a. National Water Information System Web Interface: USGS 11313405 Old River at Bacon Island. Accessed December 2018. https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=11313405.

USGS (U.S. Geological Survey). 2018b. National Water Information System Web Interface: USGS 11312676 Middle River at Middle River. Accessed December 2018. https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=11312676.

WSRCD (Western Shasta Resource Conservation District). 1998. Lower Clear Creek Watershed Management Plan. September.

2003. 2002 Riparian Revegetation Monitoring Report, Lower Clear Creek Floodway Rehabilitation Project Phases 2A, 2B North & 2B South. April.

WSRCD (Western Shasta Resource Conservation District). 2004. WY2004 Geomorphic Monitoring Report, Clear Creek Floodplain Rehabilitation Project. June.

WWD (Westlands Water District). 2013. Water Management Plan, 2012. April 19.

YCWA (Yuba County Water Agency). 2012. Yuba County Water Agency's *Yuba River Development Project Relicensing*.

Appendix B New Melones Stepped Release Plan Daily Hydrographs for Critical, Dry, Below Normal, Above Normal and Wet Year Types

New Melones Stepped Release Plan Daily Hydrographs for Critical Year Types

OCT	CFS	NOV	CFS	DEC	CFS	JAN	CFS	FEB	CFS	MAR	CFS	APR	CFS	MAY	CFS	JUN	CFS	JUL	CFS	AUG	CFS	SEP	CFS
1	200	1	200	1	200	1	200	1	200	1	200	1	200	1	725	1	150	1	150	1	150	1	150
2	200	2	200	2	200	2	200	2	200	2	200	2	200	2	725	2	150	2	150	2	150	2	150
3	200	3	200	3	200	3	400	3	200	3	200	3	200	3	725	3	150	3	150	3	150	3	150
4	200	4	200	4	200	4	400	4	200	4	200	4	200	4	725	4	150	4	150	4	150	4	150
5	200	5	200	5	200	5	200	5	400	5	200	5	200	5	725	5	150	5	150	5	150	5	150
6	200	6	200	6	200	6	200	6	400	6	200	6	200	6	725	6	150	6	150	6	150	6	150
7	200	7	200	7	200	7	200	7	200	7	200	7	200	7	725	7	150	7	150	7	150	7	150
8	200	8	200	8	200	8	200	8	200	8	200	8	200	8	725	8	150	8	150	8	150	8	150
9	200	9	200	9	200	9	200	9	200	9	200	9	200	9	725	9	150	9	150	9	150	9	150
10	200	10	200	10	200	10	200	10	200	10	200	10	200	10	725	10	150	10	150	10	150	10	150
11	200	11	200	11	200	11	200	11	200	11	200	11	200	11	725	11	150	11	150	11	150	11	150
12	200	12	200	12	200	12	200	12	200	12	200	12	200	12	725	12	150	12	150	12	150	12	150
13	200	13	200	13	200	13	200	13	200	13	200	13	200	13	550	13	150	13	150	13	150	13	150
14	200	14	200	14	200	14	200	14	200	14	200	14	200	14	450	14	150	14	150	14	150	14	150
15	500	15	200	15	200	15	200	15	200	15	200	15	350	15	300	15	150	15	150	15	150	15	150
16	750	16	200	16	200	16	200	16	200	16	200	16	500	16	150	16	150	16	150	16	150	16	150
17	1000	17	200	17	200	17	200	17	200	17	200	17	725	17	150	17	150	17	150	17	150	17	150
18	1250	18	200	18	200	18	200	18	200	18	200	18	725	18	150	18	150	18	150	18	150	18	150
19	1250	19	200	19	200	19	200	19	200	19	200	19	725	19	150	19	150	19	150	19	150	19	150
20	1250	20	200	20	200	20	200	20	200	20	200	20	725	20	150	20	150	20	150	20	150	20	150
21	1250	21	200	21	200	21	200	21	200	21	200	21	725	21	150	21	150	21	150	21	150	21	150
22	1250	22	200	22	200	22	200	22	200	22	200	22	725	22	150	22	150	22	150	22	150	22	150
23	1250	23	200	23	200	23	200	23	200	23	200	23	725	23	150	23	150	23	150	23	150	23	150
24	1250	24	200	24	200	24	200	24	200	24	200	24	725	24	150	24	150	24	150	24	150	24	150
25	1250	25	200	25	200	25	200	25	200	25	200	25	725	25	150	25	150	25	150	25	150	25	150
26	1000	26	200	26	200	26	200	26	200	26	200	26	725	26	150	26	150	26	150	26	150	26	150
27	750	27	200	27	200	27	200	27	200	27	200	27	725	27	150	27	150	27	150	27	150	27	150
28	500	28	200	28	200	28	200	28	200	28	200	28	725	28	150	28	150	28	150	28	150	28	150
29	200	29	200	29	200	29	200			29	200	29	725	29	150	29	150	29	150	29	150	29	150
30	200	30	200	30	200	30	200			30	200	30	725	30	150	30	150	30	150	30	150	30	150
31	200			31	200	31	200			31	200			31	150			31	150	31	150		
mo cfs	17900		6000		6200		6600		6000		6200		13800		12400		4500		4650		4650		4500
conv factor	1.984																						
mo af	35505	0	11901	0	12298	0	13091	0	11901	0	12298	0	27372	0	24595	0	8926	0	9223	0	9223	0	8926
yr af	2E+05																						

New Melones Stepped Release Plan Daily Hydrographs for Dry Year Types

OCT	CFS	NOV	CFS	DEC	CFS	JAN	CFS	FEB	CFS	MAR	CFS	APR	CFS	MAY	CFS	JUN	CFS	JUL	CFS	AUG	CFS	SEP	CFS
1	200	1	200	1	200	1	200	1	200	1	200	1	200	1	1000	1	200	1	200	1	200	1	200
2	200	2	200	2	200	2	200	2	200	2	200	2	200	2	1000	2	200	2	200	2	200	2	200
3	200	3	200	3	200	3	400	3	200	3	200	3	200	3	1000	3	200	3	200	3	200	3	200
4	200	4	200	4	200	4	400	4	200	4	200	4	200	4	1000	4	200	4	200	4	200	4	200
5	200	5	200	5	200	5	400	5	400	5	200	5	200	5	1000	5	200	5	200	5	200	5	200
6	200	6	200	6	200	6	200	6	400	6	200	6	200	6	1000	6	200	6	200	6	200	6	200
7	200	7	200	7	200	7	200	7	400	7	200	7	200	7	1000	7	200	7	200	7	200	7	200
8	200	8	200	8	200	8	200	8	200	8	200	8	350	8	1000	8	200	8	200	8	200	8	200
9	200	9	200	9	200	9	200	9	200	9	200	9	500	9	1000	9	200	9	200	9	200	9	200
10	200	10	200	10	200	10	200	10	200	10	200	10	750	10	1000	10	200	10	200	10	200	10	200
11	200	11	200	11	200	11	200	11	200	11	200	11	1000	11	1000	11	200	11	200	11	200	11	200
12	200	12	200	12	200	12	200	12	200	12	200	12	1000	12	1000	12	200	12	200	12	200	12	200
13	200	13	200	13	200	13	200	13	200	13	200	13	1000	13	1000	13	200	13	200	13	200	13	200
14	200	14	200	14	200	14	200	14	200	14	200	14	1000	14	1000	14	200	14	200	14	200	14	200
15	500	15	200	15	200	15	200	15	200	15	200	15	1000	15	1000	15	200	15	200	15	200	15	200
16	750	16	200	16	200	16	200	16	200	16	200	16	1000	16	800	16	200	16	200	16	200	16	200
17	1000	17	200	17	200	17	200	17	200	17	200	17	1000	17	600	17	200	17	200	17	200	17	200
18	1250	18	200	18	200	18	200	18	200	18	200	18	1000	18	450	18	200	18	200	18	200	18	200
19	1250	19	200	19	200	19	200	19	200	19	200	19	1000	19	300	19	200	19	200	19	200	19	200
20	1250	20	200	20	200	20	200	20	200	20	200	20	1000	20	200	20	200	20	200	20	200	20	200
21	1500	21	200	21	200	21	200	21	200	21	200	21	1000	21	200	21	200	21	200	21	200	21	200
22	1500	22	200	22	200	22	200	22	200	22	200	22	1000	22	200	22	200	22	200	22	200	22	200
23	1500	23	200	23	200	23	200	23	200	23	200	23	1000	23	200	23	200	23	200	23	200	23	200
24	1250	24	200	24	200	24	200	24	200	24	200	24	1000	24	200	24	200	24	200	24	200	24	200
25	1250	25	200	25	200	25	200	25	200	25	200	25	1000	25	200	25	200	25	200	25	200	25	200
26	1250	26	200	26	200	26	200	26	200	26	200	26	1000	26	200	26	200	26	200	26	200	26	200
27	1000	27	200	27	200	27	200	27	200	27	200	27	1000	27	200	27	200	27	200	27	200	27	200
28	750	28	200	28	200	28	200	28	200	28	200	28	1000	28	200	28	200	28	200	28	200	28	200
29	500	29	200	29	200	29	200			29	200	29	1000	29	200	29	200	29	200	29	200	29	200
30	200	30	200	30	200	30	200			30	200	30	1000	30	200	30	200	30	200	30	200	30	200
31	200			31	200	31	200			31	200			31	200			31	200	31	200		
mo cfs	19700		6000		6200		6800		6200		6200		23000		19550		6000		6200		6200		6000
conv factor	1.9835																						
mo af	39075	0	11901	0	12298	0	13488	0	12298	0	12298	0	45621	0	38777	0	11901	0	12298	0	12298	0	11901

New Melones Stepped Release Plan Daily Hydrographs for Below Normal Year Types

OCT	CFS	NOV	CFS	DEC	CFS	JAN	CFS	FEB	CFS	MAR	CFS	APR	CFS	MAY	CFS	JUN	CFS	JUL	CFS	AUG	CFS	SEP	CFS
1	250	1	200	1	200	1	200	1	200	1	200	1	400	1	1500	1	900	1	250	1	250	1	250
2	250	2	200	2	200	2	200	2	200	2	200	2	750	2	1500	2	600	2	250	2	250	2	250
3	250	3	200	3	200	3	400	3	200	3	200	3	1000	3	1500	3	600	3	250	3	250	3	250
4	250	4	200	4	200	4	400	4	200	4	200	4	1250	4	1500	4	600	4	250	4	250	4	250
5	250	5	200	5	200	5	400	5	400	5	200	5	1500	5	1500	5	600	5	250	5	250	5	250
6	250	6	200	6	200	6	400	6	400	6	200	6	1700	6	1500	6	600	6	250	6	250	6	250
7	250	7	200	7	200	7	200	7	400	7	200	7	2000	7	1500	7	450	7	250	7	250	7	250
8	250	8	200	8	200	8	200	8	400	8	200	8	2000	8	1500	8	450	8	250	8	250	8	250
9	250	9	200	9	200	9	200	9	200	9	200	9	2000	9	1500	9	450	9	250	9	250	9	250
10	250	10	200	10	200	10	200	10	200	10	200	10	1500	10	1500	10	450	10	250	10	250	10	250
11	250	11	200	11	200	11	200	11	200	11	200	11	1500	11	1500	11	300	11	250	11	250	11	250
12	250	12	200	12	200	12	200	12	200	12	200	12	1500	12	1500	12	300	12	250	12	250	12	250
13	250	13	200	13	200	13	200	13	200	13	200	13	1500	13	1500	13	300	13	250	13	250	13	250
14	250	14	200	14	200	14	200	14	200	14	200	14	1500	14	1250	14	300	14	250	14	250	14	250
15	500	15	200	15	200	15	200	15	200	15	200	15	1500	15	1250	15	250	15	250	15	250	15	250
16	750	16	200	16	200	16	200	16	200	16	200	16	1500	16	1250	16	250	16	250	16	250	16	250
17	1000	17	200	17	200	17	200	17	200	17	200	17	1500	17	1250	17	250	17	250	17	250	17	250
18	1250	18	200	18	200	18	200	18	200	18	200	18	1500	18	1250	18	250	18	250	18	250	18	250
19	1500	19	200	19	200	19	200	19	200	19	200	19	2000	19	1250	19	250	19	250	19	250	19	250
20	1500	20	200	20	200	20	200	20	200	20	200	20	2000	20	1000	20	250	20	250	20	250	20	250
21	1500	21	200	21	200	21	200	21	200	21	200	21	2000	21	1000	21	250	21	250	21	250	21	250
22	1500	22	200	22	200	22	200	22	200	22	200	22	2000	22	1000	22	250	22	250	22	250	22	250
23	1500	23	200	23	200	23	200	23	200	23	200	23	1500	23	1000	23	250	23	250	23	250	23	250
24	1500	24	200	24	200	24	200	24	200	24	200	24	1500	24	1000	24	250	24	250	24	250	24	250
25	1500	25	200	25	200	25	200	25	200	25	200	25	1500	25	1000	25	250	25	250	25	250	25	250
26	1500	26	200	26	200	26	200	26	200	26	200	26	1500	26	1000	26	250	26	250	26	250	26	250
27	1500	27	200	27	200	27	200	27	200	27	200	27	1500	27	900	27	250	27	250	27	250	27	250
28	1250	28	200	28	200	28	200	28	200	28	200	28	1500	28	900	28	250	28	250	28	250	28	250
29	1000	29	200	29	200	29	200			29	200	29	1500	29	900	29	250	29	250	29	250	29	250
30	750	30	200	30	200	30	200			30	200	30	1500	30	900	30	250	30	250	30	250	30	250
31	500			31	200	31	200			31	200			31	900			31	250	31	250		
mo cfs	24000		6000		6200		7000		6400		6200		46100		38500		10900		7750		7750		7500
conv factor	1.9835																						
mo af	47604	0	11901	0	12298	0	13885	0	12694	0	12298	0	91439	0	76365	0	21620	0	15372	0	15372	0	14876

New Melones Stepped Release Plan Daily Hydrographs for Above Normal Year Types

OCT	CFS	NOV	CFS	DEC	CFS	JAN	CFS	FEB	CFS	MAR	CFS	APR	CFS	MAY	CFS	JUN	CFS	JUL	CFS	AUG	CFS	SEP	CFS
1	250	1	200	1	200	1	200	1	200	1	200	1	400	1	1500	1	900	1	250	1	250	1	250
2	250	2	200	2	200	2	200	2	200	2	200	2	750	2	1500	2	600	2	250	2	250	2	250
3	250	3	200	3	200	3	400	3	200	3	200	3	1000	3	1500	3	600	3	250	3	250	3	250
4	250	4	200	4	200	4	400	4	200	4	200	4	1250	4	1500	4	600	4	250	4	250	4	250
5	250	5	200	5	200	5	400	5	400	5	200	5	1500	5	1500	5	600	5	250	5	250	5	250
6	250	6	200	6	200	6	400	6	400	6	200	6	1700	6	1500	6	600	6	250	6	250	6	250
7	250	7	200	7	200	7	200	7	400	7	200	7	2000	7	1500	7	450	7	250	7	250	7	250
8	250	8	200	8	200	8	200	8	400	8	200	8	2000	8	1500	8	450	8	250	8	250	8	250
9	250	9	200	9	200	9	200	9	200	9	200	9	2000	9	1500	9	450	9	250	9	250	9	250
10	250	10	200	10	200	10	200	10	200	10	200	10	1500	10	1500	10	450	10	250	10	250	10	250
11	250	11	200	11	200	11	200	11	200	11	200	11	1500	11	1500	11	300	11	250	11	250	11	250
12	250	12	200	12	200	12	200	12	200	12	200	12	1500	12	1500	12	300	12	250	12	250	12	250
13	250	13	200	13	200	13	200	13	200	13	200	13	1500	13	1500	13	300	13	250	13	250	13	250
14	250	14	200	14	200	14	200	14	200	14	200	14	1500	14	1250	14	300	14	250	14	250	14	250
15	500	15	200	15	200	15	200	15	200	15	200	15	1500	15	1250	15	250	15	250	15	250	15	250
16	750	16	200	16	200	16	200	16	200	16	200	16	1500	16	1250	16	250	16	250	16	250	16	250
17	1000	17	200	17	200	17	200	17	200	17	200	17	1500	17	1250	17	250	17	250	17	250	17	250
18	1250	18	200	18	200	18	200	18	200	18	200	18	1500	18	1250	18	250	18	250	18	250	18	250
19	1500	19	200	19	200	19	200	19	200	19	200	19	2000	19	1250	19	250	19	250	19	250	19	250
20	1500	20	200	20	200	20	200	20	200	20	200	20	2000	20	1000	20	250	20	250	20	250	20	250
21	1500	21	200	21	200	21	200	21	200	21	200	21	2000	21	1000	21	250	21	250	21	250	21	250
22	1500	22	200	22	200	22	200	22	200	22	200	22	2000	22	1000	22	250	22	250	22	250	22	250
23	1500	23	200	23	200	23	200	23	200	23	200	23	1500	23	1000	23	250	23	250	23	250	23	250
24	1500	24	200	24	200	24	200	24	200	24	200	24	1500	24	1000	24	250	24	250	24	250	24	250
25	1500	25	200	25	200	25	200	25	200	25	200	25	1500	25	1000	25	250	25	250	25	250	25	250
26	1500	26	200	26	200	26	200	26	200	26	200	26	1500	26	1000	26	250	26	250	26	250	26	250
27	1500	27	200	27	200	27	200	27	200	27	200	27	1500	27	900	27	250	27	250	27	250	27	250
28	1250	28	200	28	200	28	200	28	200	28	200	28	1500	28	900	28	250	28	250	28	250	28	250
29	1000	29	200	29	200	29	200			29	200	29	1500	29	900	29	250	29	250	29	250	29	250
30	750	30	200	30	200	30	200			30	200	30	1500	30	900	30	250	30	250	30	250	30	250
31	500			31	200	31	200			31	200			31	900			31	250	31	250		
mo cfs	24000		6000		6200		7000		6400		6200		46100		38500		10900		7750		7750		7500
conv factor	1.9835																						
mo af	47604	0	11901	0	12298	0	13885	0	12694	0	12298	0	91439	0	76365	0	21620	0	15372	0	15372	0	14876

New Melones Stepped Release Plan Daily Hydrographs for Wet Year Types

OCT	CFS	NOV	CFS	DEC	CFS	JAN	CFS	FEB	CFS	MAR	CFS	APR	CFS	MAY	CFS	JUN	CFS	JUL	CFS	AUG	CFS	SEP	CFS
1	300	1	200	1	200	1	200	1	200	1	200	1	3000	1	3000	1	1200	1	300	1	300	1	300
2	300	2	200	2	200	2	200	2	200	2	350	2	3000	2	3000	2	1200	2	300	2	300	2	300
3	300	3	200	3	200	3	400	3	200	3	700	3	3000	3	3000	3	1200	3	300	3	300	3	300
4	300	4	200	4	200	4	400	4	200	4	1200	4	3000	4	3000	4	1200	4	300	4	300	4	300
5	300	5	200	5	200	5	400	5	400	5	1800	5	2300	5	2300	5	1200	5	300	5	300	5	300
6	300	6	200	6	200	6	400	6	400	6	2300	6	1500	6	1500	6	1200	6	300	6	300	6	300
7	300	7	200	7	200	7	400	7	400	7	3000	7	1200	7	1500	7	1200	7	300	7	300	7	300
8	300	8	200	8	200	8	200	8	400	8	3000	8	800	8	1500	8	1200	8	300	8	300	8	300
9	300	9	200	9	200	9	200	9	400	9	3000	9	800	9	1500	9	1000	9	300	9	300	9	300
10	300	10	200	10	200	10	200	10	200	10	3000	10	800	10	1500	10	1000	10	300	10	300	10	300
11	300	11	200	11	200	11	200	11	200	11	3000	11	800	11	1500	11	1000	11	300	11	300	11	300
12	300	12	200	12	200	12	200	12	200	12	3000	12	800	12	1500	12	1000	12	300	12	300	12	300
13	300	13	200	13	200	13	200	13	200	13	1200	13	800	13	1500	13	1000	13	300	13	300	13	300
14	300	14	200	14	200	14	200	14	200	14	800	14	800	14	1500	14	1000	14	300	14	300	14	300
15	500	15	200	15	200	15	200	15	200	15	800	15	800	15	1200	15	1000	15	300	15	300	15	300
16	750	16	200	16	200	16	200	16	200	16	800	16	800	16	1200	16	1000	16	300	16	300	16	300
17	1000	17	200	17	200	17	200	17	200	17	800	17	800	17	1200	17	1000	17	300	17	300	17	300
18	1250	18	200	18	200	18	200	18	200	18	800	18	800	18	1200	18	1000	18	300	18	300	18	300
19	1500	19	200	19	200	19	200	19	200	19	800	19	800	19	1200	19	1000	19	300	19	300	19	300
20	1500	20	200	20	200	20	200	20	200	20	800	20	800	20	1200	20	1000	20	300	20	300	20	300
21	1500	21	200	21	200	21	200	21	200	21	800	21	800	21	1200	21	1000	21	300	21	300	21	300
22	1500	22	200	22	200	22	200	22	200	22	800	22	800	22	1200	22	1000	22	300	22	300	22	300
23	1500	23	200	23	200	23	200	23	200	23	800	23	800	23	1200	23	1000	23	300	23	300	23	300
24	1500	24	200	24	200	24	200	24	200	24	800	24	800	24	1200	24	750	24	300	24	300	24	300
25	1500	25	200	25	200	25	200	25	200	25	800	25	800	25	1200	25	750	25	300	25	300	25	300
26	1500	26	200	26	200	26	200	26	200	26	800	26	800	26	1200	26	500	26	300	26	300	26	300
27	1500	27	200	27	200	27	200	27	200	27	1200	27	1500	27	1200	27	500	27	300	27	300	27	300
28	1250	28	200	28	200	28	200	28	200	28	1500	28	2300	28	1200	28	500	28	300	28	300	28	300
29	1000	29	200	29	200	29	200			29	2300	29	3000	29	1200	29	300	29	300	29	300	29	300
30	750	30	200	30	200	30	200			30	3000	30	3000	30	1200	30	300	30	300	30	300	30	300
31	500			31	200	31	200			31	3000			31	1200			31	300	31	300		
mo cfs	24700		6000		6200		7200		6600		47150		42000		48200		28200		9300		9300		9000
conv factor	1.9835																						
mo af	48992	0	11901	0	12298	0	14281	0	13091	0	93522	0	83307	0	95605	0	55935	0	18447	0	18447	0	17852
yr af	483676.5																						

Appendix C Real-Time Water Operations Charter

C.1 PURPOSE

The “Core Water Operation” serves as the foundation for meeting the requirements of D-1641 and providing for Reclamation and DWR to operate the CVP and SWP while reducing the stressors on listed species influenced by the ongoing operation of the CVP and SWP. For the Core Water Operation, Reclamation would implement activities, monitor performance, and report on compliance with the commitments in the Proposed Action. Implementing the Core Water Operation will require coordination between CDFW, DWR, FWS, NMFS, and Reclamation (collectively, the “5 Agencies”) and stakeholders. This Charter describes how the 5 Agencies and stakeholders will plan, communicate, and coordinate real-time water operations decisions on the Core Water Operation for the ROC on LTO.

C.2 BACKGROUND

Investments in science, monitoring, and decision support tools since the 2008 and 2009 BiOps provides the ability to reduce reliance on professional opinion and increase the use qualitative and quantitative models to assess risk in real-time based on the real-time monitoring of species and relevant other physical and biological factors. While Reclamation and DWR hold the responsibility for operating the CVP and SWP, many agencies and organizations assist in monitoring field conditions to provide information that assists in real-time decisions. Communication on real-time conditions and the implementation of water operations provides assurance that Reclamation and DWR are meeting the commitments within the Proposed Action.

C.3 SCOPE

Portions of the Core Water Operation rely upon real-time monitoring to inform Reclamation and DWR on how to minimize and/or avoid stressors on listed species. The Proposed Action seeks to take advantage of the expertise within the federal and state fisheries agencies in the real-time monitoring of species distribution and life-stage. Reclamation and DWR would then use qualitative and quantitative tools to perform risk analyses that inform operations. Actions within the Core Operation to address stressors on listed species seasonally and in real-time include, for example, Old and Middle River Flow Management, Shasta Cold Water Pool Management, and Delta Cross Channel Gate Operations.

Some elements of the Core Water Operation provide for seasonal input by the federal and state regulatory agencies on the scheduling and routing of certain flow volumes to benefit fisheries. Actions include, for example, Stanislaus pulse flows, Suisun Marsh Salinity Control Gate operation for Delta Smelt fall habitat, and restoration of rearing habitat.

The Core Water Operation in the Proposed Action provides for regulatory coordination if real-time conditions exceed the ability to anticipate how Reclamation and DWR would operate (“Outliers”). Outliers include, for example, insufficient cold water pool in Shasta Reservoir to support a winter-run

Chinook salmon year class and the need for conservation measures such as trap and haul and/or hatchery production.

Reclamation and DWR must demonstrate compliance with the commitments in the Proposed Action and provide sufficient information for an evaluation of reinitiation triggers through regular monitoring and reporting. New information and changing conditions may exceed a reinitiation trigger and could require subsequent consultation. Examples of for compliance include seasonal and annual reporting.

Program Teams will implement conservation measures. These Program Teams will include representatives from agencies and stakeholders.

C.4 TERM

The term of this Charter is the duration of the ROC on LTO Biological Opinion (2030).

C.5 DELIVERABLES

One or more groups under this Charter shall be responsible for the products on the schedule identified below. Exhibits A though XX to this Charter identify the requirements for each deliverable.

1. Monitoring Program for Core Water Operations, Ongoing
2. December - June, Weekly and Biweekly, Real-Time Species Distribution and Life Stage
3. Monthly (and as needed), Water Operation Status
4. Monthly (and/or as needed), Specific operations for:
    a. Old and Middle Reverse Flow Storm Events (Dec. - June)
    b. Shasta Cold Water Pool Management (May - Oct.)
    c. Folsom Cold Water Pool Management (May - Oct.)
    d. Delta Smelt Fall Habitat and Suisun Marsh Salinity Control Gates (May)
5. As Needed, Coordination on Outlier Years
6. Annually, As Needed, Habitat Restoration Updates
7. Seasonal and Annual Compliance Reporting
    a. December, Shasta Cold Water Pool Management
    b. June, Shasta Cold Water Pool Rebuilding and Spring Pulse
    c. September, Annual Summary of Water Supply and Fish Operations

Reclamation and DWR will continue to provide standard reporting on real-time operations, environmental conditions, and biological parameters, such as species distribution, life stage, and dynamics. These data are available daily through Reclamation and DWR websites and additional tools such as CDEC, NWIS, RWIS, SacPAS, Bay-Delta Live, and SHOWR.

This Charter provides the monitoring and water operations information that will be available as part of the Core Operation. Additional monitoring or water operations information, beyond the scope of this

Charter, may be required for tracking the status and trends of species and for efforts beyond operation of the CVP and SWP.

C.6 PARTICIPANTS

Action Agencies: Reclamation and DWR

Regulatory Agencies: USFWS, NMFS, CDFW, SWRCB, ACOE, DSC

Stakeholders: Public Water Agencies

C.7 DECISION MAKING

Nothing in this Charter modifies the rights and responsibilities of the Participants. Decisions shall be made consistent with the authorizing legislation and the regulations and policies under the federal and state Endangered Species Acts, as appropriate.

Reclamation and DWR shall retain sole discretion for:

- Water Operations of the CVP and SWP, including Allocations, under Reclamation Law and the State Water Project, as appropriate
- Agency Appropriations (budget requests, fund alignment, contracting, etc.)
- Section 7 Action Agency and Applicant (consultation)
- Coordination and cooperation with PWAs as required by Contracts and Agreements

CDFW, FWS, and NMFS shall retain sole discretion for:

- Consultation under Section 7 of the federal ESA and California Fish and Game Code, as appropriate and the associated Incidental Take Statements/Permits
- Agency Appropriations

State Water Resources Control Board

- Enforcement as allowable under federal and state law.

Operating Entities other than CVP and SWP shall retain sole discretion for:

- Operation of Non-CVP and Non-SWP Diversion Facilities
- Contract and/or Agreement Terms
- WIIN Act Requirements

If Reclamation determines to modify the proposed action, Reclamation will evaluate changes to one or more elements of the proposed action based on the reinitiation triggers provided by 50 CFR 402.16. These triggers include:

(a) If the amount or extent of taking specified in the incidental take statement is exceeded;

(b) If new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered;

(c) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion; or

(d) If a new species is listed or critical habitat designated that may be affected by the identified action.

Consistent with 50 CFR 402.16, the FWS and/or NMFS may also reinitiate formal consultation. Reclamation will coordinate with DWR as the “Applicant”.

Reclamation will continue to coordinate with the Delta Stewardship Council and US Army Corps of Engineers as appropriate, including venues such as the Interagency Ecological Program. Other agencies that may be involved in monitoring include the US Geological Survey.

C.8 ORGANIZATION

The organization of water operations and related species recovery in the Central Valley spans a number of overlapping programs across federal, state, and local entities as well as the public. The Core Water Operation anticipates increasing levels of coordination under efforts such as Voluntary Agreements, the Adaptive Management Framework developed under California Water Fix, and the Delta Science Plan. The Core Water Operation does not rely upon any specific structure, but is designed to support the following functions:

- Adaptation:
- Integration:
- Implementation:

Figure C.8-1 shows the different functional needs.

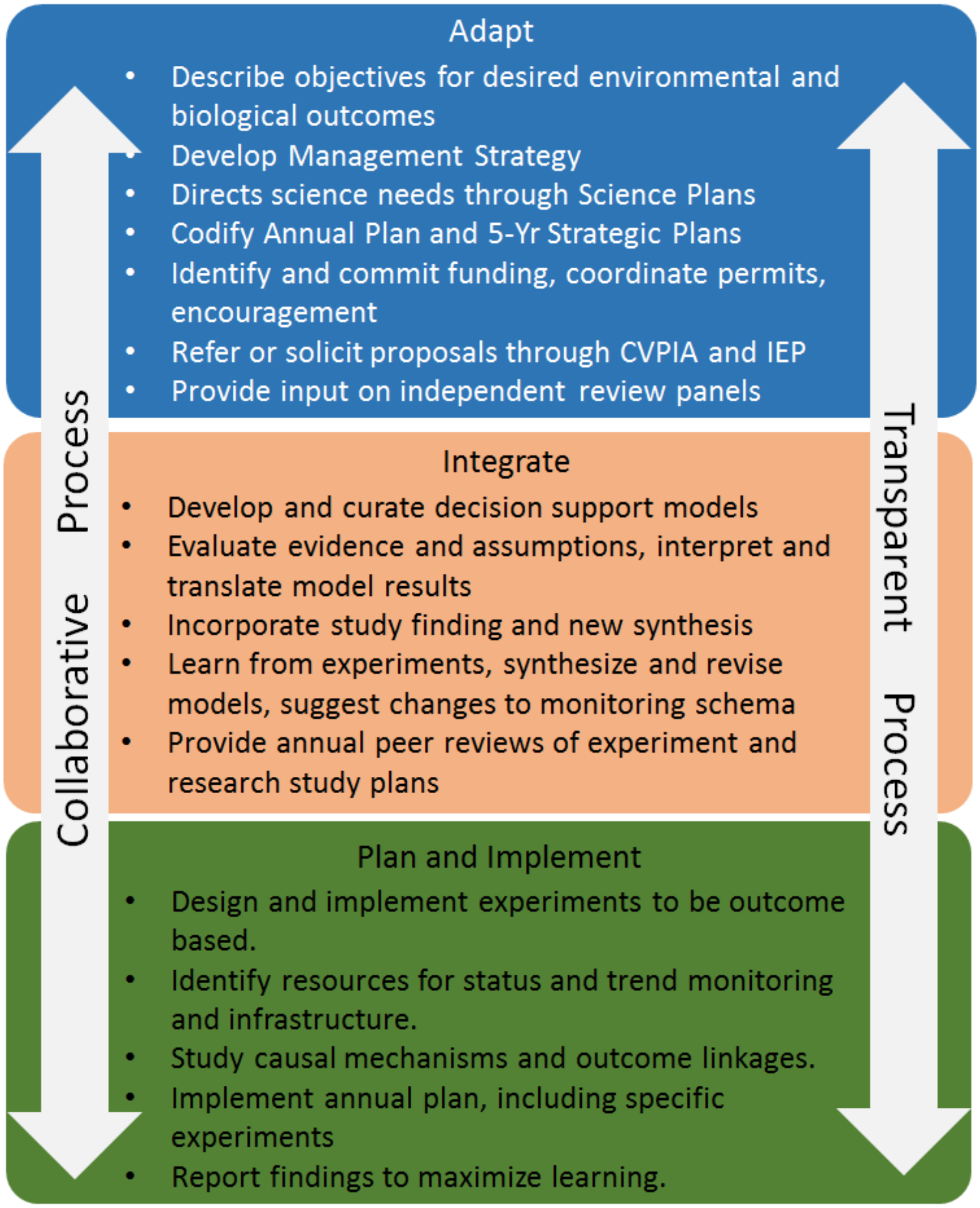


Figure C.8-1. Activities for the Implementation of Water Operations and Species Recovery

The major overarching forums where Reclamation coordinates with partner agencies and stakeholders include the Central Valley Project Improvement Act (focused primarily on tributary actions), Interagency Ecological Program (focused primarily on Delta actions), and the Collaborative Science and Adaptive Management Program. Each forum includes workgroups and teams for specific needs. Figure C.8-2 shows how the functions align with existing programs and activities and includes a role for Independent Review. The Core Water Operations maintains, modifies, and establishes specific workgroups and teams in consideration of existing programs and groups, but does not depend upon the existing programs and groups.

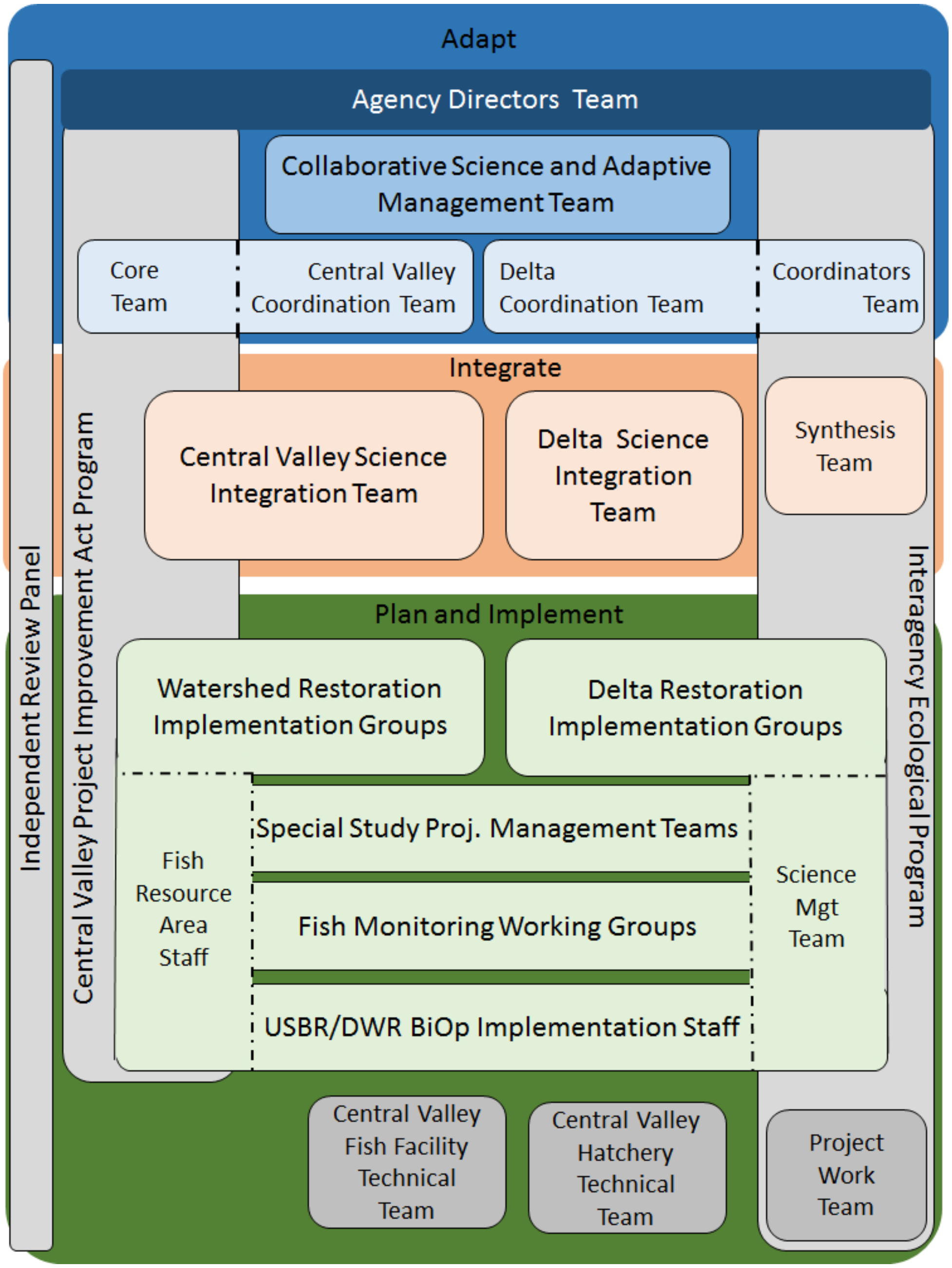


Figure C.8-2. Existing Programs and Groups within the Functions of Water Operations and Species Recovery

Consistent with the Proposed Action, Reclamation and DWR propose to convene Watershed Monitoring Workgroups for each of the Upper Sacramento, American, Delta, and Stanislaus watersheds ("Watershed Monitoring Workgroups"). Each of the Watershed Monitoring Workgroups will be responsible for real-time synthesis of fisheries monitoring information and providing recommendations on scheduling specific volumes of water as specified in the Proposed Action. The Delta Monitoring Workgroup shall be responsible for integrating species information across watersheds, including Delta Smelt and Winter-run Chinook, and other salmonids and sturgeon. In addition to Delta Watershed Monitoring Workgroup, the program may include a Smelt Monitoring and Salmonid Monitoring Teams. The Watershed Monitoring

Workgroups will include technical representatives from federal and state agencies and stakeholders and will provide information to Reclamation and DWR on species abundance, species distribution, life stage transitions, and relevant physical parameters.

A Water Operations Management Team (WOMT) comprised of agency managers will coordinate on overall water operations to oversee the implementation of various real-time provisions. The WOMT shall be responsible for overseeing the Watershed Monitoring Workgroups and elevating disagreements to the Directors of the 5 agencies where necessary.

- Directors
- WOMT
- Watershed Monitoring Workgroups
    - Sacramento River Temperature Task Group
    - American River Group
    - Stanislaus Operating Group
    - Delta Monitoring Workgroup
        - Smelt Monitoring Team
        - Salmon Monitoring Team
        - Program Teams

The WOMT shall coordinate the preparation of seasonal and annual reporting in coordination with the Watershed Monitoring Teams

C.9 PROCESS

The coordinated operation of the CVP requires the following functions for the Core Water Operation.

- Monitoring (Exhibit A)
    - Real-Time Physical and Biological Parameters (Species Distribution and Life-Stage)
    - Long-Term Proposed Action Performance Monitoring
- Water Operation Decisions
    - Projections based on Forecasts and Real-Time Reporting
    - Scheduling Recommendations for Specific Blocks of Water
    - Outlier Conditions and Coordination
- Seasonal Reporting
    - Fall Cold Water Pool Management and Winter- and Fall-run Redd Dewatering
    - Spring Pulse and Shasta Storage Rebuilding
- Annual Reporting and Evaluation of Reinitiation Triggers
- Targeted Consultation, if Required

In October, Reclamation will coordinate with Sacramento River Settlement Contractors (SRSCs) to lower peak diversions for rice decomposition by spreading diversions over a longer time period. Reclamation will and evaluate winter-run redd dewatering in the current year against the probability of sufficient cold water in the subsequent year based on end of September Shasta storage. Reclamation and DWR will also manage for fall Delta Smelt habitat. By the end of December, Reclamation will post a seasonal report on Shasta Cold Water Pool Management.

In December and/or January, the onset of Old and Middle River Reverse Flow Management begins depending on the real-time distribution of species. Reclamation and DWR will manage exports to limit entrainment and to take advantage of storm flows. Reclamation will post a risk analysis for each time Reclamation increases exports to capture peak storm flows. If conditions fall within the bounds of the Proposed Action, Reclamation and DWR will increase exports. If conditions exceed the criteria in the Proposed Action and Reclamation and DWR desire to increase exports, Reclamation and DWR will seek technical assistance from CDFW, FWS, and NMFS.

In February, consistent with contracts and agreements, Reclamation will create and post a projection of water operations using, at minimum, a 90% forecast to determine whether a Shasta-Critical year is in effect and make an initial allocation. The projection will include, at minimum, the likelihood of a spring pulse flow on the Sacramento River and the likelihood for each tier of Shasta cold water pool management based on potential storage levels. If the projection identifies a Tier 4 year, Reclamation will coordinate and seek technical assistance from NMFS and coordinate with CDFW and FWS. In each March, April, and May, Reclamation will update and post the projection.

Starting in April and no later than the end of May, depending upon when stratification of Shasta Reservoir occurs, Reclamation shall post a seasonal report on the refill of Shasta and prepare a Shasta Cold Water Pool Management Plan in coordination with the Sacramento River Temperature Task Group. The Shasta Cold Water Pool Management Plan will include the projected Shasta cold water pool management tier at the 90% confidence level. If the projection identifies a Tier 4 year, Reclamation will seek technical assistance from NMFS and coordinate with CDFW and FWS.

Starting in April, and no later than the end of May, depending upon stratification of Folsom Reservoir, Reclamation shall prepare a Folsom Cold Water Pool Management Plan in coordination with the American River Group. If the Folsom Cold Water Pool Management Plan is unable to meet a daily average water temperature of 65°F or lower at Watt Avenue Bridge from May 15 through October 31, Reclamation will use the ARG and elevate to WOMT.

In each month, through October, Reclamation will update and post the Shasta Cold Water Pool Management Plan.

In May, Reclamation and DWR shall coordinate a plan for the Operation of the Suisun Marsh Salinity Control Gates to create habitat for Delta Smelt and/or offramp flows if conditions do not warrant habitat for Delta Smelt.

By the end of September, Reclamation shall post an annual report that covers the prior fall/winter seasonal operation, spring operation, and summer conditions. The annual report will include a determination on whether there is new information on the effects of the Proposed Action or a desire to modified the Proposed Action that warrants targeted reinitiation on one or more components of the Proposed Action.

C.10 DISPUTE RESOLUTION

In the event of a dispute within any of the groups, the groups will elevate the dispute to the WOMT for resolution. In the event the WOMT cannot resolve the dispute, the WOMT will elevate to the Directors.

C.11 AMENDMENTS

Reclamation, in coordination with DWR, may amend this Charter at any time and will provide at minimum 2 weeks' notice. Amendments may trigger reinitiation of consultation consistent with 50 CFR 402.16.

C.12 DEPENDENCIES

The Proposed Action coordinates actions within the following forums that are beyond the sole control of Reclamation and DWR.

- CVPIA Fish Resource Area Programs - Monitoring, restoration, and special studies
- Interagency Ecological Program - Permitting and Coordination for Physical and Biological Monitoring
- Collaborative Science and Adaptive Management Program - Synthesis

In the event the above groups are unwilling or unable to provide for the commitments in the Proposed Action, Reclamation and DWR will confer with CDFW, FWS, and NMFS on alternative implementation paths.

C.13 SIGNATURES

To be updated.

Exhibit A - Monitoring Program for Core Operations

Monitoring Program for Core CVP and SWP Operation

This monitoring program for the Core Water Operation of the CVP and SWP identifies the information required for:

- Real-time water operations,
- Demonstrating compliance with Core Water Operation commitments in the Proposed Action, and
- Evaluating re-initiation triggers.

Additional monitoring to determine status and trends of species and understanding ecosystem interactions may occur through other processes, such as Voluntary Agreements and/or existing water quality permits , are listed, but are not explicitly relied upon for the Core of the Proposed Action. Reclamation and DWR may accomplish the monitoring through agreements with other agencies, partnerships with local water users, and/or contracts with private entities.

This Core Monitoring Program considers the information developed by the Salmon and Sturgeon Assessment of Indicators by Lifestage (SAIL) Program (Johnson et al. 2017) and the Enhanced Delta Smelt Monitoring (EDSM) Program (cite). This Core Monitoring Program focuses on the functions met by the different efforts and use the current technologies as examples that meet the functions. Additionally, the Core Monitoring provides support for the necessary studies to develop annual incidental take limits. Monitoring methodologies may change as technology advances or research supports better protocols.

Core Water Operations

Core water operations include Shasta and Folsom Cold Water Pool Management, Delta Cross Channel Gate Operations, Old and Middle River Reverse Flow Management, and Delta Smelt Fall Habitat. Physical information for real-time operations includes:

- Delta Flow, Temperature, Turbidity, and Salinity Stations
- Tributary Flow and Temperature Stations
- Folsom Reservoir Temperature Profiles
- Shasta Reservoir Temperature Profiles

Biological information required for real-time operations includes:

- Chinook Salmon
    - Redd Timing and Location: Provides the spatial and temporal risk of mortality for the different flow and temperature regimes as well as the potential for dewatering. Currently accomplished through weekly visual surveys that identify new redds by reach.

  - Carcass Surveys: Supplements the redd surveys to account for unobserved redds to help assess the significance of individual redds. Currently accomplished by field crews per well established protocols on the number of adults and the proportion that are female.
  - Juvenile Abundance and Timing: Identifies the production of juveniles salmonids (Red Bluff Diversion Dam), migration of salmon for operation of the Delta Cross Channel (Knights Landing Rotary Screw Trap), and the implementation of OMR reverse flow actions (Sacramento Trawl and Chipps Island Trawl).
  - Delta Distribution: Informs OMR actions and is currently supported through beach seines, acoustic tagging, and some EDSM.
  - Salvage Count: Informs the direct effects on listed fish
  - Genetic Identification: Informs the salvage of listed Chinook salmon species versus non-listed Chinook salmon species.
- Delta Smelt
  - Turbidity Stations: Informs the potential for a "turbidity bridge" that would inform OMR Actions.
  - Temperature Stations: Informs the transition between life stages and the need for protective measures.
  - Water Quality Stations: tracks the movement of the low salinity zone and parameters associated with the food web, e.g. chlorophyll.
  - Delta Distribution: Informs the entrainment risk due to OMR actions and is currently would be supported by EDSM.
  - Fish Condition: Informs when adults have spawned and the need for larval protections.
- Steelhead
  - American River and Clear Creek Redd Surveys
  - Salvage Count
- Sturgeon
  - Salvage Count

Table C-1 lists the current programs in place that would support Core Water Operations for the ROC on LTO.

Table C-1. Real-time monitoring

ID	Monitoring Program	Typical Time Of Year Operating	Target Species/ Parameter	Site/Region
1	Adult Spring Chinook Escapement Monitoring in Clear Creek.		Chinook carcass and weir abundance counts	Clear Creek
2	Red Bluff Diversion Dam Rotary Screw Trap Juvenile Monitoring Program	January - December	Juvenile Chinook salmon productivity	Red Bluff Diversion Dam, American River, Stanislaus River
3	Juvenile Salmon Emigration Real-time Monitoring (Seines and Trawls)	October 1-November 30	Juvenile Chinook and steelhead relative abundance	North Delta
4	Juvenile Salmon Delta Abundance Trawling (expanded DJFMP trawling)	December-May	Juvenile Chinook salmon abundance and condition	Sacramento and Chipps trawl
5	Genetic Identification of Salmonids and Smelt to Inform Central Valley Project Operations and Bay-Delta Monitoring	January-December	Chinook salmon and Smelt diversity	Central Valley (RBDD to Chipps Island)
6	Lower Sacramento River Juvenile Salmon and Steelhead Monitoring Project	August - June	Juvenile Chinook salmon and Steelhead distribution and productivity	Middle Sacramento River at Knights Landing
7	Winter-run Chinook Salmon Escapement Monitoring	May-August	Winter-run Chinook carcass and redd abundance and distribution	Sacramento
8	Fish Salvage Operations	January - December	Juvenile Fish abundance	CVP and SWP Delta Fish Protection Facilities
9	Enhanced Delta Smelt Monitoring	January-December	Delta Smelt abundance, distribution, condition, and productivity	San Francisco Estuary
10	Delta Flow Measurement and Database Management	January - December	Flow and water quality	Bay-Delta
11	Operation of Thermograph Stations	January - December	Temperature and sediment loads	
12	Hatchery Marking (100% Tagging)		Winter-run Chinook, Spring-run Chinook Salmon, Late-Fall Chinook salmon, Steelhead	Livingston Stone National Fish Hatchery, Feather River Hatchery, Coleman National Fish Hatchery, Nimbus Hatchery

Effects to listed fish due to CVP and SWP operations would be expected from decisions on winter-run temperature dependent mortality to preserve future year classes, redd dewatering to preserve fall-run future winter-run year classes, habitat parameters within the Delta, and salvage at the Delta pumping facilities of all species. As many effects depend upon hydrology and meteorology beyond the control of Reclamation and DWR, effects would be compared based on the range of conditions within a water year.

Status and Trend Monitoring

Status and trend monitoring characterizes the population of species and their environments over time include the effects of stressors from sources other than the CVP and SWP. Recovery plans characterize the status and trends differently depending upon the species in the general categories of abundance, production, life history diversity, and geographic diversity. In addition to the Core Monitoring, a number of additional programs are anticipated to continue, the majority of which are supported by Reclamation and DWR for CVP, SWP, and Delta watersheds:

- Hatchery Proportion (Constant Fractional Marking)
- Genetic Analyses of California Salmonid Populations: Parentage Based Tagging (PBT) of salmonids in California Hatcheries
- Fall Midwater Trawl
- 20-mm Survey monitoring to determine distribution and relative abundance of Delta Smelt and Longfin Smelt
- Spring Kodiak Trawl
- Estuarine and Marine Fish Abundance and Distribution Survey
- Smelt Larva Survey (SLS)
- Summer Townet Survey
- Environmental Monitoring Program (EMP)

Table C-2. Status and Trends Monitoring

ID	Monitoring Program	Typical Time of Year Operating	Target Species/ Parameter	Site/Region
13	Hatchery Proportion (Constant Fractional Marking)		Fall run Chinook salmon	Coleman NFH, Nimbus Hatchery, Feather River Hatchery
14	Genetic Analyses of California Salmonid Populations: Parentage Based Tagging (PBT) of salmonids in California Hatcheries		Hatchery Steelhead	Coleman NFH, Nimbus Hatchery, Feather River Hatchery
15	Fall Midwater Trawl monitoring	September - December	Pelagic fish	San Pablo Bay and Delta
16	20-mm Survey monitoring to determine distribution and relative abundance of Delta Smelt and Longfin smelt	March - July	Delta Smelt and Longfin Smelt	Sacramento-San Joaquin Delta and Upper Estuary
17	Spring Kodiak Trawl	January - May, December	Delta Smelt	
18	Estuarine and Marine Fish Abundance and Distribution Survey (Bay Study)	January - December	Fish and macroinvertebrates	San Francisco Bay and lower Sacramento and San Joaquin Rivers
19	Smelt Larva Survey (SLS)	January - March	Longfin Smelt larvae	Bay-Delta, Suisun Bay, Suisun Marsh
20	Summer Townet Survey	June - August	Young pelagic fish and water quality	Upper San Francisco Estuary, San Joaquin River, lower Sacramento River
21	Environmental Monitoring Program	January-December	Water quality, chlorophyll, phytoplankton, invertebrates	Bay-Delta, Suisun bay, San Pablo Bay
22	Delta Juvenile Salmon Monitoring (DJFMP trawls and beach seining)	January - December	Juvenile Chinook salmon abundance, distribution, and condition	Bay-Delta
23	Juvenile Spring-Run and Steelhead Production Monitoring in Clear Creek		Spring-run Chinook and Steelhead productivity	Clear Creek
24	Adult Steelhead and Late-fall Chinook Escapement Monitoring in Clear Creek		Steelhead and Late-fall run Chinook carcass and weir abundance counts	Clear Creek
25	Spring, Fall, and Late Fall Chinook Salmon and Steelhead Escapement Monitoring in the Upper Sacramento River Basin	May-March	Spring-run Chinook and Steelhead weir and carcass abundance counts	Sacramento River
26	American River Chinook Salmon and Steelhead Escapement Monitoring	September-January	Fall-run Chinook and Steelhead weir, redd, and carcass abundance counts	American River

ID	Monitoring Program	Typical Time of Year Operating	Target Species/ Parameter	Site/Region
27	Stanislaus River Chinook Salmon and Steelhead Escapement Monitoring	September-January	Fall-run Chinook and Steelhead weir, redd, and carcass abundance counts	Stanislaus River
28	Enhanced Acoustic Tagging, Analysis, and Real-time Monitoring	November-June	Juvenile Chinook salmonid survival	Central Valley
29	Mossdale Spring Trawl	March-May	Juvenile Chinook and steelhead relative abundance	Lower San Joaquin River

Adaptive Management Special Studies

Ongoing research programs to improve the state of science and address questions by one or more managing agencies occur on an ongoing basis.

Table C-3. Adaptive Management Program Monitoring

ID	Monitoring Program	Typical Time of Year Operating	Target Species/ Parameter	Site/Region
1	Estuarine and Marine Fish Abundance and Distribution Survey (Bay Study)	January - December	Fish and macroinvertebrates	San Francisco Bay and lower Sacramento and San Joaquin Rivers
2	Bay Salinity Monitoring	January - December	Conductivity and water temperature	Bay-Delta
3	Directed Outflow Project	April-November	habitat condition, water quality, food web	Bay-Delta

Description of Programs

Monitoring of the Central Valley and Bay-Delta Watershed requires extensive coordination across multiple agencies and offices within the different agencies as well as academia and private entities. The following sections describe the organization into various programs in more detail.

Real-Time Monitoring

Adult Spring Chinook Escapement Monitoring in Clear Creek

The goal of this program is to estimate population size and distribution of adult spring Chinook holding and spawning in Clear Creek. This monitoring information is used to inform Clear Creek in-season operations like spring attraction pulses. This monitoring activity produces annual adult escapement of spring Chinook into Clear Creek using two methods: video counts and snorkel-based estimates. Count data will be posted on the publicly accessible USFWS website for interested parties.

Objectives:

- Operate a video weir station to count and identify fish entering and leaving the watershed
- Index adult holding population size by visual counts made during snorkel surveys
- Estimate the spatial and temporal distribution of holding and spawning through snorkel surveys
- Estimate spawning population size using redd counts produced during snorkel surveys Spawning success is an indicator of the effectiveness of water and temperature management especially during the summer holding period when reservoir management is particularly important
- Obtain genetic samples, scales, and otoliths to determine run, age, natal origin, and juvenile life history of Chinook spawning in Clear Creek

Red Bluff Diversion Dam Rotary Screw Trap Juvenile Monitoring Project

This program quantifies passage and production of juvenile salmonids produced in the upper Sacramento River. This project allows for evaluation of flow and temperature operations from Whiskeytown and Shasta/Keswick reservoirs and provides real-time information to fishery monitoring team to inform fishery and water operations management. Data on the production trends of endangered winter-run Chinook Salmon, threatened spring-run Chinook, the Central Valley ESU of Steelhead as well as the Southern Distinct Population Segment of the North American Green Sturgeon will be derived. Biweekly catch data and passage estimates will be posted on the publicly accessible USFWS website for interested parties.

Objectives:

- Estimate total annual production of juvenile winter-run Chinook Salmon produced in the mainstem Sacramento River and compare these data to adult escapement estimates.
- Estimate juvenile production of fall, late-fall, and spring-run Chinook Salmon.
- Measure relative abundance of Lamprey and Green Sturgeon passing Red Bluff Diversion Dam.

Juvenile Salmon Delta Emigration Real Time Monitoring (expanded DJFMP seines and trawls)

This Delta Juvenile Fish Monitoring Program (DJFMP) monitoring project includes expanded beach seining and surface trawling 3 additional days/week from October 1st to November 30 near Sacramento (Sacramento and Chipps Island) to detect the arrival of older juvenile Chinook Salmon entering the Delta. Monitoring data are used to inform Delta Cross Channel Gate closure decisions from October 1st to November 30 to minimize the diversion and mortality of emigrating juvenile winter-run sized Chinook Salmon. Catch data will be posted on the publicly accessible USFWS website for interested parties.

Objective:

- Provide data for Delta Cross-channel Gate operational triggers.

Juvenile Salmon Delta Abundance Trawling (expanded DJFMP trawling)

This program involves surface trawling (Sacramento and Chipps Island) for increased capture of specific CWT groups released with acoustically tagged releases of juvenile hatchery salmonids during the winter and spring. This includes expanded surface trawling to achieve daily trawling at these sites for at least 5 days/week during the period these groups are likely to be encountered. This period is flexible dependent on the requirements of the releases, but typically runs from early December until early May, approximately five months. If acoustic tag groups are not released, this monitoring study should not be undertaken.

Objective:

- Provide CWT recapture data for estimating the number of juvenile salmonids entering and exiting the Delta.
- Collect tissue samples for genetic stock identification of fish at Chipps and Sacramento trawl.

Genetic Identification of Salmonids and Smelt to Inform Central Valley Project Operations and Bay-Delta Monitoring

Project operations requires accurate information regarding what species are being encountered at various locations in the Central Valley. Historically, juveniles salmonid have been identifed based on two length-at-date models, which have been demonstrated to be inaccurate. The population-of-origin is determined for juveniles by comparing their genotypes to reference genetic baselines in order to quantify the number and distribution of true ESA-listed (genetic) winter and spring runs categorized by length-at-date criteria models. The overarching goal of this work is to directly target (and reduce) one source of uncertainty in the estimation of loss for listed Chinook Salmon (but primarily winter run) at South Delta fish salvage facilities and from other CVP monitoring sites. Also, this study provides genetic information at various locations in the Delta to improve accuracy of identifying juvenile salmonids and larval fishes to inform operations and monitoring activities. Species identification information is relied upon to estimate the effects of project operations. Annual genetic identification data will be incorporated into the annual incidental take report for interested parties.

Objectives:

- Genetic classification of Chinook salmon captured from SWP and CVP fish protection facilities for improved estimation of facility loss. This information is provided through multiple potential time steps including: rapid (<48hours), biweekly, and seasonally.
- Genetic classification of Chinook salmon in monitoring programs (e.g., RBDD, Sacramento Trawl, Chipps Island Trawl, Knights Landing, Upper Sacramento stranding surveys). These data are required for agency estimates of juvenile production at Red Bluff Diversion Dam and Sacramento and Chipps trawls.
- Assist with species identification of fish larvae or other difficult to identify samples collected at the fish protection facilities.

Lower Sacramento River Juvenile Salmon and Steelhead Monitoring Project

This program monitors out-migrant juvenile Sacramento River Chinook salmon and steelhead utilizing rotary screw traps located near Knights Landing on the Sacramento River. Juvenile salmonid monitoring in the upper Sacramento River between Red Bluff Diversion Dam and confluence with the Feather provide an early warning of increases in emigration rates of listed salmonids out of the upper Sacramento River toward the Sacramento-San Joaquin Delta. This near real-time data and early warning information provided by the program allows for data related triggers for the operation of the DCC. Daily catch data are posted on the publicly accessible CalFISH website for interested parties.

Objectives:

- Monitor and report the outmigration of juvenile salmonids from the Sacramento River as they move toward the Sacramento-San Joaquin Delta on a real-time basis.
- Monitor, record and compare movements of emigrating salmonids during specific environmental conditions.
- Estimate emigrating salmonid numbers and composition in the lower Sacramento River above the Delta.
- Examine the influences of Sacramento River flood relief structures on emigrating juvenile salmonids.

Winter-run Chinook Salmon Escapement Monitoring

This project monitors the annual abundance, timing, distribution, and several life history characteristics of naturally spawning winter Chinook salmon. Estimates of abundance of Sacramento River Winter Chinook Salmon provide the basis for monitoring the population status and trends of this endangered species. Information generated from this project also provides the basis for evaluating the supplementation program at the winter run Chinook salmon conservation propagation program at Livingston Stone National Fish Hatchery. Recoveries of coded-wire tags from this project feed into cohort reconstructions, which provide the basis for estimating survival rates and evaluating the effects of ocean harvest upon this endangered species. Recoveries of coded-wire tags will be reported to the Regional Mark Information System for use in a cohort reconstruction analysis. Weekly carcass data are posted on the publicly accessible CalFISH website for interested parties.

Objectives:

- Estimate of winter Chinook spawner abundance generated based on carcass mark-recapture estimation methods.
- Estimate escapement and contribution to natural spawning by natural and hatchery origin winter Chinook.
- Estimate of pre-spawning mortality

Fish Salvage Operations

Sampling of entrained fish at the Tracy Fish Collection Facility (TFCF) and Skinner Delta Fish Protective Facility (SDFPF) is the source for CDFW's daily salvage and loss estimates for the monitoring of incidental take of listed fish species.

Fish salvage and loss information at the SDFPF and TFCF is used extensively in water project monitoring and planning. The Fish Facilities Monitoring Project manages the data collected on fish entrained and salvaged at the SDFPF and TFCF. This project maintains one of the largest historical databases on Delta species available and has been used in assessing the effects of new facilities and programs, water project operations proposals, and evaluation of proposed CALFED alternatives. Daily data can be obtained via the California Department of Fish and Wildlife's Bay-Delta FTP server.

Objectives:

- Report fish salvage count data for regular operations and special studies
- Report physical and operational conditions at SDFPF and TFCF including temperature, bypass operations, facility flows, primary and secondary channels flows and depths, and holding tank flows.
- Collect tissue samples for distribution to Agency tissue archives.

Enhanced Delta Smelt Monitoring

High-frequency sampling of the Enhanced Delta Smelt Monitoring (EDSM) program is stratified by regions that, based on differences in hydrodynamics, differ in Delta Smelt density and risk of entrainment. The EDSM program provides an early warning of entrainment events in a broader context than the previous Early Warning Survey and employs a stratified sampling design that includes multiple crews trawling concurrently at multiple sites in pre-defined density strata within the low- and/or high-risk zones of entrainment in the San Francisco Estuary. Stopping rules were developed to minimize the impact of take on the population and effort can be modified to adapt to changing management needs and priorities.

For real-time purposes, EDSM may replace a number of historic trawls. However, for Delta species status and population trends, the long-running trawls may provide useful comparative information. These trawls have been included below in the Status and Trends Monitoring section.

Objectives

- Biweekly estimates of life stage specific abundance
- Biweekly estimates of distribution within different regions of the Bay-Delta.

Delta Flow Measurement and Database Management

The Delta Flow Network consists of 35 flow and water quality monitoring stations located throughout the Sacramento-San Joaquin Delta; eleven of these stations are supported by the IEP. Data from this network of stations are used by Delta managers and scientists to make real-time decisions and plan for future events such as climate change, water operations, restoration projects, evaluate fish transport, and migration issues. In addition, these data are used to calibrate and validate numerical models that are used to predict water levels, flow speeds, and spatial and temporal evolution of salinity in the Delta. The data collected at these stations are critical for understanding the circulation and mixing patterns in the complex and interconnected channels that comprise the Delta region. Understanding Delta hydrodynamics is imperative to understanding the impacts of proposed major infrastructure projects and regulatory actions being taken to protect endangered species in the Delta.

Objective:

- Provide accurate continuous flow data throughout Bay-Delta.

Operation of Thermograph Stations

This program provides continuous information on the temperature and sediment regimes in the rivers in order to evaluate effects on the restoration of native species fisheries, amphibians and other aspects of the aquatic ecosystem. An additional goal is to better understand the transition from cold water to warm water regimes and how flow magnitude interacts to control the transition.

Objectives:

- Provide accurate continuous temperature readings.
- Provide data regarding sediment loading.

Status and Trends Monitoring

Existing monitoring techniques below assist in understanding species status and population trends. The information may also be useful in annual reporting and demonstrating compliance with ESA. However, they do not necessarily provide real-time operational benefits.

Genetic Analyses of California Salmonid Populations: Parentage Based Tagging (PBT) of salmonids in California Hatchery Programs.

The purpose of this task is to collect tissue samples and conduct the genetic analyses necessary to evaluate the genetic pedigree relationships of California salmonid hatchery broodstock. This information is used to inform hatchery broodstock management, including supporting recovery actions for ESA listed Central Valley salmonids stocks.

California hatcheries release a large number of juvenile salmonids every year, and genetic parentage based tagging (PBT) of adult spawners provides critical information about spawner age distribution, inbreeding, distribution of reproductive success among spawners, migration among Central Valley hatcheries, and other population parameters. The California Hatchery Scientific Review Group recommended PBT as an effective monitoring tool for the management of hatchery broodstock programs.

Objectives

- Genotype samples
- Use broodstock PBT to support Central Valley salmon and steelhead monitoring programs and hatchery broodstock management by identifying hatchery-of-origin and brood year for field caught and hatchery return samples and monitoring inbreeding and migration among Central Valley salmon and steelhead hatcheries.

- Evaluate genetic data for special hatchery broodstock projects to improve broodstock management

Fall Midwater Trawl

Fall Midwater Trawl Survey (FMWT) sampling began in 1967 to measure the abundance and distribution of age-0 Striped Bass and has since collected similar information on a suite of pelagic fishes including Delta Smelt and Longfin Smelt. Survey staff calculates annual abundance indices based on September through December monthly sampling data collected from San Pablo Bay through the Delta. The survey sampling has expanded into Cache Slough and the Sacramento Deepwater Ship Channel and may include zooplankton sampling and processing.

The survey's catch data provides means to calculate adult Delta Smelt incidental take at the export facilities. The State Water Project Incidental Take Permit for Longfin Smelt requires the FMWT Longfin Smelt abundance index to calculate the incidental take limit for the salvage facilities.

Objectives:

- To annually measure the relative abundance and distribution of selected species of pelagic fishes in the estuary.
- To detect introductions of new exotic fish and invertebrates.
- Provide baseline data to evaluate management plans and habitat restoration projects.
- To measure availability of fall planktonic food resources (since 2010).

20-mm Survey monitoring to determine distribution and relative abundance of Delta Smelt and Longfin smelt

The 20-mm Survey monitors juvenile Delta and Longfin Smelt distribution and abundance throughout their historic spring range in the Sacramento-San Joaquin Delta and upper Estuary. This survey monitors Delta Smelt around 20 mm TL in size which is the size that larval "take" is counted against the SWP and CVP. This information allows managers to vary water operations and provide sufficient flows to maintain Delta Smelt rearing habitat away from the south and central Delta and minimize entrainment.

Objectives:

- Determine the distribution of juvenile Delta and Longfin Smelt in relation to the major water diversions
- Compare current relative abundance to historical relative abundances
- Provide concurrent zooplankton density information to monitor the suitability of their food supply

Spring Kodiak Trawl

The Spring Kodiak Trawl (SKT) began in 2002 and is designed to provide information on the distribution of pre-spawning and spawning Delta Smelt, to improve our ability to detect adult Delta Smelt, obtain maturity status data, and provide results on a near "real-time" basis to assist in water management and export decisions. The survey is designed to determine pre-spawning and spawning distribution of adult Delta Smelt in relation to the CVP and SWP water export facilities. Due to its superiority in sampling efficiency to the earlier Fall Midwater Survey, the early results of the SKT are also been used to help estimate the relative abundance of adult Delta Smelt at extremely low population levels.

Objectives:

- Determine the distribution of maturing Delta Smelt during the period of December through May
- Evaluate the sexual maturation of Delta Smelt during this period and detects the start of spawning migration
- Report current relative abundance compared to historical estimates

Estuarine and Marine Fish Abundance and Distribution Survey

Since 1980, 52 channel and shoal stations from South San Francisco Bay to the lower Sacramento and San Joaquin rivers have been sampled monthly with a midwater and otter trawl. In addition to tracking abundance trends and distributional changes of individual species, data from this study is used to determine changes in the fish communities over time.

Objectives:

- Determine the effects of outflow related mechanisms on the abundance and distribution of estuarine and marine fishes.

Smelt Larva Survey (SLS)

This survey provides near real-time abundance and distribution data for Longfin (LFS) Smelt larvae in the Delta, Suisun Bay and Suisun Marsh. Data are used by agency managers to assess vulnerability of Longfin Smelt larvae to entrainment in south Delta export pumps. Sampling begins within the first two weeks in January and repeats every other week through the second week in March. The data is used to assess the risks of entrainment by the SWP and CVP and to determine OMR levels designed to minimize take of juvenile LFS at these facilities.

Summer Townet Survey

Summer Townet Survey (STN) is a long-term effort to monitor young pelagic fishes in the upper San Francisco Estuary. Since 1959, STN has sampled fixed locations from eastern San Pablo Bay to Rio Vista on the Sacramento River, and to Stockton on the San Joaquin River; and a single station in the lower Napa River. The study area was expanded in 2011 to include the Sacramento Deep Water Ship Channel and Cache Slough. Currently, 40 stations are sampled every other week June through August using a conical, fixed-frame net, which is pulled obliquely through the water column 2 to 3 times at each station. Data collected at 31 stations are used to calculate annual relative abundance indices for age-0 Striped Bass (*Morone* saxatilis) and Delta Smelt (*Hypomesus transpacificus*). The remaining 8 stations are sampled to increase our understanding of juvenile fish abundance and distribution in the lower Napa River and the north Delta. In 2005, STN added a zooplankton net to assess fish food resources at each station. A subset of the fish collected are retained for diet analysis. The STN also measures water temperature, water clarity and specific conductivity. Managers and researchers use the data collected by STN to inform decisions and improve our understanding of the health of the upper San Francisco Estuary.

While the original intent was to monitor the population of age-0 Striped Bass throughout the upper San Francisco Estuary, its scope has broadened to include other species of fish such as Delta Smelt and the food resources they rely upon.

Objectives:

- Measure annual abundance of selected age-0 fish

- Measure factors affecting abundance and distribution of age-0 Striped Bass, Delta Smelt and other fish in the estuary
- Measure availability of summer planktonic food resources
- Examine summer diets of young Striped Bass, Delta Smelt, and other pelagic fishes

Environmental Monitoring Program

The Environmental Monitoring Program (EMP) was established in 1971 to collect environmental data for resource management, to better understand estuarine processes, and to document compliance with State Water Resources Control Board Water Right Decision D-1379. This program collects water quality, chlorophyll, phytoplankton, benthic, and zooplankton samples at fixed locations in the Sacramento-San Joaquin Delta, Suisun Bay, and San Pablo Bay. Two of the program's strengths are continuity and data integration; the EMP is one of the nation's oldest environmental monitoring programs and has compiled over four decades of consistent and comprehensive water quality and biological data.

This is a comprehensive monitoring program that helps to ensure compliance with water quality objectives and standards, which were established to protect the beneficial uses of water in Sacramento-San Joaquin Delta and Suisun Marsh.

Objectives:

- Provide accurate and validated water quality and biological information to managers for real-time and adaptive management of the SWP and CVP
- Document and evaluate long term water quality and ecological trends in the San Francisco Estuary
- Detect and document invasive species, such as *Microcystis aeruginosa* and *Potamocorbula amurensis,* and conduct specials studies to discern their impact on native species, the food web, and human health.

Delta Juvenile Salmon Monitoring (DJFMP seines and trawls)

This program involves year-around beach seining and surface trawling (Mossdale, Sacramento, and Chipps Island) throughout the San Francisco Estuary to monitor the relative abundance and distribution (spatial and temporal) of juvenile Chinook Salmon and other native species in the Central Valley of California.

Objectives:

- Determine the status and trends of juvenile Chinook Salmon in the San Francisco Estuary.
- Examine factors influencing the status and trends of juvenile Chinook Salmon.

Juvenile Spring-Run and Steelhead Production Monitoring in Clear Creek

The goal of this program is to estimate production of juvenile salmonids in Clear Creek. Clear Creek juvenile salmon and steelhead production estimates are used to guide and evaluate the effectiveness of proposed actions. It also serves a status and trend purpose to provide information for ESA status consideration. This monitoring activity results in juvenile production estimates for spring-run and steelhead in Clear Creek. Biweekly count and passage estimates data will be posted on the publicly accessible USFWS website for interested parties.

Objectives:

- Operate a rotary screw trap to catch, identify, and count juvenile fish leaving Clear Creek.
- Use rotary screw trap capture-efficiency trials to transform juvenile counts into total production estimates for salmon and steelhead.
- Estimate spawning success by combining juvenile production estimates with adult population estimates. Spawning success can be an indicator of the effectiveness of water management, habitat restoration and environmental variables.

Adult Steelhead and Late-fall Chinook Escapement Monitoring in Clear Creek

The goal of this program is to estimate population size and distribution of adult steelhead and late-fall Chinook spawning in Clear Creek. This monitoring activity is used to guide and evaluate the effectiveness of the proposed actions. It also serves a status and trend purpose to provide information for ESA status consideration. The activity estimates annual adult populations of steelhead and late-fall Chinook in Clear Creek using two methods: video counts and kayak-based redd counts. Count data will be posted on the publicly accessible USFWS website for interested parties.

Objectives:

- Operate a video weir station to count and identify fish entering and leaving the watershed.
- Estimate spawning population size using redd counts produced during kayak surveys.
- Estimate spawning success by combining redds counts with estimates of the number of juvenile fish produced. Spawning success can be an indicator of the effectiveness of water management and habitat restoration.
- Collect spawning habitat data for use as an indicator of the effectiveness of habitat restoration.
- Estimate the spatial and temporal distribution of spawning through kayak-based surveys.

Spring, Fall, and Late-fall Chinook Salmon and Steelhead Escapement Monitoring in the Upper Sacramento River Basin

Conduct mark-recapture carcass surveys, aerial and wading redd surveys, video counts, and snorkel surveys of the mainstem Sacramento River and its major tributaries (Battle Creek, Cow Creek, Bear Creek, Antelope Creek, Mill Creek, and Deer Creek) to estimate adult salmon and steelhead escapement. Data collected may include: hatchery mark status, gender, tag status, carcass condition, spawning status, fork length, and disposition, from all or a subset of carcasses handled. Other samples may include biological samples, such as: head, fin tissue, otoliths, and scales, from a subset of carcasses handled during the survey. Annual data are posted on the publicly accessible CalFISH website for interested parties.

Objectives:

- Estimate of spring run, fall run, and late-fall run Chinook and steelhead spawner abundance generated based on carcass mark-recapture or Vaki/video count estimation methods on the mainstem Sacramento River.
- Estimate escapement and contribution to natural spawning by natural and hatchery origin winter Chinook.
- Estimate of pre-spawning mortality in upper Sacramento River

American River Chinook Salmon and Steelhead Escapement Estimation

Conduct mark-recapture carcass surveys, aerial and wading redd surveys and snorkel surveys of the American River to estimate fall run Chinook and steelhead escapement. This activity generally runs mid-September through March. Data collected may include: hatchery mark status, gender, tag status, carcass condition, spawning status, fork length, and disposition, from all or a subset of carcasses handled. Other samples may include biological samples, such as: head, fin tissue, otoliths, and scales, from a subset of carcasses handled during the survey. Weekly carcass data are posted on the publicly accessible CalFISH website for interested parties.

Objectives

- Estimate the number of Chinook salmon spawning in the lower American River on an annual basis, beginning in mid-September.
- Estimate of escapement and contribution of hatchery-origin fish
- Estimate of pre-spawning mortality

Stanislaus River Chinook Salmon and Steelhead Escapement Estimation

Conduct mark-recapture carcass surveys, aerial and wading redd surveys and snorkel surveys of the American River to estimate fall run Chinook and steelhead escapement. This activity generally runs mid-September through March. Data collected may include: hatchery mark status, gender, tag status, carcass condition, spawning status, fork length, and disposition, from all or a subset of carcasses handled. Other samples may include biological samples, such as: head, fin tissue, otoliths, and scales, from a subset of carcasses handled during the survey. Weekly carcass data are posted on the publicly accessible CalFISH website for interested parties.

Objectives

- Estimate the number of Chinook salmon spawning in the Stanislaus River on an annual basis, beginning in mid-September.
- Estimate of escapement and contribution of hatchery-origin fish
- Estimate of pre-spawning mortality

Enhanced Acoustic Tagging, Analysis, and Real-time Monitoring

This monitoring program supports an acoustic receiver network and associated real-time and retrospective modeling of the data. This monitoring may include (1) the deployment of real-time receivers that will provide timely information on migrating salmon smolt and green sturgeon location and timing, (2) expansion of the existing autonomous acoustic array to increase the coverage and detection efficiency; (3) development of new metrics for the real-time data for key management relevant questions such as entrainment estimates at critical junctions (Georgiana Slough and Delta Cross Channel); and (4) retrospective analyses directly geared toward improving the quality and robustness of forecasting models (e.g., enhanced particle tracking models, fish migration models). Survival modeling and forecasting will be posted on the publicly accessible NOAA-Fisheries website for interested parties.

Objectives:

- Real-time estimates of reach-specific survival for juvenile salmonids in the Sacramento River and Delta

- Real-time estimates of route-entrainment for juvenile salmonids in the Delta

Mossdale Spring Trawl

This monitoring program is a long-term San Joaquin River basin juvenile Chinook salmon monitoring using a trawl net. The project samples on San Joaquin River near Mossdale County Park. This program identifies annual juvenile Chinook salmon production in the San Joaquin River Basin. Catch data will be posted on the publicly accessible CalFISH website for interested parties.

Objectives:

- Determine annual juvenile Chinook salmon production in the San Joaquin River Basin
- Determine how water quantity and quality conditions affect smolt production trends and *Oncorhynchus mykiss* passage at Mossdale trawl.

Adaptive Management Program Monitoring

Tidal Wetland Monitoring Studies

This program collects fish and invertebrate data near existing and tidal wetlands and planned tidal wetland restoration sites. These data provide information on how fish and invertebrate communities change pre-/post-restoration. Tidal wetland habitat restoration in the Sacramento-San Joaquin Delta and Suisun Marsh is important for improving habitat and food web resources for threatened fishes. This program is responsible for biological monitoring in these restored tidal habitats to assess their success for providing benefits for at-risk native fishes. Pre-project monitoring data allows project managers to evaluate the effectiveness of tidal wetland restoration projects.

Objectives:

- Determine the extent to which long-term sampling reflects conditions in nearby shallow water and wetland habitats.
- Determine whether gear efficiency evaluations are feasible using new sampling technology
- Determine the level of spatial and temporal replication necessary to make sampling design recommendations for long-term monitoring.
- Continue developing a baseline of biomass, community composition, and fish condition for fish and invertebrates near planned tidal restoration and comparison sites. This will allow us to make pre-and-post-restoration comparisons for evaluating restoration progress.

Bay Salinity Monitoring

Salinity and water temperature are collected in San Francisco Bay. Data are used to better understand the hydrodynamics of the estuary and calibration of multi-dimensional flow and transport models. Understanding how these variables are distributed around the Bay leads to a better understanding of habitat types and distribution in the Bay. Time series of water temperature and specific conductance (salinity is calculated from conductivity and water temperature) are needed (1) to improve our understanding of the hydrodynamics of the estuary (e.g., gravitational circulation), (2) for calibration of multi-dimensional flow and transport models of the Bay, (3) to better understand the distribution of physio-chemical habitat types throughout the Bay, and (4) to provide supporting data for numerous estuarine studies of the Bay and Delta.

Upper Estuary Zooplankton Sampling

The Zooplankton Study has estimated the abundance of zooplankton taxa in the upper San Francisco Estuary since 1972 as a means of assessing trends in fish food resources and is part of a D-1641 mandate to monitor water quality and related parameters. Sampling with three gear types occurs monthly at 22 stations located throughout San Pablo Bay, Suisun Marsh, Suisun Bay, and the Delta. Zooplankton are an important trophic link between primary producers and fish. The Zooplankton Study provides abundance estimates and distributional data for fish food resources in the upper San Francisco Estuary. This information is used by aquatic ecologists to understand the lower food web and some biological drivers of the Delta Smelt population. The study also detects and monitors zooplankton recently introduced to the estuary and determines their effects on native zooplankton species.

Objectives:

- Determine abundance and distribution of zooplankton in the upper San Francisco Estuary
- Determine the relationships between species abundance and temperature, salinity, turbidity, and chlorophyll
- Determine long-term abundance trends for all species and if these trends show significant declines or increases
- Determine if introduced species becoming established in the estuary

Upper Sacramento River Habitat Restoration Monitoring Project

Sacramento River Spawning and Rearing Habitat Restoration Monitoring Program

- Determine the effectiveness of habitat improvement project sites at improving habitat for adult and juvenile Chinook salmon and steelhead trout.
- Determine species presence assemblage and density over time through repeated surveys.
- Collect spatial fish data by snorkel, videography, seine, or electrofish surveys.
- Compare habitat attributes between control and treatment sites before and after project implementation. Metrics can include water temperatures, velocities, depths, substrates, cover, vegetation, temperature stratification in backwaters, hyporheic conditions, and macroinvertebrate metrics.

Reporting

Various reporting is completed by the multiple agency and consultants completing the monitoring describe above. The Real Time Monitoring activities currently provide their data through various sites. Communication of these data has typically been supported through email, and more recently through web-based aggregation and visualization sites such as Bay-Delta Live, SacPAS, and SHOWR. These sites will continue to support the needs for rapid analytical and reporting of Real Time Monitoring data.

Bay-Delta Live

Bay-Delta Live is a collaborative community of interests with the goal of expanding open and transparent sharing of information essential in understanding the complex and dynamic ecosystem of the Sacramento-San Joaquin Bay Delta. Bay-Delta Live provides information from multiple sources using enhanced visual interfaces. Bay-Delta Live is used by resource managers, scientists, conservationists, policy makers, academics, and others local community interestes. BDL is supported through contributions from federal and state agencies, as well as community and agency information.

https://www.baydeltalive.com/

SacPAS

This website provides monitoring, evaluation, and web-based data products and services for primary and associated activities funded by the U.S. Bureau of Reclamation (USBR) and mandated by the Endangered Species Act (ESA). It serves as a means by which information integration services can be provided to the Central Valley Project Improvement Act (CVPIA) and ESA participants. Web-based services relate fish passage to environmental conditions and provide resources for evaluating the effects of river management and environmental conditions on salmon passage and survival. This website is maintained by University of Washington with funds from US Bureau of Reclamation.

http://www.cbr.washington.edu/sacramento/

Objective

- Provide a publicly accessible, web-based query and reporting system of historical and current fish, environmental, and hydrologic information, vital to year-round planning and adaptive management of the Central Valley Project and State Water Project.
- Provide basic conditions, performance measures, and threshold-based alerts are available through data aggregation and analysis of environmental conditions.

SHO-WR

SHOWR is designed to help decision makers and interested stakeholders understand and engage in the complicated process of managing Shasta Reservoir operations to protect Winter Run Chinook Salmon.The SHO-WR application demonstrates the power of open data paired with open source analytics and visualization tools for California water resources management. The application has been developed iteratively as part of a demonstration project led by the Sacramento River Settlement Contractors (SRSC). The primary objective of this demonstration project is to integrate diverse flow, water operations, fishery, and water quality data into a single, open data environment that facilitates more data-driven and timely decision making. On the section of the Sacramento River immediately below Lake Shasta, the fishery agencies have targeted water temperature as the most critical resource to successful spawning of winter-run Chinook salmon from late April through September. This single parameter controls the operation of Shasta Reservoir, SRSC diversions, the Central Valley Project (CVP), other project reservoirs, and the Bay Delta.

https://flowwest.shinyapps.io/showr/

Table C-4: Availability of data generated by Real Time Monitoring Projects.

Id	Monitoring Program	Bay Delta Live	Sacpas	Showr
1	Adult Spring Chinook Escapement Monitoring in Clear Creek.		Adult escapement	
2	Red Bluff Diversion Dam Rotary Screw Trap Juvenile Monitoring Program		Juvenile Production	
3	Juvenile Salmon Emigration Real-time Monitoring (Seines and Trawls)	Abundance Index, Distribution	Abundance Index, Distribution	
4	Juvenile Salmon Delta Abundance Trawling (expanded DJFMP trawling)			
5	Genetic Identification of Salmonids and Smelt to Inform Central Valley Project Operations and Bay-Delta Monitoring			
6	Lower Sacramento River Juvenile Salmon and Steelhead Monitoring Project	Abundance Index, Distribution	Abundance Index, Distribution	
7	Winter-run Chinook Salmon Escapement Monitoring			
8	Fish Salvage Operations	Daily Loss	Daily Loss	
9	Enhanced Delta Smelt Monitoring	Daily distribution		
10	Delta Flow Measurement and Database Management	Flow Characteristics	Flow Characteristics	
11	Operation of Thermograph Stations	Temperature Characteristics	Temperature Characteristics	Temperature Characteristics
12	Hatchery Marking (100% Tagging)		Smolt-to Adult Return ratios, Daily Loss	

References

Johnson, RC, S. Windel, PL Brandes, JL Conrad, J Ferguson, PAL Goertler, BN Harvey, J Heublein, JA Israel, DW Kratville, JE Kirsch, RW Perry, J Piscitooto, WR Poytress, K Reece, BG Swart. 2017. Science Advancements Key to Increasing Management Value of Life Stage Monitoring Networks for Endangered Sacramento River Winter-Run Chinook Salmon in California. San Francisco Estuary and Watershed Science. 15: 1-41.

Exhibit B - Real-Time Species Distribution and Lifestage

Fish monitoring technical teams shall regularly report the following information from December through June as appropriate to the species' lifestage.

Salmonids

Upper Sacramento Fish Monitoring: redd counts and sampling at rotary screw traps

Lower Sacramento Fish Monitoring: sampling in trawls and beach seines.

Fish Distribution: Estimated percentage of the population upstream of Knight's Landing, In the Delta, and Past Chipps Island for winter-run, and spring-run Chinook salmon.

Delta Distribution: Estimated percentage of the population is different strata within the Delta.

Migration Cues: Other factors and indicators of fish distribution and lifestage.

Smelt

Environmental Data: water temperature thresholds, turbidity, food indicators, etc.

Fish Monitoring: gear deployments, counts by strata, and body condition from EDSM

Migration Cues: Other factors and indicators of fish distribution and lifestage.

Salvage

Salvage: reports from the state and federal facilities.

Exhibit - C Water Operation Status

Monthly, Reclamation shall provide a report on the status of CVP and SWP operations including:

- Reservoir Storage
- Reservoir Inflow
- Deliveries and Delta Outflow
- Delta Water Quality Stations
- VA Experiments

Exhibit D.a. - Old and Middle River Storm Event

See WIIN

Exhibit D.b. - Shasta Cold Water Pool Management

See SRTTG

Exhibit D.c. - Folsom Cold Water Pool Management

See ARG

Exhibit D.d. - Suisun Marsh and Fall Delta Smelt Habitat

Reclamation and DWR shall investigate Delta Smelt fall habitat to determine how the components of habitat interact with the species and affect its viability. Components of habitat include food, turbidity, salinity, velocity, and temperature - the physical and geographic features. Viability includes stomach fullness, length, and overall fitness including freedom from disease. This study program shall use a scientific approach of hypothesis identification, testing, and synthesis through Structured Decision Making, as discussed in the Adaptive Management Program. The Delta XXXX group would meet to determine how to implement this action each year. To inform the Delta XX group, Reclamation and/or DWR would conduct Delta hydrodynamic modeling on an annual basis to evaluate the potential action(s). Each year, this program shall implement actions that may include (but are not limited to): monitoring, modeling, surveys, changes in existing physical structures or gates, additional flow, and/or the addition of substrate or turbidity. The synthesis and results from these investigations shall be published annually. Reclamation, DWR and Service shall conduct a comprehensive review of the outcomes of the Fall Investigations and the effectiveness of the adaptive management program ten years from the signing of the biological opinion, or sooner if circumstances warrant. This review shall entail an independent peer review. The purposes of the review shall be to evaluate the outcomes of the investigations to determine the then-current understanding of fall habitat, and to evaluate the effectiveness of the adaptive management program. At the end of 10 years or sooner, these investigations, based on the peer review and Service determination as to its efficacy shall either be continued, modified, or terminated.

Exhibit E - Outlier Years

In the event Reclamation and DWR identify conditions outside of the range of the Proposed Action, Reclamation and DWR will provide the following information to CDFW, FWS, and NMFS for technical assistance.

- Real-Time Species Distribution and Life History
- Water Operation Status
- Forecasts at the 50% and 90% confidence levels
- Potential Alternative Actions
- Other Relevant Information

Reclamation and DWR anticipate additional information may be required and would be developed through collaboration on the technical assistance.

Exhibit F - Habitat Restoration Updates

Annually and/or as needed, Reclamation and DWR would list the planned, under construction, and recently completed habitat restoration actions. For each action, the list would include:

- Name of the Project
- Completion Date (Planned or Actual)
- Changes to Operational Metrics (e.g. Acres Inundated, X2 Relationship)
- Changes to Habitat Metrics (e.g. Rearing, Spawning, Foraging, Etc.)
- Relevant Flow Experiments

Exhibit G.a. - Shasta Cold Water Pool Management

By the end of December of each year, Reclamation shall provide information on the prior year's management of the Shasta cold water pool in order to inform the upcoming temperature management season due April 1. Information will include, at minimum:

- Adult Winter-Run Carass Survey
- Winter-Run Chinook Salmon Redd Timing and Location
- Reservoir Inflow and Meteorology
- Narrative on the use of Cold Water Resources
- Measured Reservoir Profiles and Water Temperatures
- Estimated Temperature Dependent Mortality
- Monthly Water Operation Status Reports
- Shasta Cold Water Pool Status Reports
- Technical Assistance and Other Fish Agency Communications to Reclamation

Exhibit G.b. - Shasta Storage Rebuilding and Spring Pulse

By the end of June of each year, Reclamation shall provide information on the outcomes of fall-winter and spring actions to rebuild storage in Shasta Reservoir to inform actions for the upcoming fall. Information will include, at minimum:

- Rice Decomposition Schedules
- Number of Winter-Run Redds Dewatered
- Number of Fall-Run Redds Dewatered
- Estimated Increase in Storage due to Actions
- Flood Conservation Space Releases, if Taken
- Spring Pulse Action, if Taken

Exhibit G.c. - Annual Summary Of Water Supply and Fish Operations

On or about the end of September of each year, Reclamation and DWR propose to provide to the USFWS, NMFS, and CDFW a report on the prior year activities through the spring of each year. The annual report shall include, at minimum:

- Hydro-Meteorology: Precipitation; reservoir inflow; air temperatures; and other environmental factors affecting water availability and demands.
- Non-Flow Construction: Summary of projects committed to in this consultation that are initiated; ongoing; and completed.
- Water Operations Summary: Conditions from the prior year (spring to spring); allocations; flows; diversions; and reservoir, release, and river temperatures.
- Flow Experiments under Voluntary Agreements: Accounting for conditions and the flow actions including.
- Fisheries Performance: Results from monitoring stations; surveys; salvage; harvest; and physical factors influencing fish populations.
- Intervention Measures: Hatchery intakes; releases; and other measures.
- Predictive Tools: Summary of the performance of the risk analysis tools used during the year.

Appendix XX provides an outline of the annual report.