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List of Abbreviations and Acronyms

µg/L	micrograms per liter
µg/m^3	micrograms per cubic meter
µS/cm	microSiemens per centimeter
A	ampere
AADT	annual average daily traffic
AASHTO	American Association of State Highway Transportation Officials
AB	Assembly Bill
ACS	American Community Survey
AEP	annual exceedance probability
AF	acre-feet
AFRP	Anadromous Fish Restoration Program
AP	air pollutant
APE	area of potential effects
AQMD	Air Quality Management District
ARCFP	American River Common Features Project
ARPA	Archaeological Resources Protection Act
ATCM	Airborne Toxic Control Measure
BACT	best available control technology
Banks	Harvey O. Banks Pumping Plant
Bay-Delta	San Francisco Bay/Sacramento-San Joaquin Delta
BCC	birds of conservation concern
BDCP	Bay-Delta Conservation Plan
BEP	Business Emergency Plan
bgs	below ground surface
BMO	basin management objective
BMP	best management practice
BO	biological opinion
BPM	Bypass Production Model
BWFS	Basin-Wide Feasibility Study
°C	degrees Celsius
CAA	Clean Air Act
CAAQS	California Ambient Air Quality Standard
CalEPA	California Environmental Protection Agency
Cal-IPC	California Invasive Plant Council
CalEEMod	California Emissions Estimator Model
CALFED	CALFED Bay-Delta Program
CAL FIRE	California Department of Forestry and Fire Protection
Cal OES	California Governor’s Office of Emergency Services
Cal OSHA	California Occupational Safety and Health Administration (
CalParks	California Department of Parks and Recreation

CalRecycle	California Department of Resources Recycling and Recovery
Caltrans	California Department of Transportation
CAPCOA	California Air Pollution Control Officers Association
CARB	California Air Resources Board
CASGEM	California Statewide Groundwater Monitoring
CBD	Colusa Basin Drain
CCAA	California Clean Air Act
CCCC	California Climate Change Center
CCF	Clifton Court Forebay
CCP	Comprehensive Conservation Plan
CCR	California Code of Regulations
CCSM	National Center for Atmospheric Research Community Climate System Model
CDC	California Debris Commission
CDEC	California Data Exchange Center
CDFA	California Department of Food and Agriculture
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife (after January 1, 2013)
CDPH	California Department of Public Health
CDPR	California Department of Pesticide Regulation
CEC	California Energy Commission
CEQ	Council on Environmental Quality
CEQA	California Environmental Quality Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CESA	California Endangered Species Act
CFCP	California Farmland Conservancy Program
CFR	Code of Federal Regulations
cfs	cubic foot per second
CGPS	continuous global positional system
CGS	California Geological Survey
CH_4	methane
CHRIS	California Historical Resources Information System
cm	centimeters
cms	cubic meter per second
CNDDB	California Natural Diversity Database
CNEL	Community Noise Equivalent Level
CNPS	California Native Plant Society
CNRA	California Natural Resources Agency
CNRM	Centre National de Recherches Meteorologiques
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent

COA	Coordinated Operations Agreement
CPUC	California Public Utilities Commission
CR	County Road
CRHR	California Register of Historical Resources
CRMP	Construction Risk Management Plan
CRPR	California Rare Plant Rank
CUPA	Certified Unified Program Agency
CVFMP	Central Valley Flood Management Planning
CVFPB	Central Valley Flood Protection Board
CVFPP	Central Valley Flood Protection Plan
CVHM	Central Valley Hydrologic Model
CVHS	Central Valley Hydrology Study
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CWA	Clean Water Act
CWC	California Water Commission
CY	cubic yards
dB	decibel
dBA	A-weighted decibel
DMC	Delta-Mendota Canal
DDT	dichloro-diphenyl-trichloroethane
Delta	Sacramento-San Joaquin Delta
DFG	California Department of Fish and Game (prior to January 1, 2013)
DJUSD	Davis Joint Unified School District
DMCP	Delta Mercury Control Porgram
DO	dissolved oxygen
DOC	California Department of Conservation
DOGGR	California Department of Conservation, Division of Oil, Gas, and Geothermal Resources
DOI	United States Department of the Interior
DOT	United States Department of Transportation
DPC	Delta Protection Commission
DPM	diesel particulate matter
DPR	California Department of Parks and Recreation
DPS	distinct population segment
DSC	Delta Stewardship Council
DTSC	California Department of Toxic Substances Control
DWR	California Department of Water Resources
DWSC	Deep Water Ship Canal
EC	electrical conductivity
EDD	California Employment Development Department
EDR	Environmental Data Resources
EFH	Essential Fish Habitat
EHD	Environmental Health Department
E/I ratio	Export/Inflow ratio

EIR	Environmental Impact Report
EIS	Environmental Impact Statements
ELAM	Eulerian-Lagrangian Agent Method
EMS	Emergency Medical Services
EO	Executive Order
EPOM	Environmental Permitting for Operations and Maintenance
ER	Environmental Resource
ESA	Endangered Species Act
ESRP	Endangered Species Recovery Program
Estuary	San Francisco Bay/Sacramento-San Joaquin River Delta Estuary
ESU	evolutionarily significant unit
°F	degrees Fahrenheit
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FETT	Fisheries and Engineering Technical Team
FHWA	Federal Highway Administration
FL	fork length
FMMP	Farmland Mapping and Monitoring Program
FPD	Fire Protection District
FR	Federal Regulation
FSZ	Farmland Security Zone
ft/sec	feet per second
FHWG	Fisheries Hydroacoustic Working Group
FTA	Federal Transit Authority
FWCA	Fish and Wildlife Coordination Act
FWWA	Fremont Weir Wildlife Area
GAMA	Groundwater Ambient Monitoring and Assessment
GCID	Glenn Colusa Irrigation District
GCM	global climate model
GGERP	Greenhouse Gas Emissions Reduction Plan
GHG	greenhouse gas
GIS	geographic information system
GMP	Groundwater Management Plan
gpm	gallons per minute
GPS	Global Positioning System
GRR	General Reevaluation Report
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
GWP	global warming potential
HAER	Historic American Engineering Record
HAP	hazardous air pollutant
HCM	Highway Capacity Manual
HCP	Habitat Conservation Plan
HD	United States House Document

HDR	HDR, Inc.
HEC-RAS	Hydrologic Engineering Center River Analysis System
Hg	mercury
HGWP	high global warming potential
HHW	household hazardous waste
HMBP	Hazardous Materials Business Plan
HMMP	Hazardous Materials Management Plan
hp	horsepower
HPS	Hantavirus Pulmonary Syndrome
Hz	hertz
I	Interstate
IMPLAN	Impact Planning and Analysis
in/sec	inches per second
IS/EA	Initial Study/Environmental Assessment
ITA	Indian Trust Asset
IWM	instream woody material
Jones	C.W. “Bill” Jones Pumping Plant
JPOD	joint points of diversion
KLOG	Knights Landing Outfall Gates
km	kilometer
km^2	square kilometer
kVA	kilovolt-amps
kW	kilowatt
lbs/ton	pounds per ton
lbs/VMT	pounds per vehicle mile traveled
LEBLS	Lower Elkhorn Basin Levee Setback Project
LESA	Land Evaluation and Site Assessment
Leq	Equivalent energy level
LIER	Liberty Island Ecological Reserve
LMP	Land Management Plan
LOD	level of development
LOS	level of service
LSZ	low-salinity zone
LURMP	Land Use and Resources Management Plan
Lv	vibration velocity level
m	meter
M&I	municipal and industrial
MAF	million acre-feet
MBTA	Migratory Bird Treaty Act
MCL	maximum contaminant level
MeHg	methylmercury
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
MIG	Minnesota IMPLAN Group
MLD	most likely descendent

mm	millimeter
MM	mitigation measure
MMRP	Mitigation Monitoring and Reporting Program
$MMTCO_2e$	million metric tons CO_2 equivalent
MOU	memorandum of understanding
mph	miles per hour
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
$MTCO_2e$	metric tons CO_2e
MVCAC	Mosquito and Vector Control Association of California
MVCD	Sacramento-Yolo Mosquito & Vector Control District
MWD	Metropolitan Water District of Southern California
N_2O	nitrous oxide
NAA	nonattainment area
NAAQS	National Ambient Air Quality Standard
NAGPRA	Native American Graves Protection and Repatriation Act
NAHC	Native American Heritage Commission
NAVD 88	North American Vertical Datum of 1988
NAWCA	North America Wetlands Conservation Act
NAWMP	North American Waterfowl Management Plan
NAWQA	National Water Quality Assessment Program
NCADAC	National Climate Assessment and Development Advisory Committee
NCAR	National Center for Atmospheric Research
NCCP	Natural Communities Conservation Plan
NCP	Noise Control Plan
NDOI	Net Delta Outflow Index
NEPA	National Environmental Policy Act
ng/L	nanograms per liter
NGO	non-governmental organization
NHPA	National Historic Preservation Act
NMFS	National Oceanic and Atmospheric Administration National Marine Fisheries Service
NMFS BO	Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
NOAA	National Oceanic and Atmospheric Administration
NOD	Notice of Determination
NOI	Notice of Intent
NOP	Notice of Preparation
NPDES	National Pollutant Discharge Elimination System

NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NTU	nephelometric turbidity unit
NVCP	Noise and Vibration Control Plan
O_3	ozone
O&M	operation and maintenance
OES	Office of Emergency Services
OHWM	ordinary high water mark
OMR	Old and Middle River
OPR	Office of Planning and Research
OSHA	United States Department of Labor, Occupational Safety and Health Administration
Pb	lead
PCB	polychlorinated biphenyl
PCM	Parallel Climate Model
PG&E	Pacific Gas and Electric Company
PLC	programmable logic controller
$PM_{2.5}$	fine particulate matter, particles up to 2.5 microns
PM_{10}	coarse particulate matter, particles up to 10 microns
Porter-Cologne Act	Porter-Cologne Water Quality Control Act
ppb	parts per billion
ppm	parts per million
ppt	parts per thousand
PPV	peak particle velocity
PRC	Public Resources Code
Project	Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project
RBDD	Red Bluff Diversion Dam
RBPP	Red Bluff Pumping Plant
RCRA	Resource Conservation and Recovery Act
RD	Reclamation District
RD 1641	Revised Decision 1641
Reclamation	United States Department of the Interior, Bureau of Reclamation
RM	river mile
ROD	Record of Decision
ROG	reactive organic gases
ROW	right-of-way
RPA	Reasonable and Prudent Alternative
RSP	rock slope protection
RST	rotary screw trap
RWMP	Regional Flood Management Plan
RWQCB	Regional Water Quality Control Board
SACOG	Sacramento Area Council of Governments
SARA	Superfund Amendments and Reauthorization Act
SB	Senate Bill

SBM	Salmon Benefits Model
SBWA	Sacramento Bypass Wildlife Area
SCH	State Clearinghouse
SCORP	Statewide Comprehensive Outdoor Recreation Plan
SCUSD	Sacramento City Unified School District
SCVWD	Santa Clara Valley Water District
SD 18	Swampland District No. 18
SDWA	Safe Drinking Water Act
Secretary	Secretary of the Interior
SEL	sound exposure level
SFCWA	State and Federal Contractors Water Agency
SGMA	Sustainable Groundwater Management Act
SHPO	State Historic Preservation Officer
SIP	State Implementation Plan
SMARA	Surface Mining and Reclamation Act of 1975
SMP	Suisun Marsh Plan
SNE	Sacramento Northern Electric
SO_2	sulfur dioxide
SO_x	sulfur oxides
SP	State Park
SPCCP	Spill Prevention, Control, and Countermeasure Plan
SPFC	State Plan of Flood Control
SPOA	Survey on Public Opinions and Attitudes on Outdoor Recreation
SR	State Route
SRA	shaded riverine aquatic
SRBPP	Sacramento River Bank Protection Project
SRFCP	Sacramento River Flood Control Project
SRGRR	Sacramento River General Reevaluation Report
SRH-2D	Sedimentation and River Hydraulics – Two Dimensional Model
SSC	Species of Special Concern
SSIA	State Systemwide Investment Approach
State	State of California
SVAB	Sacramento Valley Air Basin
SVI	Sacramento Valley Index
SWP	State Water Project
SWPPP	Stormwater Pollution Prevention Plan
SWRCB	State Water Resources Control Board
TAC	toxic air contaminant
TAF	thousand acre-feet
TAF/yr	thousand acre-feet per year
TCP	traditional cultural property
TDS	total dissolved solids
Term 91	Standard Permit Term 91
TMDL	total maximum daily load

TN	ton
tpd	tons per day
tpy	tons per year
TSCA	Toxic Substances Control Act
TUFLOW	Two-Dimensional Unsteady Flow Model
UCCE	University of California Cooperative Extension
UC Davis	University of California at Davis
USACE	United States Army Corps of Engineers
USC	United States Code
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UST	underground storage tank
VAC	volts alternating current
VdB	vibration decibels
VOC	volatile organic compound
vs	versus
VSP	viable salmonid population
WQCP	Water Quality Control Plan
WRDA	Water Resources Development Act
YBFEPT	Yolo Bypass Fisheries Enhancement Planning Team
YBPASS Tool	Yolo Bypass Passage for Adult Salmonids and Sturgeon Tool
YBWA	Yolo Bypass Wildlife Area
YCP	Yolo Conservation Plan
YHC	Yolo Habitat Conservancy

1 Introduction

The Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Project) has been developed to improve fish passage and increase floodplain fisheries rearing habitat in the Yolo Bypass and the lower Sacramento River basin. The United States Department of the Interior, Bureau of Reclamation (Reclamation), as the Federal lead agency under the National Environmental Policy Act (NEPA), and the California Department of Water Resources (DWR), as the State of California (State) lead agency under the California Environmental Quality Act (CEQA), have prepared this joint Environmental Impact Statement/Environmental Impact Report (EIS/EIR) to assess impacts of the Project. The Project actions would implement Reasonable and Prudent Alternative (RPA) action I.6.1 and, in part, RPA action I.7, as described in the 2009 National Oceanic and Atmospheric Administration National Marine Fisheries Service (NMFS) *Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project* and the 2012 Yolo Bypass Salmonid Habitat Restoration and Fish Passage Implementation Plan (Reclamation and DWR 2012).

Authority for combined Federal and State documents is provided in Title 40, Code of Federal Regulations (CFR), Sections 1502.25, 1506.2, and 1506.4 (Council on Environmental Quality's Regulations for Implementing NEPA [CEQ Regulations]) and California Code of Regulations (CCR) Title 14, Division 6, Chapter 3 (State CEQA Guidelines), Section 15222 (Preparation of Joint Documents). This document was prepared consistent with United States Department of the Interior regulations specified in 43 CFR, Part 46 (United States Department of the Interior Implementation of NEPA, Final Rule).

This EIS/EIR evaluates reasonably foreseeable potential direct, indirect, and cumulative impacts on the environment that could result from implementing the Project alternatives. In addition, this EIS/EIR includes feasible mitigation measures to avoid, minimize, rectify, reduce, or compensate for adverse impacts.

1.1 Background

Substantial modifications have been made to the historical floodplain of California's Central Valley for water supply and flood control purposes. These activities, and other environmental stressors, have resulted in losses of rearing habitat, migration corridors, and food web production for fish, adversely affecting native fish species that rely on floodplain habitat during part or all of their life history.

DWR is responsible for operating and maintaining the State Water Project (SWP), and Reclamation is responsible for managing the Central Valley Project (CVP). The SWP and CVP are operated in a coordinated manner to deliver water to agricultural, municipal, and industrial contractors throughout California. The NMFS BO, issued on June 4, 2009, concluded that, if left unchanged, CVP and SWP operations are likely to jeopardize the continued existence of four anadromous fish species listed under the Federal Endangered Species Act (ESA): Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and the Southern Distinct Population Segment (DPS) of North American green sturgeon. In addition, the NMFS BO concluded that operations were likely to destroy or adversely modify designated critical habitat for the four anadromous fish species. The NMFS BO sets forth RPA actions that would allow CVP and SWP operations to remain in compliance with the ESA.

The NMFS BO identified activities in RPA actions I.7 and I.6.1 to improve fish passage and habitat restoration actions in the lower Sacramento River basin, including the Yolo Bypass. The Yolo Bypass, which currently experiences at least some flooding in approximately 70 percent of years (Nurmi 2017), retains many characteristics of the historical floodplain habitat that are favorable to various fish species. Implementation of the RPA actions would expand the availability of floodplain rearing habitat in the lower Sacramento River basin and improve fish passage in the Yolo Bypass. The primary function of the Yolo Bypass is flood control, with much of it also managed as agricultural land or wetland waterfowl habitat. Major California restoration planning efforts (e.g., CALFED Bay-Delta Program, the Bay Delta Conservation Plan, and California EcoRestore) have identified the Yolo Bypass, as well as other areas, as a prime area of the Sacramento Valley for enhancement of seasonal floodplain fisheries rearing habitat.

The two RPA actions that formed the basis for alternatives considered for analysis in this EIS/EIR are summarized below:

- RPA Action I.6.1: Restore floodplain rearing habitat for juvenile Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead through increased acreage of seasonal floodplain inundation within the lower Sacramento River basin.
- RPA Action I.7: Reduce migratory delays and loss of salmon, steelhead, and sturgeon at Fremont Weir and other structures in the Yolo Bypass (NMFS 2009).

In addition to the species included in the NMFS BO, two other species designated as California Department of Fish and Wildlife (CDFW) Species of Special Concern may benefit from increased floodplain rearing habitat: Sacramento splittail and Sacramento River fall-run Chinook salmon.

1.2 Purpose and Uses of this EIS/EIR

The purpose of this EIS/EIR is to disclose the potential direct, indirect, and cumulative impacts of implementing any of the Project alternatives, pursuant to RPA Action I.6.1 and, in part, RPA Action I.7, consistent with NEPA and CEQA requirements. This EIS/EIR serves as an informational document for decision makers, public agencies, non-governmental organizations, and the public.

As discussed in Chapter 23.6, DWR has identified Alternative 1 as the preferred alternative for CEQA purposes. DWR's identification of a preferred alternative does not foreclose any alternatives or mitigation measures, however, and any alternative could be selected by the lead agencies following the conclusion of environmental review. Reclamation has identified Alternative 1 as the NEPA preferred alternative. However, the Record of Decision (ROD) will identify the alternative selected by Reclamation for implementation.

1.2.1 NEPA

NEPA provides an interdisciplinary framework for Federal agencies to take environmental factors into account during a decision-making process (42 United States Code 4321, 40 CFR 1500.1). NEPA requires an EIS whenever a proposed major Federal action (e.g., a proposal for legislation or an activity financed, assisted, conducted, or approved by a Federal agency with Federal agency control) significantly affects the quality of the human environment. Section 1508.14 of the CEQ Regulations defines the human environment to include "the natural and physical environment and the relationship of people with that environment."

The EIS, in conjunction with other relevant material, is used by the Federal government to plan actions and make decisions. Section 1502.1 of the CEQ Regulations states that an EIS primarily serves as an action-forcing device to infuse the policies and goals defined in NEPA into ongoing programs and actions of the Federal government. As an informational document, an EIS provides a rigorous and objective evaluation of all reasonable alternatives, full and open disclosure of environmental consequences before agency action, an interdisciplinary approach to project evaluation, identification of measures to mitigate impacts, and an avenue for public and agency participation in decision making (40 CFR 1502.1). NEPA defines mitigation as avoiding, minimizing, rectifying, reducing, or compensating for significant effects of a proposed action (40 CFR 1508.20). NEPA also requires evaluating a proposed action and alternatives at an equal level of detail.

1.2.2 CEQA

The State CEQA Guidelines (14 CCR Section 15064(f)(1)) require that an EIR be prepared whenever a project may result in a significant environmental impact. Section 15064(d) states that "in evaluating the significance of the environmental effect of a project, the lead agency shall consider direct physical changes in the environment which may be caused by the project and reasonably foreseeable indirect physical changes in the environment which may be caused by the project." An EIR is an informational document used to inform public agency decision makers and the public of the significant environmental effects of a project and identify possible ways to mitigate or avoid the significant effects. When determining whether to approve a project, State and local public agencies are required by CEQA to consider the information presented in the EIR.

Section 15126.6(a) of the State CEQA Guidelines also requires that an EIR describe and evaluate a reasonable range of alternatives that feasibly would attain most of the basic project objectives and avoid or substantially lessen any significant impact of the project, as proposed. A range of reasonable alternatives is analyzed to define issues and provide a clear basis for choice among options. CEQA requires that the lead agency consider alternatives that would avoid or reduce one or more of the significant impacts identified for a project in an EIR. The State CEQA Guidelines state that the range of alternatives required to be evaluated in an EIR is governed by the "rule of reason"—the EIR needs to describe and evaluate only those alternatives necessary to permit a reasonable choice and foster informed decision making and informed public participation (Section 15126.6(f)). Consideration of alternatives focuses on those that can either eliminate significant adverse environmental impacts or reduce them to less-than-significant levels. Alternatives considered in this context may include those that are more costly and those that could impede to some degree the attainment of all project objectives (Section 15126(b)).

CEQA does not require alternatives to be evaluated at the same level of detail as the proposed project.

1.2.3 Compliance and Permits Supported by the EIS/EIR

Reclamation and DWR will obtain all necessary permits, as required by law. This EIS/EIR supports the needed permits, petitions, and similar compliance, coordination, and consultation efforts for the proposed Project actions. Permits that may be required are shown in Table 1-1.

Table 1-1. Compliance, Consultation, and Coordination to Be Supported by this EIS/EIR

Applicable Resource	Laws/Regulations/Permits	Regulating Agency/Agencies
Wetlands and Waters of the United States	Section 10 of the Rivers and Harbors Act – Individual or General Permit	United States Army Corps of Engineers (USACE)
	Section 401 of the Clean Water Act – Water Quality Certification or Waiver	Regional Water Quality Control Board
	Section 402 of the Clean Water Act – National Pollutant Discharge Elimination System permit(s)	State Water Resources Control Board and Regional Water Quality Control Board
	Section 404 of the Clean Water Act – Individual or General Permit	USACE
Federally Listed Species	Section 7 of the ESA – Section 7 Consultation	United States Fish and Wildlife Service (USFWS) and NMFS
State Protected Species	California Fully Protected Species	CDFW
Fish and Wildlife Resources	Magnuson-Stevens Fishery Conservation and Management Act	NMFS
	Fish and Wildlife Coordination Act report	USFWS
	Migratory Bird Treaty Act	USFWS
	Bald and Golden Eagle Protection Act	USFWS
	California Endangered Species Act (CESA)	CDFW
	Lake and Streambed Alteration, Section 1602	CDFW
Cultural Resources	National Historic Preservation Act – Section 106 Consultation	State Historic Preservation Officer
Levees and Floodways	Section 14 of the Rivers and Harbors Act (“Section 408”) – Permission	USACE and Central Valley Flood Protection Board (CVFPB)
	Section 208 of the 1954 Flood Control Act	USACE and CVFPB
	Encroachment Permit	CVFPB
Air Quality	Authority to Construct, Permit to Operate	Yolo-Solano Air Quality Management District

1.3 Purpose and Need and Project Objectives

The planning objectives are described in the purpose and need statements (under NEPA) and objectives (under CEQA), which describe the underlying need for and purpose of a project. The purpose statement is a critical part of the environmental review process because it helps to set the overall direction of an EIS/EIR, identify the range of reasonable alternatives, and focus the scope of analysis.

1.3.1 Purpose and Need

The need for action is to address decreased habitat quality in the Sacramento River and an inadequate ability to access higher quality habitat, which has led to a decline in abundance, spatial distribution, and life history diversity for native ESA-listed and CESA-listed fish species. The purpose of the action is to enhance floodplain rearing habitat and fish passage in the Yolo Bypass and/or other suitable areas of the lower Sacramento River basin by implementing RPA action I.6.1 and, in part, RPA action I.7, as described in the NMFS BO, to benefit Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and the Southern DPS of North American green sturgeon.

1.3.2 Project Objectives

The objective of RPA action I.6.1 is to increase the availability of floodplain fisheries rearing habitat for juvenile Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead. This action can also improve conditions for Sacramento splittail and Central Valley fall-run Chinook salmon. Specific biological objectives include:

- Improve access to seasonal habitat through volitional entry
- Increase access to and acreage of seasonal floodplain fisheries rearing habitat
- Reduce stranding and presence of migration barriers
- Increase aquatic primary and secondary biotic production to provide food through an ecosystem approach

The objective of RPA action I.7 is to reduce migratory delays and loss of fish at Fremont Weir and other structures in the Yolo Bypass. Specific biological objectives include:

- Improve connectivity within the Yolo Bypass for passage of salmonids and green sturgeon
- Improve connectivity between the Sacramento River and the Yolo Bypass to provide safe and timely passage for:
  - Adult Sacramento River winter-run Chinook salmon between mid-November and May when water surface elevations in the Sacramento River are amenable to fish passage
  - Adult Central Valley spring-run Chinook salmon between January and May when water surface elevations in the Sacramento River are amenable to fish passage

- Adult Central Valley steelhead in the event their presence overlaps with the defined seasonal window for other target species when water surface elevations in the Sacramento River are amenable to fish passage
- Adult Southern DPS of North American green sturgeon between February and May when water surface elevations in the Sacramento River are amenable to fish passage

1.4 Responsibilities of Lead Agencies and Responsible Agencies

Reclamation is the lead NEPA agency, and DWR is the lead CEQA agency for this EIS/EIR. As Lead Agencies, Reclamation and DWR are responsible for completing the Draft and Final EIS/EIR documents, selecting a preferred alternative, approving an alternative, completing the ROD (Reclamation) and Notice of Determination (DWR), implementing the project as ultimately approved, and ensuring completion of all project mitigation measures in the Environmental Commitment Plan/Mitigation, Monitoring, and Reporting Plan. The Lead Agencies will be responsible for obtaining all required approvals and permits necessary to implement the Project.

1.5 Project Area

The Project area includes the lower Sacramento River basin, including the Yolo Bypass, in Sacramento, Solano, Sutter, and Yolo counties, California. Figure 1-1 shows the neighboring local jurisdictions, including the cities of Davis, Sacramento, West Sacramento, and Woodland. Major water bodies and infrastructure located within the Project area include the Sacramento River; Fremont, Sacramento, and Lisbon weirs; Knights Landing Ridge Cut and Wallace Weir; Cache and Putah creeks; Willow Slough Bypass; Tule Canal; and the Toe Drain. Project actions are primarily located along Fremont Weir and within the Fremont Weir Wildlife Area south to Agricultural Road Crossing 1. Some alternatives include additional actions farther south within the Yolo Bypass.

1.5.1 Yolo Bypass

The Yolo Bypass is part of the Sacramento River Flood Control Project, which includes levees, weirs, and bypass facilities that help manage the historic flooding in the Sacramento Valley (DWR 2010). The Yolo Bypass is about a 59,000-acre area that can convey a design flow of 343,000 cubic feet per second, which is about 80 percent of the floodwaters in this area (DWR 2010). Flows enter the Yolo Bypass through Fremont Weir, which is on the Sacramento River just upstream of the confluence with the Feather River, and Sacramento Weir, which is on the Sacramento River just upstream of the confluence with the American River. The water that enters the Yolo Bypass helps protect the cities of Sacramento and West Sacramento from flood flows on the Sacramento River system. Water flows through the Yolo Bypass and into the Cache Slough complex, then joins the Sacramento River just north of Rio Vista.

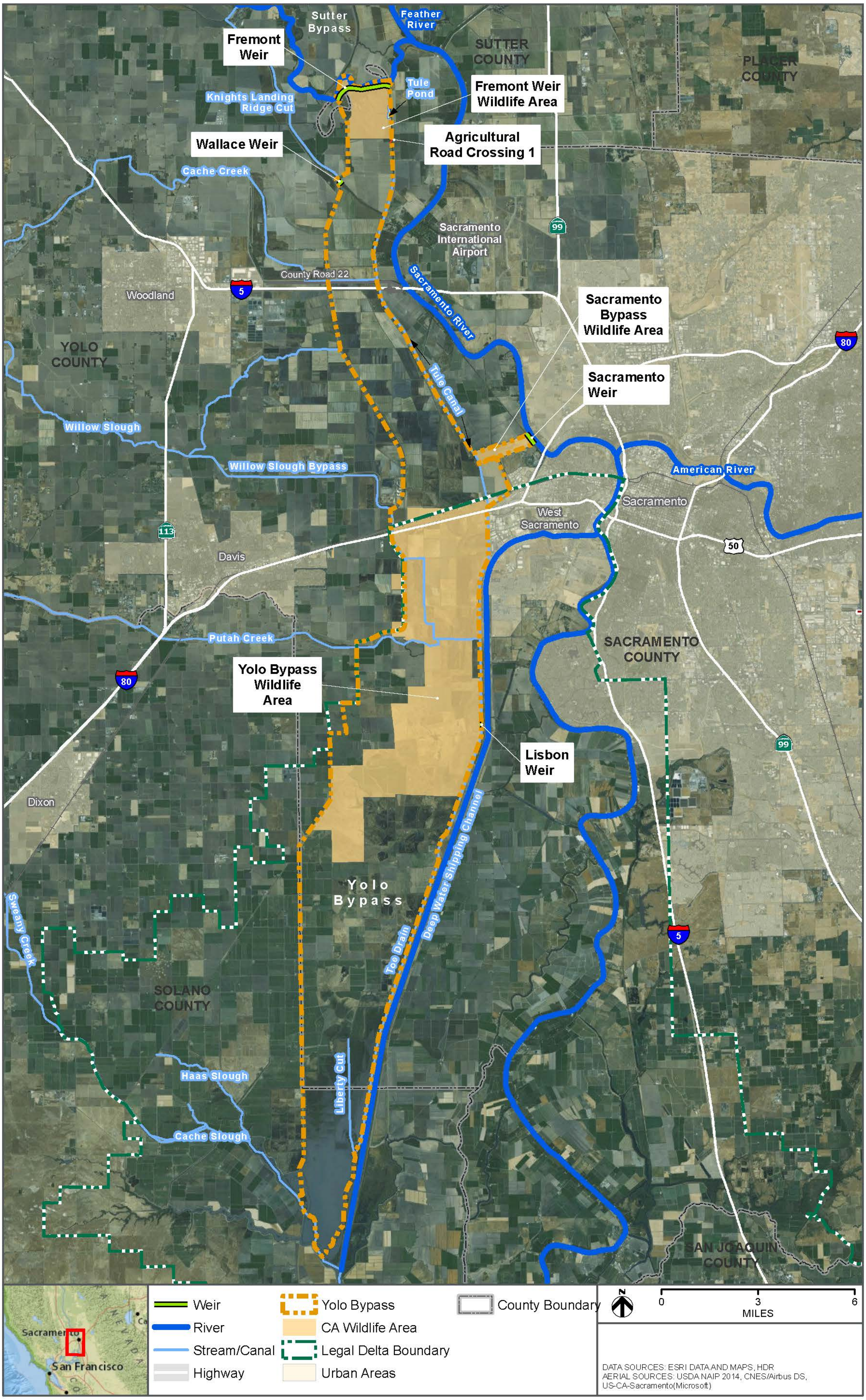

Figure 1-1. Project area

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1.5.2 Fremont Weir

The Fremont Weir is an ungated, fixed-crest, concrete weir measuring 1.8 miles long, 6 feet high, and 35 feet wide, located on the downstream right bank of the Sacramento River. The Fremont Weir was designed to allow flow into the Yolo Bypass during high-flow events when the Sacramento River is higher than the Fremont Weir 32-foot weir crest elevation. The weir is a "J" shaped concrete structure with a 5- to 6-foot high north wall, 25- to 35-foot stilling basin and 1-foot high south wall. The weir was constructed to dissipate flood water energy and reduce erosion. Flood waters overtop the north wall, lose energy, and flow south into the Yolo Bypass. The approximately 1.8-mile weir is bisected at the west side by earthen fill higher than the crest of the weir (referred to as "Rattlesnake Island").

When the Sacramento River stage is two to three feet higher than the weir, passage is possible for salmonids and, to a lesser extent, sturgeon. When the river stage is just barely above the crest of the Fremont Weir, the lack of suitable water depth makes it difficult for salmonids to reach the Sacramento River and likely creates a complete barrier for sturgeon. For fish to volitionally reconnect with the Sacramento River, their arrival at the Fremont Weir must coincide when 1) the Sacramento River stage is high enough to allow fish to swim directly over the crest of Fremont Weir or 2) there is sufficiently deep water flowing through the Fremont Weir fish ladder to allow fish to reconnect with the river.

The Fremont Weir fish ladder is a 4-foot-wide and 6-foot-deep concrete modified Denil-type fish ladder with a crest elevation of 31.8 feet. It is in the process of being replaced with a new fish passage facility to improve fish passage after a Fremont Weir overtopping event (through the Fremont Weir Adult Fish Passage Modification Project, implemented under EcoRestore).

1.5.3 Sacramento Weir

Sacramento Weir is located along the right bank of the Sacramento River approximately two miles upstream from the mouth of the American River. Its primary purpose is to protect the City of Sacramento from excessive flood stages in the Sacramento River channel downstream of the American River. The weir limits flood stages (water surface elevations) in the Sacramento River to project design levels through the Sacramento/West Sacramento area. It is 1,920 feet long and consists of 48 gates that divert Sacramento and American rivers' floodwaters to the west down the mile-long Sacramento Bypass to the Yolo Bypass. The Sacramento Weir obstructs fish passage.

1.5.4 Tule Pond

Tule Pond is an approximately 20-acre perennial pond in the Yolo Bypass located about 13 miles north of Interstate (I) 80. It is likely that the pond is sustained by multiple sources, including impounded floodwater, leakage from an agricultural canal at its southern end, and groundwater.

Following overtopping events, adult sturgeon have been observed and rescued in Tule Pond (CDFW 2016). These stranded fish may have attempted to migrate upstream on the tail-end of a Fremont Weir overtopping event, which left them unable to navigate closer to Fremont Weir. Another possibility is that these stranded fish successfully made it to Fremont Weir but were unable to ascend the weir and retreated to Tule Pond.

1.5.5 Agricultural Road Crossing 1

Agricultural Road Crossing 1, which is the northernmost agricultural road crossing in Tule Canal at the southeastern corner of the Fremont Weir Wildlife Area (see Figure 1-1), serves as a vehicular crossing and a water delivery feature. The crossing consists of two earthen berms, with the southern used as the road crossing. Together the berms create a cross canal that conveys water across the Yolo Bypass from Wallace Weir to two 36-inch culverts that pass through the Yolo Bypass east levee. The culverts deliver water via gravity flow into the Elkhorn area for agricultural use.

The cross-canal berms are flow barriers in Tule Canal. The top of the berm has an elevation of approximately 21 feet, which backs up water originating from the Knights Landing Ridge Cut for conveyance east into the northern Elkhorn Basin. This cross-canal berm leaks in some years, which provides water inflow to the upstream wooded area and Tule Pond. Additionally, when overtopping of Fremont Weir ends and flows recede, the cross-canal berm continues to impound water to the north. The local landowners make periodic repairs to the cross canal to maintain functionality.

The cross-canal berms and road crossing create a migratory barrier for adult salmonids and sturgeon under low flows, which results in fish stranding. In addition, adult fish that are able to migrate upstream of the cross-canal berms become stranded in Tule Pond and are not able to migrate downstream to the Wallace Weir Fish Rescue Facility. After overtopping flows recede beneath the crest of Fremont Weir, the area upstream of Agricultural Road Crossing 1 has the potential to become isolated from Tule Canal and Tule Pond, resulting in stranding and the need for fish rescue at Fremont Weir.

1.5.6 Tule Canal

Tule Canal is a channel along the east side of the Yolo Bypass, which begins south of Agricultural Road Crossing 1. Tule Canal receives water from westside tributaries (Knights Landing Ridge Cut and Cache Creek, as shown on Figure 1-1), groundwater contributions, and agricultural diversions almost year-round. Tule Canal also drains the initial flows from the Sacramento River when the river rises above the crest of Fremont Weir.

There are four earthen agricultural road crossings/impoundments in Tule Canal that control water and provide access for vehicles and farming equipment from the Yolo Bypass east levee road to the agricultural fields. The crossings are commonly referred to as Agricultural Road Crossings 1, 2, 3, and 4 (from north to south). These structures control water during the agricultural season but sometimes wash out during overtopping events. Agricultural Road Crossings 2, 3, and 4 are being removed or replaced to provide fish passage by separate projects.

Adult salmonids and sturgeon may experience delays if they encounter Agricultural Road Crossing 1 at lower flows when the crossing may not be submerged. The agricultural road crossing becomes submerged during higher flow conditions, such as when Fremont Weir overtops, eventually allowing salmonids or sturgeon to move beyond them. Adult and juvenile migratory fish, including salmonids and sturgeon, may become trapped upstream of the crossing as higher flows recede.

Fremont Weir receding flows drain into Tule Canal and continue to provide attraction flows for fish in the Yolo Bypass after fish passage connectivity to the Sacramento River is compromised, which also contributes to stranding in this area (CDFW 2016).

1.5.7 Toe Drain

The Tule Canal becomes the Toe Drain south of the I-80 Yolo Causeway. The perennially wetted Toe Drain extends south approximately 20 miles and becomes increasingly tidal as it connects with Cache Slough. The water elevation in the Toe Drain is affected by tidal actions as far north as I-80 and the water surface elevation fluctuates zero to four feet a few hundred feet south of the Lisbon Weir (California Department of Fish and Game 2008).

The Toe Drain receives water from the Tule Canal, westside tributaries (Willow Slough Bypass and Putah Creek, as shown on Figure 1-1), groundwater contributions, and agricultural diversions almost year-round. During non-flooded periods, sturgeon and migrating adult salmonids are contained in the Toe Drain from where they enter at the south end of the Yolo Bypass. Fish are likely drawn into the Yolo Bypass initially by the tidal flux that occurs near Cache Slough but could be attracted farther north into the Yolo Bypass because of flow in the Toe Drain originating from westside tributaries and the Sacramento River.

1.5.8 Lisbon Weir

Lisbon Weir is the southernmost water-control structure that crosses the Toe Drain. Lisbon Weir provides higher and more stable water levels to water users north of the weir. The weir is composed of an earthen island, a rock weir, and flap gates. The main part of the weir is on the east side of the earthen island, which includes the rock weir reinforced on the downstream side with sheet piling. On the west side of the earthen island, there is a structure with tidally operated flap gates open during the flood tide to allow freshwater input to the Toe Drain and closed to impound water on the ebb tide. Lisbon Weir blocks the channel and limits the range of tidal fluctuation upstream of the weir. The weir operates passively by impounding upstream inflows and tidal water at a minimum elevation that is equal to the weir crest elevation. At high tide, the weir is completely submerged, but at low tide the water surface elevation can be 2.5 feet below the weir crest and impede fish passage. Lisbon Weir is being modified to improve fish passage as part of a separate project.

1.6 Public Involvement

1.6.1 Public Scoping

The Lead Agencies conducted public and stakeholder outreach activities to engage all interested parties and inform them of Project activities. Reclamation initiated the NEPA process by issuing a Notice of Intent on March 4, 2013 to prepare an EIS and hold public scoping meetings. DWR initiated the CEQA process by issuing a Notice of Preparation on the same date to prepare an EIR and hold public scoping meetings. Reclamation and DWR accepted scoping comments throughout the public scoping period of March 4 through May 6, 2013.

The Lead Agencies held public scoping meetings on March 14, 2013 in the cities of West Sacramento and Woodland, California. During the scoping meetings and throughout the public scoping comment period, Reclamation and DWR accepted comments to help determine the range of alternatives, the environmental effects, and the mitigation measures to be considered in this EIS/EIR. Comments and suggestions regarding alternatives were documented in the Public Scoping Report published in July 2013 (Reclamation and DWR 2013).

Public and stakeholder involvement and outreach activities have continued since 2013 and have enabled the Lead Agencies to successfully involve stakeholders and incorporate public and stakeholder input into the development of this EIS/EIR. These activities have sought to create an open and transparent process through which the public, stakeholders, and other interested parties can track and participate in Project activities, including the formulation of alternatives for this EIS/EIR. Chapter 2, *Description of Alternatives*, describes stakeholder involvement in the alternatives formulation process in more detail, and Chapter 24, *Consultation and Coordination*, includes more details about general stakeholder and agency involvement.

1.6.2 Final EIS/EIR Development

Reclamation published a Notice of Availability for the Draft EIS/EIR in the Federal Register (Vol. 82, No. 248, 61584-61585 [FR DOC # 2017-28059]) on December 28, 2017. Public meetings were held January 17, 2018 and January 18, 2018 in the cities of Woodland and West Sacramento, California, respectively. The public comment period concluded February 15, 2018. Public meeting minutes and copies of all public comments received during the comment period are included in Appendix N, *Comment Letters*, and all responses to comments received are included in Appendix O, *Comments and Responses*. All revisions made from the Draft EIS/EIR to the Final EIS/EIR are shown in underlined text (additions) and strikeout text (deletions).

1.7 Issues of Known Controversy

Key issues raised during the public involvement process that warrant inclusion in the EIS/EIR are listed below.

- **Fish**.
  - The Project could affect how many fish enter the Yolo Bypass. The EIS/EIR should establish a target of how many additional fish to include in the Yolo Bypass and analyze how well each alternative meets that target. The analysis should estimate fish passage performance and juvenile entrainment performance.
  - There are concerns regarding increased inundation periods and how shallow water habitats could expose fish to warm weather conditions during the months of January to May, creating a potentially uninhabitable environment. Increased water temperatures within the Yolo Bypass could also cause increased temperatures downstream in the Sacramento-San Joaquin Delta (Delta).
  - The fish stage that would most benefit from rearing habitat would be younger juveniles (fry and parr), but these fish are generally too small to tag and track during scientific investigations. Many studies track movement of larger juveniles (smolts) as a proxy for fry and parr, but it is uncertain if the smolts behave in the same way.

- **Terrestrial Resources.**
  - Changing the inundation pattern of the Yolo Bypass could reduce habitat for waterfowl that need a specific depth for foraging. The EIS/EIR should evaluate the change in habitat for waterfowl and other migratory birds.
  - Increasing the duration and area of inundation could affect terrestrial resources, including the giant garter snake, and must be analyzed in the environmental document.
- **Water Quality**.
  - The Project could affect salt water intrusion in the statutory Delta. The EIS/EIR should analyze the Project alternatives for their influence on salt water intrusion.
  - The alternatives could have the potential to increase methylmercury production within the Yolo Bypass through increases in depth and duration of inundation. The EIS/EIR should examine the potential for resuspension of mercury or methylmercury from in-water work in terms of both overall water quality and the region's compliance with total maximum daily loads.
  - The EIS/EIR should address whether the Project could increase regulations on agricultural drainage into the Yolo Bypass.
- **Agriculture**. Cultivation of crops, particularly rice, could be affected by the seasonal timing of inundation of the Yolo Bypass. Increased inundation could have adverse economic effects to both the landowners and the local economy, including related to grazing activities. The EIS/EIR should consider potential impacts on a scale to understand impacts to individual landowners.
- **Mosquito Vector Control**. The EIS/EIR should evaluate the potential for unintended and secondary effects from late spring flooding that could result in increased mosquito populations.
- **Flood Control**. The EIS/EIR should evaluate the extent to which land-use changes could affect vegetation growth and reduce flood carrying capacity.
- **Land Use**.
  - The project alternatives and the EIS/EIR should be developed consistent with the Yolo Habitat Conservation Plan/Natural Community Conservation Plan (HCP/NCCP), particularly regarding effects to habitat conservation easements opportunities in the Yolo Bypass. The Yolo HCP/NCCP identifies over 28,000 acres of the Yolo Bypass as acquisition lands for the Yolo HCP/NCCP reserve system. These lands were identified as having a high acquisition priority for the conservation of the Yolo HCP/NCCP’s covered species based on the potential habitat that they provide to multiple Yolo HCP/NCCP covered species including giant garter snake, western pond turtle, Swainson’s hawk, white-tailed kite, yellow-billed cuckoo, and least Bell’s vireo.
  - The project alternatives and the EIS/EIR should be developed consistent with the Central Valley Joint Venture Implementation Plan and existing wetland conservation easements in the Yolo Bypass.

- **Recreation.** The EIS/EIR should discuss potential changes to operations and maintenance of the Yolo Bypass Wildlife Area, including education access, wetland habitat, effects on grazing leases, and hunting and wildlife viewing access.

1.8 Organization of the EIS/EIR

The EIS/EIR is organized into the following remaining chapters:

- Chapter 2, *Description of Alternatives*, summarizes the alternatives development process and describes the No Action Alternative and action alternatives.
- Chapter 3, *Approach to the Environmental Analysis*, presents the NEPA and CEQA requirements for the analysis.
- Chapters 4 through 22 describe the affected environment; evaluation methods; direct, indirect, and cumulative effects of the alternatives; and mitigation measures for environmental resources.
- Chapter 23, *Other NEPA/CEQA Required Disclosures*, describes irreversible and irretrievable commitment of resources, the relationship between short-term uses and long-term productivity, growth-inducing impacts, and unavoidable adverse impacts.
- Chapter 24, *Consultation and Coordination*, describes the consultation and outreach activities that have occurred during the EIS/EIR preparation process.
- Chapter 25, *List of Preparers*, lists the authors and other contributors to the development of the EIS/EIR and their qualifications.
- Chapter 26, *Glossary*, contains an index of key terms.

Additional appendices are attached that provide more background and detailed technical information on the analysis conducted for the EIS/EIR.

On May 2, 2019 DWR announced that it will withdraw proposed permits for the California WaterFix project, which is described in DWR's Final Environmental Impact Report, State Clearinghouse No. 2008032062, and to pursue a smaller, single-tunnel conveyance through the Sacramento-San Joaquin Delta. Although California WaterFix was included in the analysis for this Project as a part of future reasonably foreseeable conditions, the recent announcement does not change the impact conclusions described in this EIS/EIR. All of the alternatives analyzed in this EIS/EIR would be located upstream of California WaterFix and would only provide for flow into the Yolo Bypass when sufficient water levels exist (see Section 2.3.3 discussing water levels and gravity flows into the Yolo Bypass). Appendix E includes a sensitivity study to consider if removing California WaterFix from the No Action Alternative CalSim modeling would change the impact analysis in the EIS/EIR. As demonstrated in the CalSim modeling results in Appendix E, removal of California WaterFix from the No Action Alternative would not change the impact analysis. Reclamation and DWR have not updated modeling or analysis in this EIS/EIR to account for a single-tunnel conveyance because planning for such a tunnel is in the early stages and any assumptions regarding design or operations would be speculative.

1.9 References

California Department of Fish and Game. 2008. *Yolo Bypass Wildlife Area Land Management Plan*. Available from: http://yolobasin.org/ybwa-management-plan/. Accessed on October 4, 2017.

CDFW (California Department of Fish and Wildlife). 2016. *Summary of Fish Rescues Conducted within the Yolo and Sutter Bypasses. North Central Region.* Prepared for the United States Bureau of Reclamation. July.

DWR (California Department of Water Resources). 2010. *Fact Sheet: Sacramento River Flood Control Project Weirs and Flood Relief Structures.* December 2010. Accessed on October 2, 2017. Available at: http://www.water.ca.gov/newsroom/docs/WeirsReliefStructures.pdf

NMFS (National Oceanic and Atmospheric Administration National Marine Fisheries Service). 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, Long Beach, CA. June 4, 2009.

Nurmi, F. (California Department of Water Resources). 2017. *Correspondence to Daniel Constable (Delta Stewardship Council)*. January 18, 2017.

Reclamation (Bureau of Reclamation) and DWR (California Department of Water Resources). 2012. *Yolo Bypass Salmonid Habitat Restoration and Fish Passage Implementation Plan, Long-Term Operation of the Central Valley Project and State Water Project Biological Opinion Reasonable and Prudent Alternative Actions I.6.1 and I.7*. Available at: https://www.usbr.gov/mp/BayDeltaOffice/docs/bypass-fish-passage-implementation-plan.pdf. September 2012.

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2 Description of Alternatives

Chapter 2 summarizes the alternatives development process for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Project) and the alternatives analyzed in this Environmental Impact Statement/Environmental Impact Report (EIS/EIR).

2.1 Alternatives Formulation Process

The Lead Agencies used a comprehensive process to develop alternatives that included review of existing material, public input, and comparison and evaluation of initial alternatives using the Federal planning criteria and purpose and need for the Project. Appendix A, *Plan Formulation Report*, includes a more detailed description of this process.

2.1.1 Alternatives Development Process

The alternatives development process involved input and review from resource agencies, local agencies, landowners, non-governmental organizations (NGOs), and stakeholders. Resource agencies and local agencies were involved at a detailed level, including participation in technical teams (such as the Fisheries and Engineering Technical Team).

The alternatives development process included public scoping conducted in March 2013. Public scoping allowed the Lead Agencies to provide preliminary information on the purpose and need for the Project. This step also allowed the Lead Agencies to solicit ideas for achieving the Project's purpose and need and learn of potential impacts.

Alternatives development focused on providing fish passage and juvenile floodplain-rearing habitat. Key considerations for adult and juvenile fish movement included:

- Adult fish passage: Passage must consider both salmonids and green sturgeon, but sturgeon passage requirements are generally more stringent. As benthic swimmers, sturgeon generate speed through body curvature, which can limit passage if a channel has submerged obstacles, orifices, or jumps (California Department of Water Resources [DWR] 2017). Sturgeon avoid turbulent flow conditions, so passage must be provided by non-turbulent, open channel flow structures (DWR 2017). Both salmonids and sturgeon need to pass on their own volition, eliminating trap and haul as a primary means for fish passage (DWR 2017).
- Juvenile migration: Structures must be designed so that fish are not disoriented as they pass through the gates. Juvenile salmonids migrate down the river in the top third of the water column. Functional design concepts must avoid impingement[1] and the creation of eddies[2] that can increase predation. Juvenile fish should enter the Yolo Bypass on their own volition with the redirected flow from the Sacramento River; trapping fish in the Sacramento River and

[1] Impingement occurs when fish are held against a structure.

[2] Eddies are circular flow patterns that can delay fish.

relocating them to the Yolo Bypass would not satisfy the requirement for volitional passage (DWR 2017).

The Lead Agencies developed fish passage criteria to comply with during design of Project structures so that adult salmonids and sturgeon would be able to pass (Table 2-1). More detail about how these criteria were developed is included in Appendix C, *Adult Fish Passage Criteria for Federally Listed Species within the Yolo Bypass and Sacramento River* (DWR 2017), of the *Plan Formulation Report* (in Appendix A of this EIS/EIR).

Table 2-1. Summary of Fish Passage Criteria for Federally Listed Species within the Yolo Bypass and Sacramento River

Species	Adult Migration Time	Minimum Depth of Flow (Short Distance)	Minimum Depth of Flow (Long Distance)	Minimum Channel Width	Maximum Velocity (Short Distance)	Maximum Velocity (Long Distance)
Adult Sturgeon	Jan-May	3 feet	5 feet	10 feet	6 feet/ second*	4 feet/ second
Adult Salmonids	Nov-May	1 feet	3 feet	4 feet		

Source: DWR 2017

* Short distance velocity is for a maximum length of 60 feet

Juvenile salmonids out-migrate past Fremont Weir at different times of year, depending on hydrologic conditions. The majority of juvenile winter-run Chinook salmon migrate through this area from December through January and continue to migrate through mid-April to early May (United States Department of the Interior, Bureau of Reclamation [Reclamation] and DWR 2012). The early pulse of out-migration is strongly correlated with the first flushing flow of over 15,000 cubic feet per second (cfs) in the Sacramento River at the Wilkins Slough gage (Reclamation and DWR 2012). The majority of juvenile Central Valley spring-run Chinook salmon pass through this area in late-November through December, with out-migration continuing through mid-May (but primarily is complete in mid-April) (Reclamation and DWR 2012). Diverting fish into the Yolo Bypass (or “entrainment”) would need to occur at times when fish are present in the river near Fremont Weir.

2.1.2 Initial Component Identification and Screening

After the public scoping process, the Lead Agencies collected initial components of alternatives that could help achieve the purpose and need of the Project. A component is a project or plan that could contribute to meeting the purpose and need but may not be able to fully accomplish it independently. The Bay-Delta Conservation Plan (BDCP) included a planning effort to identify actions that could expand rearing habitat and improve fish passage in the Yolo Bypass (DWR 2011). The materials developed in that effort provided initial components for consideration. These components were augmented with suggestions from the Lead Agencies’ technical experts and comments during the public scoping process. The BDCP also formed a stakeholder group, the Yolo Bypass Fisheries Enhancement Planning Team (YBFEPT), which included resource agencies, landowners, and NGOs, to help develop a plan for the Yolo Bypass. The Lead Agencies solicited additional suggestions from the YBFEPT. The Lead Agencies performed an initial screening of the components that came out of this process. Components were not considered further if they would not contribute toward accomplishing the purpose and need of the project or if they were deemed technically infeasible.

2.1.3 Initial Alternatives Formulation

After screening the initial components for their ability to help accomplish the purpose and need of the project, the remaining components were combined into initial alternatives in 2014. The six initial alternatives included:

- No Action and No Project Alternative – Describes conditions if no actions are taken as part of this project to accomplish the project objectives. This alternative is required under the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA).
- Fremont Weir Notch – Constructs a new gated notch in Fremont Weir to function as the primary adult fish passage mechanism and allow flow and juvenile fish to enter the Yolo Bypass before the Sacramento River rises above the Fremont Weir crest.
- Westside – Allows additional flow to enter the bypass through the Knights Landing Ridge Cut (west of the Yolo Bypass). Fish rearing would be accomplished through aquaculture, and upstream fish passage would be accomplished through fish rescue.
- Elkhorn Area – Constructs floodplain-rearing habitat within the Elkhorn Area (to the east of the Yolo Bypass) along the Sacramento River.
- Sacramento Weir Notch – Constructs a new gated notch in the Sacramento Weir to function as the primary adult fish passage mechanism and allows flow and juvenile fish to enter the Yolo Bypass through the Sacramento Bypass before the Sacramento River rises above the Sacramento Weir crest.
- Sutter Bypass – Constructs a new gated notch in Tisdale Weir and expands rearing opportunities in the Sutter Bypass. Construction would need to occur in both the Sutter and Yolo bypasses because adult fish passage facilities at Fremont Weir would also be included.

Each of these alternatives also included variations in the size and location of structures. The Lead Agencies completed an initial evaluation of these alternatives based on the Federal planning criteria included in the *Principles, Requirements and Guidelines for Federal Investments in Water Resources* (PR&Gs) (United States Department of the Interior [DOI] 2013, 2014). The evaluation considered:

- Effectiveness: How well an alternative plan would achieve rearing habitat and fish passage objectives.
- Completeness: Whether an alternative plan would provide improvements for all four focus fish (Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and the Southern Distinct Population Segment [DPS] of North American green sturgeon).
- Acceptability: Whether an alternative plan would be compatible with other efforts in the bypass and minimize effects to agriculture, waterfowl, education, and biological resources.
- Efficiency: How well an alternative plan would deliver economic benefits relative to project costs.

Applying these criteria, the No Action and No Project Alternative and variations of the Fremont Weir Notch Alternative were considered for further evaluation. These alternatives are described in Sections 2.2 through 2.9. The remaining alternatives were dismissed. Section 2.1.5 describes the reasoning for dismissal.

2.1.4 Value Planning

Value Planning is part of the Federal process in planning projects. The purpose of Value Planning is to take a big-picture look at project alternatives and see if there is a better way to achieve the greatest value. Reclamation conducted a Value Planning session in August 2014. Value Planning can include agency representatives, landowners, NGOs, and other stakeholders, but it is designed to focus on those that have not been key participants in the alternatives formulation process. The Value Planning team concluded that more focus should be placed on integrating flood projects with restoration efforts and recommended including water control structures to help increase inundation on the Yolo Bypass. Reclamation and DWR have worked to coordinate closely with the ongoing flood projects. Water control structures have been incorporated into Alternative 4 in this EIS/EIR.

2.1.5 Alternatives Evaluation Process

After the initial evaluation and feedback from the Value Planning process, the Lead Agencies moved forward with a more detailed analysis of the remaining alternatives, which were further developed and modeled to better characterize each alternative. The Lead Agencies then established evaluation criteria based on the Federal planning criteria (DOI 2013, 2014), as shown in Table 2-2.

Table 2-2. Alternatives Evaluation Criteria

Federal Planning Criterion[1]	Category	Performance Measure	Method to Measure Performance
Effectiveness: How well an alternative would alleviate problems and achieve opportunities	Increase access to floodplain habitat	Entrainment of winter-run Chinook salmon onto floodplain	Entrainment model
		Entrainment of spring-run Chinook salmon onto floodplain	Entrainment model
	Increase seasonal floodplain fisheries rearing habitat	Percent increase in winter-run Chinook salmon escapement	Juvenile floodplain production model
		Percent increase in spring-run Chinook salmon escapement	Juvenile floodplain production model
	Increase area of floodplain habitat	Inundation area (area inundated at least 14 days in 50 percent of years)	TUFLOW model
	Increase duration of flooded habitat	Wetted acre-days when fish are likely present	TUFLOW model
	Increase food production as part of an ecosystem approach	Increase in food production	Foodweb tool

Federal Planning Criterion[1]	Category	Performance Measure	Method to Measure Performance
	Adult fish passage	Days with depth barrier to adult volitional passage	Fish passage tool
		Days with velocity barrier to adult volitional passage	Fish passage tool
		Operational range for adult fish passage	Fish passage tool
		Percent of season that meets adult fish passage criteria	Fish passage tool
		Fish passage facilities incorporate open channel flow	Qualitative assessment of number of fish passage facilities to provide passage and complexity of operations between passage facilities
	Juvenile fish passage	Potential for juvenile stranding or predation risk	Qualitative assessment of need for complex mechanized operation
Completeness: Whether an alternative would account for all investments or other actions necessary to realize the planned efforts	Provide complete fish benefits	Addresses all four focus fish (Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and Southern DPS North American green sturgeon)	Qualitative assessment
		Long-term stability of facilities	Qualitative assessment of maintenance requirements
Acceptability: The viability of an alternative with respect to acceptance by other Federal, State of California (State), and local entities and compatibility with existing laws	Agricultural impacts	Inundation effects on agricultural production	Bypass Production Model
		Inundation effects on winter maintenance activities (increased wetted acre-days)	TUFLOW model

Federal Planning Criterion[1]	Category	Performance Measure	Method to Measure Performance
	Recreation impacts	Inundation of recreational areas that could impact hunting activities	TUFLOW model
	Waterfowl impacts	Available foraging habitat	TUFLOW model
		Inundation of areas that reduce waterfowl food production	TUFLOW model
		Impacts to road access for bird viewing in refuge	TUFLOW model
		Impacts to refuge drainage	Qualitative assessment
	Education impacts	Inundation of areas used for educational outreach	TUFLOW model
	Biological impacts	Impacts from construction (benefits addressed under “effectiveness” criterion)	Qualitative assessment
	Cultural impacts	Relative potential to encounter unexpected resources	Qualitative assessment
	Flood impacts	Relative potential to affect flood management or operations and maintenance	TUFLOW model and qualitative assessment (for operations and maintenance)
	Water supply impacts	Relative potential to affect agricultural or municipal water supplies	Qualitative assessment
		Relative potential to affect groundwater resources	Qualitative assessment of groundwater based on TUFLOW model surface water changes
		Decreased diversions in the Sacramento-San Joaquin Delta (Delta) (at existing or likely future facilities)	CalSim
	Compatibility with other related efforts	Potential to affect future options or costs for other flood and restoration planning efforts	Qualitative assessment
Efficiency: How well an alternative would deliver economic benefits relative to project costs	Cost effectiveness	Relative benefits and costs	Rough cost estimates compared to benefits

Notes:

[1] Federal planning criteria are from the Principles, Requirements, and Guidelines (DOI 2013, DOI 2014)

During alternatives evaluation in 2015, BDCP planners split the BDCP into two separate plans: California WaterFix and EcoRestore. As a result, the YBFEPT no longer gathered for meetings. Instead, the Lead Agencies began working with the Yolo Bypass Working Group, a collection of local agencies, landowners, NGOs, and stakeholders that began meeting after the Value Planning effort. The Lead Agencies worked with this group to refine the alternatives evaluation and add additional alternatives. Additionally, several of the common elements that had previously been considered in the action alternatives have independent utility as restoration projects and were separated from this effort to be a part of the EcoRestore program. These projects include Wallace Weir improvements, modifications to existing fish passage at Fremont Weir, removal and replacement of three agricultural road crossings in the Tule Canal, and modification of Lisbon Weir. These projects are now underway as separate efforts.

After the initial evaluation, the alternatives focused on a smaller, more passively operated gated notch in Fremont Weir that would allow a maximum flow of 6,000 cfs (see Appendix A, *Plan Formulation Report*, for more details). The Yolo Bypass Working Group expanded on the benefits of several other alternatives and included additional alternatives to incorporate smaller and larger flows, water control structures, multiple gates, and increased duration of floodplain habitat in the northern bypass.

2.1.6 Alternatives Considered but Eliminated from Further Evaluation

During the alternatives formulation process, multiple alternatives were considered but eliminated from further consideration. Table 2-3 provides an overview of these alternatives; they are discussed in more detail in Appendix A.

Table 2-3. Alternatives Considered but Eliminated from Further Evaluation

Alternative	Key Components	Reasons Alternative was Not Retained
Westside Alternative	Flows would enter the Yolo Bypass through the Knights Landing Ridge Cut, juvenile fish would be transported onto inundated fields for rearing, and fish rescue at Fremont Weir would provide upstream fish passage.	Lack of volitional fish passage prevents the alternative from meeting the project objectives.
Westside Alternative with Volitional Passage	Knights Landing Ridge Cut would be re-plumbed to allow flow and juvenile fish from the Sacramento River to enter the Yolo Bypass; upstream adult fish passage would be provided at Fremont Weir.	Routing flows and juvenile fish through the Knights Landing Ridge Cut is less effective for fish survival and more costly than other alternatives.
Elkhorn Alternative	Levee setbacks on the Sacramento River into the Elkhorn Area (east of the Yolo Bypass) would provide floodplain-rearing habitat; upstream fish passage would be provided at Fremont Weir.	Creating floodplain-rearing habitat in the Elkhorn Area could have acceptability concerns because it would take agricultural land out of production, and grading costs would be prohibitively high.

Alternative	Key Components	Reasons Alternative was Not Retained
Sacramento Weir Alternative	Flows and juvenile fish would enter the Yolo Bypass through a gated notch in the Sacramento Weir; upstream adult fish passage would be provided at Fremont Weir.	Flows would primarily inundate habitat south of the Sacramento Bypass in the Yolo Bypass, which would have fewer rearing habitat benefits because approximately 1/3 of the Yolo Bypass area would be inaccessible to juvenile fish.
Sutter Bypass Alternatives	Flows and juvenile fish would enter the Sutter Bypass through a gated notch at Tisdale Weir, and a bypass expansion would provide additional habitat. Upstream adult fish passage would be provided at Fremont Weir.	Expanding the Sutter Bypass would have acceptability concerns because it would take agricultural land out of production, and costs would be higher than other alternatives (relative to benefits accomplished) because improvements would need to be constructed in both the Sutter and Yolo Bypasses.

2.1.7 Summary of Alternatives Retained for Further Evaluation

After the alternatives formulation and evaluation effort, six action alternatives were retained for detailed evaluation in the EIS/EIR. Table 2-4 summarizes the key components of each alternative.

Table 2-4. Summary of Alternatives Retained for Detailed Evaluation in this EIS/EIR

Components	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Maximum design flow (cfs)	6,000	6,000	6,000	3,000	3,400	12,000
Gated notch and channel location	East	Central	West	West	Central (Multiple)	West
Supplemental fish passage	West	West	East	East	West	East
Downstream channel improvements	X	X	X	X		X
Agricultural road crossing 1	X	X	X	X	X	X
Tule Canal water control structures				X		
Tule Canal floodplain improvements (program-level)					X	
Closure date for inundation flows	March 15	March 15	March 15	March 15 or March 7	March 15	March 15

Key: cfs = cubic feet per second

2.2 No Action and No Project Alternative

NEPA and CEQA require the evaluation of an alternative that presents the reasonably foreseeable future conditions in the absence of the project. This alternative is called the No Action Alternative under NEPA and the No Project Alternative under CEQA. The No Action or No Project Alternative allows decision makers to compare the impacts of approving the project to the impacts of not approving the project. This alternative is referred to in the remainder of the document as the “No Action Alternative.” Under NEPA, the No Action Alternative also serves as the baseline to which action alternatives are compared to determine potential impacts. This differs from CEQA wherein existing conditions serve as the baseline to determine potential impacts of the alternatives. The No Action Alternative may differ from the existing conditions if other actions that could occur in the Project area in the future do not rely on approval or implementation of the project. The No Action Alternative and the existing conditions will be used as the environmental baseline for identifying project effects (see Section 3.2.1 for more details).

Under the No Action Alternative, the Yolo Bypass would continue to be inundated from the westside tributaries and overtopping events at Fremont and Sacramento weirs. Juvenile fish would enter the bypass with overtopping flood flows from Fremont and Sacramento weirs, and the fish would benefit from the rearing opportunities in the Yolo Bypass. Additional flow and fish would not pass through Fremont Weir when the Sacramento River elevation is below the crest of Fremont Weir or Sacramento Weir.

Adult fish may move upstream in Tule Canal in response to tidal influence in Cache Slough, flows over Fremont Weir, or when the westside tributaries attract fish. As under existing conditions, fish would either move downstream and migrate back into the Sacramento River, pass over Fremont Weir, pass through the existing fish passage structure at Fremont Weir, become stranded at Fremont Weir, or move to the Wallace Weir Fish Rescue Facility. Other projects in the Yolo Bypass and Sacramento River region would continue to move forward, including California EcoRestore projects, Battle Creek Salmon and Steelhead Restoration project, California WaterFix, Environmental Permitting for Operation and Maintenance of flood facilities, Oroville Facilities Federal Energy Regulatory Commission Relicensing and License Implementation, and Sacramento Regional Wastewater Treatment Plant Upgrade. These efforts are described in more detail in Section 3.2.2.1.

2.3 Components Common to Multiple Action Alternatives

This section describes components included in multiple action alternatives. The construction details (borrow material, construction equipment, schedules) are integrated into the alternative descriptions in the following sections.

2.3.1 Agricultural Road Crossing 1 and Cross-Canal Berms

The northernmost agricultural road crossing in Tule Canal is both a vehicular crossing and water delivery feature (see Figure 1-1 for location). The crossing consists of two earthen berms, with the southern used as the road crossing. Together the berms create a cross canal that conveys water across the Yolo Bypass from Wallace Weir to two 36-inch culverts that pass through the

Yolo Bypass east levee. The culverts deliver water via gravity flow into the Elkhorn area for agricultural use.

The cross-canal berms are flow barriers in Tule Canal and form barriers that maintains water levels in the greater Tule Pond wetland (just upstream). The wetland area north of Agricultural Road Crossing 1 and south of Tule Pond is referred to as the "wooded area" and does not have a defined channel. The top of the berm has an elevation of approximately 21 feet[3] and holds water in the wooded area and Tule Pond (see Figure 2-1) after Fremont Weir overtopping events to cover an area of about 85 acres. During the late winter and early spring, shallow groundwater levels are high enough (HDR, Inc. 2017) that they likely contribute water to the Tule Pond and wooded area. Additionally, the berms leak in some years, which provides water inflow into the wooded area (and allows some outflow when water levels are high during the wet season). The local landowners typically make periodic repairs that decrease the leakage.

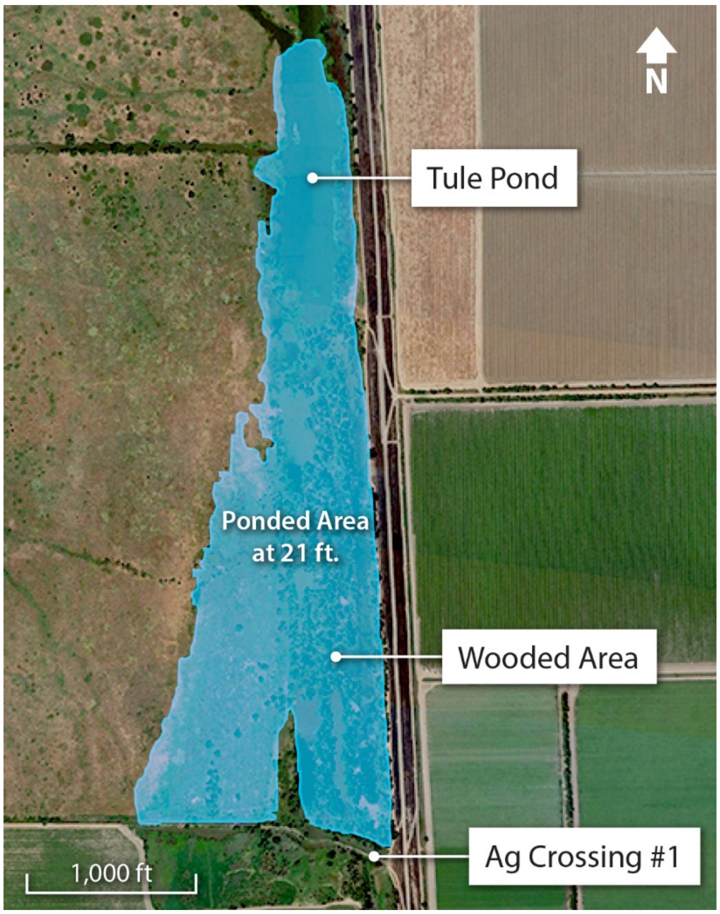

Figure 2-1. Existing Inundation Area North of Agricultural Road Crossing 1

[3] Elevations in the EIS/EIR are compared to the North American Vertical Datum of 1988 (NAVD 88).

Agricultural Road Crossing 1 improvements would include removal of the cross-canal berms and road crossing that create a fish passage barrier, construction of a bridge for vehicular traffic, and construction of an inverted siphon beneath the new Tule Canal connection to maintain water deliveries to the agricultural water users in the Elkhorn Area. Removing the barriers to fish passage would also remove a flow barrier that retains water in the Tule Pond and wooded area to the north and a source of water for these areas in the cross-canal. The bridge would be 18 feet wide and 80 feet long. It would include concrete abutments on each end to span Tule Canal. Figure 2-2 shows the proposed improvements at Agricultural Road Crossing 1. These improvements are included in all action alternatives.

The cross-canal berm would be removed and the channel regraded to connect proposed upstream channel improvements (described in Section 2.3.2) to Tule Canal. A turnout structure would be constructed on the west side of the new Tule Canal connector channel. Two 36-inch, 270-foot-long pipes would run under the new connection with Tule Canal from the turnout structure and tie into a concrete junction box on the east side of Tule Canal that would feed the supply pipes through the existing levee. An emergency overflow bypass structure would be installed immediately adjacent and northwest of the turnout structure to prevent overtopping the canal embankments into the surrounding fields during non-flood events. Overtopping the embankments could cause erosion, so the overflow bypass would reduce operations and maintenance needs on the canal embankments. The overflow bypass structure would discharge high flows south into existing Tule Canal.

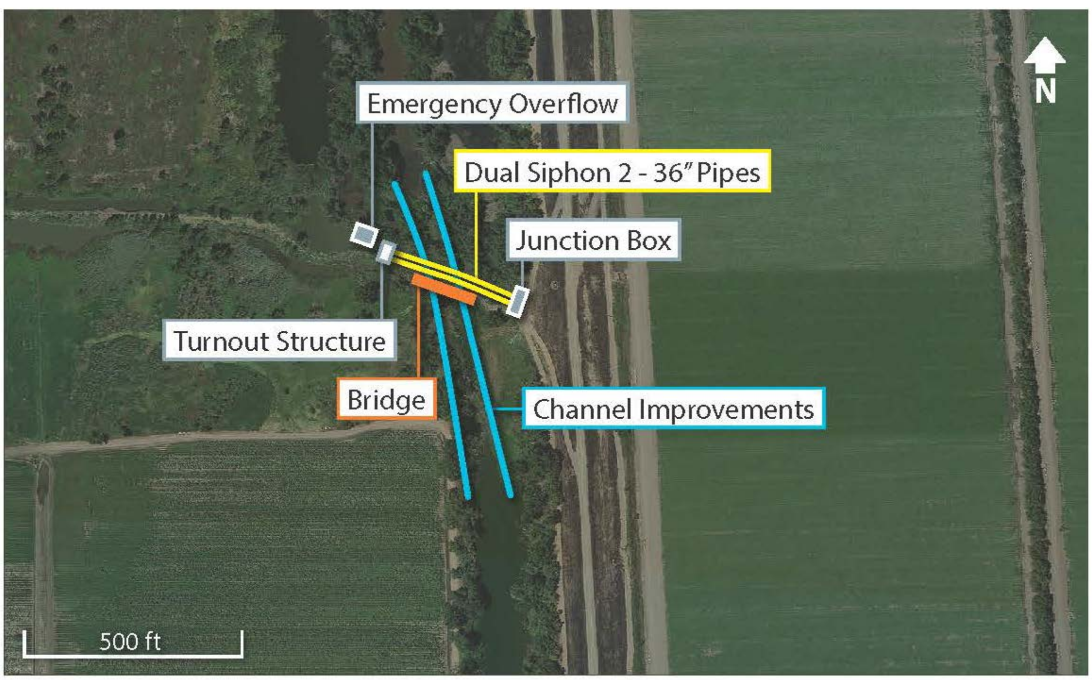

Figure 2-2. Agricultural Road Crossing 1 Improvements

2.3.2 Downstream Channel Improvements

With the exception of Alternative 5, all proposed alternatives include an engineered, trapezoidal channel that connects a new gated notch in Fremont Weir to Tule Pond. Alternative 5 varies from the other alternatives because it includes a multi-channel complex that connects to Tule Canal south of Tule Pond (near Agricultural Road Crossing 1); the conditions and improvements described in this section do not apply to Alternative 5.

The area just south of Tule Pond is referred to as the “wooded area” on Figure 2-1 and does not have a defined channel. Discussed as part of the Agricultural Road Crossing 1 improvements, water is often ponded in this area, allowing vegetation and tree growth. The area is often wet outside of the winter season and is dominated by tule growth.

The lack of a defined channel within the wooded area makes fish passage more difficult during periods when the entire area is not inundated. Fish do not have a clear path to move between Tule Pond and the wooded area just upstream of Agricultural Road Crossing 1.

Under Alternatives 1 through 4 and 6, improvements would be made to connect isolated pools within the wooded area that extends from the Tule Pond outlet downstream to Agricultural Road Crossing 1 where the Tule Canal begins. Improvements include a trapezoidal channel with constant slope. The improvements would facilitate upstream adult fish passage between the existing Tule Canal and Tule Pond. The engineered, trapezoidal channel would begin downstream of Agricultural Road Crossing 1 and extend north to Tule Pond. The channel would have a 20-foot-bottom width and a 3:1 side slope (horizontal to vertical). The top of channel would be 60 to 70 feet wide, with eight feet of revetment and a 12-foot wide maintenance corridor on either side.

To avoid concerns about levee seepage and stability near the channel improvements, Alternatives 1 through 4 and 6 would include a subsurface cutoff wall in the levee parallel to the channel. A subsurface cutoff wall is a structure that uses a slurry or cement mix to create a “wall” along a levee to prevent seepage under the levee or address other levee stability and seepage concerns. This cutoff wall would be included because the channel construction would cut through an existing clay blanket layer that currently prevents levee underseepage. The cutoff wall would be approximately 3,150 feet long and 30 feet deep. The location is at the toe of the levee, and the cutoff wall would be entirely underground. Figure 2-3 presents a preliminary concept for the channel improvements.

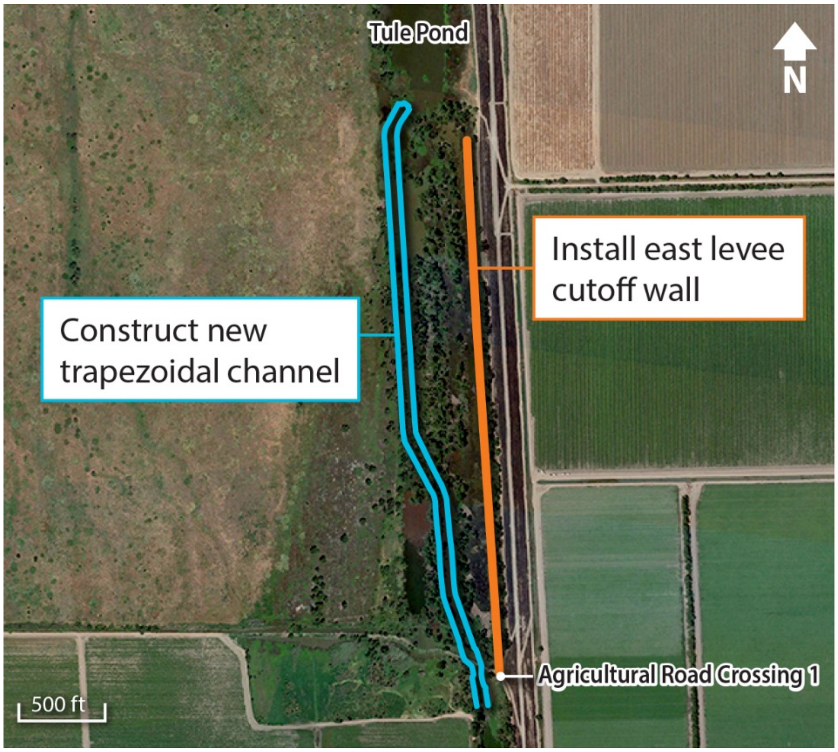

Figure 2-3. Downstream Channel Improvements

2.3.3 Operational Timeframe

The action alternatives all include one (or multiple) gated notch structures to allow flow through gravity into the Yolo Bypass. These facilities would not involve pumping water from the Sacramento River into the Yolo Bypass, so the water could only enter the bypass if the Sacramento River water elevation is higher than the bottom of the gated notch(es) and the water leve in the Tule Canal.

All of the new gated notch structures have the potential to begin operations on November 1. As described in Section 2.1.1, juvenile salmonid out-migration typically begins during early storms in November. The gates would open as river elevations rise, which is discussed in more detail in the operations section of each alternative description.

The gated notch structures were originally planned to stay open through April to allow juveniles to enter the Yolo Bypass, but discussions with stakeholders indicated that an earlier inundation end date (originally suggested as March 15) would reduce impacts to agricultural users and wetlands. The Lead Agencies analyzed whether this change would result in a substantive decrease in benefits to the focus fish species and found little change in benefits, so the end date was changed for all alternatives to March 15. Subsequent discussion with landowners identified potential benefits from an earlier closure date of March 7, and this date was incorporated as a variation of Alternative 4.

After March 15 (or March 7 in the Alternative 4 variation), the new gated notch structure could remain partially open to provide adult fish passage until the end of May. The gated notch would only allow flows up to the available capacity in Tule Canal (typically about 300 cfs) to avoid inundating areas outside of Tule Canal. The amount of flow that could enter through the gated notch would be limited by the available capacity in Tule Canal at the point with the smallest capacity (between Agricultural Road Crossing 1 and just downstream of Interstate 5). Alternative 6 would not allow operation during this period because the facilities would not provide sufficient depths and velocities for fish passage at these low flows.

2.3.4 Best Management Practices

All of the alternatives incorporate typical measures to reduce impacts, typically called Best Management Practices (BMPs). All action alternatives incorporate BMPs and have been designed to avoid and minimize impacts to the maximum extent practicable.

2.3.4.1 BMPs for Construction and Maintenance Activities to Reduce Greenhouse Gas (GHG) Emissions

The following measures are considered BMPs for DWR construction and maintenance activities. Implementation of these practices will reduce GHG emissions from construction projects by minimizing fuel usage by construction equipment, reducing fuel consumption for transportation of construction materials, reducing the amount of landfill material, and reducing emissions from the production of cement.

2.3.4.1.1 Pre-Construction and Final Design BMPs

Pre-construction and Final Design BMPs are designed to ensure that individual projects are evaluated and their unique characteristics taken into consideration when determining if specific equipment, procedures, or material requirements are feasible and efficacious for reducing GHG emissions from the project. While all projects will be evaluated to determine if these BMPs are applicable, not all projects will implement all the BMPs listed below.

- BMP 1. Evaluate project characteristics, including location, project work flow, site conditions, and equipment performance requirements, to determine whether specifications of the use of equipment with repowered engines, electric drive trains, or other high efficiency technologies are appropriate and feasible for the project or specific elements of the project.
- BMP 2. Evaluate the feasibility and efficacy of performing on-site material hauling with trucks equipped with on-road engines.
- BMP 3. Ensure that all feasible avenues have been explored for providing an electrical service drop to the construction site for temporary construction power. When generators must be used, use alternative fuels, such as propane or solar, to power generators to the maximum extent feasible.
- BMP 4. Evaluate the feasibility and efficacy of producing concrete on-site and specify that batch plants be set up on-site or as close to the site as possible.
- BMP 5. Evaluate the performance requirements for concrete used on the project and specify concrete mix designs that minimize GHG emissions from cement production and curing while preserving all required performance characteristics.

- BMP 6. Limit deliveries of materials and equipment to the site to off peak traffic congestion hours.

2.3.4.1.2 Construction BMPs

Construction BMPs apply to all construction and maintenance projects that DWR completes or for which DWR issues contracts. All projects are expected to implement all construction BMPs unless a variance is granted by the Division of Engineering Chief, Division of Operation and Maintenance Chief, or Division of Flood Management Chief (as applicable) and the variance is approved by the DWR CEQA Climate Change Committee. Variances will be granted when specific project conditions or characteristics make implementation of the BMP infeasible and where omitting the BMP will not be detrimental to the project's consistency with the GHG Emissions Reduction Plan.

- BMP 7. Minimize idling time by requiring that equipment be shut down after five minutes when not in use (as required by the State airborne toxics control measure 13 California Code of Regulations [CCR] 2485). Provide clear signage that posts this requirement for workers at the entrances to the site and provide a plan for the enforcement of this requirement.
- BMP 8. Maintain all construction equipment in proper working condition and perform all preventative maintenance. Required maintenance includes compliance with all manufacturer's recommendations, proper upkeep and replacement of filters and mufflers, and maintenance of all engine and emissions systems in proper operating condition. Maintenance schedules shall be detailed in an Air Quality Control Plan prior to commencement of construction.
- BMP 9. Implement a tire inflation program on the jobsite to ensure that equipment tires are correctly inflated. Check tire inflation when equipment arrives on-site and every two weeks for equipment that remains on-site. Check vehicles used for hauling materials off-site weekly for correct tire inflation. Procedures for the tire inflation program shall be documented in an Air Quality Management Plan prior to commencement of construction.
- BMP 10. Develop a project specific ride share program to encourage carpools, shuttle vans, transit passes and/or secure bicycle parking for construction worker commutes.
- BMP 11. Reduce electricity use in temporary construction offices by using high efficiency lighting and requiring that heating and cooling units be Energy Star compliant. Require that all contractors develop and implement procedures for turning off computers, lights, air conditioners, heaters, and other equipment each day at close of business.
- BMP 12. For deliveries to project sites where the haul distance exceeds 100 miles and a heavy-duty class 7 or class 8 semi-truck or 53-foot or longer box type trailer is used for hauling, a SmartWay[4] certified truck will be used to the maximum extent feasible.

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[4] The U.S. Environmental Protection Agency has developed the SmartWay truck and trailer certification program to set voluntary standards for trucks and trailers that exhibit the highest fuel efficiency and emissions reductions. These tractors and trailers are outfitted at point of sale or retrofitted with equipment that significantly reduces fuel use and emissions including idle reduction technologies, improved aerodynamics, automatic tire inflation services, advanced lubricants, advanced powertrain technologies, and low rolling resistance tires.

- BMP 13. Minimize the amount of cement in concrete by specifying higher levels of cementitious material alternatives, larger aggregate, longer final set times, or lower maximum strength where appropriate.
- BMP 14. Develop a project specific construction debris recycling and diversion program to achieve a documented 50 percent diversion of construction waste.
- BMP 15. Evaluate the feasibility of restricting all material hauling on public roadways to off-peak traffic congestion hours. During construction scheduling and execution minimize, to the extent possible, uses of public roadways that would increase traffic congestion.

2.3.4.2 Air Quality BMPs

Fugitive dust control measures required by the Sacramento Metropolitan Air Quality Management District (AQMD) will be implemented as environmental commitments for all alternatives. The BMPs required by the Sacramento Metropolitan AQMD (2016) to allow non-zero particulate matter significance thresholds are as follows:

1. Water all exposed surfaces two times daily. Exposed surfaces include but are not limited to soil piles, graded areas, unpaved parking areas, staging areas, and access roads.
2. Cover or maintain at least two feet of freeboard space on haul trucks transporting soil, sand, or other loose material on the site. Any haul trucks that would be traveling along freeways or major roadways should be covered.
3. Use wet power vacuum street sweepers to remove any visible track out mud or dirt onto adjacent public roads at least once a day. Use of dry power sweeping is prohibited.
4. Limit vehicle speeds on unpaved roads to 15 mph.
5. All roadways, driveways, sidewalks, and parking lots to be paved should be completed as soon as possible. In addition, building pads should be laid as soon as possible after grading unless seeding or soil binders are used.
6. Minimize idling time either by shutting equipment off when not in use or reducing the time of idling to 5 minutes [required by CCR, Title 13, sections 2449(d)(3) and 2485]. Provide clear signage that posts this requirement for workers at the entrances to the site.
7. Maintain all construction equipment in proper working condition according to manufacturer’s specifications. The equipment must be checked by a certified mechanic and determine to be running in proper condition before it is operated.

2.3.5 Sediment Disposal

All of the action alternatives would generate sediment during construction and would require removal of deposited sediments during operations. Reclamation and DWR would seek opportunities for practical reuse of the sediment removed, including partnerships with local landowners to receive the excess soils or other local construction projects that may need additional materials. Partnerships with local landowners would be for landowners that could use additional sediment on their fields to assist in their agricultural operations, not convert agricultural land to other purposes. If no options are available for reuse, Reclamation or DWR would purchase land outside the bypass for the sediment removed during maintenance actions.

Reclamation and DWR would complete appropriate environmental compliance for this transaction if land acquisition is desired in the future for sediment removal.

2.4 Alternative 1: East Side Gated Notch

Alternative 1, East Side Gated Notch, would allow increased flow from the Sacramento River to enter the Yolo Bypass through a gated notch on the east side of Fremont Weir. The gated notch would create an opening in Fremont Weir that is deeper than Fremont Weir, with gates to control water going through the facility into the Yolo Bypass. The invert of the new notch would be at an elevation of 14 feet, which is approximately 18 feet below the existing Fremont Weir crest. Water would be able to flow through the notch during periods when the river elevations are not high enough to go over the crest of Fremont Weir (at an elevation of 32 feet).

Alternative 1 would connect the new gated notch to Tule Pond with a channel that parallels the existing east levee of the Yolo Bypass. Alternative 1 would have the shortest and most direct access to the Tule Canal for migrating fish. Alternative 1 would allow flows up to 6,000 cfs, depending on Sacramento River elevation, through the gated notch to provide open channel flow for adult fish passage, juvenile emigration, and floodplain inundation. This alternative would include a supplemental fish passage facility on the west side of Fremont Weir and improvements to allow fish to pass through Agricultural Road Crossing 1 and the channel north of Agricultural Road Crossing 1, as described in Section 2.3. Figure 2-4 shows key components of the alternative and the common elements described in Section 2.3. Alternative 1 is the CEQA and NEPA preferred alternative (as described in more detail in Section 23.6).

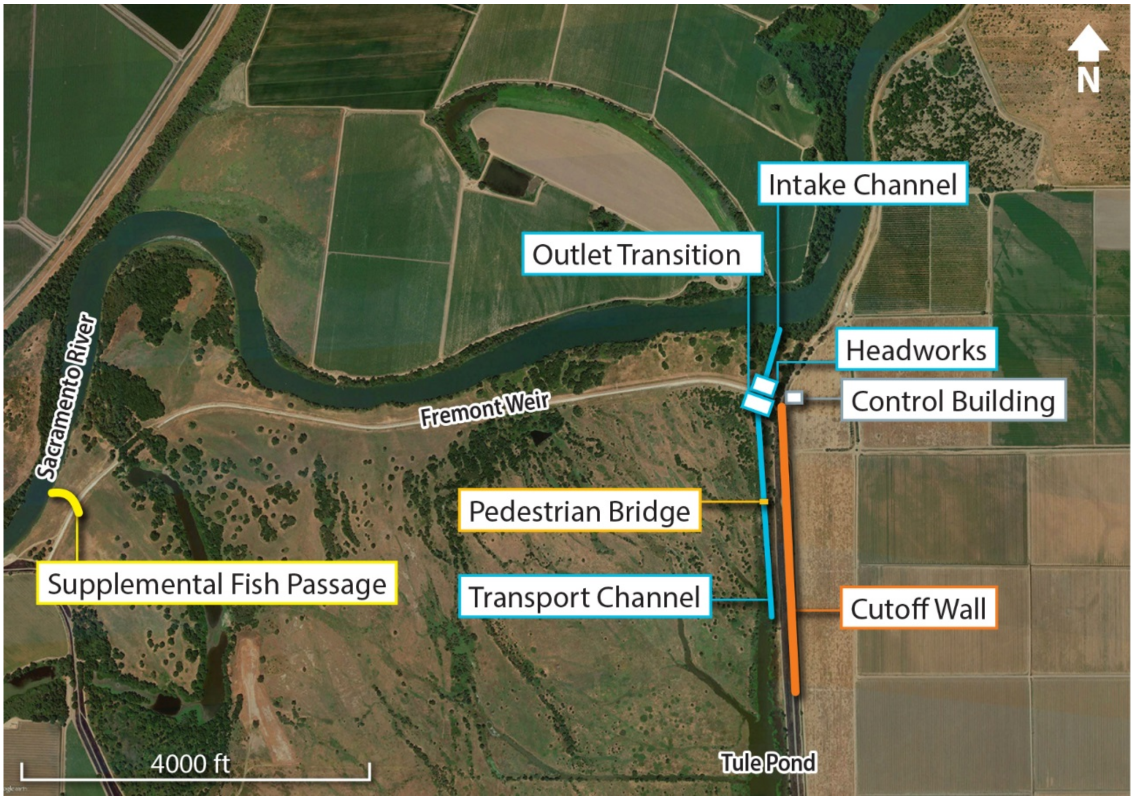


Figure 2-4. Alternative 1 Key Components

The next section includes descriptions of the facilities, construction methods, operations, required maintenance, and environmental commitments associated with this alternative. More detailed construction information is included in Appendix B, *Constructability and Construction Considerations.*

2.4.1 Facilities

2.4.1.1 Intake Channel

The primary purpose of the intake channel is to draw juvenile salmonids and floodplain inundation flows from the Sacramento River to the new headworks structure (described in Section 2.4.1.2) and provide upstream adult fish passage between the headworks structure and the Sacramento River. The intake channel would be constructed with a 98-foot-bottom width with 3:1 side slopes (horizontal to vertical). It would have a gentle slope away from Fremont Weir so that flows would drain toward the river. It would reach the river with an invert elevation of 12 feet (compared to the invert of 14 feet at Fremont Weir). At the downstream end of the intake channel (near the headworks at Fremont Weir), there would be a short transition from the trapezoidal intake channel to the rectangular sides of the headworks structure. To avoid scour, the channel would be lined with angular rock placed along the bank slopes and rounded rock placed along the channel bottom.

2.4.1.2 Headworks Structure

The headworks structure would control the diversion of flow from the Sacramento River to the Yolo Bypass. It would serve as the primary upstream fish passage facility for adult fish and the primary facility for conveying floodplain inundation flows and juvenile salmonids onto the Yolo Bypass.

The headworks structure would be a three-bay, pile-supported, reinforced concrete structure that would bisect the existing Fremont Weir at an eastern location. It was designed to convey 6,000 cfs at a river elevation of 28 feet (14 feet of water depth in the headworks structure) with all gates fully open to meet the applicable requirements for fish passage and flood control. It would house three operating control gates and include a concrete control structure, an upstream vehicular bridge crossing, and a concrete channel transition, which would transition the rectangular sides of the control structure to the side channel slopes of the outlet channel. It would have a sheet pile cutoff wall on the river side of the structure under the gates and on both sides of the structure to prevent underseepage from the river. The gate structure would be 65 feet (upstream to downstream) by 108 feet, and the sheet piles would add 50 feet on either side of the gate structure.

Stoplogs would be provided at each of the three headworks bays upstream of the control structure to dewater the gates for maintenance and as a backup closure for the structure. Six stoplogs are required for the larger gate and four for the two smaller gates. Installation of the stoplogs would require a mobile crane capable of lifting approximately 10,000 pounds. Stoplogs would be stored off site and could only be installed or removed when there would be no flow through the headworks structure or when the gates are closed. The stoplogs would be used to prevent groundwater or small amounts of river flow from entering the structure during maintenance activities.

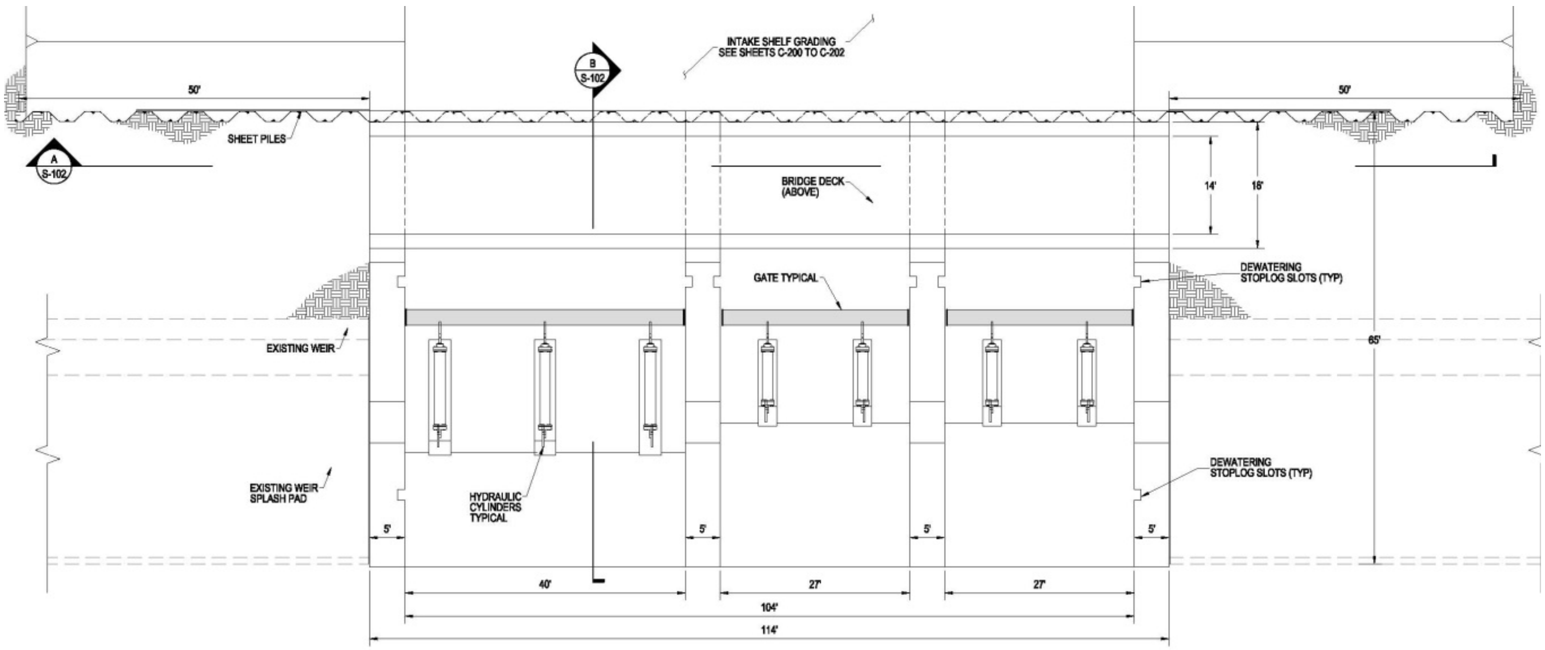
Three hydraulically or pneumatically operated, flush-mounted bottom hinge gates would be used in the headworks structure. These gates would be able to operate under variable river elevations and overtopping events. The top of the gate elevation of 32 feet would be flush with the existing Fremont Weir crest. The upstream face of the control gates would be approximately in-line with the upstream face of the existing Fremont Weir. When fully open, the gates would be flush with the channel invert. Table 2-5 presents the dimensions, invert elevation, and expected weight of the gates to be installed under Alternative 1.

Table 2-5. Gate Specifications for Alternative 1

Gate	Height x Width (feet)	Invert Elevation (feet)	Expected weight (pounds)
1	18 x 34	14.0	65,000
2 and 3	14 x 27	18.0	40,000 each

The gates would open to allow a maximum flow of 6,000 cfs when the water surface elevation in the river reaches 28 feet. Each gate would be capable of independent operation via submersible hydraulic cylinders or inflatable reinforced bladders located beneath the gate. Mechanical and electrical control components for each gate would be housed in a control building outside of the bypass on the eastern levee. Figure 2-5 and Figure 2-6 show the headworks structure design.

View from top of structure looking down



Cross-section (viewing from bypass side of Fremont Weir)

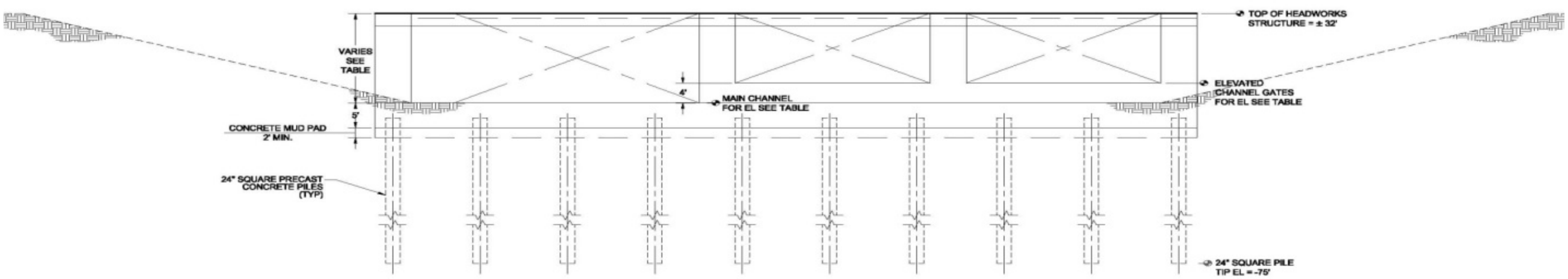


Figure 2-5. Alternative 1 Headworks Cross-Section and Top Views

View from side of structure

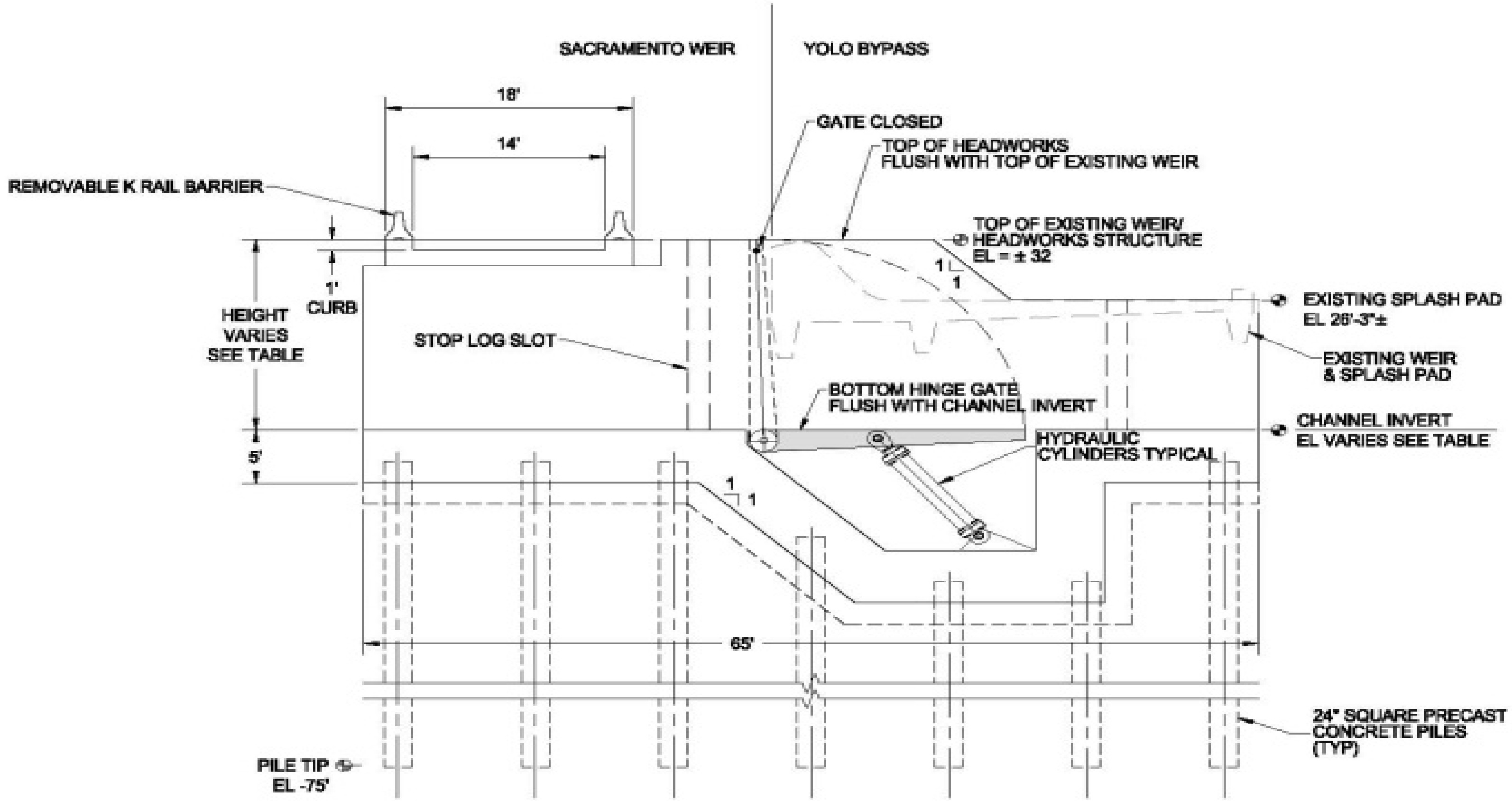


Figure 2-6. Alternative 1 Headworks Side View

Debris is expected within the Sacramento River, and debris accumulation could affect hydraulic performance or fish passage. Debris fins would be installed between gates of the headworks structure (on the river side) to redirect debris to pass through or over the gates rather than become stuck on the gate walls or facilities. Figure 2-7 shows an example of debris fins.

Figure 2-7. Debris Fins Incorporated at Headworks Structure (Example)

2.4.1.3 Control Building

The control building would be a single-story, 18- by 18-foot concrete masonry unit. The building would be located on the eastern levee. It would house, among other equipment, a programmable logic controller (PLC) for the gates, three hydraulic power units, and a motor control center. The electrical service required would be three- phase at approximately 100 amperes (A) and 480 volts alternating current (VAC) (80 kilovolt-amps [kVA]). There would be no backup or standby emergency generator; however, the units would include connections for a portable generator. Active ventilation would be required during the operation of the equipment and would be achieved by installing a roof-mounted fan that vents to the outside of the structure.

2.4.1.4 Access Structures

A reinforced concrete, three-span vehicular headworks bridge would be on the upstream side of Fremont Weir to connect to the existing access road. The bridge would span the channels through the new headworks structure. The bridge would be built at nearly the same alignment and elevation as the existing upstream maintenance road and would allow for continued patrolling and maintenance access along the weir. The bridge would have a roadway width of 14 feet and an overall width of 18 feet. Top curb elevation would be equal to the top of the weir elevation.

Temporary barrier rails ("K rails") would be installed and removed such that no part of the bridge extends above the top of the weir during an overtopping event.

Table 2-6 presents the bridge span corresponding to each control gate.

Table 2-6. Bridge Span Specifications for Alternative 1

Gate	Bridge Span (feet)
1	34
2 and 3	27

The headworks bridge would provide a vehicular and pedestrian crossing on the north side of Fremont Weir. However, when water begins to flow through the new notch in Fremont Weir, the channels south of the weir would fill and create a barrier. If recreational users are in the Fremont Weir Wildlife Area, they may not be able to cross the channel back to where they accessed the area. For this purpose, Alternative 1 includes a 130-foot-long, eight-foot-wide steel-trussed pedestrian bridge just south of Fremont Weir (and north of Tule Pond), as shown in Figure 2-4.

2.4.1.5 Outlet Transition

The outlet transition would be a 100-foot-long reinforced concrete channel that provides gradual hydraulic transition from the headworks into the graded transport channel. The width varies from 108 feet at the headworks to 196 feet at the transport channel. The cross-section of the headworks includes three rectangular gates (one large gate with an invert elevation of 14 feet and two small gates with an invert elevation of 18 feet, shown in Figure 2-5). The outlet transition would be a structure that transitions from the headworks gates to the trapezoidal downstream transport channel. The transition would be accomplished with reinforced retaining walls that flair out from the headworks abutment piers and a reinforced concrete slab-on-grade bottom, which would gradually transition into the slopes of the trapezoidal transport channel. The outlet transition would have a gentle slope consistent with the downstream transport channel.

2.4.1.6 Transport Channel

The transport (outlet) channel would be a graded trapezoidal channel with an interior inline bench. Figure 2-8 shows the transport channels for Alternatives 1 (east), 2 (central), and 3 and 4 (west). The interior bench would help maintain acceptable velocities for fish passage at higher river elevations. The transport channel would serve as the primary facility for upstream adult fish passage between the existing Tule Pond and the headworks structure. It also would serve as the primary channel for conveying juvenile salmonids and rearing habitat flows from the headworks structure to the existing Tule Pond.

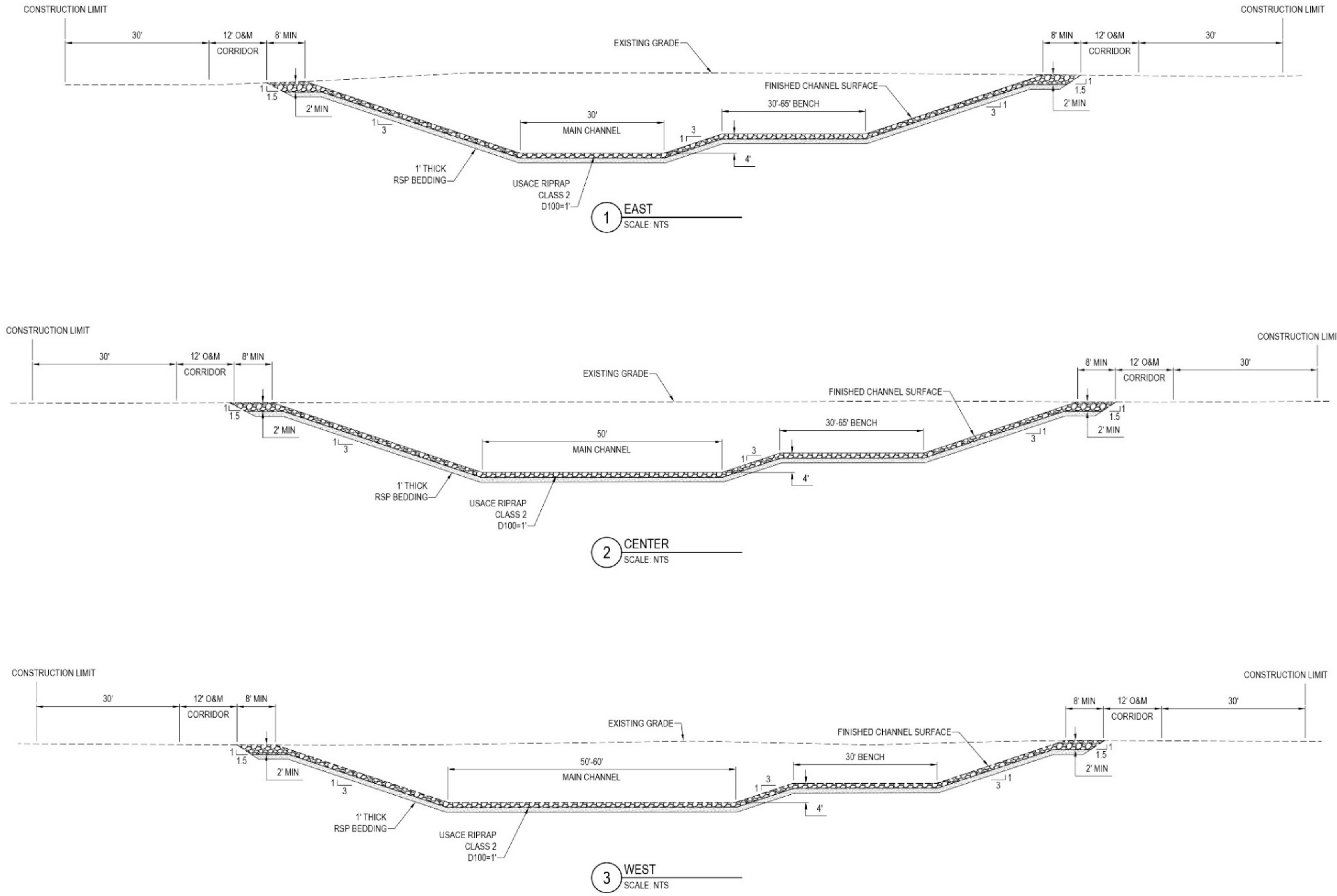


Figure 2-8. Transport Channel Cross-Section

The main channel within the trapezoidal channel would have a bottom width of 30 feet. The bench would be on the east side of the channel and elevated four feet above the main channel. The bench width would vary between 30 and 65 feet. The trapezoidal channel would have 3:1 side slopes (horizontal to vertical). The top of the channel would be approximately 150 feet wide. The channel would be about 2,650 feet long with a gradual downward slope toward Tule Pond (a slope of 0.00075). The entire channel would be lined with rounded rock revetment on the channel bottom and angular rock on the bank slopes. It would be designed to convey up to 6,000 cfs at a river elevation of 28 feet while maintaining velocities that permit fish passage. At the top of each side of the channel, an eight-foot-wide area with rock (a “rock key”) would be added to reduce the potential for the channel to head cut the channel banks. The facility also would have a 12-foot-wide maintenance corridor at the top of each side of the channel.

2.4.1.7 Seepage Measures

The transport channel for the new gated notch would be immediately adjacent to the east levee of the Yolo Bypass and would cut through the clay blanket layer at the toe of the levee, which raises concerns about increased levee underseepage. Levee underseepage could cause levee stability concerns. To reduce seepage, a cutoff wall would be constructed at the levee toe from Fremont Weir to the central part of Tule Pond. The cutoff wall would be approximately 2,850 feet long and 30 feet deep, and the wall would be completely underground.

2.4.1.8 Supplemental Fish Passage Facility

The proposed gated notch in Fremont Weir would serve as the primary fish passage facility in Alternative 1. Another project in the Yolo Bypass, the Fremont Weir Adult Fish Passage Modification Project, is constructing an improved fish passage facility at the location of the existing, smaller fish ladder (near the middle of Fremont Weir on the eastern side of Rattlesnake Island) to provide fish passage immediately after an overtopping event. These two facilities would improve fish passage from the Yolo Bypass into the Sacramento River; the proposed gated notch would provide the main passage route, and the improved fish passage structure would pass additional fish on the eastern side of Fremont Weir after overtopping events. However, after an overtopping event, fish on the western side of Fremont Weir would not be able to pass over to the eastern side to access these two fish passage facilities because Rattlesnake Island prevents movement.

An additional fish passage facility would be constructed at a western location along the existing Fremont Weir (Figure 2-9). This facility would provide another opportunity for adult fish to travel from the Yolo Bypass into the Sacramento River. This structure would allow fish that are trapped in the stilling basin (on the bypass side of Fremont Weir) to move back into the Sacramento River after an overtopping event. The facility would have a gentle slope away from Fremont Weir so that flows would drain toward the river. It would reach the river with an invert elevation at 20 feet (compared to the invert of 22 feet at Fremont Weir). The supplemental fish passage channel would have 10-foot-bottom width and 3:1 side slopes, stretch over 350 feet measured from Fremont Weir to Sacramento River, and connect to the fish passage facility through a channel transition. The transition would be 10-feet-long and connect the 10-foot wide channel to the 15-foot width of the fish passage structure. The concrete fish passage structure would have an elevation of 22 feet at Fremont Weir and house an approximately 15-foot-wide hinge gate, recessed air bladder, and metal grate. Sheet piles would be installed north of Fremont

Weir to prevent underseepage. When open, the gate would allow less than approximately 1,000 cfs to enter the Yolo Bypass. At an elevation of 32 feet, the concrete wall of the fish passage structure would be flush with the top of the existing weir. The structure would have a 16-foot-wide traffic-rated deck to allow vehicular passage.

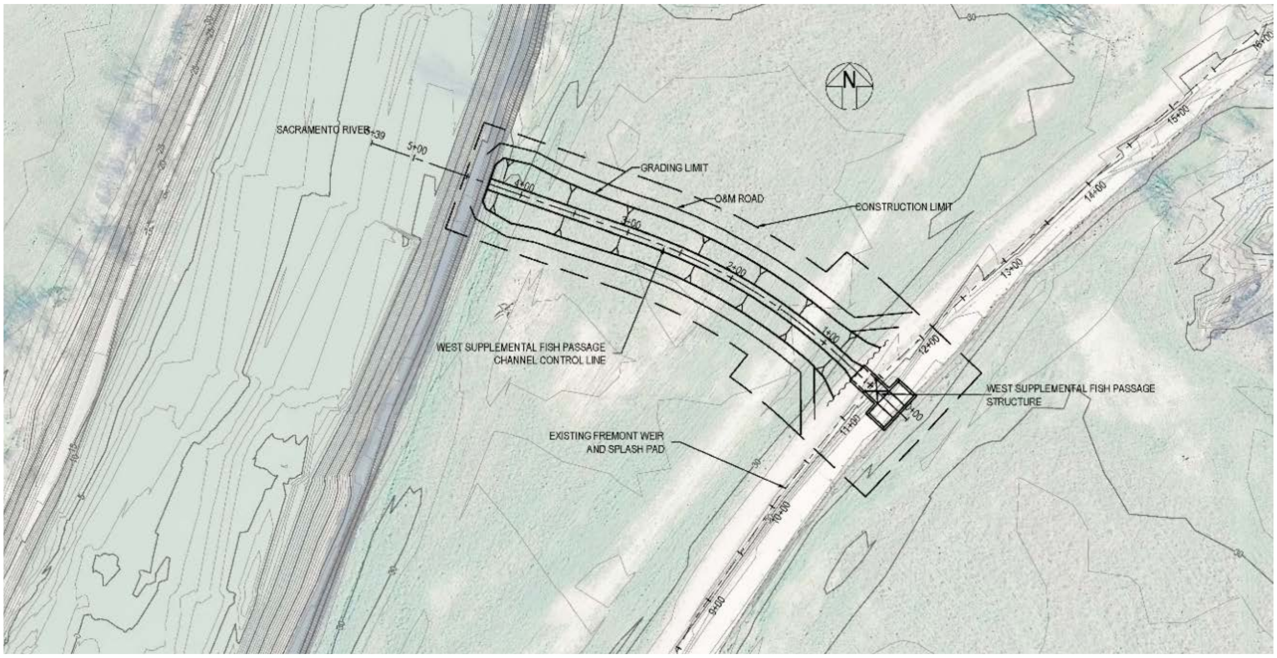


Figure 2-9. Alignment of the Western Supplemental Fish Passage Facility

2.4.2 Construction Methods

Construction of the components of Alternative 1 would begin with the demolition of a portion of the existing concrete Fremont Weir. This step would be completed in about one week. The limits for the weir demolition would extend a minimum of five feet beyond both sides of the headworks footprint to allow for excavation down to an elevation of seven feet and installation of a temporary sheet pile cofferdam.

Construction of the headworks structure, intake channel, and outlet channel would occur concurrently. It would take approximately 25 weeks to construct the headworks structure. Installation and testing of the gates and mechanical equipment would take an additional 3 to 5 weeks.

Grading of the transport channel would begin at the downstream outlet (at the northern end of Tule Pond) and progress upstream toward the headworks structure, with grading of the intake channel occurring last. This order would avoid potential interruptions to the headworks construction and allow construction to occur in the less saturated soil first as groundwater levels decrease with increasing distance from the Sacramento River. Groundwater levels are anticipated to be high, especially in the spring months, so dewatering efforts likely would be required to construct the headworks structure, especially where the intake channel meets the Sacramento River. About 60 to 80 percent of the channel excavation could be performed in dry unsaturated soil conditions by scrapers and bulldozers. The remaining portion would be performed in wet, saturated soil conditions by hydraulic excavators and haul trucks.

2.4.2.1 Excavated Material

Alternative 1 would require excavation of the intake channel, transport channel, and downstream facilities. Table 2-7 shows the estimated quantities of excess excavated material that would be generated from each facility and would require removal from the construction area. Depending on the type of material excavated, a portion of the material could be re-used within the project area or for other nearby projects.

Table 2-7. Estimated Excess Excavated Material Quantities for Alternative 1

Component	Estimated Excess Excavated Material (cubic yards)
East Intake Channel	64,150
East Transport Channel	116,600
Headworks	6,150
Downstream Channel	72,520
Supplemental Fish Passage (West)	3,230
Agricultural Road Crossing 1	3,170
TOTAL	*265,820*

Reclamation or DWR would purchase land within two miles of the edge of the Yolo Bypass to receive this excess material. Alternative 1 would require seven to eight acres of land to spoil excess construction-related material. This spoil site would be used for excess excavated soil and green waste. Other construction waste would be hauled to a landfill.

2.4.2.2 Construction Materials

Material imported to the project site would be obtained from existing permitted commercial sources located within approximately 65 miles of the project site. The haul routes for these materials would be along public streets, including Interstate (I) 5; State Route 99; and County Roads (CRs) 105, 16, 116A, and 117. Table 2-8 provides potential locations and haul routes for offsite import of materials. The exact source of the materials would be determined by the construction contractor, but these potential sources provide reasonable estimates for distances and haul routes.

Table 2-8. Construction Material Quantities, Sources, and Haul Routes

Material	Quantity	Potential Location	Haul Route	Distance
Aggregate base for road maintenance		Teichert Aggregates	Interstate 5; County Roads 16, 117, and 17; Old River Road	26 miles
Riprap material	66,860 tons	Parks Bar Quarry	County Roads 16 and 117, Old River Road, Interstate 5, State Route 99	66 miles
Rock slope protection bedding	68,618 tons	Parks Bar Quarry	County Roads 16 and 117, Old River Road, Interstate 5, State Route 99	66 miles
Equipment		Construction Contractor Office (likely access from Interstate 5)	County Roads 16 and 117, Old River Road, Interstate 5, Elkhorn Boulevard	20 miles (estimate, varies depending on contractor)

2.4.2.3 Staging Areas and Access

The construction easements for Alternative 1 would encompass staging areas for equipment, mobilization, and spoiling sites. The construction footprints analyzed in this EIS/EIR include space for staging areas. After construction, staging areas would be returned to pre-construction condition. Construction sites would be accessed by the use of I-5 to CR 117 (paved rural road), north to CR 16 (paved and dirt road), west to the Yolo Bypass east levee, and then north on the east levee crown road to access the site. The use of CR 16 for equipment and offsite haul would substantially degrade the quality of the road and require re-grading and gravelling (and potentially repaving) to restore it to pre-project conditions. In addition, portions of the existing levee crown roads would be used for hauling. The levee crown consists of only aggregate surfacing in marginal conditions. It is anticipated that use of the levee crown for hauling would trigger the need to resurface the levee crown to pre-project conditions with six inches of aggregate base material.

The county roads and levee crown roads utilized for site access and haul would be inspected periodically during construction operations. As areas of damage are identified, they would be temporarily repaired to accommodate ongoing operations. At the completion of project construction, all roads that have been temporarily repaired would be repaved as specified by the governing local, county, or State standards.

2.4.2.4 Construction Equipment

A list of the major equipment needs for the construction of both the alternative-specific and common downstream channel improvement actions is provided in Table 2-9. Equipment specifics may vary based on the contractor’s capabilities and the availability of equipment. Appendix B, *Constructability and Construction Considerations,* includes information on how many of each type of equipment would be used.

Table 2-9. List of Major Equipment Needed for Construction of Alternative 1

List of Major Equipment	
• 0.8-CY backhoe loaders	• 4.5-CY hydraulic excavator
• 1.5-CY front end loader crawler	• 40-TN truck-mounted hydraulic crane
• 10-TN smooth roller	• 4,000-gallon water truck
• 100-TN off highway trucks	• 450-HP dozer crawler
• 100-foot auger track-mounted drill rig	• 6-inch diameter pump engine drive
• 12-foot blade grader	• 75-TN crane crawler pile hammer
• 165-HP dozer	• Concrete mixer truck
• 2.5-CY hydraulic excavator	• Concrete pump boom, truck-mounted
• 2.5-inch diameter concrete vibrator	• Extended boom pallet loader
• 24-TN truck end dump	• Flatbed truck
• 3.5-CY hydraulic excavator	• Haul truck oversize transport
• 3-axle haul trucks	• Hydroseeding truck
• 30-CY scrapers	• Pickup trucks, conventional
• 300-kW generator	

Key: CY = cubic yards; HP = horsepower; kW = kilowatt; TN = ton

2.4.2.5 Construction Schedule and Workers

Alternative 1 construction likely would begin in late 2020 or early 2021 and is estimated to last 28 weeks. All project components are expected to be completed in one construction season during times that are outside the flood period (construction from April 15 through November 1). The headworks structure would have the longest construction duration and would start at the beginning of the construction period. Construction of channel improvements would commence the same week as the headworks structure construction activities.

Construction would occur 6 days per week, 10 hours per day between 7 a.m. and 6 p.m. Construction workers would be divided into multiple crews and would work one shift per day. Maintenance and equipment upkeep crews would work on equipment at night when it is not in use. The peak number of construction workers, which would be needed for one week in July, is estimated to be 202.

2.4.3 Operations

The goal of Alternative 1 operations is to maximize the number of out-migrating juvenile winter-run Chinook salmon that enter the Yolo Bypass. Downstream out-migration is triggered during the first wet season event. Gate operations could begin each year on November 1 and would first open based on river conditions. All gates would be opened when the river elevation reaches 15 feet, which is one foot above the lowest gate invert. At this river elevation, about 130 cfs would enter the gated notch. If the river continues to rise, the gates would stay open until the flow through the gates reaches 6,000 cfs. Figure 2-10 shows a curve that represents the amount of water that would flow through the gated notch at different Sacramento River elevations. The flow through the gates would reach 6,000 cfs when the river elevation is about 28 feet; at this point, the two smaller gates would be programmed to start closing to maintain flows of 6,000 cfs. The flow may fluctuate so that it is a little higher or a little lower than 6,000 cfs during this time. Gate closures would be controlled so that there is not a sudden reduction in flow. Gate 1, the larger gate, would remain fully open throughout operations. Figure 2-11 shows a graphical representation of gate operations at different Sacramento River elevations.

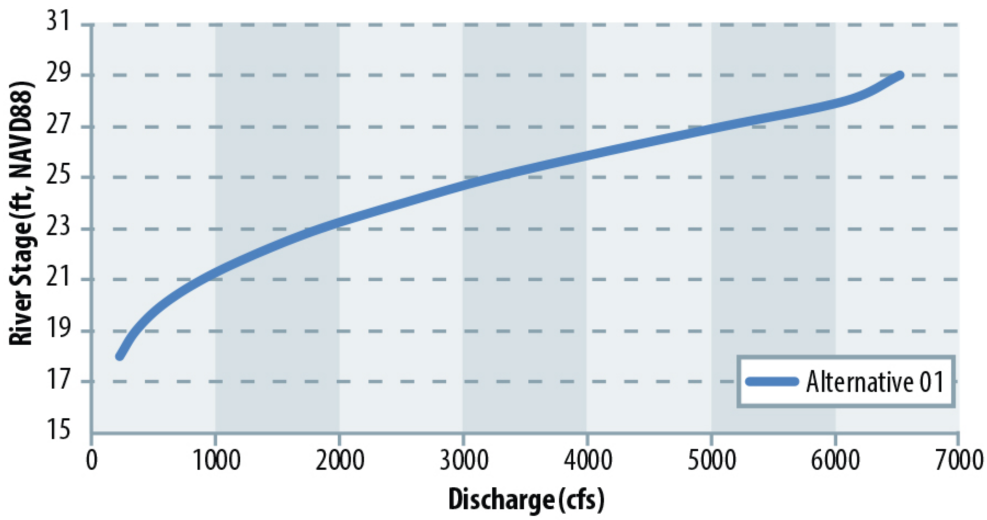


Figure 2-10. Flow through the Gated Notch at Different Sacramento River Elevations under Alternative 1

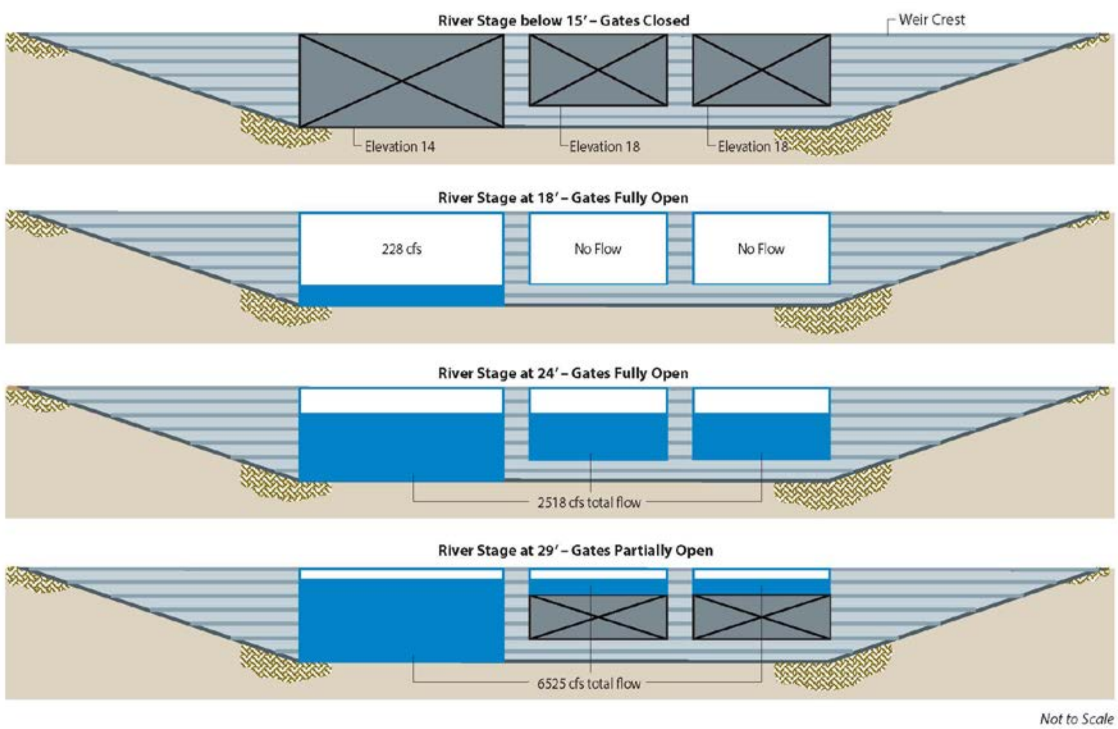


Figure 2-11. Graphical Representation of Gate Operations at Different Sacramento River Elevations

Once Fremont Weir begins to overtop, the smaller gates would remain in their last position prior to the weir overtopping (generally both would be closed at this point). After the overtopping event is over, the smaller gates would open and close as needed to keep the flow through the gate as close as possible to 6,000 cfs. All gates would close when the river elevation falls below 14 feet. Gate operations to increase inundation could continue through March 15 of each year, based on hydrologic conditions. The gates may remain partially open after March 15 to provide adult fish passage. However, flows through the gates after March 15 could not exceed the available capacity of Tule Canal (typically about 300 cfs) so that these flows do not inundate areas outside of the canal and affect landowners.

The headworks structure would house three operating control gates and include a “dogging” device on each gate to be used when the gates are raised (closed) for long periods of time. The dogging device, when manually engaged, would relieve the hydraulic operating equipment of the need to maintain pressure to keep the gates from lowering.

Each control gate would be capable of independent operation via submersible hydraulic cylinders located beneath the gate. Operation of the gates would occur from an operating control building that would house the service panel board and electrical controls for the gates, including a PLC panel.

2.4.4 Inspection and Maintenance

Maintenance activities would include debris removal, sediment removal, and facility inspections. To prevent corrosion, the gates would be rinsed at the end of the flood season as part of the facility inspections. As the Sacramento River rises, some components would no longer be accessible for maintenance. Bridge guardrails would be removed before the river rises to 28 feet. The installation of dewatering stoplogs could not be performed under any flow conditions but rather could only be installed below a river elevation of 14 feet or when the river elevation is between 14 and 28 feet and the gates are raised. When the river elevation is greater than 28 feet, with the gates open or partially open, there would be no safe access to the headworks or bridges. Table 2-10 provides a list of accessible components at varying river stages.

Table 2-10. Maintenance Accessibility by River Elevation

River Elevation	Areas Accessible for Maintenance
Below 14 feet	All components of the headworks structure, bridges, gates (upstream and downstream), and operating components. Stoplogs could be installed for all gates.
14 to 28 feet (gate closed)	Upstream sides of Gates 2 and 3 (from 14 to 18 feet), downstream components of the headworks structure, bridges, gates, and operating components. Stoplogs could be installed for Gates 2 and 3.
14 to 28 feet (gate open)	Upstream bridge deck.
Above 28 feet (gate open)	All components inaccessible.

2.4.4.1 Sediment Deposition

Estimates indicate that approximately 659,000 cubic yards of sediment enter the bypass annually under existing conditions. A portion of this sediment settles in the Yolo Bypass and must be removed through current maintenance efforts. Alternative 1 would increase sediment entering the bypass to a total of about 743,000 cubic yards annually. Most of the additional sediment (about 45 percent) would settle out in the Fremont Weir Wildlife Area, about 25 percent would settle south of Agricultural Road Crossing 1 but north of Interstate 80, and the remaining 30 percent of sediment would remain in suspension and flow out of the bypass. Most of the sediment that settles out would be removed through flood maintenance in the Fremont Weir Wildlife Area, as under existing conditions. The additional deposition would be in areas inundated regularly under Alternative 1 (in and around channels), and sediment removal efforts associated with Alternative 1 would focus on the channel system. Alternative 1 would accumulate an additional 37,800 cubic yards of sediment annually that would be removed every five years.

New channel areas that are constructed perpendicular to the direction of flow in the bypass would incur greater sedimentation. The eastern channel alignment included in Alternative 1 likely would have less sedimentation and debris accumulation than the other action alternatives because it is the shortest and most aligned with the direction of flood flows.

2.4.4.2 Headworks Inspection and Debris Removal

The serviceability and proper function of gates, their actuators, controls, hydraulic cylinders, and the recessed areas for stoplogs and gates would be inspected at the beginning and end of the flood season and after overtopping events. Concrete spalling or severe cracking, material corrosion, or identified weakness would be noted and evaluated to determine whether repair or replacement is necessary. Any sediment deposits or accumulated debris would be removed. Debris removal in and around the headworks would be accomplished using an excavator or a crane.

2.4.4.3 Vegetation Removal

Maintenance activities would include removing vegetation and debris from the project channels annually. Grasses and woody vegetation would be allowed to grow within the proposed transport channel, which is deeper than the existing ground within the Yolo Bypass. The grasses and woody vegetation would not be allowed to be higher than the elevation of the adjacent ground outside of the proposed transport channel or the Tule Pond/Tule Canal within the Fremont Weir Wildlife Area. Therefore, because the vegetation would not grow into the existing cross-section of the Yolo Bypass, vegetation within the channel would not reduce the flood capacity of the Yolo Bypass.

Maintenance, such as mowing or new tree growth removal, would be focused during dry periods but could occur when the channel is wet (such as for portions of the transport channel that may have standing water much of the year). Intake channel maintenance would occur during dry conditions.

2.4.5 Monitoring and Adaptive Management

During project implementation, DWR and Reclamation would monitor fish activity (in close coordination with CDFW) to identify if the project objectives are being met. Specifically, the agencies would monitor:

- Fremont Weir splash pad after overtopping events to identify if fish pass into the Sacramento River (through visual inspection)
- Structures within the Tule Canal/Toe Drain to identify fish passage concerns (through visual inspection)
- Stranding within the floodplain areas (through visual inspection and reports from landowners or visitors)
- Juvenile fish entrainment at the Fremont Weir gated notch (through camera footage at the structure)

If DWR and Reclamation identify concerns or areas where performance could improve, they would consider taking an adaptive management action. Appendix C describes the Adaptive Management Framework that would be implemented.

In addition to monitoring for fish, DWR and Reclamation would monitor groundwater levels in the area surrounding the Yolo Bypass during and after periods when the gated notch would be operating. DWR has a groundwater monitoring network in this area and the wells are checked regularly. DWR and Reclamation would consider groundwater levels each operating season to identify if the gated notch operations could be elevating shallow groundwater levels such that they could affect surrounding lands. The monitoring effort would identify times when the groundwater levels were shallower than five feet below ground surface. This indicates the elevation where groundwater levels would be within the crop root zone for surrounding agricultural areas and could affect agricultural productivity for the types of crops surrounding the Yolo Bypass (SJRRP 2017). Groundwater levels sometimes rise to this level under existing conditions because of high flow conditions in the Sacramento River and inundation events in the Yolo Bypass. If the agencies identify potential effects to surrounding landowners because of shallow groundwater levels from Alternative 1 (at times when the new gated notch structure allows increased flows into the Yolo Bypass), they would work with landowners to consider a physical solution to the high groundwater elevation, property easements, or consideration of damages.

2.5 Alternative 2: Central Gated Notch

Alternative 2, Central Gated Notch, would provide a new gated notch through Fremont Weir similar to the notch described for Alternative 1. The primary difference between Alternatives 1 and 2 is the location of the notch; Alternative 2 would site the notch near the center of Fremont Weir. This gated notch would be similar in size to Alternative 1 but would have an invert elevation that is higher (14.8 feet) because the river is higher at this upstream location. This location is on an outside bend of the river. Studies have indicated that juvenile fish may be found in greater numbers on the outside edge of river bends (DWR 2017). The new gated notch would allow flow to pass into the Yolo Bypass at lower river elevations than under existing conditions, where flows only enter the Yolo Bypass when Fremont Weir overtops.

Alternative 2 would include facilities to connect the gated notch to the existing Tule Pond. Alternative 2 would allow flows up to 6,000 cfs, depending on Sacramento River elevation, through the gated notch to provide open channel flow for adult fish passage, juvenile emigration, and floodplain inundation. This alternative would also include a supplemental fish passage facility on the western end of Fremont Weir and improvements downstream of Tule Pond as described in Section 2.3. Figure 2-12 shows the key components of this alternative and the common elements described in Section 2.3.

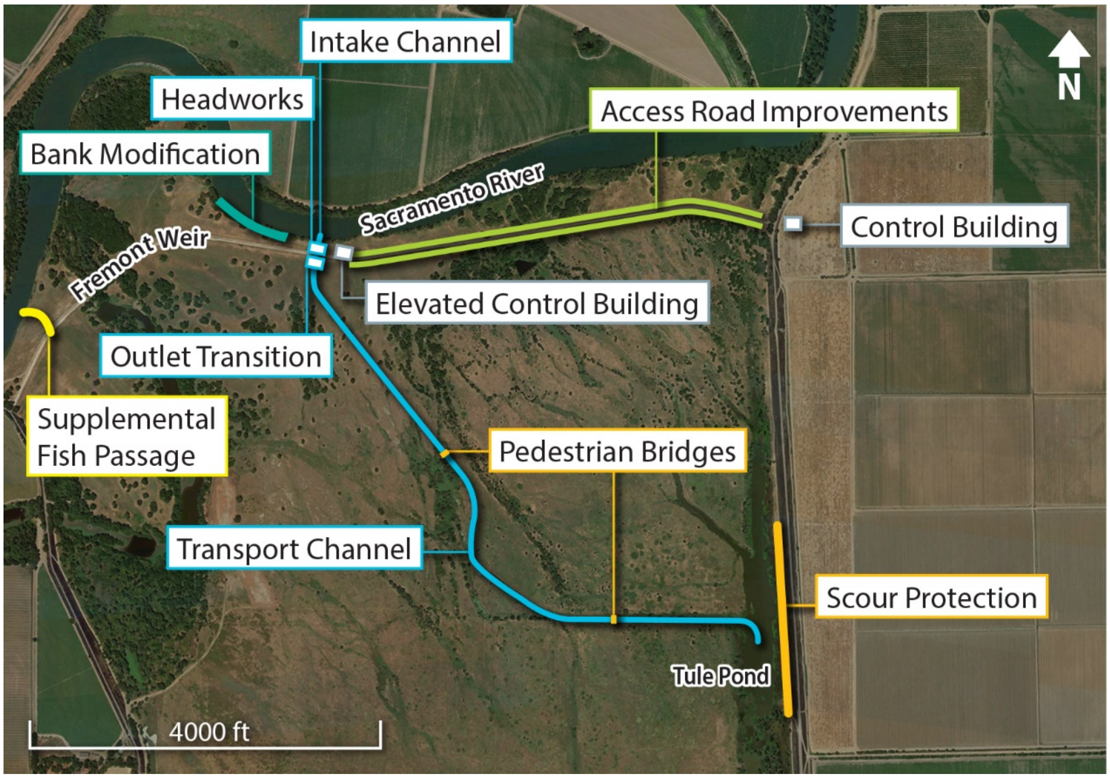


Figure 2-12. Alternative 2 Key Components

The next section includes descriptions of the facilities, construction methods, operations, required maintenance, and environmental commitments associated with this alternative. More detailed construction information is included in Appendix B, *Constructability and Construction Considerations.*

2.5.1 Facilities

2.5.1.1 Intake Channel

Similar to Alternative 1, the primary purpose of the intake channel is to draw juvenile salmonids and floodplain inundation flows from the Sacramento River to the new headworks structure (described in Section 2.5.1.2) and provide upstream adult fish passage between the headworks structure and the Sacramento River. The dimensions and design details would be the same as described for Alternative 1, but the channel would be located in a central location. The Sacramento River bank just upstream and along the intake channel would be modified by removing roughage (existing rock revetment, piles and large wood) in the wetted channel, resloping the bed and embankment contours, and smoothing channel edges along the intake channel.

2.5.1.2 Headworks Structure

Because of the different location, the headworks structure in Alternative 2 would have a slightly different gate configuration than described for Alternative 1. The overall structure and foundation would be the same as described for Alternative 1, but the structure would be a little longer (the gate structure would be 114 feet compared to 108 feet for Alternative 1).

Three hydraulically operated, flush-mounted bottom hinge gates would be used in the headworks structure. These gates would be capable of operating under variable river elevations and overtopping events. The top of the gate elevation would be flush with the existing Fremont Weir crest (32 feet). The upstream face of the control gates would be approximately in-line with the upstream face of the existing Fremont Weir. When fully open, the gates would be flush with the channel invert. Table 2-11 presents the dimensions, invert elevation, and expected weight of the gates to be installed under this alternative. The layout of the facilities would be the same as described for Alternative 1, shown in Figures 2-5 and 2-6, including debris fins.

Table 2-11. Gate Specifications for Alternative 2

Gate	Height x Width (feet)	Invert Elevation (feet)	Expected weight (pounds)
1	17 x 40	14.8	65,000
2 and 3	13 x 27	18.8	40,000 each

2.5.1.3 Control Buildings

Due to the maximum distance over which hydraulic lines can function, two separate control buildings would be required: an operating control building and an elevated control building for hydraulics. The operating control building would be a concrete masonry unit, measuring approximately 12 by 12 feet, located on the eastern levee. The building would house a PLC for the gates and would require three-phase electrical service at approximately 100 A and 480-VAC (80kVA). There would be no backup or standby emergency generator; however, the units would include connections for a portable generator. Active ventilation would be required during the operation of the equipment and would be achieved by installing a roof-mounted fan that vents to the outside of the structure.

The elevated control building would be located on the river side of the weir near the headworks structure. The building would be of similar size and construction as the operating control structure but would be raised above the probable maximum flood elevation (about 41.4 feet). The foundation of the raised building would consist of H-piles, a reinforced concrete pile cap, and a pair of streamlined reinforced concrete columns on which the building slab would rest.

2.5.1.4 Access Structures

A reinforced concrete, three-span vehicular headworks bridge would be on the upstream side of Fremont Weir to connect to the existing access road. The bridge would span the channels through the new headworks structure. Table 2-12 presents the bridge span corresponding to each control gate. The details of the headworks bridge, other than the span specifications, would be the same as discussed for Alternative 1.

Table 2-12. Bridge Span Specifications for Alternative 2

Gate	Bridge Span (feet)
1	40
2 and 3	27

The headworks bridge would provide a vehicular and pedestrian crossing on the north side of Fremont Weir. As discussed in Alternative 1, the channels south of Fremont Weir could be a barrier to access for recreational users in the Fremont Weir Wildlife Area. For this purpose, Alternative 2 includes two 170-foot-long, eight-foot-wide steel-trussed pedestrian bridges south of Fremont Weir (and north of Tule Pond), as shown in Figure 2-12. Alternative 2 includes two bridges (instead of the one bridge in Alternative 1) because of the longer length of the transport channel.

The Sacramento River carries a large amount of debris during high flow events that could accumulate in the new headworks gates. Access immediately after an overtopping event may be necessary to remove debris before a subsequent event, but the existing access roads near Fremont Weir are unpaved and too muddy to travel on for several weeks after overtopping. Alternative 2 would include stabilized access on the north and south sides of Fremont Weir to provide access following overtopping events earlier than under existing conditions. On the north side (closer to the Sacramento River), the 14-foot-wide existing access road would be excavated by two feet. The excavation would be filled with two feet of riprap with rocks less than 12 inches in diameter flush to existing grade. On the south side, the 14-foot-wide access road would be stabilized by placing two feet of riprap on top of the existing access road.

2.5.1.5 Outlet Transition

The outlet transition from the headworks to the transport channel would be the same as described for Alternative 1.

2.5.1.6 Transport Channel

The transport (outlet) channel would be a graded trapezoidal channel with an interior bench. The channel would serve the same function as described for Alternative 1. Figure 2-8 shows the cross-section of the transport channel for Alternative 2 (the central location).

The main channel within the trapezoidal channel would have a bottom width of 50 feet. The bench would be on the east side of the channel and elevated four feet above the main channel. The bench width would vary between 30 and 65 feet. The trapezoidal side slopes would have 3:1 slopes (horizontal to vertical). The top of the channel would be approximately 170 feet wide. The channel would be about 7,570 feet long with a gradual downward slope toward Tule Pond (a slope of 0.00037). The entire channel would be lined with rounded rock revetment on the channel bottom and angular rock revetment on the bank slopes. At the top of each side of the channel, an eight-foot-wide area of rock (a rock key) would be added to reduce the potential for the channel to head cut the channel banks. The facility also would have a 12-foot-wide maintenance corridor at the top of each side of the channel.

2.5.1.7 Scour Protection

The transport channel would enter Tule Pond at an angle, which could cause erosion concerns on the eastern Yolo Bypass levee. Rock revetment would be incorporated on the eastern edge of Tule Pond that is 50 feet wide, 2,500 feet long, and 2.5 feet thick, with 1.5:1 side slopes (horizontal to vertical). Additionally, there are several locations along the proposed transport channel where the channel could interact with existing scour channels. These five areas could experience head cutting as a result of the new facilities. Additional channel revetment would be incorporated at these locations; these improvements are included in the construction quantities.

2.5.1.8 Supplemental Fish Passage Facility

As discussed for Alternative 1, additional fish passage would be needed for the western side of Fremont Weir. Alternative 2 includes a supplemental fish passage facility with the same location and dimensions as described for Alternative 1.

2.5.2 Construction Methods

The construction methods and process would be similar to those described for Alternative 1. Construction would start with demolition of a portion of Fremont Weir and continue with the headworks and channel construction. In addition to the construction activities described for Alternative 1, dewatering (using a sheet pile cofferdam) would be required for the material removal and regrading at the bank of the Sacramento River near the intake channel.

2.5.2.1 Excavated Material

Alternative 2 would require excavation of the intake channel, transport channel, and downstream facilities. Table 2-13 shows the estimated quantities of excess excavated material that would be generated from each facility and would require removal from the construction area.

Table 2-13. Estimated Excess Excavated Material Quantities for Alternative 2

Component	Estimated Excess Excavated Material (cubic yards)
Central Intake Channel	3,360
Central Transport Channel	457,120
Headworks	6,460
Downstream Channel	72,520
Supplemental Fish Passage (West)	3,230
Agricultural Road Crossing 1	3,170
Sacramento River Bank Modification	44,523
Fremont Weir Access Road Improvements	4,961

Component	Estimated Excess Excavated Material (cubic yards)
TOTAL	*595,336*

Reclamation or DWR would purchase land outside of the Bypass within two miles of the edge of the Yolo Bypass to receive this excess material. Alternative 2 would require 12 to 14 acres of land to spoil excess construction-related materials. This spoil site would be used for excess excavated soil and green waste. Other construction waste would be hauled to a landfill.

2.5.2.2 Construction Materials

Material imported to the project site would be obtained from existing permitted commercial sources located within approximately 65 miles of the project site. These sites and the associated haul routes would be the same as described for Alternative 1.

2.5.2.3 Staging Areas and Access

The construction easements for Alternative 2 would encompass staging areas for equipment, mobilization, and spoiling sites. The construction footprints analyzed in this EIS/EIR include space for staging areas. After construction, staging areas would be returned to pre-construction condition. Access roads would be the same as described for Alternative 1.

2.5.2.4 Construction Equipment

A list of the major equipment needs for the construction of both the alternative-specific and common downstream channel improvement actions is provided in Table 2-14. Equipment specifics may vary based on the contractor’s capabilities and the availability of equipment. Appendix B, *Constructability and Construction Considerations,* includes information on how many of each type of equipment would be used.

2.5.2.5 Construction Schedule and Workers

Construction of Alternative 2 likely would begin in 2020 or 2021 and is estimated to last 28 weeks. The construction schedule is the same as Alternative 1. The peak number of construction workers, which would be needed during one week in early August, is estimated to be 223.

Table 2-14. List of Major Equipment Needed for Construction of Alternative 2

List of Major Equipment	
• 0.8-CY backhoe loaders	• 4.5-CY hydraulic excavator
• 1.5-CY front end loader crawler	• 40-TN truck-mounted hydraulic crane
• 10-TN smooth roller	• 4,000-gallon water truck
• 100-TN off highway trucks	• 450-HP dozer
• 100-foot auger track-mounted drill rig	• 450-HP dozer crawler
• 12-foot blade grader	• 6-inch diameter pump engine drive
• 165-HP dozer	• 75-TN crane crawler pile hammer
• 2.5-CY hydraulic excavator	• Concrete mixer truck
• 2.5-inch diameter concrete vibrator	• Concrete pump boom, truck mounted
• 24-TN truck end dumps	• Extended boom pallet loader
• 3.5-CY hydraulic excavator	• Flatbed truck
• 3-axle haul trucks	• Haul truck oversize transport
• 30-CY scrapers	• Hydroseeding truck
• 300-kW generator	• Pickup trucks conventional

Key: CY = cubic yards; HP = horsepower; kW = kilowatt; TN = ton

2.5.3 Operations

Alternative 2 operations would be the same as those described for Alternative 1, but the gates would open when the river elevation rises above 15.8 feet (one foot above the gate invert elevation of 14.8 feet). Figure 2-13 shows a curve that represents the amount of water that would flow through the gated notch at different Sacramento River elevations.

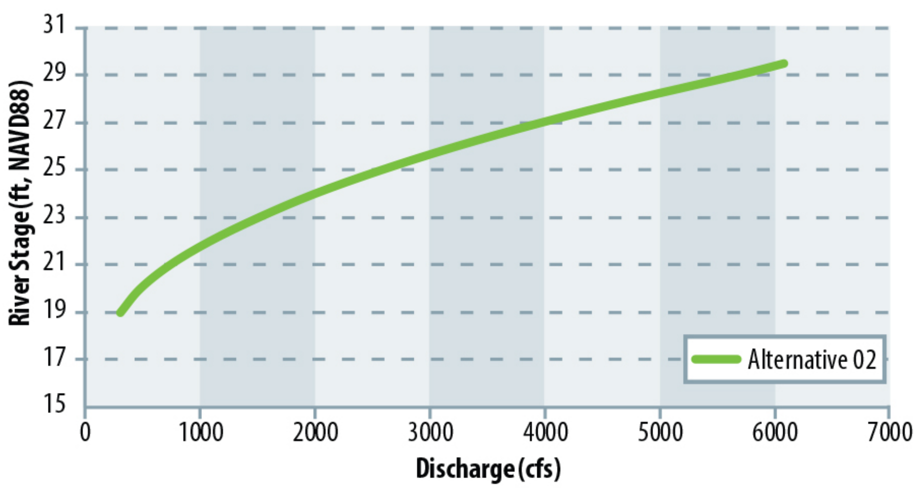


Figure 2-13. Flow through the Gated Notch at Different Sacramento River Elevations under Alternative 2

The headworks operations would be the same as described for Alternative 1. Each gate would have a dogging device to relieve the hydraulic operating equipment of the need to maintain pressure in order to keep the gates from lowering. Each control gate would be capable of independent operation via submersible hydraulic cylinders located beneath the gate.

2.5.4 Inspection and Maintenance

Maintenance activities associated with Alternative 2 mainly would include debris removal, sediment removal, and facility inspections. Inspection and maintenance would be the same as described for Alternative 1.

2.5.4.1 Sediment Deposition

The amount of sediment entering the Yolo Bypass under Alternative 2 would be the same as described for Alternative 1. The removal frequency, methods, and quantities would be the same as described for Alternative 1.

New areas that are constructed perpendicular to the direction of flow in the bypass would incur greater sedimentation deposition. The central gated notch location, based on its location along the weir and observations of existing debris stranding, likely would experience a higher occurrence of debris accumulation as compared to the west and east alignments. Therefore, debris removal in this area would be required and accomplished using an excavator or a crane.

2.5.4.2 Headworks Inspection and Debris Removal

The serviceability and proper function of gates, their actuators, controls, hydraulic cylinders, and the recessed areas for stoplogs and gates would be inspected at the beginning and end of the flood season and after overtopping events. Concrete spalling or severe cracking, material corrosion, or identified weakness would be noted and evaluated to determine whether repair or replacement is necessary. Sediment deposits or accumulated debris would be removed. Debris removal in and around the headworks would be accomplished using an excavator or a crane.

2.5.4.3 Vegetation Removal

Periodic vegetation and debris removal from project channels would be the same as described for Alternative 1.

2.5.5 Monitoring and Adaptive Management

Monitoring activities and the adaptive management framework would be the same as described for Alternative 1.

2.6 Alternative 3: West Side Gated Notch

Alternative 3, West Side Gated Notch, would provide a new gated notch through Fremont Weir similar to the notch described for Alternative 1. The primary difference between Alternatives 1 and 3 is the location of the notch; Alternative 3 would site the notch on the western side of Fremont Weir. This gated notch would be similar in size to Alternative 1 but would have an invert elevation that is higher (16.1 feet) because the river is higher at this location. The western location is on the outside of a river bend, similar to Alternative 2, but would be easier to access for operations and maintenance than a central location. The new gated notch would allow flow to pass into the Yolo Bypass at lower river elevations than under existing conditions where flows only enter the Yolo Bypass when Fremont Weir overtops.

Alternative 3 would include facilities to connect the gated notch to the existing Tule Pond. Alternative 3 would allow flows up to 6,000 cfs, depending on Sacramento River elevation, through the gated notch to provide open channel flow for adult fish passage, juvenile emigration, and floodplain inundation. This alternative would also include a supplemental fish passage facility on the eastern side of Fremont Weir and improvements downstream of Tule Pond as described in Section 2.3. Figure 2-14 shows the key components of Alternative 3 and the common elements described in Section 2.3.

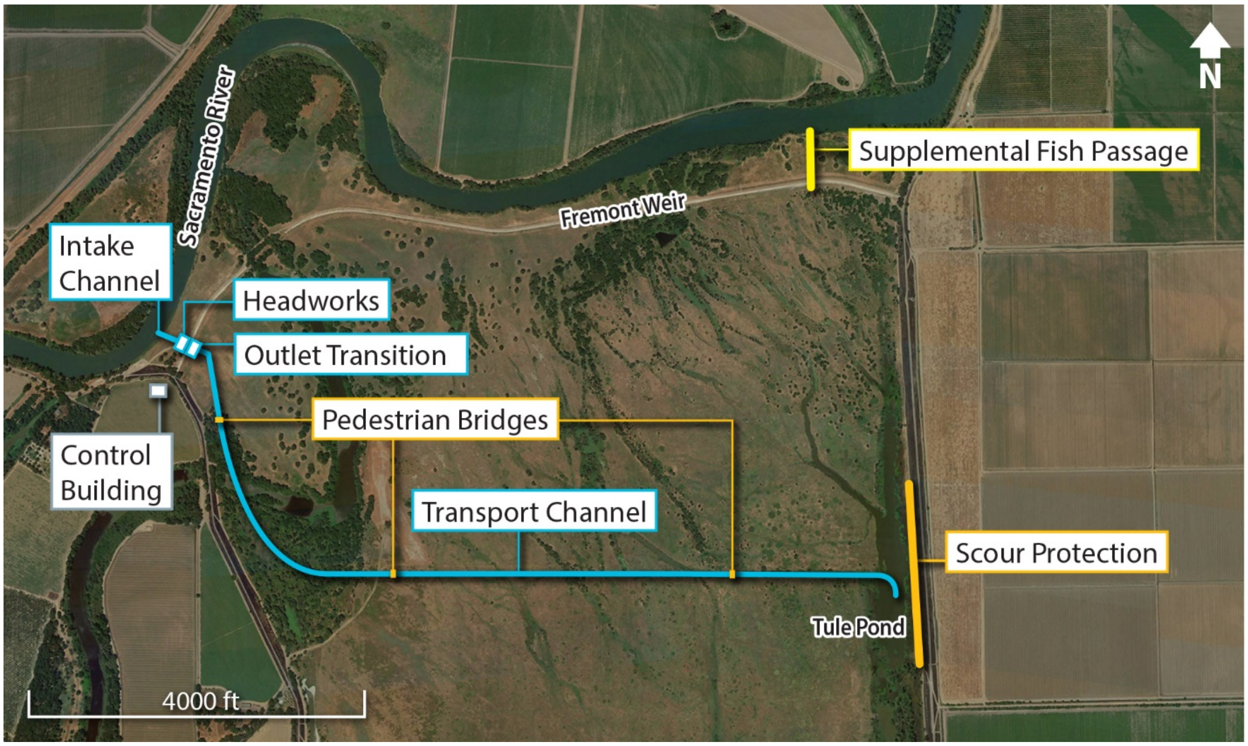


Figure 2-14. Alternative 3 Key Components

The next section includes descriptions of the facilities, construction methods, operations, required maintenance, and environmental commitments associated with this alternative. More detailed construction information is included in Appendix B, *Constructability and Construction Considerations.*

2.6.1 Facilities

2.6.1.1 Intake Channel

Similar to Alternative 1, the primary purpose of the intake channel is to draw juvenile salmonids and floodplain inundation flows from the Sacramento River to the new headworks structure (described in Section 2.6.1.2) and provide upstream adult fish passage between the headworks structure and the Sacramento River. The dimensions and design details would be the same as described for Alternative 1, but the channel would be located in a western location.

2.6.1.2 Headworks Structure

Because of the different location, the headworks structure in Alternative 3 would have a slightly different gate configuration than described for Alternative 1. The overall structure and foundation would be the same as described for Alternative 1, but the structure would be a little longer (the gate structure would be 114 feet compared to 108 feet for Alternative 1).

Three hydraulically operated, flush-mounted bottom hinge gates would be used in the headworks structure. These gates would be capable of operating under variable river elevations and overtopping events. The top of the gate elevation would be flush with the existing Fremont Weir (32 feet). The upstream face of the control gates would be approximately in-line with the upstream face of the existing Fremont Weir. When fully open, the gates would be flush with the channel invert. Table 2-15 presents the dimensions, invert elevation, and expected weight of the gates to be installed under this alternative. The layout of the facilities would be the same as described for Alternative 1 (Figures 2-5 and 2-6), including debris fins.

Table 2-15. Gate Specifications for Alternative 3

Gate	Height x Width (feet)	Invert Elevation (feet)	Expected weight (pounds)
1	16 x 40	16.1	65,000
2 and 3	12 x 27	20.1	40,000 each

2.6.1.3 Control Building

The control building would be a single-story concrete masonry unit, measuring 18 by 18 feet, located on the western levee. The building would house the same equipment as described for Alternative 1.

2.6.1.4 Access Structures

A reinforced concrete, three-span vehicular headworks bridge would be on the upstream side of Fremont Weir to connect to the existing access road. The bridge would span the channels through the new headworks structure.

Table 2-16 presents the bridge span corresponding to each control gate. The details of the headworks bridge, other than the span specifications, would be the same as discussed for Alternative 1.

Table 2-16. Bridge Span Specifications for Alternative 3

Gate	Bridge Span (feet)
1	40
2 and 3	27

The headworks bridge would provide a vehicular and pedestrian crossing on the north side of Fremont Weir. As discussed in Alternative 1, the channels south of Fremont Weir could be a barrier to access for recreational users in the Fremont Weir Wildlife Area. For this purpose, Alternative 3 includes three 185-foot-long, eight-foot-wide steel-trussed pedestrian bridges south of Fremont Weir (and north of Tule Pond), as shown in Figure 2-14.

2.6.1.5 Outlet Transition

The outlet transition from the headworks to the transport channel would be the same as described for Alternative 1.

2.6.1.6 Transport Channel

The transport (outlet) channel would be a graded trapezoidal channel with an interior bench. The channel would serve the same function as described for Alternative 1. Figure 2-8 shows the cross-section of the transport channel for Alternative 3 (the western location). The transport channel would cross the “oxbow” wetland area on the western side of the Yolo Bypass, but the channel would not have a hydraulic connection to the oxbow. A portion of the oxbow near the western Yolo Bypass levee would be filled to approximately existing grade, then the transport channel would be excavated through the filled section.

The main channel within the trapezoidal channel would have a bottom width of 50 to 60 feet. The bench would be on one side of the channel and elevated four feet above the main channel. The bench width would be approximately 30 feet. The trapezoidal side slopes would have 3:1 slopes (horizontal to vertical). The top of the channel would be approximately 180 feet wide. The channel would be about 10,180 feet long with a gradual downward slope toward Tule Pond (a slope of 0.0004). The entire channel would be lined with rounded rock revetment on the channel bottom and angular rock revetment on the bank slopes. At the top of each side of the channel, an eight-foot-wide area of rock (a rock key) would be added to reduce the potential for the channel to head cut the channel banks. The facility also would have a 12-foot-wide maintenance corridor at the top of each side of the channel.

2.6.1.7 Supplemental Fish Passage Facility

Alternative 3 would provide primary fish passage through the new gated notch on the western side of Fremont Weir. The improved fish passage facility at the existing fish ladder would provide passage immediately after an overtopping event near the center of Fremont Weir, but the eastern section of Fremont Weir is very long. To further improve fish passage from the Yolo Bypass into the Sacramento River after an overtopping event, Alternative 3 would include an additional fish passage facility at an eastern location along the existing Fremont Weir (see Figure 2-15). The supplemental fish passage channel would stretch over 500 feet and connect to the fish passage facility through a channel transition. The 10-foot-long channel transition facilitates the transition from the 10-foot width of the channel to the 15-foot width of the fish passage structure. The concrete fish passage structure would house an approximately 12-foot-wide hinge gate, a recessed air buffer, and a metal grate. The concrete wall of the fish passage structure would be flush with the top of the existing weir (elevation 32 feet).

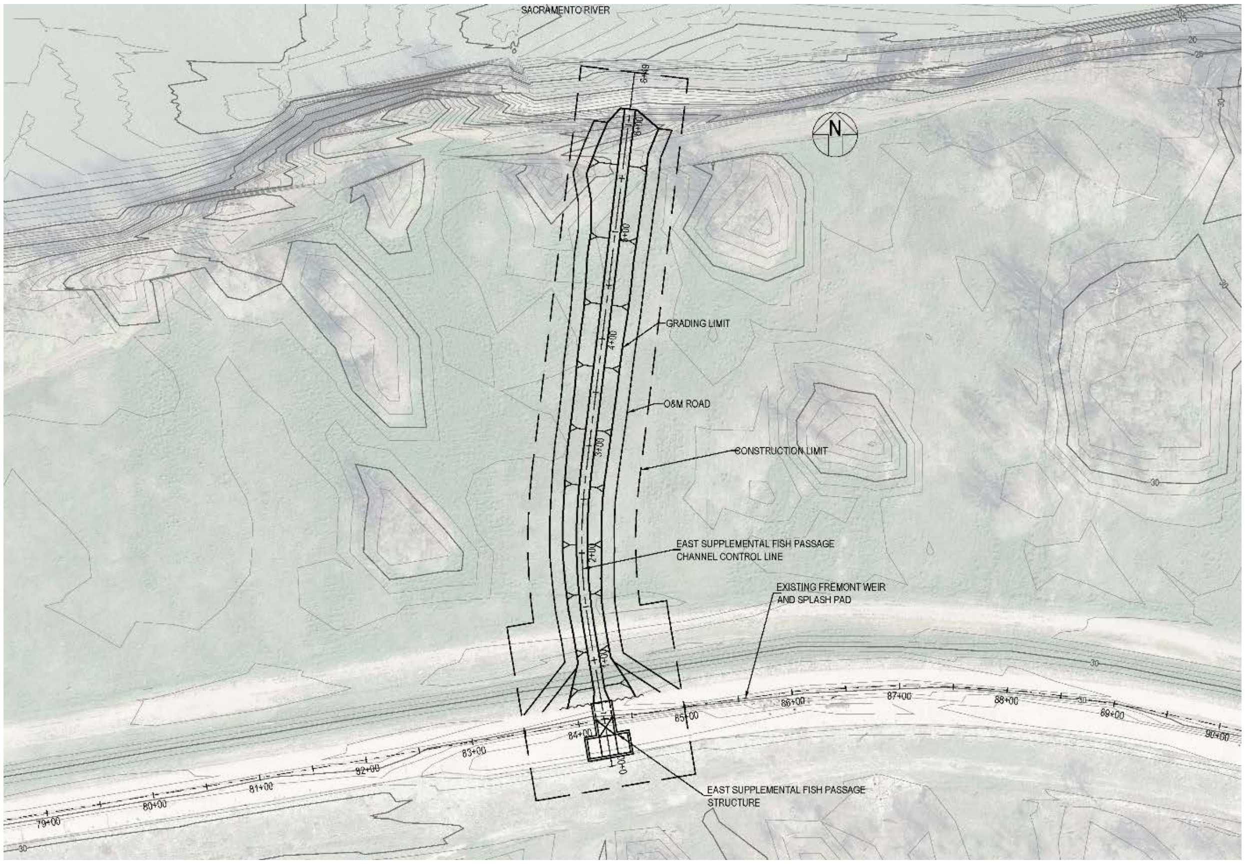


Figure 2-15. Eastern Supplemental Fish Passage

2.6.1.8 Scour Protection

The transport channel would enter Tule Canal at an angle, which could cause erosion on the eastern Yolo Bypass levee. Rock revetment would be placed on the eastern edge of Tule Pond that is 50 feet wide, 2,500 feet long, and 2.5 feet thick, with 1.5:1 side slopes (horizontal to vertical). Additionally, there are several locations along the proposed transport channel where the channel could interact with existing scour channels. These areas could experience head cutting as a result of the new facilities. Additional channel revetment would be incorporated at these locations; these improvements are included in the construction quantities.

2.6.2 Construction Methods

The construction methods and process would be very similar to those described for Alternative 1. Construction would start with demolition of Fremont Weir and continue with the headworks and channel construction.

2.6.2.1 Excavated Material

Alternative 3 would require excavation of the intake channel, transport channel, and downstream facilities. Table 2-17 shows the estimated quantities of excess excavated material that would be generated from each facility and would require removal from the construction area.

Table 2-17. Estimated Excess Excavated Material Quantities for Alternative 3

Component	Estimated Excess Excavated Material (cubic yards)
West Intake Channel	32,720
West Transport Channel	687,640
Headworks	6,460
Downstream Channel	72,520
Supplemental Fish Passage (East)	3,540
Agricultural Road Crossing 1	3,170
TOTAL	*806,050*

Reclamation or DWR would purchase land outside of the bypass within two miles of the edge of the Yolo Bypass to receive this excess material. Alternative 3 would require 17 to 20 acres of land to spoil excess construction-related materials.

2.6.2.2 Construction Materials

Material imported to the project site would be obtained from existing permitted commercial sources located within approximately 65 miles of the project sites. These sites and the associated haul routes would be the same as described for Alternative 1.

2.6.2.3 Staging Areas and Access

The construction easements for Alternative 3 would encompass staging areas for equipment, mobilization, and spoiling sites. The construction footprints analyzed in this EIS/EIR include space for staging areas. After construction, staging areas would be returned to pre-construction condition. Access roads would be the same as described for Alternative 1.

2.6.2.4 Construction Equipment

A list of the major equipment needs for the construction of both the alternative-specific and common downstream channel improvement actions is provided (Table 2-18). Equipment specifics may vary based on the contractor's capabilities and the availability of equipment. Appendix B, *Constructability and Construction Considerations*, includes information on how many of each type of equipment would be used.

Table 2-18. List of Major Equipment Needed for Construction of Alternative 3

List of Major Equipment	
• 0.8-CY backhoe loaders • 1.5-CY front end loader crawler • 10-TN smooth roller • 100-TN off highway trucks • 100-foot auger track-mounted drill rig • 12-foot blade grader • 165-HP dozer • 2.5-CY hydraulic excavator • 2.5-inch diameter concrete vibrator • 24-TN truck end dump • 3.5-CY hydraulic excavator • 3-axle haul trucks • 30-CY scrapers • 300-kW generator	• 4.5-CY hydraulic excavator • 40-TN truck-mounted hydraulic crane • 4,000-gallon water truck • 450-HP dozer crawler • 6-inch diameter pump engine drive • 75-TN crane crawler pile hammer • Concrete mixer truck • Concrete pump boom, truck mounted • Extended boom pallet loader • Flatbed truck • Haul truck oversize transport • Hydroseeding truck • Pickup trucks, conventional

Key: CY = cubic yards; HP = horsepower; kW = kilowatt; TN = ton

2.6.2.5 Construction Schedule and Workers

Construction of Alternative 3 likely would begin in 2020 or 2021 and is estimated to last 28 weeks. The construction schedule is the same as Alternative 1. The peak number of construction workers, which would be needed during one week in the middle of July, is estimated to be 277.

2.6.3 Operations

Alternative 3 operations would be the same as those described for Alternative 1, but the gates would open when the river elevation rises above 17.1 feet (one foot above the gate invert elevation of 16.1 feet). Figure 2-16 shows a curve that represents the amount of water that would flow through the gated notch at different Sacramento River elevations.

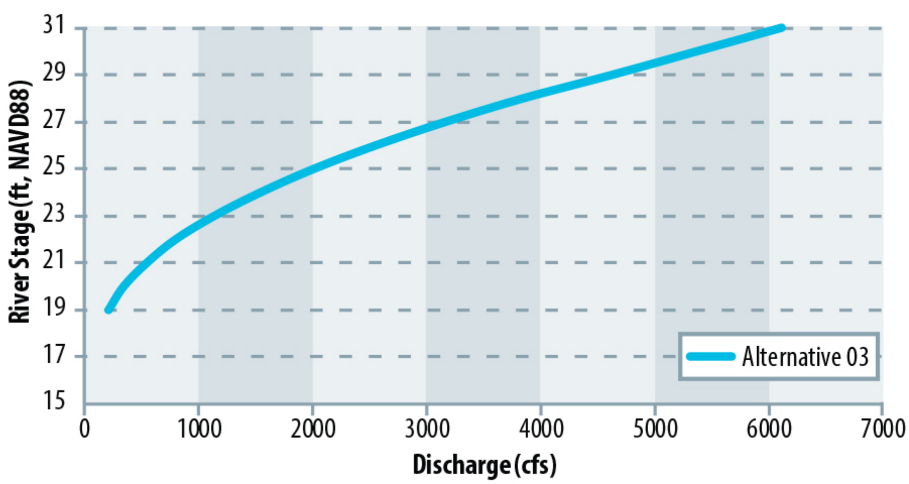


Figure 2-16. Flow through the Gated Notch at Different Sacramento River Elevations under Alternative 3

The headworks operations would be the same as described for Alternative 1. Each gate would have a dogging device to relieve the hydraulic operating equipment of the need to maintain pressure in order to keep the gates from lowering. Each control gate would be capable of independent operation via submersible hydraulic cylinders located beneath the gate.

2.6.4 Inspection and Maintenance

Maintenance activities associated with Alternative 3 would mainly include debris removal, sediment removal, and facility inspections. Inspection and maintenance would be the same as described for Alternative 1.

2.6.4.1 Sediment Deposition

The amount of sediment entering the Yolo Bypass under Alternative 3 would be the same as described for Alternative 1. The removal frequency, methods, and quantities would be the same as described for Alternative 1.

New areas that are constructed perpendicular to the direction of flow in the bypass would incur greater sedimentation deposition. This alignment (the western alignment) likely would have the highest amount of sedimentation and debris accumulation because it is the longest and has more changes in direction than the eastern or central alignments. Therefore, debris removal in this area would be required and accomplished using an excavator or a crane.

2.6.4.2 Headworks Inspection and Debris Removal

The serviceability and proper function of gates, their actuators, controls, hydraulic cylinders, and the recessed areas for stoplogs and gates would be inspected at the beginning and end of the flood season and after overtopping events. Concrete spalling or severe cracking, material corrosion, or identified weakness would be noted and evaluated to determine if repair or replacement is necessary. Sediment deposits or accumulated debris would be removed. Debris removal in and around the headworks would be accomplished by excavator or crane.

2.6.4.3 Vegetation Removal

Periodic vegetation and debris removal from project channels would be the same as described for Alternative 1.

2.6.5 Monitoring and Adaptive Management

Monitoring activities and the adaptive management framework would be the same as described for Alternative 1.

2.7 Alternative 4: West Side Gated Notch – Managed Flow

Alternative 4, West Side Gated Notch – Managed Flow, would have a smaller amount of flow entering the Yolo Bypass through the gated notch in Fremont Weir than the other alternatives, but it would incorporate water control structures to maintain inundation in defined areas for longer periods of time within the northern Yolo Bypass. Alternative 4 would include the same gated notch and associated facilities as described for Alternative 3. However, it would be operated to limit the maximum inflow to approximately 3,000 cfs.

Alternative 4 includes two water control structures on Tule Canal to extend periods of inundation locally. A bypass channel would be constructed around each water control structure to provide adult fish passage when the water control structures are controlling flow. This alternative would also provide means for fish passage on the eastern side of Fremont Weir through a supplemental fish passage facility. In addition, improvements to Agricultural Road Crossing 1 and the downstream channel would be implemented under this alternative (see Section 2.3). Figure 2-17 shows the key components of Alternative 4 and the common elements described in Section 2.3.

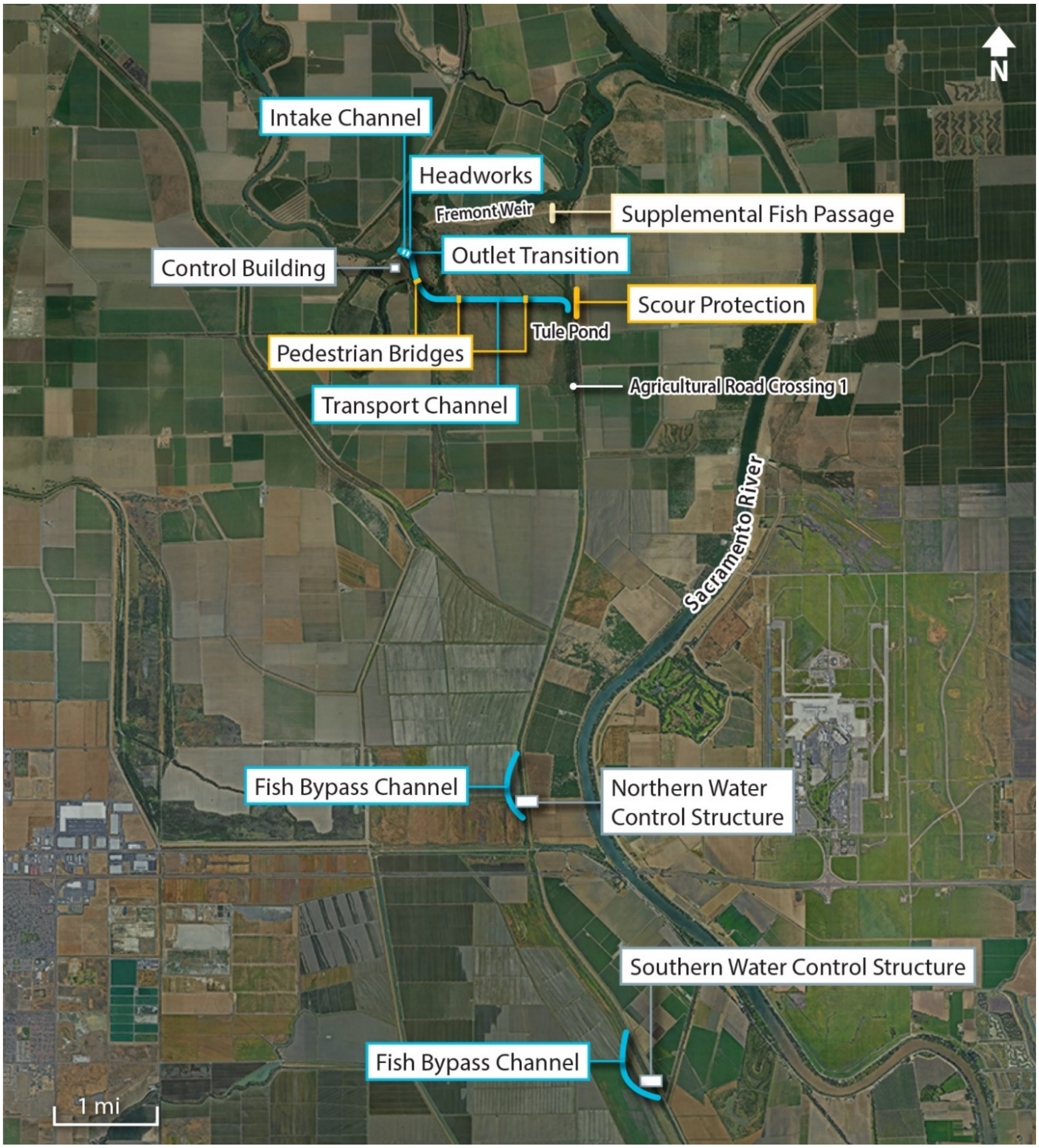


Figure 2-17. Alternative 4 Key Components

The next section includes descriptions of the facilities, construction methods, operations, required maintenance, and environmental commitments associated with this alternative. More detailed construction information is included in Appendix B, *Constructability and Construction Considerations.*

2.7.1 Facilities

The gated notch and associated facilities (intake channel, headworks, outlet transition, transport channel, control building, access structures, and supplemental fish passage) are identical to those described for Alternative 3. The decrease in flows through the gated notch would be accomplished through operations described in Section 2.7.3. This section focuses on the features that are unique to Alternative 4, including the water control structures and bypass channels.

Two bypass channels would be constructed, each as an open channel sized for 300 cfs with a 10-foot-bottom width and 3:1 side slopes. The channel near the northern water control structure would be approximately 3,275 feet long, whereas the channel near the southern water control structure would be 4,180 feet long. The channels would have no operable weir features.

2.7.1.1 Northern Water Control Structure

The northern water control structure would be just north of CR 22, as shown in Figure 2-18. The water control structure would be used to manage water levels upstream from this facility and pond water to increase duration of flooded fish-rearing habitat above this location. The concrete water control structure would include three 16-foot-wide “Obermeyer”-style inflatable gates, or bladder-type dams, that would raise to maintain water levels at an elevation of 21.5 feet. Figure 2-19 shows a picture of an Obermeyer gate with inflatable bladders that raise the gate. The structure would have a concrete bridge on top of the structure for access. It would have sheet pile walls that tie into the Tule Canal banks.

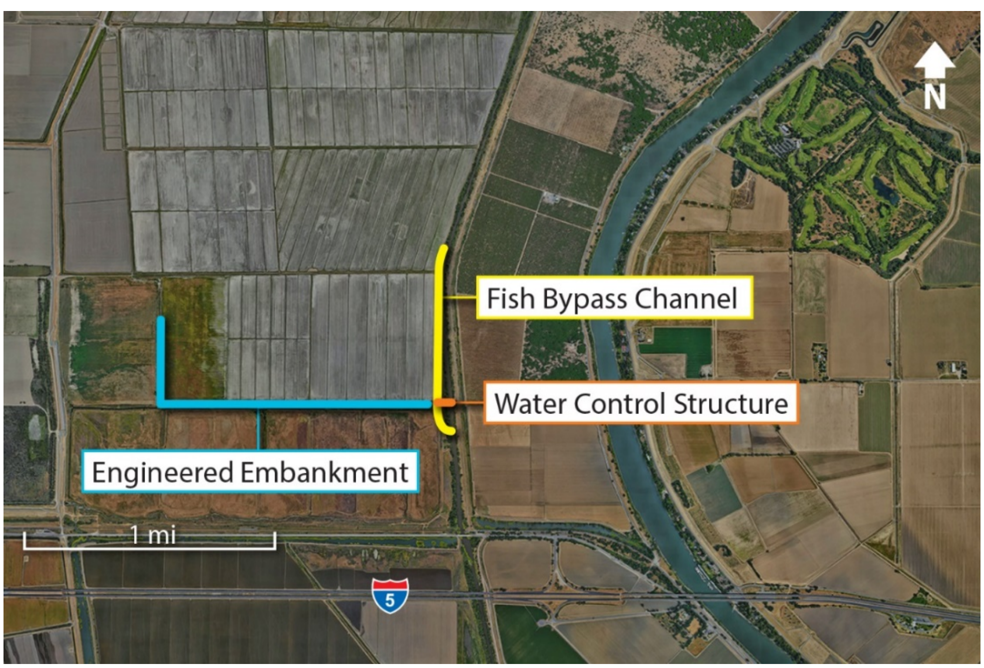


Figure 2-18. Northern Water Control Structure and Bypass Channel

Figure 2-19. Example of Obermeyer-Style Inflatable Gates

When the gates are raised, they would block fish passage through Tule Canal. To reduce fish passage delays, a bypass channel would go around the water control structure, as shown in Figure 2-18. The bypass channel would be an open, trapezoidal channel with a 10-foot-bottom width and 3:1 side slopes. Berms (two to five feet in height) would be constructed on each side of the channel to maintain water levels in the bypass channel. The channel would include two areas where it would be constricted down to a five-foot-bottom width for 60 feet. This constriction would help slow the water and meet fish passage criteria. Figure 2-20 shows a cross-section schematic of the bypass channel next to Tule Canal. The channel would be approximately 3,275 feet long with no operable features in the bypass channel. It would convey up to 300 cfs. The bypass channel would include a box culvert adjacent to the water control structure to allow vehicular access across both facilities.

An engineered, armored embankment would be added in the area of existing roads or berms west and north of the water control structure to maintain water levels north of the water control structure. This embankment would add two to six feet above the surrounding ground. The engineered embankment would be about 7,200 linear feet, as shown in Figure 2-18. The embankment would be designed to have a top elevation of 23 feet inside the Yolo Bypass.

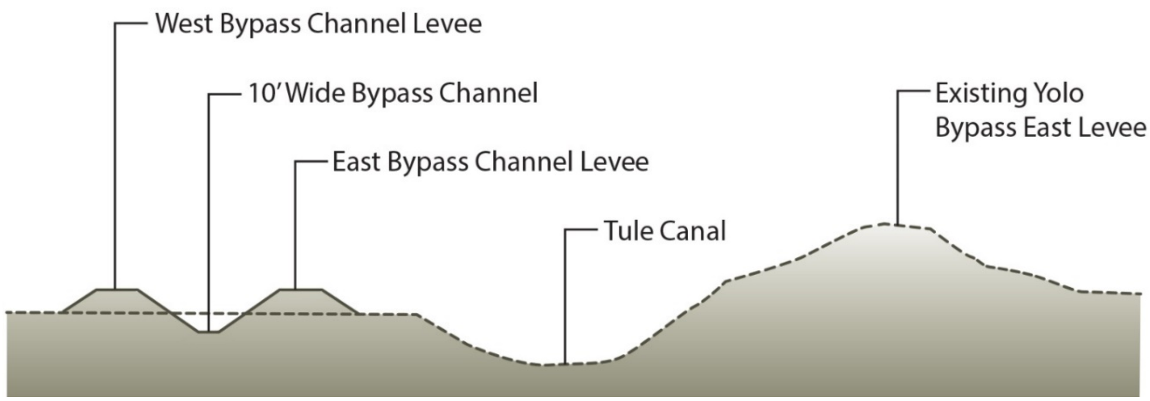


Figure 2-20. Cross-Section of Bypass Channel

2.7.1.2 Southern Water Control Structure

The southern water control structure would be south of CR 22 and north of the Sacramento Weir, as shown in Figure 2-21. The water control structure would be used to manage water levels upstream from this facility and pond water to increase rearing habitat. The concrete water control structure would include three 16-foot-wide Obermeyer-style inflatable gates or bladder-type dams that would raise to maintain water levels at an elevation of 17.5 feet. The structure would include a concrete bridge on top of the structure for access. It would have sheet pile walls that tie into the Tule Canal banks.

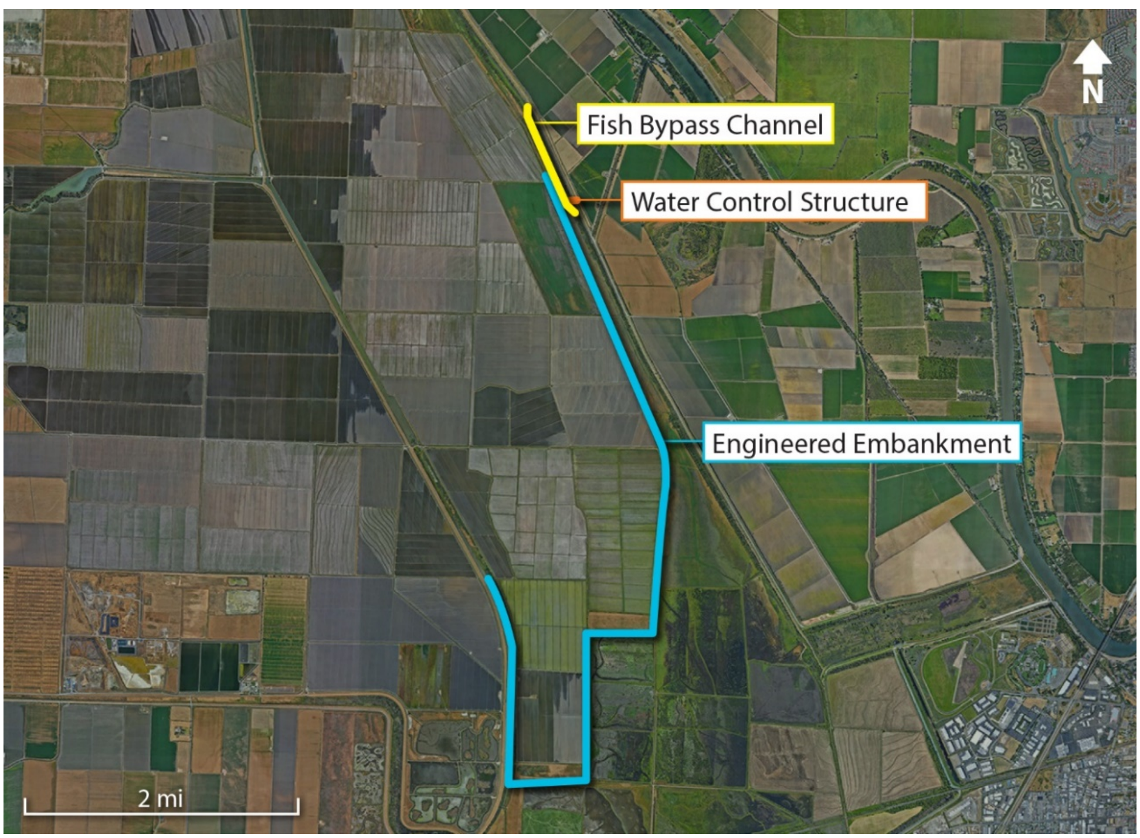


Figure 2-21. Southern Water Control Structure and Bypass Channel

When the gates are raised, they would block fish passage through Tule Canal. To reduce fish passage delays, a bypass channel would go around the water control structure, as shown in Figure 2-21. The bypass channel would be an open, trapezoidal channel with a 10-foot-bottom width and 3:1 side slopes. Berms would be constructed on each side of the channel to maintain water levels in the bypass channel. The cross-section would be similar to the northern channel, as shown in Figure 2-20. The channel would be roughly 4,180 feet long with no operable features in the bypass channel (but existing agricultural facilities would be maintained). The channel would convey up to 300 cfs. The bypass channel would include a box culvert adjacent to the water control structure to allow vehicular access across both facilities.

An engineered embankment (armored with rock) would be constructed along the alignments of existing roads or berms south then west of the water control structure to maintain water levels north of the water control structure. The existing berms would be degraded and rebuilt to meet the stability requirements to hold back water. The rebuilt embankments would be two to six feet above the existing grade on the surrounding property. The engineered embankment would be about 37,870 linear feet, as shown in Figure 2-21. The embankment would be designed to have a top elevation of 19 feet inside the Yolo Bypass.

2.7.2 Construction Methods

Construction of the intake channel, headworks, transport channel, Agricultural Road Crossing 1, and the downstream channel improvements would follow the same construction methods as discussed for Alternative 3.

The water control structures would be constructed in Tule Canal, which has a non-flood flow of approximately 1,000 cfs that would need to be maintained during the construction period. Construction would begin by creating a temporary bypass channel around the construction site to convey these flows, and then cofferdams would be installed upstream and downstream of the site with dewatering pumps to dry out the construction site. The bypass channel construction would mostly be in dry areas except for the transitions to Tule Canal.

2.7.2.1 Excavated Material

The intake channel, headworks, transport channel, downstream channel, and Agricultural Road Crossing 1 improvements under Alternative 4 would be the same as described for Alternative 3, so the excess excavated material would be the same as shown in Table 2-17. Additionally, construction activities would occur at the two water control structures and bypass channels. The excavated materials from these facilities would be re-used to construct the berms on the bypass channel and the engineered embankments. Table 2-19 shows the estimated quantities of material that would be excavated or required for fill during construction of the water control structures and bypass channels.

Table 2-19. Estimated Material Quantities for Water Control Structures in Alternative 4

Component	Net Fill (cubic yards)	Net Excavation (cubic yards)	Net Material (cubic yards)
Northern Water Control Structure and Bypass Channel	75,000	65,000	10,000 Borrow Need
Southern Water Control Structure and Bypass Channel	178,000	134,000	44,000 Borrow Need

The borrow need would be met from excess material generated during construction of the gated notch and channel at Fremont Weir. Reclamation or DWR would purchase land within two miles of the edge of the Yolo Bypass to receive excess material. Alternative 4 would require 16 to 19 acres of land to spoil excess construction-related materials.

2.7.2.2 Construction Materials

Material imported to the project site would be obtained from existing permitted commercial sources located within approximately 65 miles of the project sites. These sites and the haul routes would be the same as described for Alternative 1.

2.7.2.3 Staging Areas and Access

The construction easements for Alternative 4 would encompass staging areas for equipment, mobilization, and spoiling sites. The construction footprints analyzed in this EIS/EIR include space for staging areas. After construction, staging areas would be returned to pre-construction condition. Site access for work at Fremont Weir and in the Fremont Weir Wildlife Area would be the same as described for Alternative 1.

Construction access for the northern water control structure would be via I-5 to CR 117. The route would then follow CR 22 north onto existing agricultural roads in the bypass. CRs 22 and 117 are paved rural two-lane roads that, based on preliminary site assessment visits, are anticipated to sufficiently accommodate minor construction traffic associated with equipment and material haul for site mobilization. The agricultural roads are basic dirt roads that would need to be maintained during construction to accommodate construction traffic equipment.

Construction access for the southern water control structure would be via I-5 to CR 117 to CR 22, then south onto existing agricultural roads for the northern end of the project. The southern end of the project would be accessed via I-5 to CR 102 to CR 28H, then onto the west bypass levee down to existing agricultural roads. CRs 22, 117, 102, and 28H are paved rural two-lane roads that, based on preliminary site assessment visits, are anticipated to sufficiently accommodate minor construction traffic associated with equipment and material haul for site mobilization. The levee and agricultural roads are basic dirt roads that would need to be maintained during construction to accommodate construction traffic equipment.

2.7.2.4 Construction Equipment

A list of the major equipment needs for the construction of both the alternative-specific and common downstream channel improvement actions is provided (Table 2-20). Equipment specifics may vary based on the contractor’s capabilities and the availability of equipment.

Appendix B, *Constructability and Construction Considerations,* includes information on how many of each type of equipment would be used.

Table 2-20. List of Major Equipment Needed for Construction of Alternative 4

List of Major Equipment	
• 0.8-CY backhoe loaders • 1.5-CY front end loader crawler • 10-TN smooth roller • 100-TN off highway trucks • 100-foot auger track-mounted drill rig • 12-foot blade grader • 165-HP dozer • 2.5-CY hydraulic excavator • 2.5-inch diameter concrete vibrator • 24-TN truck end dump • 3.5-CY hydraulic excavator • 3-axle haul trucks • 30-CY scrapers • 300-kW generator	• 4.5-CY hydraulic excavator • 40-TN truck-mounted hydraulic crane • 4,000-gallon water truck • 450-HP dozer crawler • 6-inch diameter pump engine drive • 75-TN crane crawler pile hammer • Concrete mixer truck • Concrete pump boom, truck mounted • Extended boom pallet loader • Flatbed truck • Haul truck oversize transport • Hydroseeding truck • Pickup trucks, conventional

Key: CY = cubic yards; HP = horsepower; kW = kilowatt; TN = ton

2.7.2.5 Construction Schedule and Workers

Construction of Alternative 4 likely would begin in 2020 or 2021 and is estimated to last 28 weeks. The construction schedule for the gated notch and associated facilities in Fremont Weir Wildlife Area is the same as Alternative 1. Construction of channel improvements, including water control structures and bypass channels, would be completed concurrently with construction on the headworks facility.

Construction would occur 6 days per week for 10 hours per day between 7 a.m. and 6 p.m. Construction workers would be divided into multiple crews and would work one shift a day. Maintenance and equipment upkeep crews would work on equipment at night when it is not in use. The peak number of construction workers, which would be needed for one week in the middle of July, is estimated to be 363.

2.7.3 Operations

The goal of Alternative 4 operations is to increase rearing time and food production in the bypass while managing flows. Under Alternative 4, the Fremont Weir gates would be operated to limit flows to 3,000 cfs. Gate operations could begin each year on November 1 and would first open based on river conditions. All gates would be opened when the river elevation at this location reaches 17.1 feet, which is one foot above the lowest gate invert. If the river continues to rise, the gates would stay open until the flow through the gates reaches 3,000 cfs. Figure 2-22 shows a curve that represents the amount of water that would flow through the gated notch at different Sacramento River elevations. The flow through the gates would reach 3,000 cfs when the river elevation is about 26.6 feet; at this point, the two smaller gates would be programmed to start closing to maintain flows of 3,000 cfs . The flow may fluctuate so that it is a little higher or a little lower than 3,000 cfs during this time. Gate closures would be controlled so that there is not a sudden reduction in flow. Gate 1, the larger gate, would remain fully open throughout operations.

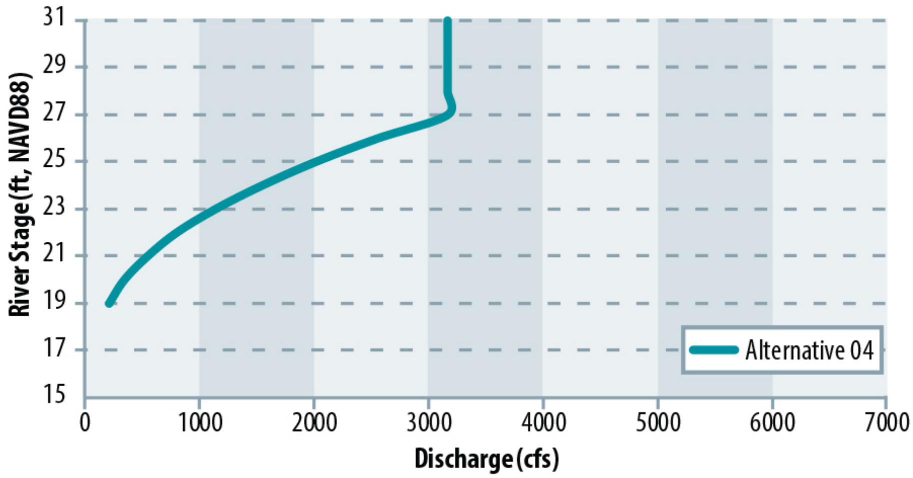


Figure 2-22. Flow through the Gated Notch at Different Sacramento River Elevations under Alternative 4

Once Fremont Weir begins to overtop, the smaller gates would remain in their last position prior to the weir overtopping (generally both would be closed at this point). After the overtopping event is over, the smaller gates would open and close as needed to keep the flow through the gate as close as possible to 3,000 cfs. The notch would close when the river falls below an elevation of 16.1 feet. Gate operations to increase inundation could continue through March 7 or March 15 of each year, based on hydrologic conditions. The gates may remain partially open after March 7 or March 15 to provide adult fish passage. However, flows through the gates after March 7 or March 15 could not exceed the available capacity of Tule Canal (typically about 300 cfs) so that these flows do not inundate areas outside of the canal and affect landowners.

Under Alternative 4, Reclamation and DWR would not select a different inundation end date (March 7 or March 15) each year. This EIS/EIR analyzes the potential impacts and benefits from each end date, and if this alternative is selected, Reclamation and DWR would use this analysis as a basis to select one end date in their decision documents.

Water control structures in Tule Canal would be raised when the notch is open. The northern water control structure would be managed to achieve a target water surface elevation of 21.5 feet. The southern water control structure would be managed to achieve a target water surface elevation of 17.5 feet. As canal stage rises above the target elevation, the water control structure gates would begin to lower so that the elevation is held constant. The gates would remain lowered after March 7 or March 15.

2.7.4 Inspection and Maintenance

Maintenance activities associated with Alternative 4 would mainly include debris removal, sediment removal, and facility inspections. Inspection and maintenance for the headworks, channels, and associated facilities would be the same as described for Alternative 3.

2.7.4.1 Sediment Deposition

Estimates indicate that approximately 659,000 cubic yards of sediment enter the bypass annually under existing conditions. A portion of this sediment settles in the Yolo Bypass and must be removed through current maintenance efforts. Alternative 4 would increase sediment entering the bypass to an estimated total of 701,000 cubic yards annually. About 25 percent would settle south of Agricultural Road Crossing 1 but north of Interstate 80, and the remaining 30 percent of sediment would remain in suspension and flow out of the bypass. Most of the sediment that settles out would be removed through flood maintenance in the Fremont Weir Wildlife Area, as under existing conditions. Alternative 4 would accumulate an additional 18,900 cubic yards of sediment annually that would be removed every five years.

2.7.4.2 Water Control Structures

The areas around the water control structures and the bypass channels would need to be inspected periodically to identify areas where sedimentation may be reducing the size of the bypass channel and affecting fish passage at the facilities. If inspections find that sedimentation is causing fish passage concerns, Reclamation or DWR would remove sediment to restore fish passage capability.

2.7.5 Monitoring and Adaptive Management

Monitoring activities and the adaptive management framework would be the same as described for Alternative 1.

2.8 Alternative 5: Central Multiple Gated Notches

Through the strategy of using multiple gates and intake channels at Fremont Weir, Alternative 5, Central Multiple Gated Notches, has the goal of increasing the number of out-migrating juvenile fish that enter the Yolo Bypass. Trapezoidal channels create some limitations for fish passage because they have smaller flows at lower river elevations (because the channel is smaller at this elevation) when winter-run Chinook salmon are out-migrating. Alternative 5 includes multiple gates so that the deeper gate could allow more flow to enter the bypass when the river is at lower elevations. Flows would move to other gates when the river is higher to control inflows while maintaining fish passage conditions.

Alternative 5 incorporates multiple gated notches in the central location on the existing Fremont Weir that would allow combined flows of up to 3,400 cfs. As the river rises, the deeper gate would close and the next gate would open. This alternative would include a supplemental fish passage facility on the western side of Fremont Weir and improvements to allow fish to pass through Agricultural Road Crossing 1 (see Section 2.3). Figure 2-23 shows the key components of this alternative.

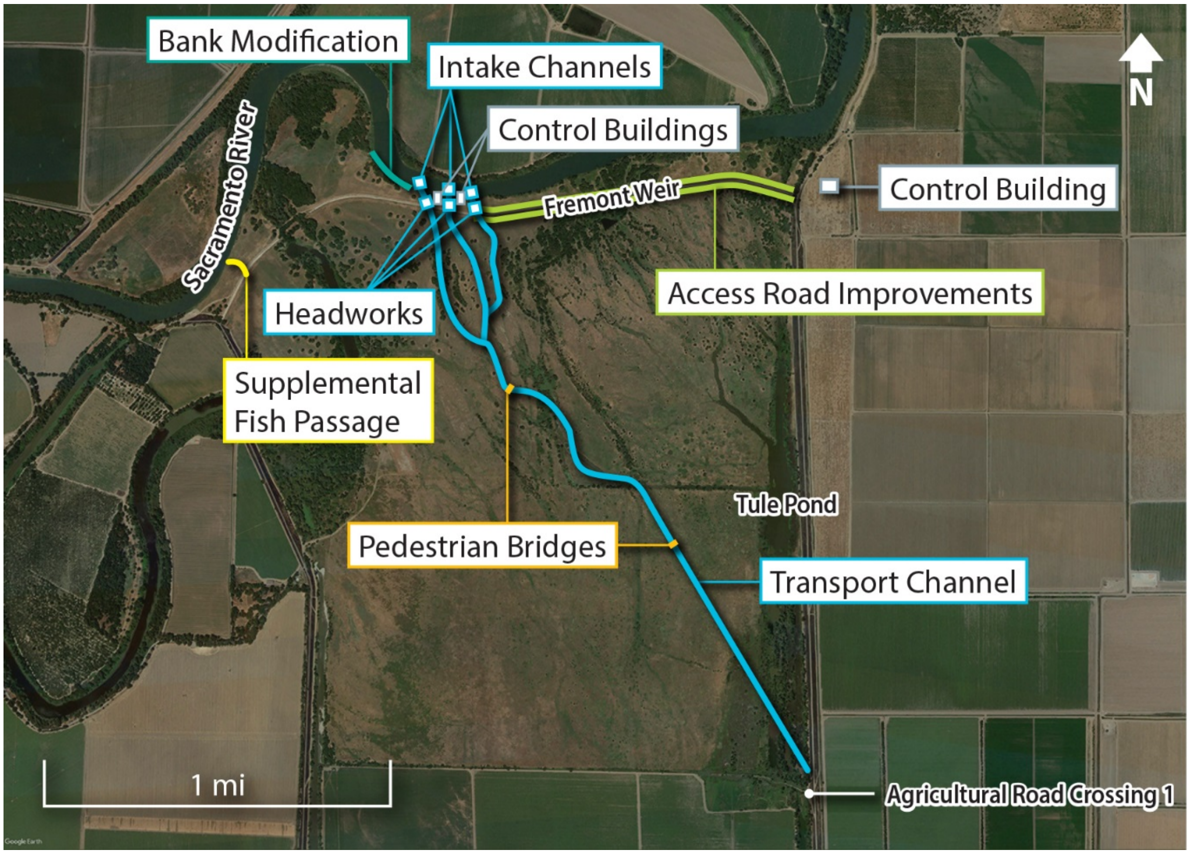


Figure 2-23. Alternative 5 Key Components

The next section includes descriptions of the facilities, construction methods, operations, required maintenance, and environmental commitments associated with this alternative. More detailed construction information is included in Appendix B, *Constructability and Construction Considerations.*

2.8.1 Facilities

2.8.1.1 Intake Channel

Alternative 5 includes four gated headworks, with two sets of gates co-located in the westernmost location of the structures. Each headworks structure would be connected to the Sacramento River with an intake channel. Also, the Sacramento River bank just upstream and along the intake channel would be modified by removing roughage (existing rock revetment, piles, and large wood) in the wetted channel, resloping the bed and embankment contours, and smoothing channel edges along the intake channel. The channels would be lined with angular rock placed along the bank slopes and rounded rock placed along the channel bottom to avoid scour.

2.8.1.2 Headworks Structure

The headworks structure would house four sets of bottom-hinge control gates with varying invert elevations, as shown in Figures 2-24 and 2-25. . Gates A and B would be located on the west side of the structure (at the central notch location at the existing Fremont Weir), Gate C would be in the middle, and Gate D would be on the eastern side of the structure. The structure would be foundationally supported by multiple 24-inch square piles with the bottom of the pile at elevation of 75 feet below NAVD 88. The gate dimensions are as follows:

- Gate group A includes three culverts with 10-foot-high by 10-foot-wide gates, with an invert set at 14 feet.
- Gate group B includes three culverts with gates that would be the same size as Gate A, with an invert set at 17 feet. These are in the same location as Gate A.
- Gate group C includes 10 box culverts with gates that would be 10 feet high by 10 feet wide, with an invert set at 20 feet.
- Gate group D includes 11 box culverts with gates that would be 10 feet wide by 7 feet high, with an invert set at 23 feet.

All box culverts include downstream bottom-hinged gates.

2.8.1.3 Control Buildings

Due to the maximum distance over which hydraulic lines can function, two types of control buildings are required: a control building on the east levee and two elevated control buildings near the gates. The operating control building on the east levee would be the same as described for Alternative 2.

Alternative 5 would include two additional elevated control buildings to house the hydraulics controls on the river side of the weir near the headworks structures. The buildings would be of similar size and construction as the operating control structure on the east levee but would be raised above the probable maximum flood elevation. The foundation of the raised buildings would consist of H-piles, a reinforced concrete pile cap, and a pair of streamlined reinforced concrete columns on which the building slab would rest.

2.8.1.4 Transport Channel

Alternative 5 includes three meandering transport channels between the intakes and the point where they come together, about 2,000 feet downstream from Fremont Weir. At this point, one channel flows toward to Tule Canal, near Agricultural Road Crossing 1 (see Figure 2-23). A description of the three channels follows:

- Channel AB would connect A and B gate groups to the Tule Canal and would be a rock-lined compound trapezoidal channel 2,250 feet long with a left bench set three feet above the channel bed.

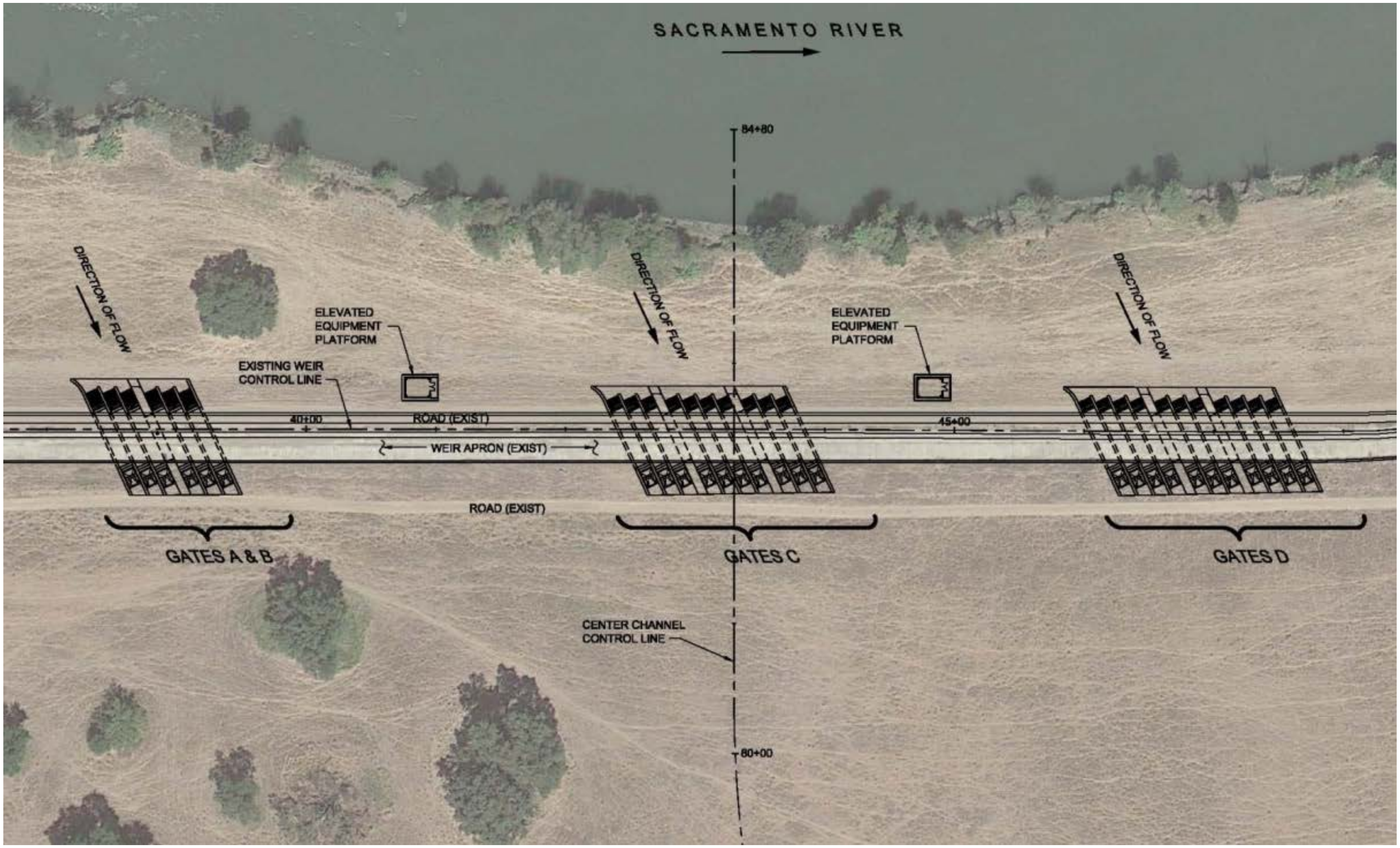


Figure 2-24. Alternative 5 Headworks (view from top looking down)

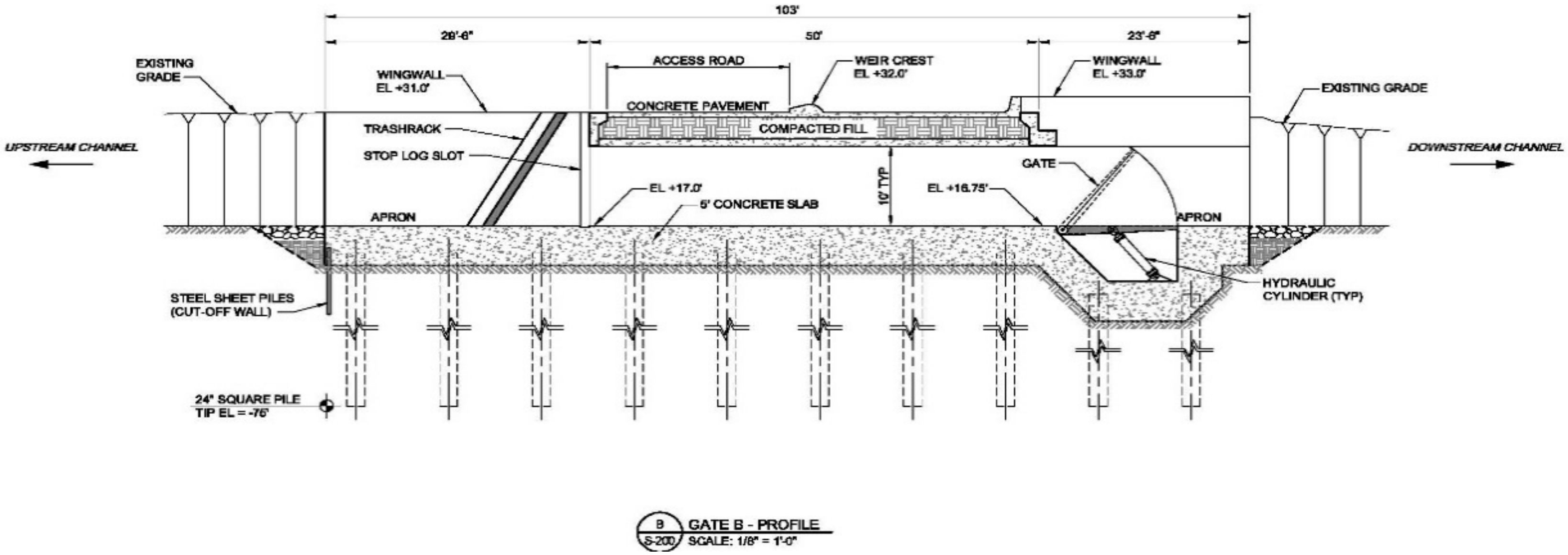


Figure 2-25. Alternative 5 Headworks (view from side of Gate Group B)[5]

[5] Figure 2-25 shows a trash rack on the headgates, but this feature has been removed as part of the process to refine alternatives and avoid impacts.

- Channel C would connect the C gate group to the Tule Canal and would be a rock-lined trapezoidal channel 1,930 feet long that connects to Channel AB at its bench.
- Channel D would connect the D gate group to the Tule Canal and would be a rock-lined trapezoidal channel 1,400 feet long that connects to Channel C.

Channel side slopes generally would be 3:1, and a 12-foot-wide maintenance access would be created on either side of each channel. From the point where all three channels are connected, the channel length would be about 8,500 feet to the connection with Tule Canal near Agricultural Road Crossing 1, with a gently downhill slope (a slope of 0.00014).

2.8.1.5 Access Structures

The design of the gates in Alternative 5 includes an area of compacted fill that would allow vehicular passage (see Figure 2-25). Alternative 5 also includes two 200-foot-long, eight-foot-wide steel-trussed pedestrian bridges (see Figure 2-23) to allow recreational users to move through the area when inundation starts, similar to the other alternatives. Similar to Alternative 2, Alternative 5 includes stabilized access roads on the north and south sides of Fremont Weir.

2.8.1.6 Supplemental Fish Passage Facility

An additional fish passage facility would be constructed at a western location along the existing Fremont Weir. This facility would be the same as described for Alternative 1.

2.8.1.7 Tule Canal Floodplain Improvements (Program Level)

Alternative 5 would include floodplain improvements along Tule Canal, just north of I-80. These improvements would not be constructed at the same time as the remaining facilities. They would not be necessary for the project-level components to function but would enhance the performance of the overall alternatives. They are included at a program level of detail to consider all of the potential impacts and benefits of Alternative 5. Subsequent consideration of environmental impacts would be necessary before construction could begin.

The floodplain improvements would develop a series of channels that connect to Tule Canal north of I-80 (see Figure 2-26). These channels would increase inundation and available fish-rearing habitat in the surrounding areas, which are currently managed as wetland habitat for waterfowl. The floodplain improvement channels would have a 30-foot-bottom width with 3:1 side slopes (horizontal to vertical). An operable weir in Tule Canal would help increase the water surface elevation upstream and move water into these channels. These improvements also include a bypass channel around the weir with a 10-foot-bottom width and 3:1 side slopes (horizontal to vertical). The bypass channel would be about 2,100 feet long and convey up to 300 cfs.

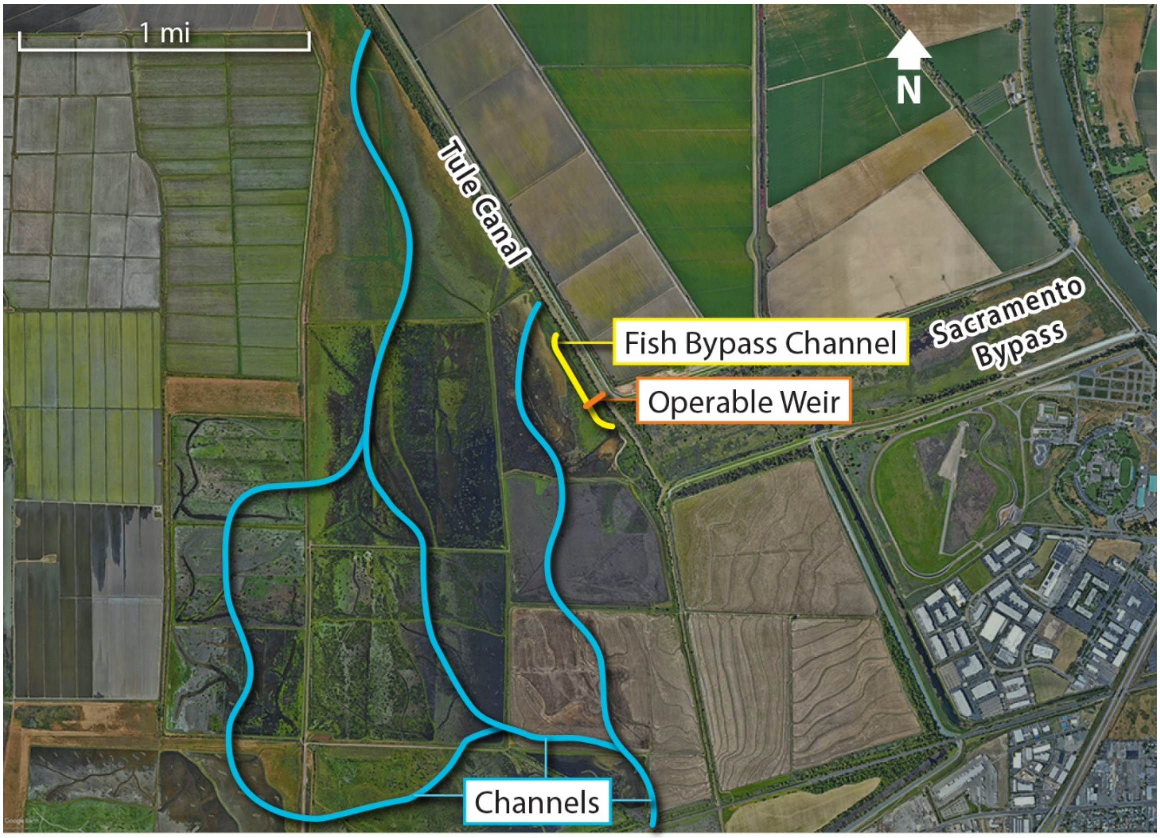


Figure 2-26. Tule Canal Floodplain Improvements (Program Level)

2.8.2 Construction Methods

Construction of the components of Alternative 5 would begin with the demolition of a portion of the existing concrete weir and the clearing and grubbing associated with the channels and canals. These activities are expected to be completed within eight weeks. Groundwater levels are anticipated to be high, especially in the spring months, so dewatering efforts prior to the construction of the floodway control and diversion structures are currently estimated to take three weeks. Additional dewatering would be required for the material removal and regrading at the bank of the Sacramento River near the intake channel.

Channel excavation would begin early in the construction efforts, with an estimated five construction crews working concurrently on the initial excavation. Grading efforts likely would start at the southern portion of the Fremont Weir Wildlife Area because groundwater levels would be deeper in this part of the construction area at the beginning of the construction season. With multiple crews, construction may proceed in multiple locations. The channel excavations would be completed under both dry and wet conditions (approximately 80 percent dry and 20 percent wet) and would not require dewatering efforts. Excavation of the downstream portion of the transport channel (near Agricultural Road Crossing 1) would be performed under wet conditions.

2.8.2.1 Excavated Material

Alternative 5 would require excavation of the intake channels, transport channels, and downstream facilities. Table 2-21 shows the estimated quantities of excess excavated material that would be generated from each facility and would require removal from the construction area.

Table 2-21. Estimated Excess Excavated Material Quantities for Alternative 5

Component	Estimated Excess Excavated Material (cubic yards)
Intake and Transport Channels	956,776
Headworks	28,710
Supplemental Fish Passage (West)	3,230
Agricultural Road Crossing 1	3,170
Sacramento River Bank Modification	44,523
Fremont Weir Access Road Excavation	4,961
TOTAL	*1,041,370*

In addition to the components included in Table 2-21, Alternative 5 could include additional Tule Canal floodplain grading (analyzed at a program level in this EIS/EIR, as described in Section 2.8.1.7). This Tule Canal floodplain grading would generate an estimated 1,053,970 cubic yards of material. If this element were constructed, the total excess materials would be 2,095,340 cubic yards.

Reclamation or DWR would purchase land within two miles of the edge of the Yolo Bypass to receive this excess material. Alternative 5 would require 69 to 79 acres of land to spoil excess construction-related materials.

2.8.2.2 Construction Materials

Material imported to the project site would be obtained from existing permitted commercial sources located within approximately 65 miles of the project sties. These sites and the haul routes would be the same as described for Alternative 1.

2.8.2.3 Staging Areas and Access

The construction easements for Alternative 5 would encompass staging areas for equipment, mobilization, and spoiling sites. The construction footprints analyzed in this EIS/EIR include space for staging areas. After construction, staging areas would be returned to pre-construction condition. Site access would be on the same roads as described in Alternative 1. If the Tule Canal floodplain improvements are constructed, access would follow the same routes as described for the southern water control structure under Alternative 4.

2.8.2.4 Construction Equipment

A list of the major equipment needs for the construction of both the alternative-specific and common downstream channel improvement actions is provided in Table 2-22. Equipment specifics may vary based on the contractor’s capabilities and the availability of equipment.

Table 2-22. List of Major Equipment Needed for Construction of Alternative 5

List of Major Equipment	
• 0.8-CY backhoe loaders	• 4.5-CY hydraulic excavator
• 1.5-CY front end loader crawler	• 40-TN truck-mounted hydraulic crane
• 10-TN smooth roller	• 4,000-gallon water truck
• 100-TN off highway trucks	• 450-HP dozer crawler
• 100-foot auger track-mounted drill rig	• 6-inch diameter pump engine drive
• 12-foot blade grader	• 75-TN crane crawler pile hammer
• 165-HP dozer	• Concrete mixer truck
• 2.5-CY hydraulic excavator	• Concrete pump boom, truck mounted
• 2.5-inch diameter concrete vibrator	• Extended boom pallet loader
• 24-TN truck end dump	• Flatbed truck
• 3.5-CY hydraulic excavator	• Haul truck oversize transport
• 3-axle haul trucks	• Hydroseeding truck
• 30-CY scrapers	• Pickup trucks, conventional
• 300-kW generator	

Key: CY = cubic yards; HP = horsepower; kW = kilowatt; TN = ton

2.8.2.5 Construction Schedule and Workers

Construction of Alternative 5 likely would begin in 2020 or 2021 and continue for two construction seasons. Construction in the first year is estimated to last 28 weeks and would be conducted during the non-flood season (construction from April 15 through November 1). No construction would occur after November 1, and efforts would continue for 13 weeks during the following year (after April 15).

Alternative 5 includes multiple headworks structures; construction of these structures would have the longest duration and would start at the beginning of the construction period. Construction would begin in the first season, but the final installation of operating gates and associated equipment would occur in the second season. After the first season of construction, the temporary cofferdam installed for dewatering of the headworks structure would remain in place through the flood season.

Construction would occur 6 days per week for 10 hours per day between 7 a.m. and 6 p.m. Construction workers would be divided into multiple crews and would work one shift per day. Maintenance and equipment upkeep crews would work on equipment at night when it is not in use. The peak number of construction workers, which would be needed for one week in July of the first season, is estimated to be 358.

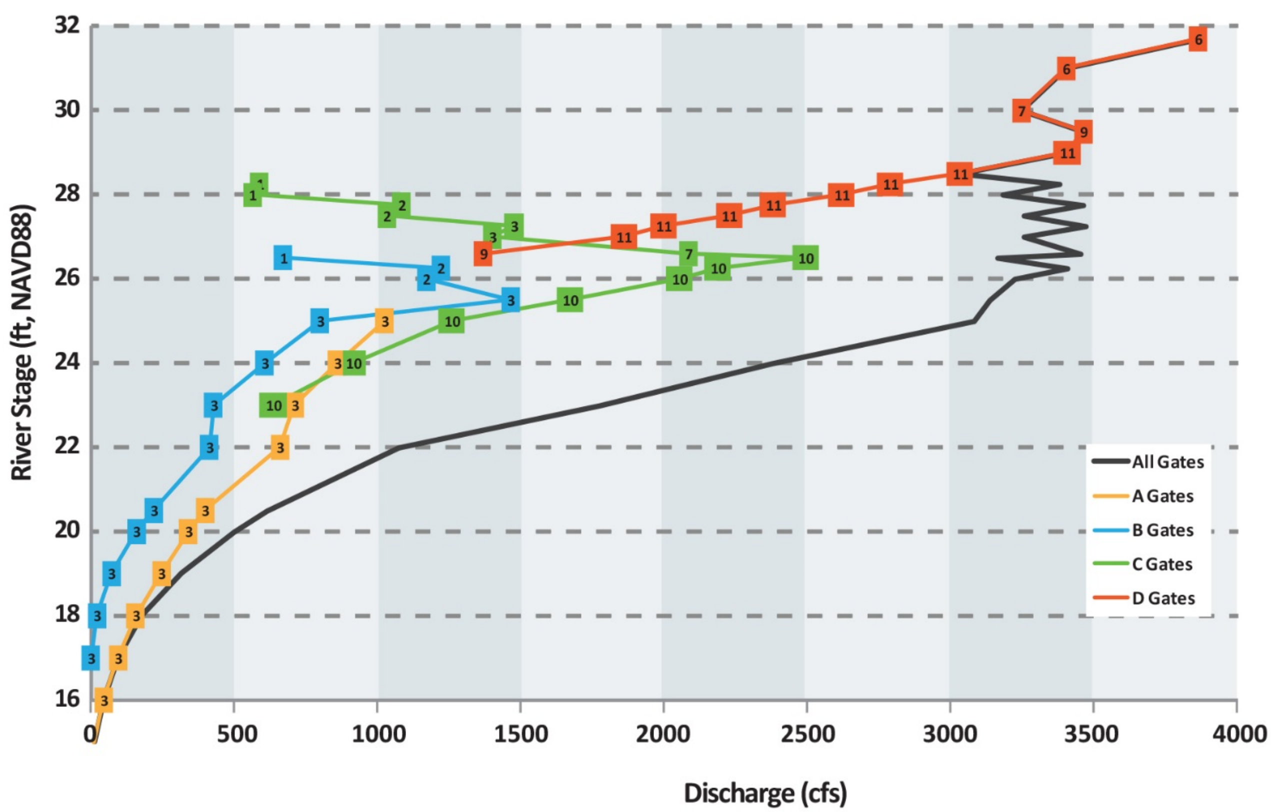
2.8.3 Operations

Operations of the notches would limit flows to about 3,400 cfs. Gate operations could begin each year on November 1 and would first open based on river conditions. The lowest intake (A gates) would operate from a Sacramento River elevation of 15 to 25 feet and would close at higher river elevations. The B gates would operate from 17 feet (i.e., the intake invert elevation) to 26.5 feet. Above 25.5 feet, some B gates would begin to close to reduce flows up to a river elevation of 26.6 feet when the last B gate is fully closed.

The C gates would start to operate as the B gates start to close. The C gates would operate from 23 to 28.25 feet. Above 26.5 feet, some C gates would begin to close to reduce flows through the gates up to a river elevation of 28.5 feet when the last C gate is fully closed.

The D gates would start to operate as the C gates start to close. The D gates would operate from 26.6 to 31.7 feet, which is just below the crest of Fremont Weir. Above 29 feet, the D gates would begin to close to restrict flows through the gates just prior to Fremont Weir overtopping. Because the velocities exceed fish passage criteria above 29 feet as flows approach 3,400 cfs, a minimum of six gates should remain open up to (and during) an overtopping event to prevent supercritical flow (rapid or unstable flow) within the culverts.

Figure 2-27 shows the overlap in the gate operations, with the number in each box showing the number of gates open at each time. The line indicating "all gates" shows the flow added together from all gates operating at the same time. Gate operations to increase inundation could continue through March 15 of each year, based on hydrologic conditions. The gates may remain partially open after March 15 to provide adult fish passage. However, flows through the gates after March 15 could not exceed the available capacity of Tule Canal (typically about 300 cfs) so that these flows do not inundate areas outside of the canal.



Note: Numbers show the numbers of gates open at one time

Figure 2-27. Flow through the Gated Notches at Different Sacramento River Elevations under Alternative 5

2.8.4 Inspection and Maintenance

Inspection and maintenance associated with Alternative 5 mainly would include sediment removal, facility inspections, and vegetation removal. As the river elevation rises, some components would no longer be accessible for maintenance. For river elevations greater than 28 feet, there would be no safe access to the headworks or bridges. Bridge guardrails would be removed before the river elevation reaches 28 feet. The installation of dewatering stoplogs could not be performed under any flow conditions. Table 2-23 provides a list of accessible components at varying river elevations.

Table 2-23. Maintenance Accessibility by River Elevation

River Elevation	Areas Accessible for Maintenance
Below 14 feet	All components of the headworks structures, bridges, gates (upstream and downstream), and operating components. Stoplogs could be installed.
14 to 20 feet (all gates closed)	Gates C and D are accessible; downstream components of Gates A and B, bridges, and operating components. Stoplogs could be installed.
14 to 20 feet (Gates A and B open)	Gates C and D are accessible and upstream bridge deck.
20 to 23 feet (all gates closed)	Gate D is accessible; downstream components of Gates A, B, and C; bridges; and operating components. Stoplogs could be installed.
20 to 23 feet (Gates A, B, and C partially or fully open)	Gate D is accessible and upstream bridge deck.
23 to 28 feet (all gates closed)	Downstream components of gates, bridges, and operating components. Stoplogs could be installed.
23 to 28 feet (gates partially or fully open)	Upstream bridge deck.
Above 28 feet	All components inaccessible.

2.8.4.1 Sediment Deposition

Estimates indicate that approximately 659,000 cubic yards of sediment enter the bypass annually under existing conditions. A portion of this sediment settles in the Yolo Bypass and must be removed through current maintenance efforts. Alternative 5 would increase sediment entering the bypass to a total of around 701,000 cubic yards annually. Most of the additional sediment (about 45 percent) would settle out in Fremont Weir Wildlife Area, about 25 percent would settle south of Agricultural Road Crossing 1 but north of Interstate 80, and the remaining 30 percent of sediment would remain in suspension and flow out of the bypass. Most of the sediment that settles out would be removed through flood maintenance in the Fremont Weir Wildlife Area, as under existing conditions. Alternative 5 would accumulate an additional 18,900 cubic yards of sediment annually that would be removed every five years.

2.8.4.2 Vegetation Removal

Periodic vegetation and debris removal from project channels would be the same as described for Alternative 1.

2.8.5 Monitoring and Adaptive Management

Monitoring activities and the adaptive management framework would be the same as described for Alternative 1.

2.9 Alternative 6: West Side Large Gated Notch

Alternative 6, Large Gated Notch, is a large notch in the western location that would allow flows up to 12,000 cfs to enter the Yolo Bypass. It was designed with the goal of entraining more fish while allowing more flow into the bypass when the Sacramento River is at lower elevations. Typically, winter-run Chinook salmon move downstream during the first high flow event of the season. This flow event is sometimes not high enough to result in what would be considered substantial flows into the bypass under Alternatives 1 through 5. The gated notch could allow more flow to enter during winter-run Chinook salmon out-migration, potentially maximizing fish entrainment. This alternative would include a supplemental fish passage facility on the eastern side of Fremont Weir and improvements to allow fish passage through Agricultural Road Crossing 1 and the channel north of Agricultural Road Crossing 1 (see Section 2.3). The alignment is the same as shown for Alternative 3 in Figure 2-8. Figure 2-28 shows the key components of Alternative 6 and the common elements described in Section 2.3.

The next section includes descriptions of the facilities, construction methods, operations, required maintenance, and environmental commitments associated with this alternative. More detailed construction information is included in Appendix B, *Constructability and Construction Considerations.*

2.9.1 Facilities

2.9.1.1 Intake Channel

The primary purpose of the intake channel is to draw juvenile salmonids and floodplain inundation flows from the Sacramento River to the new headworks structure (described in Section 2.9.1.2) and provide upstream adult fish passage between the headworks structure and the Sacramento River. The intake channel would be constructed with a 230-foot-bottom width. At the downstream end of the intake channel (near the headworks at Fremont Weir), there would be a short transition from the intake channel to the headworks. The intake channel would be rock-lined with rounded rock revetment on the channel bottom and angular rock revetment on the bank slopes to avoid scour. The transition would be constructed with concrete.

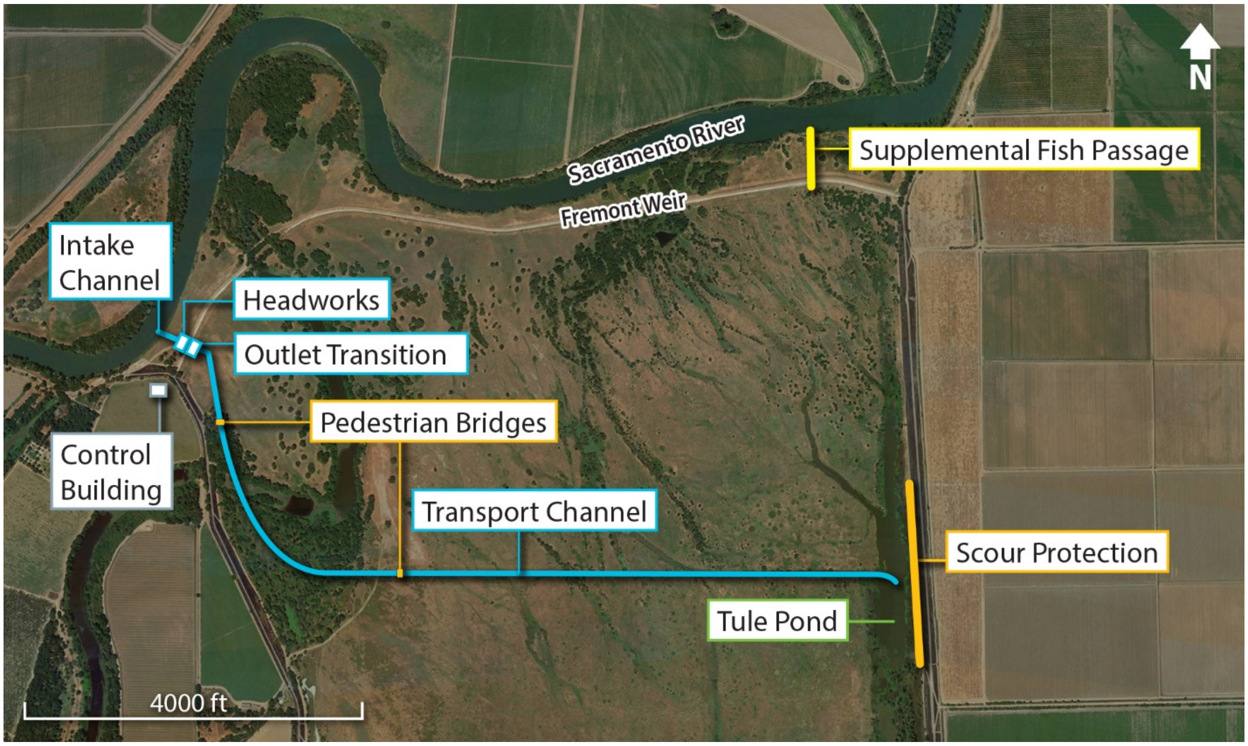


Figure 2-28. Alternative 6 Key Components

2.9.1.2 Headworks Structure

The headworks structure would control the diversion of flow from the Sacramento River to the Yolo Bypass. It would serve as the primary upstream fish passage facility for adult fish and the primary facility for conveying fish-rearing habitat flows and juvenile salmonids onto the Yolo Bypass.

The headworks structure would have five bays that are 40 feet wide and 13.1 feet high. The structure would be a pile-supported, reinforced concrete structure that would bisect the existing Fremont Weir at the western location. The invert elevation would be 16.1 feet. The structure would convey 12,000 cfs at a river elevation of 29.9 feet with all gates lowered (fully open) to meet the applicable requirements for fish passage and flood control. It would house five operating control gates and would include a concrete control structure, an upstream vehicular bridge crossing, and a concrete channel transition that transitions the rectangular sides of the control structure to the side channel slopes of the outlet channel. The overall structure would be 65 feet (upstream to downstream) by 230 feet.

Stoplogs would be provided at each of the five headworks bays upstream of the control structure to dewater the gates for maintenance and as a backup closure for the structure. Six stoplogs are required for each gate. Installation of the stoplogs would require a mobile crane capable of lifting approximately 10,000 pounds. Stoplogs would be stored off site and could only be installed or removed if no flow is moving through the notch or a small amount of flow that would not provide fish passage.

Five hydraulically operated, flush-mounted bottom hinge gates would be used in the headworks structure. These gates would be able to operate under variable river elevations and overtopping events. The top of gate elevation would be flush with the existing Fremont Weir (32 feet). The upstream face of the control gates would be approximately in-line with the upstream face of the existing Fremont Weir. When fully open, the gates would be flush with the channel invert. The gates would all be the same size, with an invert elevation of 16.1 feet and a size of 40 feet wide by 13.1 feet tall. Debris fins would be installed on the walls between gates to reduce debris accumulation.

The gates would open to allow a maximum flow of 12,000 cfs when the water surface elevation in the river reaches 29.9 feet. Each gate would be capable of independent operation via submersible hydraulic cylinders located beneath the gate. Mechanical and electrical control components for each gate would be housed in a control building outside of the bypass on the eastern levee. Figures 2-29 and 2-30 show the details of the headworks structure.

2.9.1.3 Control Building

The control building would be a single-story concrete masonry unit, measuring 18 feet by 18 feet, located on the western levee. The building would house the same equipment as described for Alternative 1.

2.9.1.4 Access Structures

The headworks bridge would be a reinforced concrete, five-span vehicular bridge on the upstream side of Fremont Weir to connect to the existing access road on the upstream side of Fremont Weir. The bridge would span the channels through the new headworks structure. The bridge would be built at nearly the same alignment and elevation as the existing upstream maintenance road and would allow for continued patrolling and maintenance access along the weir as currently exists. The bridge would have a roadway width of 14 feet and an overall width of 18 feet. The top curb elevation would be equal to the top of weir elevation.

Temporary barrier rails (K rails) would be installed and removed such that no part of the bridge extends above the top of weir during an overtopping event. Each bridge span would be 40 feet long, with an end-to-end length of 230 feet.

The headworks bridge would provide a vehicular and pedestrian crossing on the north side of Fremont Weir. As discussed in Alternative 1, the channels south of Fremont Weir could be a barrier to access for recreational users in the Fremont Weir Wildlife Area. For this purpose, Alternative 6 includes three 310-foot-long, eight-foot-wide steel-trussed pedestrian bridges, as shown in Figure 2-28.

2.9.1.5 Outlet Transition

The outlet transition would be a 100-foot-long reinforced concrete channel that provides a gradual hydraulic transition from the headworks into the graded transport channel. The cross-section of the headworks includes five rectangular gates with an invert of 14 feet. The outlet transition would be a small structure that transitions from the headworks gates to the trapezoidal downstream transport channel. The transition would be accomplished with reinforced retaining walls that flair out from the headworks abutment piers and a reinforced concrete slab-on-grade bottom slab, which gradually transitions into the slopes of the trapezoidal transport channel.

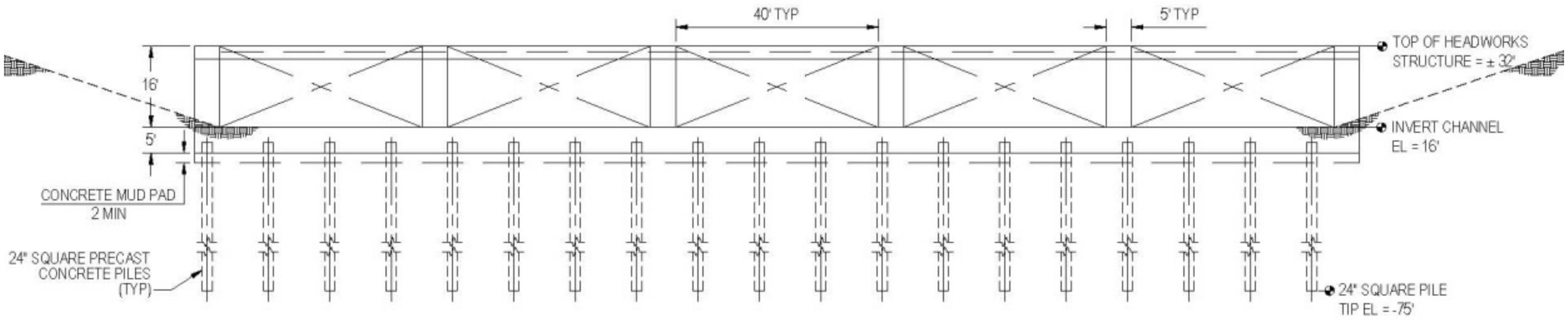


Figure 2-29. Alternative 6 Headworks Cross Section (view from river side)

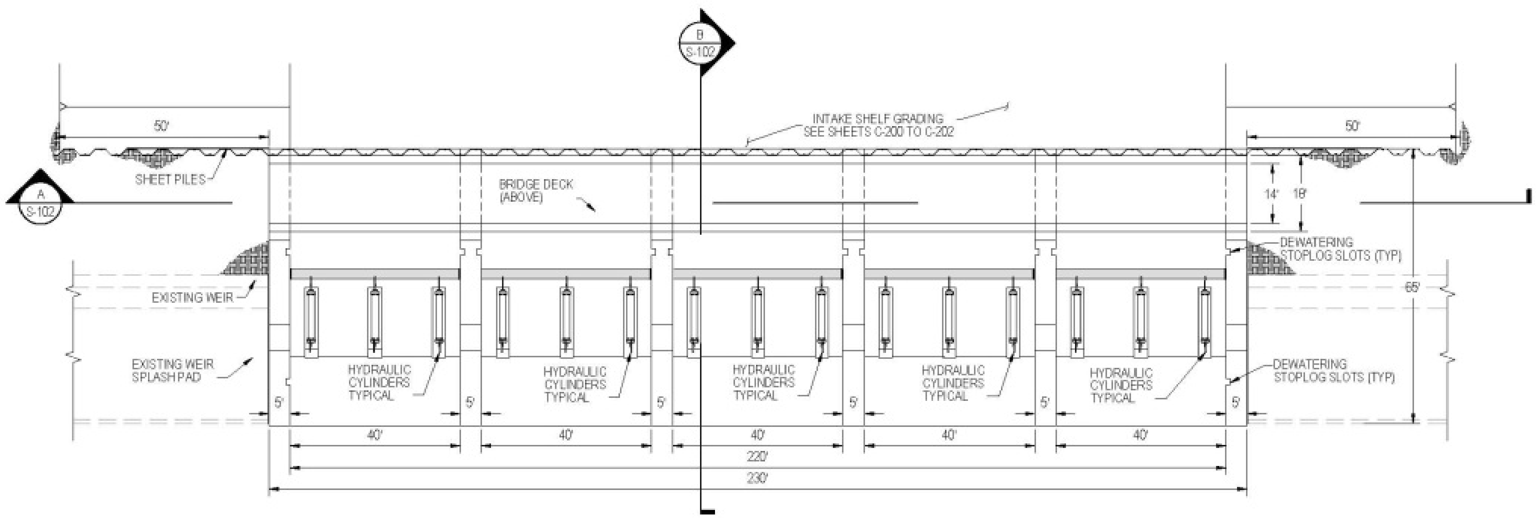


Figure 2-30. Alternative 6 Headworks (view from top of structure)

2.9.1.6 Transport Channel

The transport (outlet) channel would be a graded trapezoidal channel with a bottom width of 200 feet and side slopes of 3:1 (horizontal to vertical). The transport channel would serve as the primary facility for upstream adult fish passage between the existing Tule Pond and the headworks structure. It would also serve as the primary channel for conveying juvenile salmonids and fish-rearing habitat flows from the headworks structure to the existing Tule Pond. Unlike the other transport channels, this channel would convey higher flows and does not need to incorporate benches to help meet velocity criteria. The channel route, length, and slope would be the same as in Alternative 3. The channel would be constructed through the oxbow wetland area in the same area as Alternative 3 so that it is not connected to this wetland area. At the top of each side of the channel, an eight-foot-wide area of rock (a rock key) would be added to reduce the potential for the channel to head cut the channel banks. The facility would also have 12-foot-wide maintenance corridors on each side of the channel.

2.9.1.7 Scour Protection

The transport channel would enter Tule Canal at an angle, which could cause erosion on the eastern Yolo Bypass levee. Rock revetment would be incorporated on the eastern edge of Tule Pond that is 50 feet wide and 2.5 feet thick, with 1.5:1 side slopes (horizontal to vertical). Additionally, there are several locations along the proposed transport channel where the channel could interact with existing scour channels. These areas could experience head cutting as a result of the new facilities. Additional channel revetment would be incorporated at these locations.

2.9.1.8 Supplemental Fish Passage Facility

Alternative 6 would include the same eastern supplemental fish passage facility as described for Alternative 3.

2.9.2 Construction Methods

Construction of the components of Alternative 6 would begin with the demolition of a portion of the existing Fremont Weir and the clearing and grubbing associated with the channels and canals. These activities are expected to be completed within four weeks.

Grading of the transport channel would begin at the downstream outlet at Tule Pond and progress upstream toward the headworks structure, with grading of the intake channel occurring last. This would avoid potential interruptions to the headworks construction and allow construction to occur in the less saturated soil first. Groundwater levels are anticipated to be high, so dewatering efforts prior to the construction of the floodway control and diversion structures are currently estimated to take three weeks. The channel and canal excavations would be completed under both dry and wet conditions and would not require dewatering efforts. Excavation of the downstream reach would be performed under wet conditions. About 60 to 80 percent of the channel excavation could be performed in dry unsaturated soil conditions by scrapers and bulldozers. The remaining 20 to 40 percent would be performed in wet saturated soil conditions by hydraulic excavators and haul trucks.

2.9.2.1 Excavated Material

Alternative 6 would require excavation of the intake channel, transport channel, and downstream facilities. Table 2-24 shows the estimated quantities of excess excavated material that would be generated from each facility and would require removal from the construction area.

Table 2-24. Estimated Excess Excavated Material Quantities for Alternative 6

Component	Estimated Excess Excavated Material (cubic yards)
West Intake Channel	65,710
West Transport Channel	1,552,990
Headworks	12,750
Downstream Channel	72,520
Supplemental Fish Passage (East)	3,540
Agricultural Road Crossing 1	3,170
TOTAL	*1,710,680*

Reclamation or DWR would purchase land within two miles of the edge of the Yolo Bypass to receive this excess material. Alternative 6 would require 35 to 40 acres of land to spoil excess construction-related materials.

2.9.2.2 Construction Materials

Material imported to the project site would be obtained from existing permitted commercial sources located within approximately 65 miles of the project sites. These sites and the haul routes would be the same as described for Alternative 1.

2.9.2.3 Staging Areas and Access

The construction easements for Alternative 6 would encompass staging areas for equipment, mobilization, and spoiling sites. The construction footprints analyzed in this EIS/EIR include space for staging areas. After construction, staging areas would be returned to pre-construction condition. Site access would be on the same roads as described for Alternative 1.

2.9.2.4 Construction Equipment

A list of the major equipment needs for the construction of both the alternative-specific and common downstream channel improvement actions is provided in Table 2-25. Equipment specifics may vary based on the contractor's capabilities and the availability of equipment.

Table 2-25. List of Major Equipment Needed for Construction of Alternative 6

List of Major Equipment	
• 0.8-CY backhoe loaders	• 4.5-CY hydraulic excavator
• 1.5-CY front end loader crawler	• 40-TN truck-mounted hydraulic crane
• 10-TN smooth roller	• 4,000-gallon water truck
• 100-TN off highway trucks	• 450-HP dozer crawler
• 100-foot auger track-mounted drill rig	• 6-inch diameter pump engine drive
• 12-foot blade grader	• 75-TN crane crawler pile hammer
• 165-HP dozer	• Concrete mixer truck
• 2.5-CY hydraulic excavator	• Concrete pump boom, truck mounted
• 2.5-inch diameter concrete vibrator	• Extended boom pallet loader
• 24-TN truck end dump	• Flatbed truck
• 3.5-CY hydraulic excavator	• Haul truck oversize transport
• 3-axle haul trucks	• Hydroseeding truck
• 30-CY scrapers	• Pickup trucks, conventional
• 300-kW generator	

Key: CY = cubic yards; HP = horsepower; kW = kilowatt; TN = ton

2.9.2.5 Construction Schedule and Workers

Construction of Alternative 6 likely would begin in 2020 or 2021 and is estimated to last a total of 28 weeks. Construction is anticipated to be completed in multiple construction seasons (construction from April 15 to November 1). Construction of the headworks structure would have the longest duration and would start at the beginning of the construction period. Construction of channel improvements would commence the same week as the Alternative 6 construction activities.

Construction would occur 6 days per week for 10 hours per day between 7 a.m. and 6 p.m. Construction workers would be divided into multiple crews and would work one shift per day. Maintenance and equipment upkeep crews would work on equipment at night when it is not in use. The peak number of construction workers, which would be needed for one week in the middle of August, is estimated to be 414.

2.9.3 Operations

Alternative 6 would be operated much the same as Alternatives 1 through 3 but would allow flows of up to 12,000 cfs, rather than limiting them to 6,000 cfs. Gate operations could begin each year on November 1 and would first open based on river conditions. All gates would be opened when the river elevation reaches 17.1 feet, which is one foot above the lowest gate invert. If the river continues to rise, the gates would stay open until the flow through the gates reaches 12,000 cfs. Figure 2-31 shows a curve that represents the amount of water that would flow through the gated notch at different Sacramento River elevations. The flow through the gates would reach 12,000 cfs when the river elevation is about 29.8 feet; at this point, three of the gates would be programmed to start closing to maintain flows near 12,000 cfs. The flow may fluctuate so that it is a little higher or a little lower than 12,000 cfs during this time. Gate closures would be controlled so that there is not a sudden reduction in flow. Two of the gates would remain fully open throughout operations.

Once Fremont Weir begins to overtop, the three gates being operated would remain in their last position prior to the weir overtopping (generally they would be closed at this point). After the overtopping event is over, the three operating gates would open and close as needed to keep the flow through the gate as possible to 12,000 cfs. All gates would be closed once river elevations fall below 16.1 feet. Gate operations to increase inundation could continue through March 15 of each year, based on hydrologic conditions. The gates may remain partially open after March 15 to provide fish passage. However, flows through the gates after March 15 could not exceed the available capacity of Tule Canal (typically about 300 cfs) so that these flows do not inundate areas outside of the canal and affect landowners.

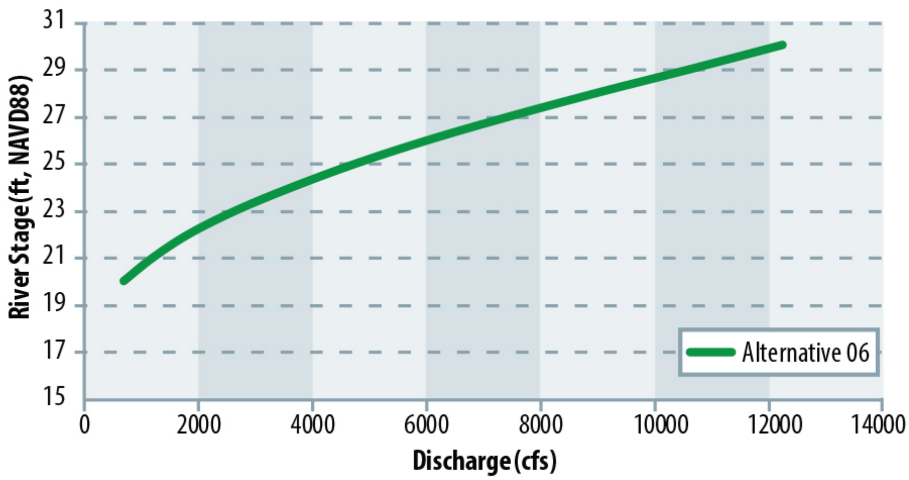


Figure 2-31. Flow through the Gated Notch at Different Sacramento River Elevations under Alternative 6

2.9.4 Inspection and Maintenance

Inspection and maintenance associated with this alternative would mainly include sediment removal, facility inspections, and vegetation removal. Inspection and maintenance would be the same as described for Alternative 1.

2.9.4.1 Sediment Deposition

Estimates indicate that approximately 659,000 cubic yards of sediment enters the bypass annually under existing conditions. A portion of this sediment settles in the Yolo Bypass and must be removed through current maintenance efforts. Alternative 6 would increase sediment entering the bypass to an estimated total of 827,000 cubic yards annually Most of the additional sediment (about 45 percent) would settle out in Fremont Weir Wildlife Area, about 25 percent would settle south of Agricultural Road Crossing 1 but north of Interstate 80, and the remaining 30 percent of sediment would remain in suspension and flow out of the bypass. Most of the sediment that settles out would be removed through flood maintenance in the Fremont Weir Wildlife Area, as under existing conditions. The additional deposition would be in areas inundated regularly under Alternative 6 (in and around channels), and sediment removal efforts associated with Alternative 6 would focus on the channel system. Alternative 6 would accumulate an additional 75,600 cubic yards of sediment annually that would be removed every five years.

2.9.5 Monitoring and Adaptive Management

Monitoring activities and the adaptive management framework would be the same as described for Alternative 1.

2.10 Summary Comparison of Alternatives

Based on the above descriptions of the alternatives, Chapters 3 through 22 include detailed impact analyses for the No Action Alternative and six action alternatives. Table 2-26 summarizes the impact analyses for resources that were evaluated under CEQA and NEPA. Table 2-27 summarizes the impact analyses for resources that were evaluated only under NEPA and do not include findings of significance. Table 2-26 uses the following abbreviations:

- B = beneficial
- LTS = less than significant
- MM = mitigation measure
- NI = no impact
- PS = potentially significant
- S = significant
- SU = significant and unavoidable

Table 2-26. Summary of Impacts Analyses and Mitigation Measures for Resources Evaluated under CEQA and NEPA

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
Flood Control					
Impact HYD-1: Change in occurrence of flows exceeding the maximum existing conditions monthly flow from the Sacramento River into the Yolo Bypass	No Action	S	2 additional occurrences of monthly flows greater than the maximum existing conditions monthly flow, 136,869 cfs.	--	S
	All Action Alternatives	LTS	Differences in month-to-month flow, but no change in number of occurrences of monthly flows greater than 136,869 cfs, compared to existing conditions. There would be no change compared to the No Action Alternative.	--	LTS
Impact HYD-2: Change in occurrence of flows exceeding the maximum existing conditions monthly flow in the Sacramento River at Freeport	No Action	S	2 additional occurrences of monthly flows greater than the maximum existing conditions monthly flow, 72,231 cfs	--	S
	All Action Alternatives	LTS	Differences in month-to-month flow, but the same number of occurrences of monthly flow greater than 72,231 cfs compared to existing conditions. There would be no change compared to the No Action Alternative.	--	LTS
Impact HYD-3: Change in 100-year Flood Hazard Area	No Action	LTS	No changes would occur to channel geometry and peak flood flows would not be impeded or redirected.	--	LTS
	1, 2, 3	LTS	Increases in peak water surface elevation (WSE) in the Yolo Bypass of up to 0.01 foot; decreases in peak WSE on the Sacramento River of up to 0.04 feet compared to existing conditions and the No Action Alternative.	--	LTS

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
	4	LTS	Decreases in peak WSE in the Yolo Bypass and on the Sacramento River of up to 0.15 feet compared to existing conditions and the No Action Alternative.	--	LTS
	5	LTS	Increases in peak WSE in the Yolo Bypass of up to 0.01 feet; decreases in peak WSE on the Sacramento River of up to 0.1 feet compared to existing conditions and the No Action Alternative.	--	LTS
	6	LTS	Increases in peak WSE in the Yolo Bypass of up to 0.02 feet; decreases in peak WSE on the Sacramento River of up to 0.16 feet compared to existing conditions and the No Action Alternative.	--	LTS
Surface Water Supply					
Impact WS-1: Changes in CVP Water Supply Deliveries North of Delta	No Action	LTS	Average water supply changes were less than 5% relative to existing conditions. Dry and critical years would be as high as 6% but annual change would be 2%	---	LTS
	1, 2, 3, 4, 5 (Project), 6	LTS	The change would be less than 1% for all build alternatives	---	LTS
	5 (Program)	NI	----	----	NI

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
Impact WS-2: Changes in CVP Water Supply Deliveries South of Delta	No Action	S	Long term decreases would be on average between 11-18%. In dry and critical years, there would be an average annual reduction of 6% and as much as 20% decrease in January.	---	S
	1, 2, 3, 4, 5 (Project), 6	LTS	The change would be less than 1% for all build alternatives	---	LTS
	5 (Program)	NI	----	----	NI
Impact WS-3: Changes in SWP Water Supply Deliveries North of Delta	No Action	S	During average years, there would be 4% decrease compared to existing conditions and during dry and critical years a decrease by as much as 17% in February.	---	S
	1, 2, 3, 4, 5 (Project), 6	LTS	The change would be less than 1% for all build alternatives	---	LTS
	5 (Program)	NI	----	----	NI
Impact WS-4: Changes in SWP Water Supply Deliveries South of Delta	No Action	S	During average years, there would be an increase compared to existing conditions and during dry and critical years a decrease by as much as 11% in November.	---	S
	1, 2, 3, 4, 5 (Project), 6	LTS	The change would be less than 1% for all build alternatives	---	LTS
	5 (Program)	NI	----	----	NI
Impact WS-5: Increase in Incidents of Term 91 being Triggered	No Action	S	There would be 84 instances when Term 91 would be initiated but not in the existing conditions.	---	S
	All Action Alternatives	NI	---	---	NI

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
Water Quality					
Impact WQ-1: Construction-or maintenance related degradation of surface water quality such that it would exceed regulatory standards or would substantially impair beneficial uses of surface water	No Action	NI	---	---	NI
	All Action Alternatives	S	Construction activities could increase downstream sedimentation and turbidity and might mobilize sediment-associated contaminants.	MM-HAZ-1 MM-WQ-1-3	LTS
Impact WQ-2: Operation-related degradation of surface water quality such that it would exceed regulatory standards or would substantially impair beneficial uses of surface water	No Action	NI	---	---	NI
	1, 2, 3, 4, 5 (Project), 6	S	Project-related flow through bypass may increase the rate and area of inundation and could increase the amount of sediment and constituents of concern entering the bypass.	MM-WQ-4	SU
	5 (Program)	LTS	The surrounding areas could experience inundation due to operation as managed wetland habitat.	----	LTS
Groundwater					
Impact GRW-1: Temporary and Short-Term Construction-Related Effects on Groundwater Levels	No Action	NI	---	---	NI
	1, 2, 3, 4, 5 (Project), 6	LTS	Temporary dewatering activities would affect groundwater levels.	---	LTS
	5 (Program)	NI	---	---	NI

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
Impact GRW-2: Temporary and Short-Term Construction-Related Effects on Groundwater Quality	No Action	NI	---	---	NI
	1, 2, 3, 4, 5 (Project), 6	S	On-site spills or waste discharge runoff during construction could impact groundwater quality.	MM-HAZ-1, MM-WQ-1-3	LTS
	5 (Program)	NI	---	---	NI
Impact GRW-3: Operational Impacts to Groundwater Recharge Could Cause a Lowering of the Local Groundwater Level that Would Impact Pre-existing or Planned Land Uses in the Area Surrounding the Yolo Bypass	No Action	NI	---	---	NI
	1, 2, 3, 4, 5 (Project), 6	LTS	Recharge to the groundwater aquifer could be slightly impeded.	---	LTS
	5 (Program)	NI	---	---	NI
Impact GRW-4: Operational Impacts to Groundwater Quality in the Area Surrounding the Yolo Bypass	No Action	NI	---	---	NI
	1, 2, 3, 4, 5 (Project), 6	LTS	Increased recharge groundwater could introduce new contaminants of concern.	---	LTS
	5 (Program)	NI	---	---	NI
Impact GRW-5: Long-Term Changes to Groundwater Levels due to Decreased Allocation to North of Delta and South of Delta Contractors	No Action	NI	---	---	NI
	1, 2, 3, 4, 5 (Project), 6	LTS	Reductions in supplies would be short-term and infrequent.	---	LTS
	5 (Program)	NI	---	---	NI

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
Impact GRW-6: Long-Term Changes to Groundwater Quality due to Decreased Allocation to North of Delta and South of Delta Contractors	No Action	NI	---	---	NI
	1, 2, 3, 4, 5 (Project), 6	LTS	The potential increase in groundwater pumping in lieu of surface water deliveries would be short-term, infrequent and of small magnitude.	---	LTS
	5 (Program)	NI	---	---	NI
Impact GRW-7: Increased Potential for Land Subsidence due to Decreased Allocation to North of Delta and South of Delta Contractors	No Action	NI	---	---	NI
	1, 2, 3, 4, 5 (Project), 6	LTS	The potential increase in groundwater pumping in lieu of surface water deliveries would be short-term and infrequent.	---	LTS
	5 (Program)	NI	---	---	NI
Aquatic Resources					
Impact FISH-1: Potential Disturbance to Fish Species or their Habitat due to Erosion, Sedimentation, and Turbidity	No Action	NI	---	—	NI
	All Action Alternatives	S	A minimal increase in sedimentation and turbidity during construction could temporarily adversely affect fish.	MM-WQ-2, 3	LTS
Impact FISH-2: Potential Disturbance to Fish Species or their Habitat due to Hazardous Materials and Chemical Spills	No Action	NI	---	—	NI

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
	All Action Alternatives	S	A minimal increase in the potential to release hazardous materials or chemicals into water bodies could adversely affect fish species of focused evaluation in the immediate vicinity and downstream of the construction area.	MM-WQ-1	LTS
Impact FISH-3: Potential Disturbance to Fish Species or their Habitat due to Aquatic Habitat Modification	No Action	NI	---	—	NI
	1	S	28.9 acres (temporary impacts) and 47.1 acres (permanent impacts) of vegetated area would have the potential to be disturbed during construction.	MM-TERR-7, 11; MM-FISH-1	LTS
	2	S	27.4 acres (temporary impacts) and 72.5 acres (permanent impacts) of vegetated area would have the potential to be disturbed during construction.	MM-TERR-7, 11; MM-FISH-1	LTS
	3	S	32.5 acres (temporary impacts) and 80.9 acres (permanent impacts) of vegetated area would have the potential to be disturbed during construction.	MM-TERR-7, 11; MM-FISH-1	LTS
	4	S	168.4 acres (temporary impacts) and 117.4 acres (permanent impacts) of vegetated area would have the potential to be disturbed during construction.	MM-TERR-7, 11; MM-FISH-1	LTS
	5	S	25.6 acres (temporary impacts) and 85.7 acres (permanent impacts) of vegetated area would have the potential to be disturbed during construction.	MM-TERR-7, 11; MM-FISH-1	LTS

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
	6	S	32.3 acres (temporary impacts) and 107.2 acres (permanent impacts) of vegetated area would have the potential to be disturbed during construction.	MM-TERR-7, 11; MM-FISH-1	LTS
Impact FISH-4: Potential Disturbance to Fish Species or their Habitat due to Hydrostatic Pressure Waves, Noise, and Vibration	No Action	NI	---	—	NI
	All Action Alternatives	S	Impacts would be substantial if impact pile driving was conducted in the Sacramento River; impact would be LTS if a vibratory pile driver can be used for construction of cofferdam.	MM-FISH-2	LTS
Impact FISH-5: Potential Disturbance to Fish Species or their Habitat due to Stranding and Entrainment	No Action	NI	---	—	NI
	All Action Alternatives	S	Minimal and temporary increase in the potential for fish species of focused evaluation to be entrained or stranded could occur during construction.	MM-FISH-3	LTS
Impact FISH-6: Potential Disturbance to Fish Species or their Habitat due to Predation Risk	No Action	NI	---	—	NI
	All Action Alternatives	S	A minimal and temporary increase in the risk of predation for species of focused evaluation could occur due to potential indirect effects of construction and maintenance activities.	MM-WQ-1-3; MM-FISH-2-3	LTS

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
Impact FISH-7: Potential Disturbance to Fish Species due to changes in Fish Passage Conditions	No Action	NI	---	—	NI
	All Action Alternatives	LTS	Fish species of focused evaluation would either not be present near temporary fish passage blockages, or would not be substantially affected by temporary blockages.	---	LTS
Impact FISH-8: Potential Disturbance to Fish Species or their Habitat due to Direct Harm	No Action	NI	---	—	NI
	All Action Alternatives	S	Minimal and temporary increase in the risk of direct harm for fish species of focused evaluation could occur due to construction and maintenance-related equipment, personnel, or debris.	MM-FISH-3-4	LTS
Impact FISH-9: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to changes in Flows in the Sacramento River	No Action	S	Substantial changes in Sacramento River flows could adversely affect fish species of focused evaluation.	—	SU
	All Action Alternatives	LTS	Minimal changes in Sacramento River flows would not adversely affect fish species of focused evaluation.	—	LTS
Impact FISH-10: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to changes in Water Temperatures in the Sacramento River	No Action	S	Substantially less suitable water temperatures in the Sacramento River could adversely affect fish species of focused evaluation.	—	SU
	All Action Alternatives	LTS	Similar Sacramento River water temperatures would not adversely affect fish species of focused evaluation.	—	LTS

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
Impact FISH-11: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Delta Hydrologic and Water Quality Conditions	No Action	S	Delta habitat conditions would be substantially more suitable for fish species of focused evaluation during some months, and substantially less suitable during some months.	—	SU
	All Action Alternatives	LTS	Similar Delta habitat conditions would not adversely affect fish species of focused evaluation.	—	LTS
Impact FISH-12: Impacts to Fisheries Habitat Conditions due to Changes in Flow-Dependent Habitat Availability in the Study Area (Yolo Bypass/Sutter Bypass)	No Action	B	Expected increases in floodplain inundation in the Yolo and Sutter bypasses may increase hydraulic habitat availability for fish species of focused evaluation.	—	B
	All Action Alternatives	B/LTS	Substantial increases in hydraulic habitat availability in the Yolo Bypass would improve conditions for fish species of focused evaluation; minimal reductions in hydraulic habitat availability in the Sutter Bypass would not adversely affect fish species of focused evaluation.	—	B/LTS
Impact FISH-13: Impacts to Fisheries Habitat Conditions due to Changes in Water Quality in the Study Area	No Action	LTS	Minor potential for increased concentrations of contaminants in the Yolo Bypass and Delta would not be expected to adversely affect fish species of focused evaluation.	—	LTS
	All Action Alternatives	LTS	Minor potential for increased concentrations of contaminants in the Yolo Bypass and Delta would not be expected to adversely affect fish species of focused evaluation.	—	LTS

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
Impact FISH-14: Impacts to Aquatic Primary and Secondary Production in the Study Area	No Action	B	Expected increases in primary and secondary production in the Yolo and Sutter bypasses and the Delta would improve conditions for fish species of focused evaluation.	—	B
	All Action Alternatives	LTS	Expected increases in primary and secondary production in the Yolo Bypass and Delta would improve conditions for fish species of focused evaluation; minor reductions in primary and secondary production in the Sutter Bypass are not expected to adversely affect fish species of focused evaluation.	—	LTS
Impact FISH-15: Impacts to Fish Species of Focused Evaluation due to changes in Adult Fish Passage Conditions through the Yolo Bypass	No Action	B	Increased flows entering the Yolo Bypass would be expected to improve adult fish passage conditions through the Yolo Bypass, benefiting fish species of focused evaluation.	—	B
	1, 2, 3, 5	B	Adult fish passage through the Yolo Bypass would occur more often, benefiting fish species of focused evaluation.	—	B
	4	S	Adult fish passage through the Yolo Bypass would occur less frequently, adversely affecting fish species of focused evaluation.	MM-FISH-5	LTS
	6	S	Adult fish passage through the Yolo Bypass could occur less frequently, potentially adversely affecting fish species of focused evaluation.	—	SU

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
Impact FISH-16: Impacts to Fish Species due to changes in Potential for Stranding and Entrainment	No Action	LTS	No facilities would be constructed that would increase the potential for stranding and entrainment of fish species of focused evaluation; therefore, there would be no change from existing conditions.	—	LTS
	1, 2, 3, 5, 6	LTS	Minor increased potential for fish stranding in the Yolo Bypass would not be expected to adversely affect fish species of focused evaluation.	—	LTS
	4	S	The presence of substantially different hydraulic conditions in the Yolo Bypass could increase the potential for stranding, potentially adversely affecting fish species of focused evaluation.	—	SU
Impact FISH-17: Impacts to Fish Species due to changes in Potential for Predation and Competition	No Action	LTS	No changes in the potential for predation of and competition with fish species of focused evaluation are expected.	—	LTS
	1, 2, 3, 5, 6	LTS	Minor increased potential for predation of and competition with fish species would not be expected to adversely affect fish species of focused evaluation.	—	LTS
	4	S	The presence of the water control structures and bypass channels could adversely affect fish species of focused evaluation due to increased potential for predation. Minor increased potential for competition with fish species would not be expected to adversely affect fish species of focused evaluation.	—	SU

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
Impact FISH-18: Impacts to Chinook Salmon Species/Runs due to Changes in Viable Salmonid Population Parameters	No Action	LTS	Potential changes in Viable Salmonid Population parameters are not expected to be substantially affected.	—	LTS
	All Action Alternatives	LTS	Viable Salmonid Population parameters would be similar or improved for all Chinook salmon runs.	—	LTS
Impact FISH-19: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Hydrologic Conditions in the SWP/CVP System	No Action	S	Substantial reductions in reservoir storages could adversely affect fish species of focused evaluation.	—	SU
	All Action Alternatives	LTS	Generally insubstantial changes in reservoir storages and instream flows would not be expected to adversely affect fish species of focused evaluation.	—	LTS
Impact FISH-20: Conflict with Adopted Habitat Conservation Plan, Natural Community Conservation Plan, or Other Approved Local, Regional, or State Habitat Conservation Plan	No Action	LTS	—	—	LTS
	All Action Alternatives	LTS	No conflicts with habitat conservation plans would be expected.	—	LTS
Impact FISH-21: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Tule Canal Floodplain Improvements (Program Level)	No Action	NI	—	—	NI
	1, 2, 3, 4, 5 (Project), 6	N/A	N/A	N/A	N/A

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
	5 (Program)	S	Could result in construction-related impacts to habitat in the Yolo Bypass, and operations of the water control structure and bypass channel could adversely affect fish species of focused evaluation.	MM-WQ-1-3; MM-TERR-11, 13; MM-FISH-1-5	SU
Vegetation, Wetlands, and Wildlife Resources					
Impact TERR-1: Potential Mortality or Loss of Habitat for Special-Status Plant Species	No Action	NI	---	—	NI
	1	S (C, M), LTS (O)	Lowest construction-related impacts to suitable and occupied habitat; approximately 29 acres of temporary habitat and 48 acres of permanent habitat losses; 1 woolly rose-mallow plant would be directly affected during construction.	MM-TERR-1	LTS
	2	S (C, M), LTS (O)	Approximately 31 acres of temporary habitat and 85 acres of permanent habitat losses; 1 woolly rose-mallow plant would be directly affected during construction; potential for impacts to other special-status plant species if found during pre-construction surveys.	MM-TERR-1, 19	LTS
	3	S (C, M), LTS (O)	Approximately 33 acres of temporary habitat and 82 acres of permanent habitat losses; 1 woolly rose-mallow plant would be directly affected during construction; potential for impacts to other special-status plant species if found during pre-construction surveys	MM-TERR-1, 19	LTS

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
	4	S (C, M), LTS (O)	Highest construction-related impacts to suitable and occupied habitat; approximately 139 acres of temporary habitat and 146 acres of permanent habitat losses; 1 woolly rose-mallow plant would be directly affected during construction; potential for impacts to other special-status plant species if found during pre-construction surveys.	MM-TERR-1, 19	LTS
	5	S (C, M), LTS (O)	Approximately 28 acres of temporary habitat and 96 acres of permanent habitat losses; 1 woolly rose-mallow plant would be directly affected during construction; potential for impacts to other special-status plant species if found during pre-construction surveys.	MM-TERR-1, 19	LTS
	6	S (C, M), LTS (O)	Approximately 34 acres of temporary habitat and 109 acres of permanent habitat losses; 1 woolly rose-mallow plant would be directly affected during construction; potential for impacts to other special-status plant species if found during pre-construction surveys.	MM-TERR-1, 19	LTS
Impact TERR-2: Potential Disturbance or Mortality of Valley Elderberry Longhorn Beetle and Loss of Its Habitat (Elderberry Shrubs)	No Action	NI	—	—	NI
	1, 2, 5	S (C, M), LTS (O)	No elderberry shrubs identified in the APE; potential for disturbance if elderberry shrubs colonize the area before construction or during maintenance activities	MM-TERR-2–11	LTS

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
	3, 4	S (C, M), LTS (O)	Approximately 1.3 acre of temporary habitat and 1.8 acres of permanent habitat losses; potential for disturbance if elderberry shrubs colonize the area before construction or during maintenance activities	MM-TERR-2–11	LTS
	6	S (C, O, M)	Approximately 1.2 acre of temporary habitat and 2.7 acres of permanent habitat losses; potential for disturbance if elderberry shrubs colonize the area before construction or during maintenance activities; additional adverse effects on elderberry shrubs could occur in areas with more flooding during operations than elderberry can tolerate.	MM-TERR-2–11	LTS
Impact TERR-3: Potential Disturbance or Mortality of, and Loss of Suitable Habitat for, Giant Garter Snake	No Action	NI	—	—	NI
	1	S (C, M), LTS (O)	Approximately 24 acres of temporary habitat and 33 acres of permanent habitat losses; permanent loss of the 20-acre Tule Pond, flooding of occupied burrows, and long-term maintenance activities.	MM-TERR-2–6, 11–14; WQ-1, 2	LTS
	2	S (C, M), LTS (O)	Approximately 15 acres of temporary habitat and 25 acres of permanent habitat losses; permanent loss of the 20-acre Tule Pond, flooding of occupied burrows, and long-term maintenance activities.	MM-TERR-2–6, 11–14; WQ-1, 2	LTS

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
	3	S (C, M), LTS (O)	Approximately 19 acres of temporary habitat and 30 acres of permanent habitat losses; permanent loss of the 20-acre Tule Pond, flooding of occupied burrows, and long-term maintenance activities.	MM-TERR-2–6, 11–14; WQ-1, 2	LTS
	4	S (C, M), LTS (O)	Approximately 117 acres of temporary habitat and 91 acres of permanent habitat losses; permanent loss of the 20-acre Tule Pond, flooding of occupied burrows, and long-term maintenance activities.	MM-TERR-2–6, 11–14; WQ-1, 2	LTS
	5	S (C, M), LTS (O)	Less than 2 acres of temporary habitat and 16 acres of permanent habitat losses; flooding of occupied burrows and long-term maintenance activities.	MM-TERR-2–6, 11–14; WQ-1, 2	LTS
	6	S (C, M), LTS (O)	Approximately 20 acres of temporary habitat and 29 acres of permanent habitat losses; permanent loss of the 20-acre Tule Pond, flooding of occupied burrows, and long-term maintenance activities.	MM-TERR-2–6, 11–14; WQ-1, 2	LTS
Impact TERR-5: Potential Disturbance or Mortality of Nesting Bird Species and Removal of Suitable Nesting and Foraging Habitat	No Action	NI	—	—	NI
	1	S (C, M), LTS (O)	Approximately 29 acres of temporary habitat and 48 acres of permanent habitat losses; adverse effects from long-term maintenance activities if conducted during the nesting season.	MM-TERR-2–6, 11, 16	LTS

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
	2	S (C, M), LTS (O)	Approximately 31 acres of temporary habitat and 85 acres of permanent habitat losses; adverse effects from long-term maintenance activities if conducted during the nesting season	MM-TERR-2–6, 11, 16	LTS
	3	S (C, M), LTS (O)	Approximately 33 acres of temporary habitat and 82 acres of permanent habitat losses; adverse effects from long-term maintenance activities if conducted during the nesting season.	MM-TERR-2–6, 11, 16	LTS
	4	S (C, M), LTS (O)	Approximately 139 acres of temporary habitat and 146 acres of permanent habitat losses; adverse effects from long-term maintenance activities if conducted during the nesting season	MM-TERR-2–6, 11, 16	LTS
	5	S (C, M), LTS (O)	Approximately 28 acres of temporary habitat and 96 acres of permanent habitat losses; adverse effects from long-term maintenance activities if conducted during the nesting season.	MM-TERR-2–6, 11, 16	LTS
	6	S (C, M), LTS (O)	Approximately 34 acres of temporary habitat and 109 acres of permanent habitat losses; adverse effects from long-term maintenance activities if conducted during the nesting season.	MM-TERR-2–6, 11, 16	LTS
Impact TERR-5: Potential Disturbance or Mortality of Nesting Bird Species and Removal of Suitable Nesting and Foraging Habitat	No Action	NI	—	—	NI

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
	1	S (C, M), LTS (O)	Approximately 29 acres of temporary habitat and 48 acres of permanent habitat losses; adverse effects from long-term maintenance activities if conducted during the nesting season.	MM-TERR-2–6, 11, 16	LTS
	2	S (C, M), LTS (O)	Approximately 31 acres of temporary habitat and 85 acres of permanent habitat losses; adverse effects from long-term maintenance activities if conducted during the nesting season	MM-TERR-2–6, 11, 16	LTS
	3	S (C, M), LTS (O)	Approximately 33 acres of temporary habitat and 82 acres of permanent habitat losses; adverse effects from long-term maintenance activities if conducted during the nesting season.	MM-TERR-2–6, 11, 16	LTS
	4	S (C, M), LTS (O)	Approximately 139 acres of temporary habitat and 146 acres of permanent habitat losses; adverse effects from long-term maintenance activities if conducted during the nesting season	MM-TERR-2–6, 11, 16	LTS
	5	S (C, M), LTS (O)	Approximately 28 acres of temporary habitat and 96 acres of permanent habitat losses; adverse effects from long-term maintenance activities if conducted during the nesting season.	MM-TERR-2–6, 11, 16	LTS
	6	S (C, M), LTS (O)	Approximately 34 acres of temporary habitat and 109 acres of permanent habitat losses; adverse effects from long-term maintenance activities if conducted during the nesting season.	MM-TERR-2–6, 11, 16	LTS
Impact TERR-6: Potential Disturbance, Injury, or Mortality of Special-Status Tree-Roosting Bats and Removal of Roosting Habitat	No Action	NI	—	—	NI

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
	1	S (C, M), NI (O)	Approximately 25 acres of temporary habitat and 36 acres of permanent habitat losses; adverse effects from long-term maintenance activities if conducted during the maternity season.	MM-TERR-2–6, 11, 17	LTS
	2	S (C, M), NI (O)	Approximately 28 acres of temporary habitat and 72 acres of permanent habitat losses; adverse effects from long-term maintenance activities if conducted during the maternity season.	MM-TERR-2–6, 11, 17	LTS
	3	S (C, M), NI (O)	Approximately 29 acres of temporary habitat and 64 acres of permanent habitat losses; adverse effects from long-term maintenance activities if conducted during the maternity season.	MM-TERR-2–6, 11, 17	LTS
	4	S (C, M), NI (O)	Approximately 93 acres of temporary habitat and 93 acres of permanent habitat losses; adverse effects from long-term maintenance activities if conducted during the maternity season.	MM-TERR-2–6, 11, 17	LTS
	5	S (C, M), NI (O)	Approximately 27 acres of temporary habitat and 89 acres of permanent habitat losses; adverse effects from long-term maintenance activities if conducted during the maternity season.	MM-TERR-2–6, 11, 17	LTS
	6	S (C, M), NI (O)	Approximately 30 acres of temporary habitat and 88 acres of permanent habitat losses; adverse effects from long-term maintenance activities if conducted during the maternity season.	MM-TERR-2–6, 11, 17	LTS
Impact TERR-7: Potential Disturbance or Mortality of American Badger and Loss of Its Habitat	No Action	NI	—	—	NI

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
	1	S (C), NI (O, M)	Approximately 18 acres of temporary habitat and 19 acres of permanent habitat losses.	MM-TERR-2–6, 18	LTS
	2	S (C), NI (O, M)	Approximately 21 acres of temporary habitat and 49 acres of permanent habitat losses.	MM-TERR-2–6, 18	LTS
	3	S (C), NI (O, M)	Approximately 20 acres of temporary habitat and 43 acres of permanent habitat losses.	MM-TERR-2–6, 18	LTS
	4	S (C), NI (O, M)	Approximately 64 acres of temporary habitat and 66 acres of permanent habitat losses.	MM-TERR-2–6, 18	LTS
	5	S (C), NI (O, M)	Approximately 20 acres of temporary habitat and 72 acres of permanent habitat losses.	MM-TERR-2–6, 18	LTS
	6	S (C), NI (O, M)	Approximately 21 acres of temporary habitat and 60 acres of permanent habitat losses.	MM-TERR-2–6, 18	LTS
Impact TERR-8: Potential Loss of Sensitive Natural Communities	No Action	NI	—	—	NI
	1	S (C), NI (O, M)	Approximately 10 acres of temporary habitat and 25 acres of permanent habitat losses.	MM-TERR-2, 3, 5, 6, 11; WQ-1, 2	LTS
	2	S (C), NI (O, M)	Approximately 8 acres of temporary habitat and 26 acres of permanent habitat losses.	MM-TERR-2, 3, 5, 6, 11; WQ-1, 2	LTS
	3	S (C), NI (O, M)	Approximately 10 acres of temporary habitat and 29 acres of permanent habitat losses.	MM-TERR-2, 3, 5, 6, 11; WQ-1, 2	LTS
	4	S (C), NI (O, M)	Approximately 22 acres of temporary habitat and 34 acres of permanent habitat losses.	MM-TERR-2, 3, 5, 6, 11; WQ-1, 2	LTS

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
	5	S (C), NI (O, M)	Approximately 8 acres of temporary habitat and 17 acres of permanent habitat losses.	MM-TERR-2, 3, 5, 6, 11; WQ-1, 2	LTS
	6	S (C), NI (O, M)	Approximately 10 acres of temporary habitat and 36 acres of permanent habitat losses.	MM-TERR-2, 3, 5, 6, 11; WQ-1, 2	LTS
Impact TERR-9: Potential Effects on USACE, CDFW, and RWQCB Jurisdictional Areas	No Action	NI	—	—	NI
	1, 5	S (C), NI (O, M)	Alternatives 1 and 5 have a similar range of effects; Alternative 5 has the lowest construction effects on jurisdictional areas.	MM-TERR-2, 3, 5, 6, 11; MM-WQ-1, 2	LTS
	2, 3, 6	S (C), NI (O, M)	Alternatives 2, 3, and 6 have a similar range of effects.	MM-TERR-2, 3, 5, 6, 11; MM-WQ-1, 2	LTS
	4	S (C), NI (O, M)	Alternative 4 has the greatest construction effects on jurisdictional areas.	MM-TERR-2, 3, 5, 6, 11; MM-WQ-1, 2	LTS
Impact TERR-10: Potential Interference with Movement of Native Resident or Migratory Wildlife Species	No Action	NI	—	—	NI
	All Action Alternatives	LTS (C), NI (O, M)	During construction minimal effect would occur to migratory wildlife. No effect would occur over existing conditions for operations or maintenance.	—	LTS
Impact TERR-11: Potential Conflict with Provisions of an Adopted HCP/NCCP or Other Approved Local, Regional, or State Habitat Conservation Plan	No Action	NI	—	—	NI

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
	All Action Alternatives	NI	No effect on an adopted HCP/NCCP or other conservation plans.	—	NI
Impact TERR-12: Potential Effects of Tule Canal Floodplain Improvements (Program Level)	No Action	NI	--	—	NI
	1, 2, 3, 4, 5 (Project), 6	NA	--	—	NI
	5 (Program)	S (C, O, M)	Permanent loss of approximately 324.9 acres of freshwater emergent wetland and 59 acres of other types of habitat.	MM-TERR-2–19; WQ-1, 2	LTS
Cultural Resources					
Impact CULT-1: Impacts on Identified Archaeological Sites and Historic-Era Built Resources Resulting from Construction	No Action	NI	---	—	NI
	All Action Alternatives	S	Potential for permanent adverse effects for cultural resources	MM-CULT-1	LTS
Impact CULT-2: Impacts on Archaeological Sites and Historic-Era Built Resources to Be Identified Through Future Inventory Efforts	No Action	NI	---	—	NI
	All Action Alternatives	S	Potential for permanent adverse effects for cultural resources	MM-CULT-2	LTS
Impact CULT-3: Impacts on Archaeological Sites that May Not Be Identified through Inventory Efforts	No Action	NI	---	—	NI
	All Action Alternatives	S	Potential for permanent adverse effects for cultural resources	MM-CULT-3, 4	SU

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
Impact CULT-4: Damage to Buried Human Remains	No Action	NI	---	—	NI
	1, 2, 3, 4, 5 (Project), 6	S	Potential for permanent adverse effects for cultural resources	MM-CULT-5	LTS
	5 (Program)	S	Potential for permanent adverse effects for cultural resources	MM-CULT-5	SU
Impact CULT-5: Impacts on Paleontological Resources Resulting from Construction	No Action	NI	---	—	NI
	All Action Alternatives	LTS	Limited potential for adverse effects on paleontological resources	—	LTS
Land Use and Agricultural Resources					
Impact AGR-1: Physically divide a community or conflict with a relevant land use plan, policy, or regulation adopted for the purpose of avoiding or mitigating an environmental effect.	No Action	NI	---	---	NI
	All Action Alternatives	LTS	Actions associated with the Project would be consistent with relevant existing land use plans, policies, or regulations adopted for the purpose of avoiding or mitigating an environment effect and would not occur near a community.	---	LTS
Impact AGR-2: Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance, which may also be protected under the Williamson Act or other conservation programs, to nonagricultural or incompatible uses	No Action	NI	---	---	NI

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
	1, 2, 3, 5 (Project), 5 (Program), 6	LTS	Impacts to agricultural land would occur, but Prime Farmland, Unique Farmland, or Farmland of Statewide Importance lands would not be converted to nonagricultural uses by construction or increased periods of inundation	---	LTS
	4	S	Impacts to agricultural land would occur and there would be a change to Prime Farmland and Unique Farmland. Construction would permanently affect approximately one acre of Prime Farmland and 30 acres of Unique Farmland and temporarily affect two acres of Prime Farmland and 50 acres of Unique Farmland.	MM-AGR-1	SU
Geology and Soils					
Impact GEO-1: Substantial increase in sediment deposition in the Yolo Bypass	No Action	NI	---	---	NI
	All Action Alternatives	LTS	The increased amount of sediment deposited in the Yolo Bypass would be removed during maintenance activities	---	LTS
Impact GEO-2: Induce levee instability at the Yolo Bypass east levee	No Action	NI	---	---	NI
	1, 2, 3, 4, 5 (Project), 6	LTS	Construction would take place outside of the waterside toe of the existing levee and could impact levee stability.	---	LTS
	5 (Program)	NI	---	---	NI
Impact GEO-3: Substantially increase soil erosion at the Yolo Bypass east levee	No Action	NI	---	---	NI
	1, 5	NI	---	---	NI

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
	2, 3, 4, 6	LTS	Soil erosion could increase, but the design incorporates erosion control measures at the Yolo Bypass east levee.	---	LTS
Impact GEO-4: Loss of availability of a known mineral resource that would be of value to the region and the residents of the state	No Action	NI	---	---	NI
	All Action Alternatives	LTS	Some oil and gas wells exist within the Yolo Bypass, but the small amount of increased inundation would be less than the flood events that the infrastructure is built to withstand.	---	LTS
Impact GEO-5: Loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan	No Action	NI	---	---	NI
	All Action Alternatives	LTS	Gas fields within the Yolo Bypass are recognized in the Yolo County General Plan, but small amount of increased inundation would not result in the loss of this resource.	---	LTS
Recreation					
Impact REC-1: Increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated	No Action	NI	---	—	NI
	All Action Alternatives	LTS	Construction effects would limit recreational uses (including hunting) in established wildlife areas during the construction period.	NEPA MM-REC-1	LTS

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
Impact REC-2: Loss of recreational and educational opportunities due to a reduction in access and/or available lands	No Action	NI	---	—	NI
	All Action Alternatives	LTS	Long term inundation effects for access for educational and other recreational activities would be reduced due to areas not being accessible due to water levels.	NEPA MM-REC-2-4	LTS
Visual Resources					
Impact VIS-1: Short-Term Construction-Related Changes in Scenic Vistas, Scenic Resources, and Existing Visual Character	No Action	NI	---	---	NI
	All Action Alternatives	LTS	Short-term construction activities would include the presence of heavy construction equipment.	---	LTS
Impact VIS-2: Long–Term Changes in Scenic Vistas, Scenic Resources, and Existing Visual Character	No Action	NI	---	---	NI
	All Action Alternatives	S	Changes to the physical environment would impact the visual composition, including vegetation removal and the addition of permanent structures.	MM-VIS-1	LTS
Impact VIS-3: Substantial Changes in Light or Glare	No Action	NI	---	---	NI
	All Action Alternatives	LTS	A new source of light or glare would not be created that would affect residents or visitors.	---	LTS
Public Services, Utilities, and Power					
Impact UTIL-1: Affect the provision of governmental services or facilities, including fire and police protection, parks, and schools	No Action	NI	---	---	NI

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
	All Action Alternatives	LTS	The use of the local workforce and construction controls for hazardous conditions would have limited effects.	---	LTS
Impact UTIL-2: Create the need for new stormwater facilities	No Action	NI	---	---	NI
	All Action Alternatives	S	The implementation of BMPs would control stormwater runoff and associated soil erosion and adequately treat anticipated stormwater runoff generated during construction and maintenance.	MM-WQ-3	LTS
Impact UTIL-3: Generate solid waste in need of disposal, which could exceed the capacity of landfills	No Action	NI	---	---	NI
	All Action Alternatives	LTS	There is adequate capacity at the landfill to accommodate disposal needs and excavated soil would not be disposed of at a public landfill.	---	LTS
Impact UTIL-4: Use and/or depletion of local or regional energy supplies	No Action	NI	---	---	NI
	All Action Alternatives	LTS	Electricity used would be provided to the site by temporary generators during construction and maintenance. Operation of the headworks structure would have low power requirements. Construction would require the transport of material to be hauled to and from the sites.	---	LTS

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
Transportation					
Impact TRAN-1: Construction Personnel Traffic	No Action	NI	----	----	NI
	All Action Alternatives	LTS	Construction personnel would not be expected to substantially encroach upon the peak travel periods in the region.	----	LTS
Impact TRAN-2: Construction Events and Vehicle Traffic	No Action	NI	----	----	NI
	1, 2, 4-6	S	Traffic associated with construction would potentially introduce congestion to nearby highway facilities due to the amount of expected hourly truck trips as a result of riprap and RSP hauling	MM-TRAN-3	LTS
	3	LTS	Traffic associated with construction would not substantially alter traffic and transportation conditions in the area.	----	LTS
Impact TRAN-3: Construction Roadway Conditions	No Action	NI	----	----	NI
	All Action Alternatives	S	Roadways would substantially degrade in quality due to vehicle weight and volume during material hauls and vehicle maneuvers.	MM-TRAN-1, 2	LTS
Impact TRAN-4: Maintenance related traffic	No Action	NI	---	---	NI
	All Action Alternatives	LTS	Traffic associated with maintenance would not substantially alter traffic and transportation conditions in the area.	---	LTS

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
Air Quality and Greenhouse Gases					
Impact AQ-1: Violate air quality standards or contribute substantially to an existing or projected air quality violation	No Action	NI	---	---	NI
	1, 2, 5	S	PM_{10} and NO_x construction emissions would exceed the significance thresholds established by the air districts, and NO_x operational emissions would exceed Yolo-Solano AQMD's significance threshold.	MM-AQ-1-4	SU
	3, 4	S	PM_{10} and NO_x construction emissions would exceed the significance thresholds for the air districts.	MM-AQ-1-5	SU
	6	S	PM_{10}, ROG, and NO_x construction emissions would exceed the significance thresholds for the air districts.	MM-AQ-1-5	SU
Impact AQ-2: Conflict with or obstruct implementation of the applicable air quality plan	No Action	NI	---	---	NI
	1, 2, 5	S	PM_{10} and NO_x construction emissions would exceed the significance thresholds for the air districts, and NO_x operational emissions would exceed Yolo-Solano AQMD's significance threshold.	MM-AQ-1-4	SU
	3, 4	S	PM_{10} and NO_x construction emissions would exceed the significance thresholds for the air districts.	MM-AQ-1-5	SU

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
	6	S	PM_{10}, ROG, and NO_x construction emissions would exceed the significance thresholds for the air districts.	MM-AQ-1-5	SU
Impact AQ-3: Expose sensitive receptors to substantial pollutant concentrations	No Action	NI	---	---	NI
	All Action Alternatives	LTS	TAC emissions would be temporary and no sensitive receptors are in the immediate vicinity of the construction footprint.	---	LTS
Impact AQ-4: Create objectionable odors affecting a substantial number of people	No Action	NI	---	---	NI
	All Action Alternatives	LTS	Construction would be temporary and no receptors are in the immediate vicinity.	---	LTS
Impact AQ-5: Generate criteria pollutants greater than general conformity *de minimis* thresholds	No Action	NI	---	---	NI
	1, 2, 3	LTS	Emissions would be less than the general conformity *de minimis* thresholds.	---	LTS
	4, 5, 6	S	NOx emissions would be greater than the general conformity *de minimis* thresholds.	MM-AQ-1-4	SU
Impact AQ-6: Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment	No Action	NI	---	---	NI
	1, 2, 3	LTS	GHG emissions would not exceed the significance threshold.	---	LTS

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
	4, 5, 6	S	GHG emissions would exceed the significance threshold.	MM-AQ-6	LTS
Impact AQ-7: Conflict with an applicable plan, policy, or regulation adopted for the purpose of reducing the emissions of GHGs	No Action	NI	---	---	NI
	1, 2, 3	LTS	GHG emissions would not exceed the significance threshold.	---	LTS
	4, 5, 6	S	GHG emissions would exceed the significance threshold.	MM-AQ-6	LTS
Hazardous Materials and Health and Safety					
Impact HAZ-1: Increase risk of exposure from hazardous materials to the public and construction workers	No Action	NI	---	---	NI
	All Action Alternatives	S	The risk of exposure to the public and construction workers from hazardous materials associated with construction projects would increase.	MM-WQ-2	LTS
Impact HAZ-2: Accidental release of hazardous materials	No Action	NI	---	---	NI
	All Action Alternatives	S	The risk of accidental release of hazardous materials would increase during construction, operation, and maintenance activities.	MM-WQ-1	LTS
Impact HAZ-3: Accidental release of hazardous materials from contaminated soil and/or groundwater	No Action	NI	---	---	NI

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
	1, 2, 3, 5, 6	S	The risk of accidental release of hazardous materials from contaminated soil and/or groundwater would increase during construction activities due to proximity of well sites and unknown soil contamination.	MM-HAZ-1	LTS
	4	S	The risk of accidental release of hazardous materials from contaminated soil and/or groundwater would increase during construction activities due to proximity of well sites and natural gas pipelines and unknown soil contamination.	MM-HAZ-1, 3	LTS
Impact HAZ-4: Increase the risk of wildfire within the vicinity of the Project area	No Action	NI	---	---	NI
	1, 2, 3, 5, 6	S	The risk of accidental release of wildfire within the vicinity of the project area would increase during construction activities due to sparks or contact between power lines and construction equipment.	MM-HAZ-2	LTS
	4	S	The risk of accidental release of wildfire within the vicinity of the project area would increase during construction activities due to sparks or contact between power lines and construction equipment.	MM-HAZ-2, 3	LTS
Impact HAZ-5: Expose workers to hazardous materials and other safety risks associated with low flying aircraft	No Action	NI	---	---	NI
	All Action Alternatives	LTS	Construction workers could be exposed to pesticides and herbicides.	---	LTS

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
Impact HAZ-6: Temporarily interfere with emergency response and evacuation plan for the area	No Action	NI	---	---	NI
	All Action Alternatives	LTS	Conflicts with emergency vehicles or evacuation efforts would have a low potential of occurring.	---	LTS
Impact HAZ-7: Public use of Fremont Weir Wildlife Area for hunting or other uses could cause unsafe situations for the public and/or construction workers	No Action	NI	---	---	NI
	All Action Alternatives	S	Construction workers could be exposed unsafe conditions due to hunting or other recreation activities at the FWWA.	MM-REC-1	LTS
Impact HAZ-8: Risk of exposure to mosquito-borne viruses could increase as a result of inundation period expansion in the Yolo Bypass for fish passage and rearing	No Action	NI	---	---	NI
	All Action Alternatives	LTS	Increased inundation periods of the Yolo Bypass would increase the risk of exposure to mosquito-borne viruses.	---	LTS
Noise					
Impact NOI-1: Exposure of persons to or generation of noise and vibration levels in excess of standards established in the local general plan or noise ordinance or applicable standards of other agencies	No Action	NI	---	---	NI

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
	1, 2, 5	LTS	Noise and vibrations from construction, operation, and maintenance noise could occur, but levels would be consistent with the general plans of Yolo and Sutter counties.	---	LTS
	3, 4, 6	S	Construction noise would not be consistent with the Sutter County General Plan.	MM-NOI-1	SU
Impact NOI-2: Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels	No Action	NI	---	---	NI
	All Action Alternatives	S	Vibrations from loaded haul trucks along the haul routes could exceed the annoyance threshold for adjacent residential receptors during construction and maintenance	MM-NOI-1	SU
Impact NOI-3: A substantial permanent increase in ambient noise levels in the Project vicinity	No Action	NI	---	---	NI
	All Action Alternatives	LTS	Permanent increases in ambient noise levels could occur, but would be minimal.	---	LTS
Impact NOI-4: A substantial temporary or periodic increase in ambient noise levels in the Project vicinity	No Action	NI	---	---	NI
	All Action Alternatives	S	Ambient noise levels for road-side receptors along the haul and commute routes could increase substantially from construction- and maintenance-related traffic.	MM-NOI-1	SU

Impact	Alternative	CEQA Level of Significance Before Mitigation	NEPA Magnitude and Direction of Impacts	Mitigation Measures	CEQA Level of Significance After Mitigation
Impact NOI-5: Exposure of people residing or working in the Project area to excessive noise levels from public or private airports	No Action	NI	---	---	NI
	All Action Alternatives	LTS	People residing or working in the Project area would not be exposed to excessive noise levels from public or private airports.	---	LTS
Population and Housing					
Impact POP-1: Construction-Related Increase in Population and Corresponding Housing Needs	No Action	NI	---	---	NI
	All Action Alternatives	LTS	No new housing or infrastructure would be needed and there would be a negligible impact on population.	---	LTS

Key: APE = area of potential effect; AQMD = Air Quality Management District; B = beneficial; BMP = best management practice; C = construction; CDFW = California Department of Fish and Wildlife; cfs = cubic feet per second; CVP = Central Valley Project; FWWA = Fremont Weir Wildlife Area; GHG = greenhouse gases; HCP = Habitat Conservation Plan; LTS = less than significant; M = maintenance; N/A = not applicable; NCCP = Natural Communities Conservation Plan; NI = no impact; NO_x = nitrogen oxides; O = operations; PM_{10} = inhalable particulate matter; ROG = reactive organic gases; RSP = rock slope protection; RWQCB = Regional Water Quality Control Board; S = significant; SU = significant and unavoidable; SWP = State Water Project; USACE = United States Army Corps of Engineers; WSE = water surface elevation

Table 2-27. Summary of Impact Analyses for NEPA-only Resources

Impact	Alternative	Magnitude and Direction of Impacts	Effects Determination
Socioeconomics			
Impact SOC-1: Increase employment, income, and output in the regional economy	No Action	---	No adverse effect
	1	Construction would temporarily increase employment, labor income, and revenue. Maintenance would occur annually and would increase employment, labor income, and revenue.	Construction Impacts: Increase of 366 jobs, $18.8 M in labor income, $55.9 M in revenue Annual Maintenance Impacts: Increase of 6 jobs, $0.4 M in labor income, $0.9 M in revenue
	2	Construction would temporarily increase employment, labor income, and revenue. Maintenance would occur annually and would increase employment, labor income, and revenue.	Construction Impacts: Increase of 585 jobs, $31.2 M in labor income, $87.1 M in revenue Annual Maintenance Impacts: Increase of 6 jobs, $0.4 M in labor income, $1.0 M in revenue
	3	Construction would temporarily increase employment, labor income, and revenue. Maintenance would occur annually and would increase employment, labor income, and revenue.	Construction Impacts: Increase of 620 jobs, $32.7 M in labor income, $82.6 M in revenue Annual Maintenance Impacts: Increase of 6 jobs, $0.4 M in labor income, $1.0 M in revenue
	4	Construction would temporarily increase employment, labor income, and revenue. Maintenance would occur annually and would increase employment, labor income, and revenue.	Construction Impacts: Increase of 876 jobs, $35.7 M in labor income, $123.6 M in revenue Annual Maintenance Impacts: Increase of 8 jobs, $0.4 M in labor income, $1.2 M in revenue
	5 (Project)	Construction would temporarily increase employment, labor income, and revenue. Maintenance would occur annually and would increase employment, labor income, and revenue.	Construction Impacts: Increase of 1,127 jobs, $59.1 M in labor income, $138.9 M in revenue Annual Maintenance Impacts: Increase of 10 jobs, $0.5 M in labor income, $1.6 M in revenue

Impact	Alternative	Magnitude and Direction of Impacts	Effects Determination
	5 (Program)	Construction would temporarily increase employment, labor income, and revenue. Maintenance would occur annually and would increase employment, labor income, and revenue.	Construction Impacts: Increase of 286 jobs, $16.4 M in labor income, $63.0 M in revenue Annual Maintenance Impacts: Increase of 10 jobs, $0.5 M in labor income, $1.6 M in revenue
	6	Construction would temporarily increase employment, labor income, and revenue. Maintenance would occur annually and would increase employment, labor income, and revenue.	Construction Impacts: Increase of 1,045 jobs, $55.6 M in labor income, $152.0 M in revenue Annual Maintenance Impacts: Increase of 11 jobs, $0.5 M in labor income, $1.8 M in revenue
Impact SOC-2: Decrease employment, income, and output in the regional economy resulting from conversion of cropland to nonagricultural use	No Action	---	No adverse effect
	1, 2, 3	Conversion of croplands to nonagricultural use would have adverse effects on the regional economy.	Loss of 0.6 jobs, $33,100 in labor income, $102,300 in revenue; Minor impacts to the regional economy due to changes to groundwater levels surrounding the bypass; no effect to forward linkages in the regional economy; potential loss of crop insurance policies or increase in premiums; increase of $1 to $29 per acre in operating costs
	4	Conversion of croplands to nonagricultural use would have adverse effects on the regional economy.	Loss of 1.3 to 1.5 jobs, $68,200 to $88,200 in labor income, $284,500 to $360,700 in revenue; Minor impacts to the regional economy due to changes to groundwater levels surrounding the bypass; no effect to forward linkages in the regional economy; potential loss of crop insurance policies or increase in premiums; increase of $1 to $29 per acre in operating costs

Impact	Alternative	Magnitude and Direction of Impacts	Effects Determination
	5 (Project)	Conversion of croplands to nonagricultural use would have adverse effects on the regional economy.	Loss of 0.7 jobs, $39,900 in labor income, $135,200 in revenue; Minor impacts to the regional economy due to changes to groundwater levels surrounding the bypass; no effect to forward linkages in the regional economy; potential loss of crop insurance policies or increase in premiums; increase of $1 to $29 per acre in operating costs
	5 (Program)	---	No effect
	6	Conversion of croplands to nonagricultural use would have adverse effects on the regional economy.	Loss of 0.9 jobs, $50,500 in labor income, $150,700 in revenue; Minor impacts to the regional economy due to changes to groundwater levels surrounding the bypass; no effect to forward linkages in the regional economy; potential loss of crop insurance policies or increase in premiums; increase of $1 to $29 per acre in operating costs
Impact SOC-3: Changes to water supply to North of Delta and South of Delta contractors affecting the regional economy	No Action	---	No adverse effect
	1, 2, 3, 4, 5 (Project), 6	Reductions would not be substantial enough to warrant water rate increases that could affect the regional economy.	Infrequent, less than 1% reduction in monthly deliveries
	5 (Program)	---	No effect
Environmental Justice			
Impact EJ-1: Exposure of a minority and/or low-income population to adverse and disproportionately high effects or hazards from project construction	No Action	---	No Impact
	All Action Alternatives	Adverse and disproportionately high noise and air quality impacts would not occur to the minority populations surrounding the Project area due to construction.	Adverse and Disproportionate Effect Would Not Occur

Impact	Alternative	Magnitude and Direction of Impacts	Effects Determination
Impact EJ-2: Conversion of cropland to nonagricultural use could result in a disproportionately high effect on minority and/or low-income employment	No Action	---	No Impact
	All Action Alternatives	The conversion of croplands to a non-production state would result in a marginal (<1%) reduction in farmworker jobs, which are held largely by minority and low-income groups.	Adverse and Disproportionate Effect Would Not Occur
Impact EJ-3: Project construction activities and annual maintenance could increase minority and/or low-income employment.	No Action	---	No impact
	All Action Alternatives	Construction activities would create temporary jobs that would be supplied by workers in Yolo, Sutter, Solano, and Sacramento counties, which could include those in Census Tracts 101.02, 112.06, and 114, all of which have minority populations over 50 percent.	Beneficial
Impact EJ-4: Project actions could reduce educational opportunities offered in the YBWA on low-income students	No Action	---	No Impact
	All Action Alternatives	The reduction in the number of field trips available at the YBWA could affect up to 30 percent of Title 1 schools in DJUSD and up to 57 percent of Title 1 schools in SCUSD.	Adverse and Disproportionate Effect Could Occur

Key: DJUSD = Davis Joint Unified School District; M = million; SCUSD = Sacramento City Unified School District; YBWA = Yolo Bypass Wildlife Area

2.11 References

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3 Approach to the Environmental Analysis

The Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Project) area is broadly defined to ensure evaluation of potential direct, indirect, and cumulative effects. The areas where direct, indirect, and cumulative effects may occur differ according to resource area; therefore, the geographic range described varies by resource. Resources are described in sufficient detail to understand the significant effects of the project alternatives.

3.1 Project Area

The Project area under all alternatives includes the Yolo Bypass, which is in the Yolo Basin of the Sacramento Valley near the cities of Davis and West Sacramento in Yolo County, and small portions of Sutter and Solano counties. The approximately 59,000-acre Yolo Bypass stretches north to Fremont Weir, south to the Liberty Island/Cache Slough Complex area, and follows the west side of the Sacramento River, as shown in Figure 1-1. Physical infrastructure within the Yolo Bypass includes Fremont, Sacramento, Wallace, and Lisbon weirs. The Project area also includes the lower Sacramento River Basin in Sacramento, Solano, Sutter, and Yolo counties.

3.2 Chapter Contents and Definition of Terms

Chapters 4 through 22 include the environmental and regulatory setting for 19 resource topics as well as discussions of methods, significance criteria, environmental consequences, mitigation measures for direct and indirect impacts, and cumulative impacts, organized by resource topic. Resources analyzed in these chapters are:

- Chapter 4: Flood Control, Hydraulics, and Hydrology
- Chapter 5: Surface Water Supply
- Chapter 6: Water Quality
- Chapter 7: Groundwater
- Chapter 8: Aquatic Resources and Fisheries
- Chapter 9: Vegetation, Wetlands, and Wildlife Resources
- Chapter 10: Cultural Resources and Indian Trust Assets
- Chapter 11: Land Use and Agricultural Resources
- Chapter 12: Geology and Soils
- Chapter 13: Recreation
- Chapter 14: Visual Resources

- Chapter 15: Public Services, Utilities, and Power
- Chapter 16: Socioeconomics
- Chapter 17: Transportation
- Chapter 18: Air Quality and Greenhouse Gases
- Chapter 19: Hazardous Materials and Health and Safety
- Chapter 20: Noise
- Chapter 21: Population and Housing
- Chapter 22: Environmental Justice

Chapter 23 discusses other disclosures required by National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA), including the irreversible and irretrievable commitment of resources, the relationship between short-term uses and long-term productivity, and growth-inducing impacts. Chapter 24, Consultation and Coordination, describes the consultation and outreach activities that have occurred during the Environmental Impact Statement/Environmental Impact Report (EIS/EIR) preparation process. Chapter 25, List of Preparers, lists the authors and other contributors to the development of the EIS/EIR and their qualifications. Chapter 26, Glossary, contains a description of key terms.

The NEPA/CEQA requirements for this EIS/EIR are summarized in the following subsection, followed by an overview of the structure and approach for the impact analysis provided in Chapters 4 through 22.

3.2.1 NEPA and CEQA Requirements

Both NEPA and CEQA require analysis of all phases of a proposed action, including development and operation. The NEPA/CEQA requirements for the environmental setting and consequences chapters are similar but not identical. These requirements are summarized below along with the organization and general assumptions used in the environmental analysis contained in this EIS/EIR. The reader is referred to the individual technical chapters regarding specific assumptions, methodology, and CEQA significance criteria (thresholds of significance) used in the analyses.

3.2.1.1 Affected Environment/Environmental Setting

Council on Environmental Quality (CEQ) Regulations specify that an EIS "shall succinctly describe the environment of the area(s) to be affected or created by the alternatives under consideration. The descriptions shall be no longer than necessary to understand the effects of the alternatives. Data and analyses in a statement shall be commensurate with the importance of an impact, with less important material summarized, consolidated, or simply referenced" (Title 40 Code of Federal Regulations [CFR] Section 1502.15).

Section 15125(a) of the State of California (State) CEQA Guidelines states that the environmental setting sections of an EIR "must include a description of the physical environment conditions in the vicinity of the project, as they exist at the time that the Notice of Preparation (NOP) is published, or if no NOP is published, at the time the environmental analysis commences from both a local and regional perspective. This environmental setting will normally constitute the baseline physical conditions by which the lead agency determines whether an impact is significant."

The California Department of Water Resources (DWR) initiated the CEQA process by issuing an NOP on March 4, 2013 (State Clearinghouse #2013032004). The environmental setting in this EIS/EIR was based on conditions as of 2013.

3.2.1.2 Environmental Consequences

The CEQ Regulations specify that a Federal agency preparing an EIS must consider the effects of the proposed action and alternatives on the environment. These include effects on ecological, aesthetic, historical, and cultural resources as well as economic, social, and health effects. Environmental effects are categorized as direct, indirect, or cumulative effects. An EIS must also discuss possible conflicts with the objectives of Federal, State, regional, and local land use plans, policies, and controls for the area concerned; energy requirements and conservation potential; urban quality; the relationship between short-term uses of the environment and long-term productivity; and irreversible or irretrievable commitments of resources. An EIS must identify relevant, reasonable mitigation measures that are not already included in the proposed action or alternatives to the proposed action that could avoid, minimize, rectify, reduce, eliminate, or compensate for the project's adverse environmental effects (40 CFR Section 1502.14, 1502.16, 1508.8). Executive Order (EO) 12898 (1994) requires NEPA documents to evaluate effects to environmental justice communities to identify and address "disproportionately high and adverse human health or environmental effects" of programs on minority and low-income populations. The evaluation of socioeconomic effects required by NEPA does not require a significance conclusion unless there is a "cause and effect" for a physical change resulting from the impact.

The State CEQA Guidelines explain that the environmental analysis for an EIR must evaluate impacts associated with the project and identify mitigation for any potentially significant impacts.

3.2.2 Significance Criteria

The thresholds of significance for impacts generally are based on the environmental checklist in Appendix G of the CEQA Guidelines, as amended. These thresholds also encompass the factors considered under NEPA to determine the context, duration, and intensity of its impacts while meeting the more specific requirements of CEQA.

3.2.2.1 Impact Comparisons and Organization

Under CEQA, the environmental analysis compares the alternatives under consideration, including the No Project Alternative (referred to in this EIS/EIR as the No Action Alternative), to existing conditions, defined at the time when the NOP was published (March 4, 2013). Under NEPA, the effects of the alternatives under consideration are determined by comparing effects between alternatives and against effects from the No Action Alternative. Consequently, baseline conditions differ between NEPA and CEQA.

Under NEPA, the No Action Alternative (i.e., expected future conditions without the project) is the baseline to which the action alternatives are compared, and the No Action Alternative is compared to existing conditions. Under CEQA, existing conditions are the baseline to which all alternatives are compared. If the No Action Alternative is unchanged from existing conditions, the impact analyses do not separate impacts compared to the No Action Alternative and existing conditions. However, for resources where the No Action Alternative may vary from existing conditions (such as in Chapter 4, *Flood Control, Hydraulics, and Hydrology*), the impact analysis compares each action alternative to both the No Action Alternative and existing conditions to characterize potential impacts.

The No Action Alternative is defined as the expected future conditions without the project, which includes other projects that have an approved decision document (Notice of Determination [NOD] for CEQA and Record of Decision [ROD] for NEPA) at the time of publication of the Draft EIS/EIR. Future projects included in the baseline of the No Action Alternative are summarized in Table 3-1.In this EIS/EIR, impacts are presented numerically and sequentially in each section. Impacts are presented with a two- to four-letter code representing the resource section and a number, followed by a short statement describing the impact. These impact numbers and statements are in bold. The impact numbering begins under the No Action Alternative. The impact sequence is carried throughout each alternative discussion. If an impact is not relevant to a specific alternative, the impact is not discussed; therefore, the impact statement sequence may skip a number.

The impact analysis uses the best available science and tools to evaluate potential impacts. Reclamation and DWR established the Fisheries and Engineering Technical Team early in the EIS/EIR process with experts from federal, state, and local agencies. Reclamation and DWR discussed potential tools with these experts and used this forum to brainstorm and collect ideas for how best to accomplish the biological objectives of the project. Additionally, Reclamation and DWR requested the Delta Science Program to perform an independent peer review of the tools being used in this EIS/EIR. The review panel found “all of the selected approaches and tools appropriate for selecting a notch location and configuration” (Tompkins et al. 2017). The panel also recommended improvements for consideration in the future during project design and implementation.

3.2.2.2 Impact Levels

Impact levels are categorized based on their level of significance and whether they can be mitigated to lessen the impact on the environment. This EIS/EIR uses the following terminology based on the State CEQA Guidelines to denote the significance of each environmental impact. CEQ Regulations for NEPA do not require significance determinations in an EIS but do require a discussion of the context and intensity of the impacts. These considerations are disclosed in each resource chapter impact discussion before the level of CEQA significance for the impact is presented.

- No Impact: No impact indicates that the construction, operation, or maintenance of the alternatives would not have any direct or indirect impacts on the environment. It means that no change from existing conditions would result from implementation of the alternative.
- Less than Significant: These are impacts resulting from the implementation of the alternative that are short term or will have little effect on the surrounding environment, residences, or operations in the Project area. CEQA does not require mitigation for this impact level.

Table 3-1. Projects Considered for the No Action Alternative

Project	Agency	Description
Battle Creek Salmon and Steelhead Restoration Project	United States Bureau of Reclamation (Reclamation), Pacific Gas and Electric Company, California State Water Resources Control Board (SWRCB), United States Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration National Marine Fisheries Service (NMFS), California Department of Fish and Wildlife (CDFW), Federal Energy Regulatory Commission (FERC), California Bay Delta Authority, and additional partners	The Battle Creek Salmon and Steelhead Restoration Project is being implemented near the town of Manton, California, in Shasta and Tehama counties. Upon its completion, the project will reestablish approximately 42 miles of prime salmon and steelhead habitat on Battle Creek and an additional 6 miles on its tributaries. Public scoping began in 2000, and the EIS/EIR was finalized in July 2005. The Findings of Fact was released in 2007 (California Department of Fish and Game [CDFG] 2007) and the ROD in 2008 (Reclamation 2008). Construction began in 2010 and will continue through 2020 to complete all phases (Reclamation 2017a).
California EcoRestore projects	California Natural Resources Agency	California EcoRestore is an initiative that will attempt more than 30,000 acres of critical Sacramento-San Joaquin Delta (Delta) restoration pursuant to the NMFS's 2009 *Biological Opinion and Conference Opinion on the Long-term Operations of the Central Valley Project and the State Water Project* and the 2008 USFWS biological opinion (BO) for Delta Smelt. A broad range of projects are included in the California EcoRestore initiative to accomplish enhancements and improvements to the overall health of the Delta, including projects within or adjacent to the Yolo Bypass (California Natural Resources Agency 2017a). The California EcoRestore projects described below are in various stages of development, from conceptual to completed.
Agricultural Road Crossing #4 Fish Passage Improvement Project	DWR, Reclamation	This is a future project that would include modification of the southernmost agricultural road crossing in the Tule Canal to improve adult fish passage.

Project	Agency	Description
Cache Slough Area Restoration – Prospect Island	DWR, CDFW	The Cache Slough Complex is in the northern Delta where Cache Slough and the southern Yolo Bypass meet. It currently includes Liberty Island, Little Holland Tract, Prospect Island, Little Egbert Tract, and the surrounding waterways. Levee height on these tracts is restricted and designed to allow overtopping in large flow events to convey water from the upper Yolo Bypass. Since 1983 and 1998, respectively, Little Holland Tract and Liberty Island have remained breached. Restoration is occurring naturally on the islands. Restoration in the Cache Slough Complex was identified as an Interim Delta Action by Governor Schwarzenegger in July 2007 and was evaluated through the *Bay Delta Conservation Plan* (BDCP) process. The Cache Slough Complex has potential for restoration success because of its relatively high tidal range, historic dendritic channel network, minimal subsidence, and remnant riparian and vernal pool habitat. Restoration efforts would support native species, including delta smelt, longfin smelt, Sacramento splittail, and Chinook salmon, by creating or enhancing natural habitats and improving the food web that fish require. Surrounding lands that are at elevations that would function as floodplain or marsh if not separated by levees could also be included in the Cache Slough Area. This broader area includes roughly 45,000 acres of existing and potential open water, marsh, floodplain, and riparian habitat. The goals of restoration in the Cache Slough Complex are to: 1) reestablish natural ecological processes and habitats to benefit native species, 2) contribute to scientific understanding of restoration ecology, and 3) maintain or improve flood safety. Three restoration actions are currently contemplated in the Cache Slough Complex, including restoration actions at Calhoun Cut, Little Holland Tract, and Prospect Island (DWR 2008).
Fremont Weir Adult Fish Passage Modification Project	DWR, Reclamation	DWR and Reclamation modified the existing Fremont Weir fish ladder to provide improved upstream passage for salmonids and sturgeon when the Sacramento River overtops Fremont Weir and immediately after the Sacramento River recedes below Fremont Weir; improved fish passage conditions in the channel that extends from the existing fish ladder upstream to the Sacramento River; improved fish passage conditions in the scour channel that extends from the existing fish ladder downstream to an existing deep pond; and removed one earthen agricultural road crossing and replaced one earthen agricultural road crossing with a structure that allows for improved fish passage through the Tule Canal and continued agricultural utility. The Final Initial Study/Environmental Assessment was released in August 2017. Reclamation's Finding of No Significant Impact (Reclamation 2017b) and DWR's Final Mitigated Negative Declaration (DWR 2017a) were both released in August 2017. Construction began in May 2018.

Project	Agency	Description
Knights Landing Outfall Gate	Reclamation District 108	This project constructed a positive fish barrier on the downstream side of the existing Knights Landing Outfall Gates (KLOG) in the Colusa Basin Drain (CBD) and placed a small amount of riprap on the right bank of the CBD immediately downstream of the KLOG. The project serves primarily as a fish passage improvement action that will prevent salmon entry into the CBD while maintaining outflows and appropriate water surface elevations. A secondary purpose of this project is to address an existing erosion site on the right bank of the CBD channel immediately downstream of the KLOG structure to enhance stability. The project was completed in November 2015 (California Natural Resources Agency 2017b). At the time that the Draft EIS/EIR was released, the fish screens on the gates were not operational; however, repairs are likely to have them operational before construction begins for the Project.
Lisbon Weir Modification Project	DWR, Reclamation	Modification of Lisbon Weir will provide an upgrade for adult migrating fish that currently face a migration delay in the Yolo Bypass. When the bypass is not flooded, salmon can only pass this rock weir when flood tides open a small section of flap gate or when a strong high tide overtops the weir. This project would improve fish passage throughout the tidal cycle while maintaining a reliable agricultural diversion. Project planning is still at a conceptual level. Construction is anticipated to begin after 2018 (DWR 2017b).
Lower Putah Creek Realignment Project	Yolo Basin Foundation, DWR, Reclamation	This project will restore ecological functions and enhance fish passage in Lower Putah Creek from the western boundary of the Yolo Bypass Wildlife Area (YBWA) to the Toe Drain. The project would create a new, realigned channel from the existing Putah Creek channel at the western YBWA boundary that would cross the YBWA, connect to tidal channels previously restored by CDFW at the southeast end of the YBWA, and enter the Toe Drain downstream of Lisbon Weir. The channel design would provide fish passage for salmonids, increase area of wetland habitat subject to tidal influence in the CDFW-restored tidal area, and increase the area of floodplain-rearing habitat for species of management concern (specifically salmonids). Project goals include: 1) improve passage, rearing, and emigration of adult and juvenile salmonids; 2) enhance habitat for salmonids and other Delta native species and wildlife within a realigned channel; 3) enhance ecological functions of the recently restored tidal habitats on the YBWA; and 4) preserve and enhance, where possible, existing beneficial uses, including public access, wildlife viewing, hunting, and fishing. This project is in the planning, designing, and environmental regulation and permitting phase of development under an Ecosystem Restoration Program Grant Agreement (California Natural Resources Agency 2017c).

Project	Agency	Description
Prospect Island Tidal Habitat Restoration Project	DWR, CDFW	This project would restore tidal action to the interior of Prospect Island in the southern end of Yolo Bypass, partially fulfilling the 8,000-acre tidal habitat restoration obligations contained within the 2008 USFWS BO. The project would result in a suite of overarching long-term ecosystem benefits, including enhancement of primary productivity and food availability for fisheries in the Delta; an increase in the quantity and quality of salmonid-rearing habitat and habitat for other listed species; enhancement of water quality, recreation, and carbon sequestration in tidal marshes; promotion of habitat resiliency; and promotion of habitat conditions that support native species. Current design of the project includes breaching the external Miner Slough levee and removing a portion of the internal cross levee to open the site to daily tidal inundation. The Draft EIR was released August 2016, and the final EIR is expected by early 2019. Construction is estimated to begin in 2020 (California Natural Resources Agency 2017d).
Tule Red Tidal Marsh Restoration Project	State and Federal Contractors Water Agency (SFCWA), DWR	This project would open more than 400 acres of wetlands to daily tides in the southern Suisun Marsh to benefit native fish species. This restoration project involves breaching a natural berm to allow for full daily tidal exchange through the interior of the project site and creation of a network of channels to convey water across the marsh plain. The Addendum for the Tule Red Tidal Restoration Project to the Suisun Marsh Plan (SMP) Habitat Management, Preservation, and Restoration Plan EIS/EIR was circulated in 2016. The SMP EIR was certified by CDFW in December 2011. The SMP EIS ROD was signed by Reclamation and USFWS in April 2014 (SFCWA 2016). Construction began in 2016 and is anticipated to be complete in 2018 (California Natural Resources Agency 2017e).
Wallace Weir Fish Rescue Facility Project	DWR, Reclamation District 108	Wallace Weir is a water control structure on the Knights Landing Ridge Cut where it enters the west side of the Yolo Bypass. Adult salmon have been found in dead-end agricultural ditches upstream of the weir in the CBD system, especially when flows in the Knights Landing Ridge Cut are high. These fish rarely, if ever, make it back to the Sacramento River to continue their upstream migration to spawning grounds, thus, dying in these dead-end ditches. The earthen dam, which washes away during high flow events, will be replaced with a permanent structure that will prevent migration of salmon and sturgeon into the CBD. The project also includes a facility to allow for efficient trapping and relocation of fish to the Sacramento River. All permitting has been completed, and the project is under construction (DWR 2017c).

Project	Agency	Description
California WaterFix	DWR, Reclamation	The BDCP is a habitat conservation plan and natural community conservation plan proposed by DWR, Reclamation, USFWS, and NMFS to contribute to the recovery of listed species, restore a more naturally functioning Delta ecosystem, and provide a reliable source of fresh water from the Delta for drinking water. The BDCP included construction of new water delivery infrastructure and aquatic habitat restoration. In 2015, a new sub-alternative (Alternative 4A) replaced Alternative 4 of the proposed BDCP as the CEQA and NEPA preferred alternative. Alternative 4A, known as California WaterFix, represents a separation of the proposed conveyance facility from the habitat restoration measures that were included in the BDCP. The habitat restoration measures are now included in the California EcoRestore initiative. The proposed conveyance facility includes construction of three new intakes in the north Delta that would supply two new parallel underground pipelines. The pipelines would convey diverted water to the existing export facilities in the south Delta. Mitigation for California WaterFix is expected to include approximately 2,300 acres of habitat restoration and up to 13,300 acres of habitat protection (California Natural Resources Agency 2017f). Restoration and protection actions would be focused mainly in the Delta, but could also result in restoration of portions of the Yolo Bypass. The final EIR/EIS for California WaterFix was released in December 2016. DWR issued the NOD in July 2017 (DWR 2017d). As explained in 1.8, DWR announced on May 2, 2019 that it will withdraw proposed permits for California WaterFix and pursue a smaller, single-tunnel conveyance through the Sacramento-San Joaquin Delta. Removal of California WaterFix from the No Action Alternative would not change the impact analysis in the EIS/EIR. Please see Appendix E for additional CalSim modeling results.

Project	Agency	Description
Environmental Permitting for Operation and Maintenance (EPOM)	DWR	DWR is mandated to maintain and operate certain levees, channels, and on appurtenant structures of the Sacramento River Flood Control Project (SRFCP) along the Sacramento River and tributaries, and part of the Middle Creek Project in Lake County, on behalf of the State pursuant to California Water Code Sections 8361 and 12878 et seq., and in accordance with federal requirements. The SRFCP levees, channels, and structures are located along the Sacramento River and its tributaries between Red Bluff and the area just south of Rio Vista, and a portion of the Middle Creek Project located near Clear Lake in Lake County. DWR maintenance activities include, but are not limited to: (1) levee maintenance (e.g., rodent abatement and damage repair, vegetation management, erosion repair, toe drain, levee crown and access road maintenance, unauthorized encroachment removal, stability berm reconstruction, and fencing/levee protection) to ensure serviceability in times of floods, and provide visibility and access for inspections, maintenance, and flood fighting activities; (2) channel maintenance (e.g., sediment removal, debris/obstruction, vegetation management, and channel and bank scour repair) to maintain flood conveyance capacity and structural integrity of channel and associated flood control structures; (3) flood control structure maintenance and repair (e.g., pumping plants, weirs and outfall gates, and bridge maintenance and repair, and pipe/culvert repair, replacement, and abandonment); and (4) data collection. The EPOM would allow the continuation of these maintenance activities within the regulatory limitations imposed by the required permits. The draft EIR was released for public review in January 2017, and a portion of the draft EIR was recirculated in September 2017 (DWR 2017e). EPOM would provide long-term maintenance of the Fremont Weir Wildlife Area and would include maintenance of the Fremont Weir Adult Fish Passage Modification Project structure.
Oroville Facilities FERC Relicensing and License Implementation	DWR	The Oroville Facilities, as part of the SWP, are also operated for flood management, power generation, water quality improvement in the Delta, recreation, and fish and wildlife enhancement. The objective of the relicensing process is to continue operation and maintenance of the Oroville Facilities for electric power generation, along with implementation of any terms and conditions to be considered for inclusion in a new FERC hydroelectric license. The initial FERC license for the Oroville Facilities, issued on February 11, 1957, expired on January 31, 2007. DWR published the Final EIR in June 2008 and the NOD in July 2008 (DWR 2017f). DWR is awaiting the FERC license renewal.

Project	Agency	Description
EchoWater Project	Sacramento Regional County Sanitation District	The Sacramento Regional County Sanitation District is upgrading its existing secondary treatment facilities at the Sacramento Regional Wastewater Plant to meet new National Pollutant Discharge Elimination System (NPDES) permit requirements. Project implementation would not result in an increase in permitted wastewater treatment capacity; however, it would result in improved treated effluent water quality. The project will upgrade existing secondary treatment facilities to advanced unit processes including improved nitrification/denitrification and filtration. The plant discharges to the Sacramento River downstream of the Fremont Weir and upstream of the Delta. Construction began in 2015 and facilities needed to meet the NPDES requirements will be completed in 2021 (Sacramento Regional County Sanitation District 2017).
South Bay Aqueduct Improvement and Enlargement Project	DWR, Zone 7 Water Agency	The South Bay Aqueduct Improvement and Enlargement Project would make improvements to bring the existing capacity of the water conveyance system up to its design capacity. The expansion portion would add conveyance capacity to meet future needs. A Final EIR was completed in 2004.
San Joaquin River Restoration Program – Restoration Flows	San Joaquin River Restoration Program	The San Joaquin River Restoration Program began Interim Flow releases from Friant Dam into the San Joaquin River on October 1, 2009. Restoration Flows began on January 1, 2014 but were curtailed in 2014 and 2015 due to drought conditions. The San Joaquin River was reconnected from Friant Dam to the Merced River confluence in August 2016. In 2017, the river saw heavy Flood Flows for the first time in years.
Grasslands Bypass Project	Reclamation, San Luis & Delta-Mendota Water Authority	The Grasslands Bypass Project prevents discharge of subsurface agricultural drainage water into wildlife refuges and wetlands in central California. The drainage water is conveyed instead through a segment of the San Luis Drain to Mud Slough, a tributary of the San Joaquin River. The Project improves water quality in the wildlife refuges and wetlands, sustains the productivity of 97,000 acres of farmland, and fosters cooperation between area farmers and regulatory agencies in drainage management reduction of selenium and salt loading.

Key: BDCP = Bay Delta Conservation Plan; BO= biological opinion; CBD = Colusa Basin Drain; CDFG = California Department of Fish and Game; CDFW = California Department of Fish and Wildlife; CEQA = California Environmental Quality Act; Delta = Sacramento-San Joaquin Delta; DWR = California Department of Water Resources; EIS/EIR = environmental impact statement/environmental impact report; EPOM = Environmental Permitting for Operation and Maintenance; FERC = Federal Energy Regulatory Commission; KLOG = Knights Landing Outfall Gates; NEPA = National Environmental Policy Act; NMFS = National Oceanic and Atmospheric Administration National Marine Fisheries; NOD = Notice of Determination; NPDES = National Pollutant Discharge Elimination System; Reclamation = United States Bureau of Reclamation; ROD = Record of Decision; SFCWA = State and Federal Contractors Water Agency; SMP = Suisun Marsh Plan; SRFCP - Sacramento River Flood Control Project; SWP = State Water Project; SWRCB = California State Water Resources Control Board; USFWS = United States Fish and Wildlife Service; YBWA = Yolo Bypass Wildlife Area

- Significant: Significant impacts are those that exceed the impact thresholds provided for each resource section and therefore could have substantial effects on the environment, residents, and/or operations in the Project area. Under CEQA, mitigation measures or alternatives to the proposed action must be provided, where applicable, to avoid or reduce the magnitude of significant impacts. Impacts are then reevaluated after mitigation and could result in the following impact categories:
  - Less than Significant after Mitigation: These are impacts that would have a significant effect to a resource prior to implementing mitigation measures. Once mitigation measures are in place, however, these impacts would no longer have a significant effect on the Project area.
  - Significant and Unavoidable: These are impacts on a resource where effects cannot be mitigated to a less than significant level.
- Beneficial: Beneficial impacts are changes to the condition of a resource that provide long-term or permanent improvements to that resource.

3.2.3 Mitigation Measures

Under CEQA, mitigation measures are provided for each significant impact where mitigation would be feasible and effective to reduce impacts of the action alternatives. Mitigation measures avoid, minimize, rectify, reduce, or compensate for significant impacts of the action alternatives to reduce them to a less-than-significant level, in accordance with CEQA Guidelines Section 15126.4. Under NEPA, where appropriate mitigation exists for adverse effects, mitigation should be considered, but the Federal lead agency does not have a similar procedural obligation as under CEQA to implement that mitigation.

For each impact where mitigation is proposed, the significance of the impact after mitigation is stated, as described above. Under CEQA, no mitigation measures are proposed when an impact conclusion is “less than significant,” “no impact,” or “beneficial.” In addition to mitigation for significant impacts under CEQA, additional mitigation measures were considered for adverse effects under NEPA where appropriate.

3.2.4 Significant and Unavoidable Impacts

Where sufficient feasible mitigation is not available to reduce impacts to a less than significant level, the impacts are identified as “significant and unavoidable.” Under CEQA, a project with significant and unavoidable impacts could proceed, but the CEQA lead agency would be required to:

1. Conclude in findings that there are no feasible means of substantially lessening or avoiding the significant impact in accordance with State CEQA Guidelines Sections 15091(a)(1), 15091(a)(2), or 15091(a)(3)
2. Prepare a statement of overriding considerations, in accordance with CEQA Guidelines Section 15093, explaining why the CEQA lead agency would proceed with the project in spite of the potential for significant impacts

3.3 Cumulative Impacts

Each resource section includes an evaluation of cumulative effects. This section examines the effects of the Project and how they may combine with the effects of other past, present, and future projects or actions to create significant impacts on specific resources.

Cumulative effects are those environmental effects that, on their own, may not be considered significant but when combined with similar effects over time have the potential to result in significant effects. Cumulative effects are important because they allow decision makers to look not only at the impacts of an individual project but also at the overall impacts on a specific resource, ecosystem, or human community over time from several different projects. NEPA and CEQA require consideration of cumulative effects in an EIS and EIR.

3.3.1 National Environmental Policy Act

According to the CEQ's regulations for implementing NEPA, cumulative effects are defined as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (federal or non-federal) or person undertakes such actions (40 CFR Section 1508.7)."

NEPA regulations require an analysis of direct, indirect, and cumulative effects and define "effects" as ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative (40 CFR Section 1508.8). Additionally, NEPA regulations state that both connected and cumulative actions must be considered and discussed in the same document as the Proposed Action (40 CFR Section 1508.25(a)(1) and (2)).

3.3.2 California Environmental Quality Act

CEQA Guidelines define cumulative effects as:

"Two or more individual effects which, when considered together, are considerable or which compound or increase other environmental impacts.

a. The individual effects may be changes resulting from a single project or a number of separate projects.

b. The cumulative impact from several projects is the change in the environment which results from the incremental impact of the project when added to other closely related past, present, and reasonably foreseeable probable future projects. Cumulative impacts can result from individually minor but collectively significant projects taking place over a period of time (CEQA Guidelines Section 15355)."

According to the CEQA Guidelines, a lead agency must discuss the cumulative impacts of a project when the total cumulative effect (the project's incremental effects combined with the effects of past, present, and probable future projects) would be significant and the project's incremental contribution to that significant cumulative effect would be "cumulatively considerable," or significant (CEQA Guidelines Section 15065(a)(3); Section 15130(a)). If the cumulative impact would not be significant, an EIR must briefly indicate why (CEQA Guidelines Section 15130(a)(2)).

In an EIR, a lead agency can determine that a project's contribution to a significant cumulative impact would be minimal (referred to as "less than cumulatively considerable") and therefore not significant. A project's contribution to a significant cumulative impact also can be less than cumulatively considerable if the project is required to implement or fund its fair share of a mitigation measure designed to address the significant cumulative impact. The lead agency must identify facts supporting this conclusion (CEQA Guidelines Section 15130(a)(3)).

3.3.3 Methods and Assumptions

The following subsections further describe the methodology and assumptions used to complete the cumulative effects analysis for the Project.

3.3.3.1 Methodology for Analyzing Cumulative Impacts

Although NEPA guidelines do not provide specific guidance on how to conduct a cumulative impact analysis, Reclamation identifies associated actions (past, present, or future) that, when viewed with the proposed or alternative actions, may have significant cumulative impacts. Cumulative impacts should not be speculative but should be based on reasonably foreseeable long-range plans, regulations, or operating agreements.

CEQA Section 15130(b)(1) identifies two methods that may be used to analyze cumulative impacts:

1. "A list of past, present, and probable future projects producing related or cumulative impacts, including, if necessary, those projects outside the control of the agency," and/or
2. "A summary of projections contained in an adopted general plan or related planning document, or prior environmental document which has been adopted or certified, which described or evaluated regional or area-wide conditions contributing to the cumulative impact. Any such document shall be referenced and made available to the public at a location specified by the lead agency."

This document analyzes cumulative effects using the project method identified above.

3.3.3.2 Cumulative Past, Present, and Reasonably Foreseeable Future Actions Considered

This section describes the past, present, and reasonably foreseeable, probable future actions and projects that have or could contribute to cumulative effects. Reasonably foreseeable probable future actions are actions that are currently under construction, approved for construction, or in final stages of formal planning. The future actions considered in this cumulative effects analysis are actions that would occur within or near the study area that potentially would affect resources that also may be affected by the Project. These actions were identified by reviewing agency websites reviewing planning and environmental documents. Actions were evaluated for inclusion in the cumulative effects analysis based on three criteria that all must be met to be considered reasonably foreseeable:

- The action has an identified sponsor actively pursuing project development; has completed or issued NEPA and/or CEQA compliance documents, such as a Draft EIS or EIR; and appears to be "reasonably foreseeable" given other considerations such as site suitability, funding and economic viability, and regulatory limitations.

- Available information defines the action in sufficient detail to allow meaningful analysis.
- The action could affect resources also potentially affected by the Project.

The actions presented in Table 3-2 have been qualitatively considered in the cumulative effects assessment of the Project. They consist of projects, resource management plans and programs, and development projects.

When comparing the cumulative condition to existing conditions for the CEQA analysis, all projects presented in Table 3-1, Projects Considered for the No Action Alternative, are also incorporated as part of the cumulative condition.

Table 3-2. Past, Present, and Future Actions and Projects Considered for the Cumulative Analysis

Project	Agency	Description
American River Common Features General Reevaluation Report (GRR)	United States Army Corps of Engineers (USACE)	The American River Common Features Project (ARCFP) was authorized by the Water Resources Development Act (WRDA) of 1996 to increase flood protection for the City of Sacramento. The ARCFP was authorized to strengthen the north and south levees of the American River and raise and strengthen the upper 12 miles of the east levee of the Sacramento River in the Natomas area. The WRDA of 1999 expanded the scope of the ARCFP to include raising and/or strengthening additional portions of levees along the American River and the Natomas Cross Canal. The USACE completed a post-authorization change study of the ARCFP in 2015 and prepared the final American River Watershed Common Features GRR (USACE 2015a) to indicate the results of reevaluating the ARCFP and identifying the levee improvements needed to provide at least a 200-year level of flood protection for the City of Sacramento and the Natomas area. Needed improvements include widening Sacramento Weir and the Sacramento Bypass on the east side of the Yolo Bypass, upstream of the confluence of the American and Sacramento rivers. This would be accomplished by constructing a new Sacramento Bypass north levee set back 1,500 feet from the existing levee, removing the existing Sacramento Weir north levee, and constructing a new weir section to lengthen the existing Sacramento Weir. USACE prepared a final EIS/EIR for the GRR's project alternatives in December 2015 (USACE 2015b).
Bay-Delta Water Quality Control Plan Update	SWRCB	The SWRCB is updating the 2006 Bay-Delta Water Quality Control Plan (WQCP) in two phases (SWRCB 2018): Phase I: The first Plan amendment is focused on San Joaquin River flows and southern Delta salinity and modifies water quality objectives (i.e., establishes minimum flows) on the Lower San Joaquin River and Stanislaus, Tuolumne, and Merced rivers to protect the beneficial use of fish and wildlife and modifies the water quality objectives in the southern Delta to protect the beneficial use of agriculture. The proposed final amendments to the Bay-Delta Plan and the Final Supplemental Environmental Document for Phase I was released in July 2018, with some additional minor changes released in August 2018. Phase II: Phase II is focused on the Sacramento River and its tributaries, Delta eastside tributaries (including the Calaveras, Cosumnes, and Mokelumne rivers), Delta outflows, and interior Delta flows.
Central Valley Flood Management Planning (CVFMP) Program	DWR	DWR launched the CVFMP program in 2008 to improve integrated flood management in California's Central Valley. The CVFMP program efforts include the preparation of the Central Valley Flood Protection Plan (CVFPP) to fulfill the requirements of the Central Valley Flood Protection Act of 2008 (DWR 2017g). A guidance document was adopted in 2012.

Project	Agency	Description
CVFPP	DWR	The CVFPP was prepared by DWR in coordination with local flood management agencies, the Central Valley Flood Protection Board (CVFPB), USACE, Federal Emergency Management Agency, and Reclamation. The CVFPP is a guidance document that proposed a State system-wide investment approach for improving integrated flood management and flood risk-reduction for areas protected by State Plan of Flood Control (SPFC) facilities along the Sacramento River and San Joaquin River systems. The SPFC represents the portion of the Central Valley flood management system for which the State has provided assurances of non-federal cooperation to the United States. SPFC facilities include levees, weirs, bypass channels, pumps, and dams. The CVFPP provides general planning and guidance for flood management system improvements over the next 20 to 25 years. The CVFPP was last adopted by the CVFPB in August 2017 and will be updated every 5 years. The NOP was released for the 2017 CVFPP update in April 2016 (DWR 2017h). The CVFPP and associated studies and plans from the contributing planning efforts mentioned after this point are all in the feasibility study and planning stages. CEQA and NEPA documents have not been completed for those plans. The planning efforts that contribute to the 2017 CVFPP recommendations include the Sacramento River Basin-Wide Feasibility Study, Lower Sacramento River/Delta North Regional Flood Management Plan, and the Central Valley Flood System Conservation Strategy. • Sacramento River Basin-Wide Feasibility Study. The Sacramento River Basin-Wide Feasibility Study (BWFS) documents the new information that provides the foundation for the 2017 CVFPP update by refining and evaluating elements broadly identified in the 2012 CVFPP. The Sacramento River BWFS evaluates options for improving the bypass system. Improvements include potential expansion of the Yolo Bypass and Fremont Weir, the Sacramento Bypass, and the Sutter Bypass (DWR 2017h). Expansion would be accomplished through various combinations of levee setbacks, weir expansions, and new bypass channels integrated with ecosystem restoration actions.

Project	Agency	Description
		• Lower Sacramento/Delta North Regional Flood Management Plan. Following adoption of the 2012 CVFPP, DWR launched a regional effort to help local agencies describe local flood management priorities, challenges, and potential funding mechanisms. The Lower Sacramento/Delta North Regional Flood Management Plan (RFMP) was developed by FloodProtect, a regional working group that includes counties, cities, flood management agencies, local maintaining agencies, water agencies, emergency response agencies, citizen groups, and tribes. RFMP planning is integrated with BWFS planning so that recommended regional improvements are considered in BWFS preparation. The Lower Sacramento/Delta North RFMP established the flood management vision for the region and identified regional solutions to flood management problems at a pre-feasibility level, including improvements to existing flood management facilities (FloodProtect 2014). The Yolo Bypass is a focus area of the Lower Sacramento/Delta North RFMP. • Central Valley Flood System Conservation Strategy (Conservation Strategy). The Conservation Strategy is integral to implementing the 2012 CVFPP State System-wide Investment Approach. The Conservation Strategy will provide a comprehensive, long-term approach to improving riverine habitat and floodplains as part of an integrated flood management plan. The Conservation Strategy will include up-to-date science and planning information, a regional permitting approach, a comprehensive and science-based approach to vegetation management, and clear ecological targets with measurable objectives. A Draft Conservation Strategy was published in 2016.
Delta Plan	Delta Stewardship Council	The Delta Plan, adopted in 2013, is a long-term management plan for the Delta. Required by the 2009 Delta Reform Act, it creates new rules and recommendations to further the State's coequal goals for the Delta, which are to improve statewide water supply reliability and protect and restore a vibrant and healthy Delta ecosystem, all in a manner that preserves, protects, and enhances the unique agricultural, cultural, and recreational characteristics of the Delta (Delta Stewardship Council 2013). The Delta Stewardship Council is currently updating the Delta Plan to adapt to changing circumstances and conditions. In 2016, updates to performance measures and single-year water transfer regulations were adopted. Updates to the Delta levees investment strategy and conveyance, storage, and operations are currently being considered.

Project	Agency	Description
Delta Wetlands Project	Semitropic Water Storage District	The Delta Wetlands Project involves the construction of a new water diversion and storage system on two islands in the Delta – Bacon Island and Webb Tract (Reservoir Islands). The Reservoir Islands provide for a total estimated storage capacity of 215,000 acre-feet (AF). The Delta Wetlands Project would increase the availability of high-quality water in the Delta for export or outflow through the following (Semitropic Water Storage District 2011): 1) diversion of water on to the Reservoir Islands during high-flow periods (i.e., December through March); 2) storage of water on the Reservoir Islands; 3) mitigation for wetland and wildlife effects of the water storage operations on the Reservoir Islands by implementing a habitat management plan on Bouldin Island and Holland Tract; 4) supplemental water storage in Semitropic Groundwater Storage Bank and the Antelope Valley Water Bank; 5) discharging water for export to designated south-of-Delta users when excess CVP or SWP pumping capacity is available (i.e., typically July through November); and 6) releasing water for water quality and outflow enhancement in the Bay-Delta Estuary typically from September through November.
Folsom Dam Water Control Manual Update	USACE	USACE is working to update the water control manual for Folsom Dam. The updated manual would reflect the physical changes from recent construction, including the new auxiliary spillway that is scheduled for completion in 2017. The manual also would consider changes to operating rules for dam safety and flood risk management. The update is scheduled to coincide with completion of construction of the auxiliary spillway in 2017.
Liberty Island Conservation Bank	Reclamation District 2093	This project received permits and approvals in 2009 to create a conservation bank on the northern tip of Liberty Island that would preserve, create, restore, and enhance habitat for native Delta fish species, including Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, delta smelt, and Central Valley fall- and late fall-run Chinook salmon (Reclamation District 2093 2009). The project consists of creating tidal channels, perennial marsh, riparian habitat, and occasionally flooded uplands on the site. The project also includes the breaching of the northernmost east/west levee and preservation and restoration of shaded riverine aquatic habitat along the levee shorelines of the tidal sloughs. The island's private levees failed in the 1997 flood and were not recovered, leaving all but the upper 1,000 acres and the adjacent levees permanently flooded. These upper acres encompass the proposed bank. The lower nearly 4,000 acres will remain, at least for the near future, predominantly open water and subtidal because tidal elevations are too great for marsh or riparian habitat (Reclamation District 2093 2009).

Project	Agency	Description
Lower Cache Creek Flood Risk Management Feasibility Study and the Woodland Flood Risk Reduction Project	USACE, DWR, City of Woodland	The Lower Cache Creek Flood Risk Management Feasibility Study will evaluate a combination of one or more flood control measures, including a setback levee along Cache Creek, stream channel improvements, a north Woodland floodway, and a northern bypass into the Colusa Drain (USACE 2015c). USACE, DWR, and the City of Woodland are preparing a draft feasibility report and draft EIS/EIR to evaluate impacts associated with this proposed flood-risk reduction project. In addition, the City of Woodland is partnering with DWR through its Urban Flood Risk Reduction program to identify and implement a State/city flood-risk reduction project that complies with the State Bill 5 requirement that urban communities have 200-year flood protection. The Woodland Flood Risk Reduction Project and associated environmental review are still in the planning stages. The project is planned to be compatible with alternatives currently being evaluated by USACE as part of the ongoing feasibility study, which is expected to be completed in 2019.
Lower Elkhorn Basin Levee Setback Project	DWR	The Lower Elkhorn Basin Levee Setback Project is the first phase of implementation of recommendations from the 2012 CVFPP and associated studies carried out by DWR. The project would contribute to the CVFPP goals of providing improved public safety for approximately 780,000 people by reducing river levels (stages) in the Sacramento River and increasing the capacity of the Yolo and Sacramento bypasses near the urban communities of Sacramento and West Sacramento, as well as Woodland, Clarksburg, and rural communities (California Natural Resources Agency 2015). The improvements also would provide system resiliency and opportunities to improve ecosystem functions such as increasing inundated floodplain habitat for fish rearing and improving the connection to the Sacramento Bypass Wildlife Area. The project consists of approximately seven miles of setback levees in the Lower Elkhorn Basin along the east side of the Yolo Bypass and the north side of the Sacramento Bypass. The project would remove all or portions of the existing levees that would be set back, remove portions of local reclamation district cross levees, and improve or relocate related infrastructure (California Natural Resources Agency 2015). DWR is coordinating closely with USACE and CVFPB to obtain necessary permits to carry out this project. DWR is also coordinating with local reclamation districts and land-use agencies on specific infrastructure relocation and improvements. The Notice of Intent and NOP for the EIS/EIR were released in September 2016. Construction of the selected alternative is expected to begin in 2020.
Lower Putah Creek 2 North American Wetlands Conservation Act (NAWCA) Project	Solano County Water Agency	The Lower Putah Creek 2 NAWCA Project authorizes the restoration of wildlife habitat by restoring the floodplain along 6,500 linear feet of Lower Putah Creek's south bank and 1,500 linear feet of McCune Creek's north bank.

Project	Agency	Description
Lower Yolo Restoration Project	SFCWA, DWR, and Memorandum of Agreement Partners	The project is a tidal and seasonal salmon habitat program restoring tidal flux to about 1,100 acres of existing pasture land. The project site includes Yolo Ranch, also known as McCormack Ranch, which was purchased in 2007 by the Wetlands Water District (SFCWA 2011). The goal of this project is to provide important new sources of food and shelter for a variety of native fish species at the appropriate scale in strategic locations, in addition to ensuring continued or enhanced flood protection. The Lower Yolo Restoration Project is part of an adaptive management approach in the Delta to learn the relative benefits of different fish habitats, quantify the production and transport of food, and understand how fish species take advantage of new habitat.
North Bay Aqueduct Alternative Intake Project	DWR, Solano County Water Agency	DWR issued an NOP in December 2009 to construct and operate an alternative intake on the Sacramento River, generally upstream of the Sacramento Regional Wastewater Treatment Plant, and connect it to the existing North Bay Aqueduct system by a new segment of pipe. The proposed alternative intake would be operated in conjunction with the existing North Bay Aqueduct intake at Barker Slough. The project would be designed to improve water quality and provide reliable deliveries of SWP supplies to its contractors, the Solano County Water Agency and the Napa County Flood Control and Water Conservation District (DWR 2009).
North Delta Fish Conservation Bank	Wildlands, Inc., The Trust for Public Land, Reclamation District 2093	In 2013, USFWS, NMFS, and CDFW approved the North Delta Fish Conservation Bank to serve as an 811-acre bank located on Liberty Island at the southern end of the Yolo Bypass. The conservation bank will provide habitat benefits to delta smelt and other state and federally listed species. The conservation bank will enhance 657 acres of tidal marsh wetlands, including emergent marsh, seasonal wetland, riparian, and shallow open water habitats, in addition to 68 acres of tidal channel enhancement and over 32 acres of tidal emergent marsh creation through the removal of levees and lowering a portion of the existing floodplain habitat. (Wildlands, Inc. 2017)
McCormack-Williamson Tract Restoration Project	DWR	Consistent with objectives contained in the CALFED Bay-Delta Program Record of Decision, the McCormack-Williamson Tract Restoration Project is intended to improve flood management and provide ecosystem benefits in the North Delta area through actions such as construction of setback levees and configuration of flood bypass areas to create quality habitat for species of concern (DWR 2010). These actions are focused on McCormack-Williamson Tract and Staten Island. The purpose of the project is to implement flood control improvements in a manner that benefits aquatic and terrestrial habitats, species, and ecological processes. Flood control improvements are needed to reduce damage to land uses, infrastructure, and the Bay-Delta ecosystem resulting from overflows caused by insufficient channel capacities and catastrophic levee failures in the Project study area. The Project area encompasses approximately 197 square miles (DWR 2010). The Final EIR was certified in November 2010.

Project	Agency	Description
Sacramento International Airport Land Use Compatibility Plan	Sacramento Area County of Government	The Sacramento Airport Land Use Compatibility Plan, adopted in 2013, identifies zones for safety, noise contours, and height restrictions along with associated compatible land uses surrounding the airport. The plan addresses noise, safety, glare, visibility, and actions that may attract wildlife within the Airport Influence Areas.
Sacramento River Bank Protection Project	USACE Sacramento District, CVFPB	The Sacramento River Bank Protection Project (SRBPP) was authorized by Section 203 of the Flood Control Act of 1960. The SRBPP is designed to enhance public safety and help protect property along the Sacramento River and its tributaries by protecting existing levee and flood control facilities of the Sacramento River Flood Control Project. The USACE, Sacramento District, is responsible for implementation of the SRBPP in coordination with its non-federal partner, the CVFPB. The SRBPP was originally authorized to rehabilitate 430,000 linear feet of bank protection (Phase I). In 1974, the WRDA authorized an additional 405,000 linear feet. In 2007, the WRDA gave supplemental authorization for an additional 80,000 linear feet. A draft post-authorization change report and draft programmatic EIS/EIR have been prepared for the supplemental authorization (USACE 2016a). Actions under the supplemental authorization may include bank protection in the form of rock revetment, biotechnical bank stabilization, setback levees, or construction of adjacent levees. Identified protection sites include a portion of the northern Yolo Bypass. Additional project-level environmental documentation will be prepared in the future to address specific project sites under this program (USACE and CVFPB 2014).
Sacramento River General Reevaluation Report	USACE	The Sacramento River GRR is being prepared by the USACE to reevaluate the Sacramento River Flood Control Project, which consists of levees, weirs, pumping plants, and bypass channels that help reduce the risk of flooding in the Sacramento Valley and Delta. The reevaluation focuses on ecosystem benefits in the flood system and flood system improvements within the flood conveyance system. The reevaluation also includes considerations for long-term operations and maintenance of system improvements (USACE 2016b). Flood system improvements to be considered include widening bypasses, modifying weir operations, and constructing setback levees. Ecosystem benefits to be considered include restoration of aquatic and riparian habitat and enhanced fish passage. Flood system improvements and ecosystem benefits include considerations within the Yolo Bypass. The SRGRR is in preparation; CEQA and NEPA documents have not been completed.

Project	Agency	Description
Sacramento-San Joaquin Delta Estuary Total Maximum Daily Load (TMDL) for Methylmercury	Central Valley RWQCB	The Central Valley RWQCB has identified the Delta as impaired because of elevated levels of methylmercury in Delta fish that pose a risk for human and wildlife consumers. As a result, it has initiated the development of a water quality attainment strategy to resolve the mercury impairment. The strategy has two components: the methylmercury TMDL for the Delta and the amendment of the WQCP for the Sacramento River and San Joaquin River Basins (the Basin Plan) to implement the TMDL program. The draft Basin Plan amendment would require methylmercury load and waste load allocations for dischargers in the Delta and the Yolo Bypass to be met as soon as possible but no later than 2030. The regulatory mechanism to implement the Delta Mercury Control Program for point sources would be through NPDES permits. Nonpoint sources would be regulated in conformance with the SWRCB's Nonpoint Source Implementation and Enforcement Policy. Both point and nonpoint source dischargers would be required to conduct mercury and methylmercury control studies to develop and evaluate management practices to control mercury and methylmercury discharges. The RWQCB will use the study results and other information to amend relevant portions of the Delta Mercury Control Program during the Delta Mercury Control Program Review (Central Valley RWQCB 2010). The draft Basin Plan amendment also would require proponents of new wetland and wetland restoration projects scheduled for construction after 2011 to either participate in a comprehensive study plan or implement a site-specific study plan, evaluate practices to minimize methylmercury discharges, and implement newly developed management practices as feasible. Projects would be required to include monitoring to demonstrate effectiveness of management practices. Activities, including changes to water management and storage in and upstream of the Delta, changes to salinity objectives, dredging and dredge materials disposal and reuse, and changes to flood conveyance flows, would be subject to the open water methylmercury allocations. Agencies would be required to include requirements for projects under their authority to conduct control studies and implement methylmercury reductions as necessary to comply with the allocations by 2030 (Central Valley RWQCB 2010).

Project	Agency	Description
Shasta Lake Water Resources Investigation	Reclamation	Reclamation undertook the Shasta Lake Water Resources Investigation to determine the type and extent of federal interest in a multiple purpose plan to modify Shasta Dam and Reservoir to increase survival of anadromous fish populations in the upper Sacramento River; increase water supplies and water supply reliability to agricultural, municipal and industrial users, and environmental purposes; and, to the extent possible through meeting these objectives, include features to benefit other identified ecosystem, flood damage reduction, and related water resources needs, consistent with the objectives of the CALFED Bay-Delta Program. The alternatives for expansion of Shasta Lake include, among other features, raising the dam from 6.5 to 18.5 feet above current elevation, which would result in additional storage capacity of 256,000 to 634,000 AF, respectively (Reclamation 2015). The increased capacity is expected to improve water supply reliability and increase the cold-water pool, which would provide improved water temperature conditions for anadromous fish in the Sacramento River downstream of the dam. The final EIS was released in 2014, and the final feasibility study was released in 2015. No ROD has been issued.
Sites Reservoir Project	Sites Project Authority and Reclamation	The Sites Reservoir Project involves the construction of offstream surface storage north of the Delta for enhanced water management flexibility in the Sacramento Valley, increased California water supply reliability, and storage and operational benefits for programs to enhance water supply reliability, both locally and State-wide, benefit Delta water quality, and improve ecosystems. Secondary objectives for the project are to: 1) allow for flexible hydropower generation to support integration of renewable energy sources, 2) develop additional recreation opportunities, and 3) provide incremental flood damage reduction opportunities (Sites Project Authority and Reclamation 2017). The Draft EIR/EIS was released for public review on August 14, 2017.

Project	Agency	Description
Upstream Sacramento River Fisheries Projects		Ongoing and reasonably foreseeable projects with the potential to affect aquatic resources and fisheries upstream of the Yolo Bypass and the Delta include levee improvement and other flood control management projects in and near the Sacramento, Feather, Yuba, and American rivers; modification of Shasta Dam operations under amendments to the 2009 *Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and the State Water Project* (i.e., water temperature management); and increasing flood protection and useable storage capacity in Folsom Lake. These projects include: • Sacramento River Flood Control Project • Natomas Levee Improvement Program • Folsom Dam Modifications • Long-term CVP and SWP Operations and 2009 *Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and the State Water Project* Reasonable and Prudent Alternative Amendments • Upper Yuba Project • Yuba River Basin Project • Central Valley Project Improvement Act projects on the Sacramento River and its tributaries
Yolo Habitat Conservation Plan/Natural Communities Conservation Plan and the Yolo Local Conservation Plan	Yolo County Joint Powers Authority	The Yolo Habitat Conservation Plan (HCP)/Natural Communities Conservation Plan (NCCP) and Yolo Local Conservation Plan were formerly known as the Yolo Natural Heritage Program. The Yolo HCP/NCCP covers 12 endangered and threatened species and 15 natural communities, enabling agencies to construct projects and implement activities that affect the habitat of the covered species, and establishes a framework to protect, enhance, and restore natural resources within Yolo County. The Yolo Local Conservation Plan expands on the Yolo HCP/NCCP to cover species and natural communities of local concern not included in the Yolo HCP/NCCP (Yolo Habitat Conservancy 2016). Covered activities include ongoing operation and maintenance of existing flood control facilities and implementation of habitat enhancement, restoration, and creation actions included in the Yolo HCP/NCCP Conservation Strategy. The Final Yolo HCP/NCCP and Final EIS/EIR were completed in April 2018.

Project	Agency	Description
Yuba River Development Project Relicensing	Yuba County Water Agency	The Yuba County Water Agency is seeking to renew their 50-year FERC license for the Yuba River Development Project (FERC Project No. 2246). The Yuba River Development Project is located on the Yuba River, the Middle Yuba River, and Oregon Creek in Yuba County, California, and consists of one reservoir (New Bullards Bar on the North Yuba River), two diversion dams (Our House Diversion Dam on the Middle Yuba River and Log Cabin Diversion Dam on Oregon Creek), three powerhouses (New Colgate, Fish Release, and Narrows No. 2), and various recreational facilities and appurtenant facilities (Yuba County Water Agency 2016). New Bullards Bar Reservoir has a capacity of 969,600 AF. The initial FERC license expired April 30, 2016, and the Yuba County Water Agency has engaged in FERC's Integrated Licensing Process to prepare an application for a new license. The Yuba County Water Agency filed a Draft Application for a New License Major Project – Existing Dam, on December 3, 2013, and a Final Application for a New License Major Project – Existing Dam, on April 28, 2014. FERC issued the Draft EIS in May 2018 and the Final EIS is expected in October 2018.

Key: AF = acre-feet; ARCFP = American River Common Features Project; BWFS = Basin-Wide Feasibility Study; CDFW = California Department of Fish and Wildlife; CEQA = California Environmental Quality Act; Conservation Strategy = Central Valley Flood System Conservation Strategy; CVFMP = Central Valley Flood Management Planning; CVFPB = Central Valley Flood Protection Board; CVFPP = Central Valley Flood Protection Plan; CVP = Central Valley Project; Delta = Sacramento-San Joaquin Delta; DWR = California Department of Water Resources; EIS/EIR = environmental impact statement/environmental impact report; FERC = Federal Energy Regulatory Commission; GRR = General Reevaluation Report; HCP = Habitat Conservation Plan; NAWCA = North American Wetlands Conservation Act; NCCP = Natural Communities Conservation Plan; NEPA = National Environmental Policy Act; NMFS = National Oceanic and Atmospheric Administration National Marine Fisheries; NOP = Notice of Preparation; NPDES = National Pollutant Discharge Elimination System; Reclamation = United States Bureau of Reclamation; RFMP = Regional Flood Management; ROD = Record of Decision; RWQCB = Regional Water Quality Control Board; SFCWA = State and Federal Contractors Water Agency; SPFC = State Plan of Flood Control; SRBPP = Sacramento River Bank Protection Project; SWP = State Water Project; SWRCB = California State Water Resources Control Board; TMDL = Total Maximum Daily Load; USACE = United States Army Corps of Engineers; USFWS = United States Fish and Wildlife Service; WQCP = Water Quality Control Plan; WRDA = Water Resources Development Act

3.3.3.3 Geographic Scope and Timeframe

Most of the cumulative effects likely would occur within the Project area, which includes the Yolo Bypass and the land adjacent to and surrounding it that would be affected by construction. However, several impacts of the project have the potential to extend beyond the boundaries of the Project area. For instance, water quality impacts have the potential to affect water quality downstream of the Project area. In these cases, the geographic scope has been expanded to account for potential cumulative effects. Table 3-3 presents the geographic scope analyzed for cumulative effects by resource type.

Table 3-3. Cumulative Effects Analysis Geographic Scope by Resource

Resource	Geographic Scope	
	Same Area of Analysis Utilized in Alternatives Analysis	Other
Flood Control, Hydraulics, and Hydrology	X	Delta region, Sacramento River system
Surface Water Supply	X	Sacramento River system
Water Quality	X	Sacramento River system
Groundwater	X	Yolo, Colusa, and Sutter subbasins
Aquatic Resources and Fisheries	X	Sacramento River system
Vegetation, Wetlands, and Wildlife Resources	X	Sacramento River system
Cultural Resources and Indian Trust Assets	X	(not applicable)
Land Use and Agricultural Resources	X	(not applicable)
Geology and Soils	X	Sacramento River system
Recreation	X	Delta region, Sacramento River system
Visual Resources	X	entire Yolo Bypass
Public Services, Utilities, and Power	X	entire Yolo Bypass
Socioeconomics	X	(not applicable)
Transportation	X	Sacramento River system
Air Quality and Greenhouse Gases	X	Sacramento Valley Air Basin
Hazardous Materials and Health and Safety	X	entire Yolo Bypass
Noise	X	(not applicable)
Population and Housing	X	(not applicable)
Environmental Justice	X	(not applicable)

The timeframe for the cumulative effects analysis varies, depending upon the nature of the impacts. Construction-related short-term impacts would end with the completion of construction; therefore, the cumulative effects analysis timeframe for these would only extend until construction is complete. Several more long-term impacts have the potential to persist after construction. The effects of these impacts are considered long-term; therefore, a 20-year timeframe is assumed for the cumulative analysis.

3.3.3.4 Determining Significance

CEQA requires a determination of the significance of the effects on cumulative conditions similar to the evaluation of project effects; however, NEPA does not require a significance conclusion. See Section 3.2.2 for more details.

3.3.3.5 Mitigation for Significant Cumulative Impacts

The requirements for mitigation for cumulative effects are the same as those described for project effects; see Section 3.2.3 for more details.

3.3.3.5.1 National Environmental Policy Act

Under NEPA, a discussion on mitigation for adverse environmental effects is required in an EIS (40 Section Part 1502.16(h), 40 CFR Section 1502.14(f)); however, a final set of mitigation measures, selected for implementation, is adopted in a ROD. If mitigation measures presented in the EIS are not adopted, the reasons why must be explained in the ROD (40 CFR Section 1505.2(c)). This cumulative effect analysis identifies potential mitigation for substantial cumulative effects. The ROD will present the final mitigation measures adopted as part of the project that will be completed for the alternative selected for implementation.

3.3.3.5.2 California Environmental Quality Act

As required by CEQA, an EIR must examine reasonable, feasible options for mitigating or avoiding the project's contribution to any significant cumulative effects (CEQA Guidelines Section 15130). This cumulative effects analysis will identify all feasible mitigation measures for effects of the project determined to be “cumulatively considerable.” The approval of the EIR and subsequent CEQA findings will describe the feasible mitigation measures adopted as part of the project.

If a significant cumulative effect is identified and the project’s incremental contribution to that significant cumulative effect would be “cumulatively considerable,” feasible mitigation measures are proposed. If no feasible mitigation would be possible (i.e., the technology does not exist) to reduce or avoid the impact, the cumulative effect is considered significant and unavoidable.

3.3.3.6 Qualitative Assessment and Other Actions

Effects of past, present, and reasonably foreseeable probable future actions were assessed qualitatively for all resource areas. Existing information on current and historical conditions was used to evaluate the combined effects of past actions on each resource area. For present and reasonably foreseeable probable future actions, a list of related actions was compiled. The combined effects of these past, present, and reasonably foreseeable probable future actions were then evaluated together with those of the project alternatives.

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4 Hydrology, Hydraulics, and Flood Control

This chapter addresses the water resources within the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Project) area and describes potential effects of Project implementation on those resources. Water resources include hydrology, hydraulics, and flood control. The analysis provided in this chapter includes a description of existing environmental conditions; methods used to assess environmental effects; potential direct, indirect, and cumulative impacts of Project implementation; and mitigation measures recommended to avoid or minimize adverse effects under National Environmental Policy Act (NEPA) and significant impacts under California Environmental Quality Act (CEQA). Federal, State of California (State), and local regulations that pertain to flood control, hydraulics, and hydrology are summarized.

4.1 Environmental Setting/Affected Environment

This section presents the environmental setting for hydrology, hydraulics, and flood control in the Project area.

4.1.1 Hydrology and Hydraulics

The Project area for hydrology and hydraulics consists of the Sacramento River from Shasta Dam to Rio Vista, the Yolo Bypass, and the Sacramento-San Joaquin Delta (Delta) in the vicinity of Cache Slough (Figure 4-1). These areas are described below.

4.1.1.1 Sacramento River

The Sacramento River has been divided into two reaches, one above the Fremont Weir, and one below the Fremont Weir. These two reaches are discussed separately because they are affected by the proposed project differently.

4.1.1.1.1 Sacramento River from Shasta Dam to Fremont Weir

Flows in the 65-mile Shasta Dam to Red Bluff (River Mile [RM] 244) reach of the Sacramento River are regulated by Shasta Dam and are reregulated downstream at Keswick Dam (RM 302), as shown in Figure 4-1. In this reach, flows are influenced by tributary inflow. Major west-side tributaries to the Sacramento River in this reach include Clear and Cottonwood creeks. Major east-side tributaries to the Sacramento River in this reach include Battle, Bear, Churn, Cow, and Paynes creeks.

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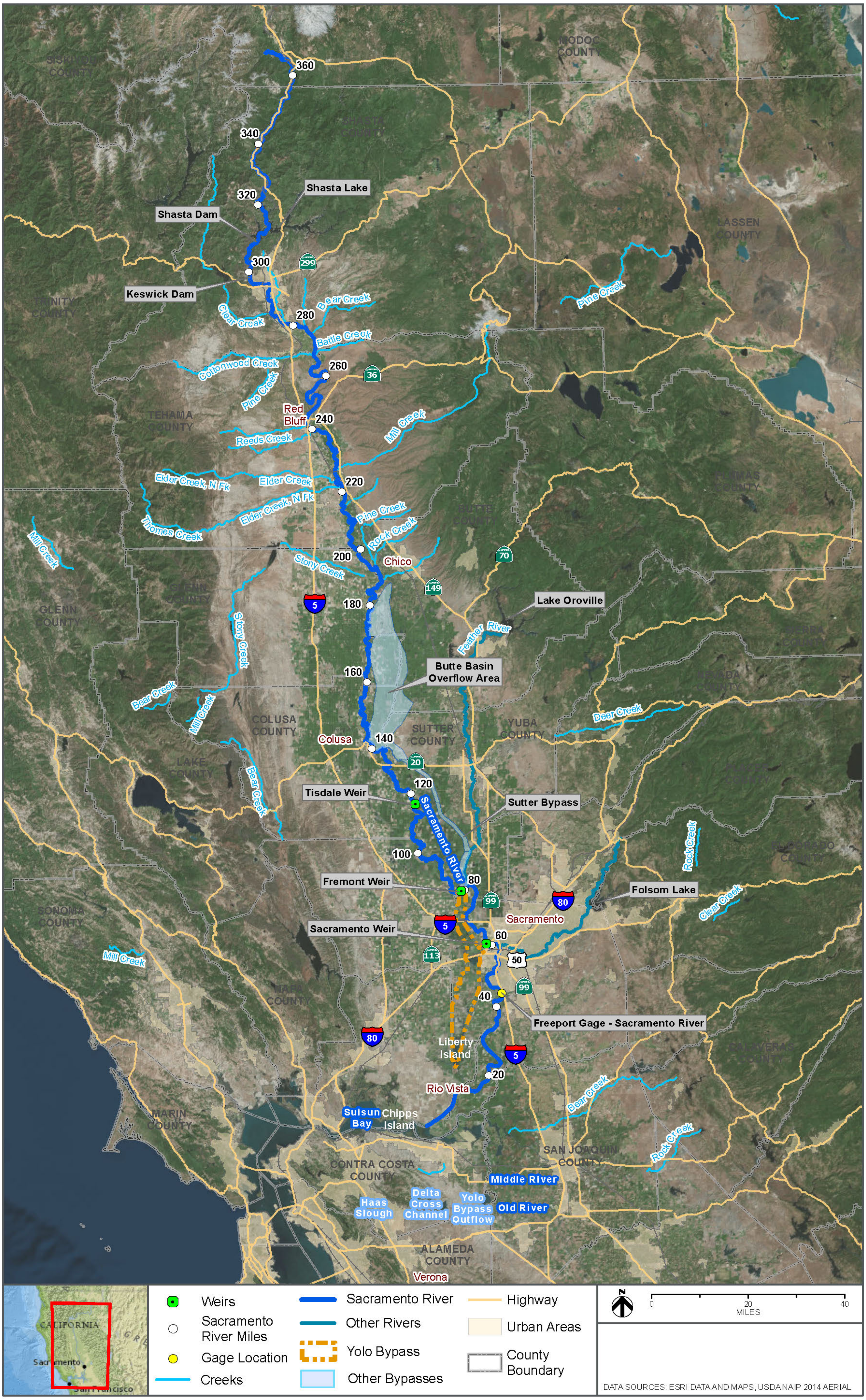

Figure 4-1. Sacramento River and Tributaries

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The Sacramento River enters the Sacramento Valley about five miles north of Red Bluff. From Red Bluff to Chico Landing (52 miles), the river receives flows from Antelope, Mill, Deer, Big Chico, Rock, and Pine creeks on the east side and Thomes, Elder, Reeds, and Red Bank creeks on the west side. From Chico Landing to Colusa (50 miles), the Sacramento River meanders through alluvial deposits between widely spaced levees. Stony Creek is the only major tributary in this segment of the river. No tributaries enter the Sacramento River between Stony Creek and its confluence with the Feather River.

Floodwaters in the Sacramento River overflow the east bank at three sites in a reach referred to by the State as the Butte Basin Overflow Area. In this river reach, several Federal projects begin, including the Sacramento River Flood Control Project (SRFCP), Sacramento River Major and Minor Tributaries Project, and Sacramento River Bank Protection Project. Levees of the SRFCP begin in this reach, downstream from Ord Ferry on the west (RM 184) and from RM 176 above Butte City on the east side of the river.

Shasta Lake is operated to meet a flow requirement in the Sacramento River at Wilkins Slough near Grimes (RM 125), also known as the Navigation Control Point. Downstream from Wilkins Slough, the Feather River, the largest east-side tributary to the Sacramento River, enters the river just above Verona. Between Wilkins Slough and Verona, floodwater is diverted at two places in this segment of the river—Tisdale Weir into the Tisdale Bypass and Fremont Weir into the Yolo Bypass. The bypass system routes floodwater away from the mainstem Sacramento River to discharge into the Delta near Rio Vista.

4.1.1.1.2 Sacramento River from the Fremont Weir to Rio Vista

The portion of the Sacramento River within the Project area begins at Fremont Weir near Verona and extends to just upstream of Rio Vista near RM 12.

Below Verona, the Sacramento River flows 79 miles to the Delta, passing the City of Sacramento and Freeport. The Yolo Bypass parallels this river reach to the west. Flows enter the Sacramento River reach at various points. First, flows from the Natomas Cross Canal enter the Sacramento River approximately one mile downstream from the mouth of the Feather River. The American River flows into the Sacramento River in the City of Sacramento. When Sacramento River system flood flows are the highest, a portion of the flow is diverted into the Yolo Bypass at Sacramento Weir, about three miles upstream from the American River confluence near downtown Sacramento. At the downstream end, Yolo Bypass flows reenter the Sacramento River near Rio Vista. As the river enters the Delta, Georgiana Slough branches off from the mainstem of the Sacramento River, routing a portion of the flow into the central Delta.

Regulated flows in the Sacramento River below the Yolo Bypass based on 2017 reservoir operations and system conditions were evaluated as a part of the 2017 CVFPP Update (DWR 2016a). Table 4-1 shows the annual exceedance probability (AEP) of flows in the Sacramento River at Freeport, as computed through the CVFPP for a no project condition. These flows would represent the combined flows within the Sacramento River and Yolo Bypass. AEP is the likelihood of flows being higher than a specified flow rate in a given year. A flow with a 0.01 AEP has a one percent likelihood of being exceeded in any given year.

Table 4-1. Annual Exceedance Probability of Combined Flows in the Sacramento River at Freeport and the Yolo Bypass

Annual Exceedance Probability --	Flow (cfs)
0.900	138,015
0.800	160,247
0.667	188,063
0.500	225,074
0.429	242,946
0.200	334,361
0.100	433,108
0.040	518,692
0.020	549,885
0.010	595,563
0.005	659,195
0.002	847,077

Source: 2017 No Project Regulated Flow Frequency Curve for SAC41, evaluated for CVFPP Update (DWR 2016a).
Key: cfs = cubic feet per second

4.1.1.2 Yolo Bypass

The Yolo Bypass is a leveed floodway on the west side of the Sacramento River between Verona and Rio Vista. The bypass flows generally north to south and extends from Fremont Weir (RM 83) downstream to Liberty Island (RM 14) in the Delta.

During high stages in the Sacramento River, water enters the Yolo Bypass from the north over Fremont Weir and from the east via the Sacramento Weir and bypass. Flows are then conveyed south around the City of West Sacramento. During periods of high stage in the Sacramento River, flows from the Colusa Basin are also discharged through the Knights Landing Ridge Cut to the Yolo Bypass. Additional flows enter the Yolo Bypass from the west-side tributaries, including Cache Creek, Putah Creek, and the Willow Slough Bypass. Flood waters reenter the Sacramento River through Cache Slough, upstream from Rio Vista. Liberty Island is the southern outlet of the Yolo Bypass.

The Yolo Bypass floods due to Fremont Weir overtopping events approximately every two out of three years. For water years 1997 to 2012, the first overtopping event of the season typically occurred during the months of December and January, with the flood season lasting as late as May and June in some years. For example, in 1998, water entered the bypass in June (United States Department of the Interior, Bureau of Reclamation [Reclamation] 2014). During the irrigation season, non-flood waters exit the bypass primarily through the east levee Toe Drain, a riparian channel running along the eastern edge of the bypass.

Regulated Fremont Weir flows based on 2017 reservoir operations and system conditions were evaluated as a part of CVFPP. Table 4-2 shows the AEP of flows at Fremont Weir as computed by the CVFPP.

Table 4-2. Annual Exceedance Probability of Regulated Peak Flows into Yolo Bypass at Fremont Weir.

Annual Exceedance Probability --	Flow (cfs)
0.900	36,043
0.800	42,309
0.667	60,228
0.500	89,189
0.429	100,879
0.200	158,580
0.100	217,221
0.040	297,720
0.020	336,440
0.010	351,801
0.005	363,896
0.002	402,613

Source: 2017 No Project Regulated Flow Frequency Curve for SAC14a, evaluated for CVFPP Update (DWR, 2016a).
Key: cfs = cubic feet per second

4.1.2 Flood Management

This section describes major features of the flood management system in the Project area, including reservoirs, levees, weirs, and bypasses. Flows within the Project area are regulated by Shasta Lake, Lake Oroville, and Folsom Lake.

Releases from Shasta, Folsom, and Oroville dams often are made for flood management. Releases for flood management occur either after a storm event to maintain the prescribed vacant flood space in the reservoir or in the fall, beginning in early October, to reach the prescribed vacant flood space. During a storm event, releases for flood management occur either over the dam spillways during large events or through river outlets for smaller events.

4.1.2.1 Shasta Lake

Shasta Dam is a curved, gravity-type, concrete structure that rises 533 feet above the streambed, with a total height above the foundation of 602 feet. The dam has a crest width of about 41 feet and a length of 3,460 feet. Shasta Lake has a storage capacity of 4,550,000 acre-feet and a water surface area at full pool of 29,600 acres. Maximum seasonal flood management storage space in Shasta Lake is 1.3 million acre-feet. Releases from Shasta Dam can be made through the power plant, over the spillway, or through the river outlets. The power plant has a maximum release capacity of nearly 20,000 cubic feet per second (cfs), the river outlets can release a maximum of 81,800 cfs at full pool, and the maximum release over the drum-gated spillway is 186,000 cfs (Reclamation 2014).

4.1.2.2 Lake Oroville

The primary flood management feature of the Feather River Basin is Lake Oroville, with a flood management reservation volume of 750,000 acre-feet. Lake Oroville releases are used to help maintain flows below the maximum flood flow of 150,000 cfs on the Feather River and, in conjunction with New Bullards Bar Reservoir on the Yuba River, to maintain flows below the maximum flood flow of 300,000 cfs at the Yuba River confluence. Levees line the Feather River from the City of Oroville (RM 63) to its confluence with the Sacramento River (Reclamation 2014).

4.1.2.3 Folsom Lake

The lower American River is primarily protected from flooding by Folsom Dam. The Folsom Lake flood management reservation volume is variable, ranging from 400,000 to 670,000 acre-feet. The target maximum release on the American River is 115,000 cfs due to the leveed capacity along the lower American River. The American River is leveed on the north bank from Carmichael Bluffs to its confluence with the Sacramento River, and on the south bank from Sunrise Boulevard Bridge (RM 19) to its confluence with the Sacramento River (Reclamation 2014).

4.1.2.4 Sacramento River

Flood management facilities along the Sacramento River and in the Delta include the levees, weirs, and bypasses of the upper and lower Butte Basin and the levees, weirs, and bypasses of the Sacramento River between Colusa and Collinsville. The levees, weirs, and bypasses are features of the SRFCP, which began operation in the 1930s and was significantly expanded in the 1950s. The following section describes reaches of the Sacramento River in terms of their flood management features.

4.1.2.4.1 Lower Butte Basin

When Sacramento River flows exceed between 90,000 and 100,000 cfs at Ord Ferry, water flows naturally over the banks of the river into the Butte Basin. In addition to the Sacramento River overbank flows at Ord Ferry, the basin receives inflow over Colusa and Moulton weirs and from tributary streams draining from the northeast, principally Cherokee Canal and Butte Creek. Outflows from the Butte Basin move through the Sutter Bypass when the Sacramento River stage is high or through the Butte Slough Outfall Gates (RM 139) into the Sacramento River when the river stage is low (Reclamation 2014).

4.1.2.4.2 Sacramento River from Colusa to Verona

The Sacramento River flows through the 64 miles between Colusa (RM 143) and Verona (RM 79). The levee system continues along both sides of this river reach. The levee spacing (or channel width), east to west, is wider between the upstream sections, from RM 176 to RM 143 at Colusa, than the levee spacing downstream from Colusa. The Feather River, the largest east-side tributary to the Sacramento River, enters the river just above Verona. Flood management diversions in this segment of the river occur at Tisdale Weir and Fremont Weir.

4.1.2.4.3 Sacramento River from Verona to the Delta

Below Verona, the Sacramento River flows 79 miles to Collinsville, at the mouth of the Delta, passing the City of Sacramento along the way. The Yolo Bypass parallels this river reach to the west. Flows enter this river reach at various points. First, flows from the Natomas Cross Canal enter the Sacramento River approximately one mile downstream from the mouth of the Feather River (RM 80). The American River (RM 60), the southernmost major Sacramento River tributary, enters the river at the City of Sacramento. Flows in the Yolo Bypass reenter the river near Rio Vista (RM 12). As the river enters the Delta, Georgiana Slough branches off from the mainstem Sacramento River, routing flows into the central Delta. The one diversion point for flood management is at Sacramento Weir, where floodwaters are diverted from the Sacramento River through the Sacramento Bypass to the Yolo Bypass under the highest flow conditions.

4.1.2.5 Yolo Bypass

Flood management facilities along the Yolo Bypass include Fremont Weir at the northern end of the bypass, levees on either side of the bypass, and the bypass itself, which conveys floodwaters from the Sacramento, American, and Feather rivers away from the cities of Sacramento and West Sacramento.

- From Fremont Weir to the Knights Landing Ridge Cut, the design capacity of the Yolo Bypass is 343,000 cfs. The west levee is about two miles long and intended to reduce flood risk to adjacent agricultural land. The Knights Landing Ridge Cut, with a design capacity of 20,000 cfs, enters the west side of the Yolo Bypass along this reach (California Department of Water Resources [DWR] 2010).
- The design capacity of the Yolo Bypass increases to 362,000 cfs from the Knights Landing Ridge Cut to Cache Creek (DWR 2010).
- From Cache Creek to the Sacramento Bypass, the design capacity of the Yolo Bypass is 343,000 cfs, with six feet of freeboard. The west levee is about 6.4 miles long and is intended to reduce flood risk to agricultural land in Reclamation District (RD) 2035 and Woodland. Maintenance of the levee is conducted by RD 2035. The east levee is about 6.1 miles long and reduces flood risk to adjacent agricultural land. Maintenance of the east levee is conducted by RD 1600. Design inflow to the Yolo Bypass from the Sacramento Bypass is 112,000 cfs (DWR 2010).
- From the Sacramento Bypass to Putah Creek, the design capacity of the Yolo Bypass is 480,000 cfs, with six feet of freeboard. The west levee is about 5.2 miles long. Willow Slough Bypass, with a design flow of 6,000 cfs, enters the Yolo Bypass within this reach. The east levee is about seven miles long and is intended to reduce flood risk to West Sacramento. The west levee of the bypass is maintained by RD 900 and DWR, and the east levee is maintained by RD 900. The Yolo Basin Wetlands are located within this reach and lie over the bypass channel. The Yolo Basin Wetlands are part of the larger Yolo Bypass Wildlife Area, which provides about 16,600 acres of wildlife habitat, including permanent wetlands, seasonal wetlands, grassland/uplands, and riparian woodland. The California Department of Fish and Wildlife operates and maintains the Yolo Bypass Wildlife Area in accordance with the United States Army Corps of Engineers (USACE) requirements.

- From Putah Creek to the Miner Slough, the Yolo Bypass has a design capacity of 500,000 cfs; from Miner Slough to the Sacramento River, the design capacity is 500,000 cfs. The design freeboard from Putah Creek to the Sacramento River is six feet. The west levee begins about seven miles downstream from Putah Creek and extends about 13 miles to the Sacramento River in the Delta, near Rio Vista. Along this reach, Cache Slough and Lindsey Slough enter the Yolo Bypass. The levee is intended to reduce flood risk to adjacent agricultural land. Maintenance is conducted by RD 536, RD 2060, RD 2098, and RD 2068. The east levee extends about 23 miles to the Sacramento River. Along this reach, Steamboat and Miner Sloughs enter into the lower Bypass. Miner Slough has a design inflow of 10,000 cfs from a series of Delta sloughs that are distributary from the Sacramento River. Steamboat Slough has a design inflow of 43,500 cfs. When it was constructed in 1963, the Sacramento Deep Water Ship Channel narrowed the channel of the Yolo Bypass and impacted the design profile. The west levee of the ship channel replaced a portion of the left levee of the Yolo Bypass (DWR 2010).
- Liberty Island, Little Holland Tract, Prospect Island, Little Egbert Tract, and other lands surrounded by private levees lie within the bypass near its southern end. The levees, generally limited in height, restrict low flows in the Yolo Bypass but overtop during high flows. Levees on Liberty Island and a portion of Little Holland Tract failed due to high Yolo Bypass flows in 1995 and 1998, and the lands have remained flooded since that time (DWR 2010).

4.2 Regulatory Setting

This section provides the regulatory setting for flood control, hydraulics, and hydrology, including potentially relevant Federal, State, and local requirements.

4.2.1 Federal Plans, Policies, and Regulations

This section discusses the Federal authorizations for Federal flood protection projects in the Project area. While each authorization covers one major project, such as the SRFCP, projects were generally implemented over time through construction of various segments of the projects. Some levees are physically disconnected from the larger system and were constructed to provide local benefits, while others were constructed to provide system benefits.

While the purpose of this section is to show the Federal authorizations, statements on each project's features are included. The statements were extracted from the congressional authorizations and their supporting USACE Chief of Engineers Reports.

4.2.1.1 Sacramento River Flood Control Project

The SRFCP is the core of the flood protection system along the Sacramento River and its tributaries. About 980 miles of levees are included in the SRFCP. Portions of these levees were originally constructed by local interests and were either included directly in the SRFCP without modification or modified to meet USACE project standards. The SRFCP was originally authorized by the Flood Control Act of 1917 and subsequently modified and extended by the Flood Control Acts of 1928, 1937, and 1941. The State adopted and authorized the SRFCP in

1953 by adding Section 12648 to the California Water Commission (CWC) regulations. Assurances of cooperation were provided in the 1953 Memorandum of Understanding (MOU) (USACE and The Reclamation Board 1953).

4.2.1.1.1 Flood Control Act of 1917

Public Law 64-367 (64th Congress) is the Flood Control Act of 1917. The authorized flood control project was in accordance with plans contained in the California Debris Commission (predecessor of the Reclamation Board) report submitted on August 10, 1910 and printed as United States House Document (HD) 81 (62nd Congress), as modified by the California Debris Commission report submitted on February 8, 1913, and printed in Rivers and Harbors Committee Document No. 5 (63rd Congress). The 1913 document provides for the rectification and enlargement of river channels and the construction of weirs (Hagwood 1981).

4.2.1.1.2 Flood Control Act of 1928

Public Law 70-391 (70th Congress) is the Flood Control Act of 1928. The 1928 act modified the Flood Control Act of 1917 in accordance with the California Debris Commission report submitted on May 1, 1924 and printed in United States Senate Document (SD) 23 (69th Congress). Major changes made by the act include the following:

- Elimination of reclamation works in Butte Basin
- Construction of a weir above Colusa
- Elimination of two of the four proposed cutoffs in the stretch of river between Colusa and the mouth of the Feather River
- Use of the existing Tisdale Weir instead of construction of a new weir
- Relocation of certain levee lines on the Feather River and in the Yolo Bypass
- Construction of settling basin at the mouth of Cache Creek
- Designation of three sloughs in the Delta to be left open instead of closed
- Increase in levee cross-section dimensions
- Conclusion that San Joaquin Valley flood problems are different from those of the Sacramento Valley, and flood control in the San Joaquin Valley should be considered in a separate report, if deemed advisable
- Assignment of some maintenance responsibility to Federal government (maintenance of enlarged channels, weirs, and certain gages)
- Increase in the flood control project cost
- Change of the cost share between the Federal government and non-Federal interests
- Establishment of design capacities to be maintained (Hagwood 1981)

4.2.1.1.3 Rivers and Harbors Act of 1937

Public Law 75-392 (75^{th} Congress) is the Rivers and Harbors Act of 1937. The prior 1917 and 1928 Flood Control Acts were modified in accordance with a Senate Commerce Committee Document (75^{th} Congress). The document concluded that maintenance by the Federal government was not consistent with policies of the Flood Control Act of 1936 (Public Law 74-738, 74^{th} Congress). Additional work was required on revetment for eroding levees, and the flood control project cost was adjusted. Requirements were added for local interests to provide rights-of-way and hold the Federal government harmless from damage claims (Hagwood 1981).

4.2.1.1.4 Flood Control Act of 1941

Public Law 77-228 (77^{th} Congress) is the Flood Control Act of 1941. The 1941 act modified previous acts in accordance with HD 205 (77^{th} Congress). The act authorized Federal expenditures for completion of the Project and required the following local cooperation:

- Furnish all rights-of-way, including railway, highway, and all other utility modifications
- Hold and save the United States free from damage claims
- Maintain and operate all works after completion in accordance with regulations prescribed by the Secretary of the Army (Hagwood 1981)

Construction of the SRFCP began in 1918 and continued for decades. By 1944, the flood control project was regarded as being about 90 percent complete (Hagwood 1981). The plan for completing the flood control project was presented in the November 30, 1953, *MOU Respecting the Sacramento River Flood Control Project* between USACE and The Reclamation Board (USACE and The Reclamation Board 1953). This MOU included levee construction standards for river project levees and bypass levees and outlined maintenance responsibilities. The plan specified no difference in levee standards for urban versus agricultural levees. By 1961, the flood control project was essentially completed (Kelley 1989).

Some documents refer to the flood control project from these authorizations as the “Old” SRFCP.

4.2.1.2 Sacramento River and Major and Minor Tributaries Project

The Sacramento River and Major and Minor Tributaries Project was initially authorized by the Federal government in the Flood Control Act of 1944 (Public Law 78-534, 78^{th} Congress) and was further amended by the Flood Control Act of 1950 (Public Law 81-516, 81^{st} Congress). The Project was a modification and extension of the SRFCP and was to supplement reservoir storage by reducing flooding potential to certain areas along the Sacramento River. Authorizing legislation by the State of California is contained in Section 12648 of the CWC regulations. Assurances of cooperation were provided in the 1953 MOU (USACE and The Reclamation Board 1953).

The Project provided for levee construction and/or channel enlargement of the following minor tributaries of the Sacramento River: Chico Creek, Mud Creek, and Sandy Gulch; Butte and Little Chico creeks; Cherokee Canal; and Elder and Deer creeks (Tehama County). In addition, the Project also included revetment of levees for the Sutter, Tisdale, Sacramento, and Yolo bypasses. Minor tributary improvements were to reduce flood risk to about 80,000 acres of agricultural land important to the economy of the region and to the City of Chico and other smaller communities. Bypass levee revetment features of the Project were to reduce flood risk to floodplain lands adjacent to the bypasses and to decrease requirements for levee repairs under emergency conditions (USACE 1999).

4.2.1.3 American River Flood Control Project

The American River Flood Control Project was authorized by the Federal government in the Flood Control Act of 1954 to reduce flood risk along the lower American River. Authorizing legislation by the State of California is contained in Section 12648.1 of the CWC regulations. The Project was constructed in 1958 by USACE and includes approximately eight miles of levee along the north bank of the American River between Carmichael Bluffs and the terminus of the SRFCP levee near the State Fairgrounds. It also includes about 10 miles of levee along the south bank of the American River from the confluence with the Sacramento River to Mayhew drain (DWR 2010).

4.2.1.4 Sacramento River – Chico Landing to Red Bluff

The Sacramento River Project for bank protection and channel improvements from Chico Landing to Red Bluff was authorized by the Flood Control Act of 1958 (Public Law 85-500, 85th Congress). Authorizing legislation by the State of California is contained in Section 12648.2 of the CWC regulations. The Project was authorized in accordance with recommendations by the USACE Chief of Engineers in HD 272 (84th Congress). The Project was a modification and extension of the SRFCP and was to increase bank protection along the Sacramento River from Chico Landing to Red Bluff and lower portions of its principal tributaries to reduce flood risk with discharges modified by Shasta Dam and Black Butte Dam. Black Butte Dam was planned to be constructed soon after this Project was completed. The area encompassed by this Project included the Sacramento River from Chico Landing to Red Bluff and lower portions of Antelope, Mill, Deer, Pine, Elder, Thomes, and Stony creeks (USACE 1999).

4.2.1.5 Oroville Project

Federal participation in the construction of Oroville Dam was authorized by the Flood Control Act of 1958 (Section 204 of Public Law 85-500, 85th Congress). The Federal interest was flood control provided by the flood control storage reservation of 750,000 acre-feet. This authorization also included the non-State Plan of Flood Control New Bullards Bar and the Marysville Dam (not constructed at the time of this report). Authorizing legislation by the State of California is contained in Sections 12648 and 12649 of the CWC regulations, though these sections refer only to a project that would accomplish the same flood control purposes as proposed by the Table Mountain Dam (DWR 2010).

4.2.1.6 Sacramento River Bank Protection Project

Erosion presents a serious ongoing threat to the SRFCP levee system. The Sacramento River Bank Protection Project was authorized by Section 203 of the Flood Control Act of 1960 (Public Law 86-645, 74 Statute 498), supplemented by Section 202 of the River Basin Monetary Authorization Act of 1974 (Public Law 93-252, 88 Statute 49), as amended by Section 3031 of the Water Resources Development Act of 2007, and further supplemented by Section 140 of

Public Law 97-377 (96 Statute 1916). Its intent was to preserve the integrity of the SRFCP levee system. Section 12649.1 of the CWC regulations provides the State authorization for the Project.

The first and second phases authorized construction of 915,000 linear feet of bank protection work. Construction of the first phase began in June 1965. The second phase of construction was authorized in 1974, and USACE began investigation of the third phase in the mid-1990s (DWR 2010).

4.2.1.7 Sacramento River Bank Protection Project, First Phase Mitigation

Environmental mitigation for the impacts of the first phase of the Sacramento River Bank Protection Project was authorized by Congress in 1986 and included a post-project mitigation program involving the purchase, protection, and revegetation of 260 acres (DWR 2010). The authorized mitigation for Phase 1 is complete (USACE 2014).

4.2.1.8 Snagging and Clearing Projects

The Continuing Authorities Program allows USACE to respond to a variety of flood problems without obtaining specific congressional authorization for each project. Section 208 of the 1954 Flood Control Act, as amended, allows work to remove accumulated snags and other debris and to clear and straighten stream channels. Section 12656.7 of the CWC regulations provides the State authorization for these types of projects. Three snag removal and stream clearing projects in the Sacramento River Basin include the following:

- Adin Project – A flood control project was authorized by the Federal government for Ash and Dry creeks at Adin in Modoc County in the Flood Control Act of 1937 and modified by the Flood Control Act of 1954. Ash and Dry creeks are tributary streams to the Pit River above Shasta Dam. This project was intended to reduce local flood risk (DWR 2010).
- Salt Creek Project – The Salt Creek Project was authorized by Section 2 of the Flood Control Act of 1937, as amended by Section 208 of the Flood Control Act of 1954. Salt Creek is a tributary stream that joins the Sacramento River one mile below Keswick Dam. This project was intended to reduce local flood risk (DWR 2010).
- McClure Creek Project – The McClure Creek Project was authorized by Section 2 of the Flood Control Act of 1937, as amended by Section 208 of the Flood Control Act of 1954. Salt Creek is a tributary stream that joins the Sacramento River below Tehama. This project was intended to reduce local flood risk (DWR 2010).

4.2.1.9 FEMA 60.3(d)(3) of the National Flood Insurance Program

The Federal Emergency Management Agency's (FEMA's) floodplain management criteria for flood-prone areas prohibits encroachments (including fill, new construction, substantial improvements, and other development) within the adopted regulatory floodway. Developments within FEMA floodways must demonstrate that the proposed encroachment would not result in any increase in flood levels within the community during the occurrence of 100-year flows.

No regulatory floodways have been defined or adopted for the Yolo Bypass or the Sacramento River. The FEMA floodway requirement states that until a regulatory floodway is designated, no new construction, substantial improvements, or other development shall be permitted unless it is demonstrated that proposed development will not increase the water surface elevation (WSE) of the one-percent-annual-chance base flood more than one foot at any point within the community.

4.2.1.10 Water Control Manual Flood Management Requirements

Pursuant to the Flood Control Act of 1944, Shasta Dam, Oroville Dam, and Folsom Dam are subject to regulations from the respective Water Control and Reservoir Regulation Manuals.

4.2.1.10.1 Shasta Dam

The Shasta Dam Water Control Manual (USACE 1977) establishes flood control regulations for Shasta Dam. According to the Shasta Dam Flood Control Diagram (USACE 1977), releases from Shasta are operated so that downstream flows do not exceed 79,000 cfs at Keswick or 100,000 cfs at Bend Bridge.

4.2.1.10.2 Oroville Dam

The Oroville Dam Reservoir Regulation Manual (USACE 1970) establishes flood control regulations for Lake Oroville. Pursuant to the Flood Control Act of 1958, DWR entered into an agreement with USACE providing for operation of the Project during floods as a Federal Energy Regulatory Commission licensing condition. Per USACE requirements outlined in the Reservoir Regulation Manual, Lake Oroville is operated to maintain a 750,000 acre-feet flood control reservation below gross pool and 150,000 acre-feet of surcharge storage space during the flood season. Reservoir releases are limited to a maximum of 150,000 cfs until the reservoir reaches 10 feet above the ungated spillway lip. Flows are also limited to achieve a maximum flow of 300,000 cfs below the Feather-Yuba confluence.

4.2.1.10.3 Folsom Dam

The 1987 Folsom Dam Water Control Manual (USACE 1987) establishes the flood control regulations for Folsom Dam. The flood control diagram was updated in 2003 (Sacramento Area Flood Control Agency 2003). USACE and Reclamation are in the process of updating the Folsom Dam Water Control Manual, but the update is not complete as of June 2017.

4.2.2 State Plans, Policies, and Regulations

This section discusses the State plans, policies, and regulations for State flood protection projects in the Project area. Applicable State plans, policies, and regulations related to minimum flows for water rights and water quality standards are described in Chapter 5, *Surface Water Supply*.

4.2.2.1 Central Valley Flood Protection Plan

The Central Valley Flood Protection Plan (CVFPP) is a strategic and long-range plan for improving flood risk management in the Central Valley. Prepared by DWR in accordance with the Central Valley Flood Protection Act of 2008 (and adopted by the Central Valley Flood Protection Board in June 2012, the CVFPP guides the State’s participation in managing flood risk in areas protected by the State Plan of Flood Control (SPFC). The adopted CVFPP describes the State Systemwide Investment Approach (SSIA) for sustainable, integrated flood management in areas protected by SPFC facilities.

The CVFPP includes a program to protect existing urban areas with populations greater than 10,000 to achieve protection against a 0.5 percent chance event, including in-place fixes such as levee raises, flood walls, levee strengthening, and levee setbacks, depending on the level of adjacent development. The CVFPP also includes a program for small communities under 10,000 for flood protection using nonstructural improvements, levee improvements, ring levees, training levees, or floodwalls to preserve development opportunities without providing urban flood protection. Improvements for rural-agricultural areas are less extensive than improvements for urban and small communities and would be focused on maintaining levee elevations and access roads, easements, and levee improvements, including setbacks where feasible.

Implementation of some flood improvements began in 2007 when bond funding provided a down payment toward SPFC improvements and extensive evaluations of SPFC facilities that were later included in the CVFPP. Since 2007, approximately 220 miles of urban and 100 miles of non-urban SPFC levees have been repaired, rehabilitated, or improved (DWR 2016a).

The CVFPP proposes system improvements, defined as physical actions or improvements with the potential to benefit large portions of the flood management system and improve the overall function and performance of the SPFC in managing large floods that affect urban, small community, and rural-agricultural areas. An important category of system improvement projects is bypass capacity expansion, which includes modifications to weirs, bypass systems, hydraulic structures, and easements. Bypass capacity could be increased by modifying existing weirs and bypasses.

The CVFPP states that the ultimate configuration of system improvement projects would be known only after future feasibility studies have explored the potential magnitude and extent of hydraulic improvements within the system (DWR 2012).

4.2.2.1.1 Central Valley Flood Protection Plan Update

The *Draft 2017 CVFPP Update* includes refinements to the SSIA that were identified through ongoing flood management planning and coordination with Federal and local partners to improve flood protection in the Central Valley (DWR 2017a).

Since 2012, DWR has completed the Sacramento River Basin-Wide Feasibility Study (BWFS) and San Joaquin River BWFS, and recommended several system improvement projects for detailed study (DWR 2017b and 2017c). These refined system improvements are identified in the 2017 CVFPP Update (DWR 2017a)

The CVFPP also identified potential improvements for the weir and bypass system, including a 1.5-mile expansion of Upper Elkhorn Basin and a 3,500-foot levee setback along the Lower Elkhorn Basin.

4.2.2.2 Delta Plan

Signed by the governor of California in 2009, the Sacramento-San Joaquin Delta Reform Act (Water Code Section 85000 et seq.) created a new Delta Stewardship Council (DSC) and gave this body broad oversight of Delta planning and resource management. DSC was tasked with developing and implementing a long-term, comprehensive management plan (Delta Plan) that emphasizes the coequal goals of “providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem” (Water Code Section 85300[a]) as the foundation for State decisions regarding Delta management.

Among other things, the Reform Act contains three specific mandates for the DSC:

- Include measures in the Delta Plan to promote statewide water conservation, water use efficiency, sustainable use of water, and improvements to water conveyance/storage and operation, to achieve the coequal goals.
- Include measures in the Delta Plan that attempt to reduce risks to people, property, and State interests in the Delta by promoting effective emergency preparedness, appropriate land uses, and strategic levee investments.
- Determine whether State or local agency projects are consistent with the Delta Plan.

In addition, the Reform Act requires the Delta Plan to cover five topic areas and goals:

- Increased water supply reliability
- Restoration of the Delta ecosystem
- Improved water quality
- Reduced risks of flooding in the Delta
- Protection and enhancement of the Delta

The final Delta Plan was adopted on May 16, 2013, and DSC is still preparing the associated EIR. Following adoption of the Delta Plan, covered actions are required to be consistent with that plan.

4.2.2.3 Delta Protection Commission’s Land Use and Resource Management Plan

The Delta Protection Commission (DPC) was created by the State legislature in 1992 with the goal of developing regional policies for the Delta to protect and enhance the existing land uses (agriculture, wildlife habitat, and recreation) in the primary zone. The DPC adopted the *Land Use and Resource Management Plan for the Primary Zone of the Delta* initially in 1995 and amended it most recently in 2010. A large portion of the YBWA is within the Primary Zone of the Delta. The DPC’s *Land Use and Resource Management Plan for the Primary Zone of the Delta* states the following goal related to water (DPC 2010): Protect and enhance long-term water quality in the Delta for agriculture, municipal, industrial, water-contact recreation, and fish and wildlife habitat uses, as well as all other beneficial uses.

The DPC’s *Land Use and Resource Management Plan for the Primary Zone of the Delta* also includes the following policies related to water:

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

4.2.3 Regional and Local Plans, Policies, and Regulations

4.2.3.1 Lower Sacramento/Delta North Regional Flood Management Plan

The *Regional Flood Management Plan for the Lower Sacramento/Delta North Region* is the regional follow-on to the 2012 *Central Valley Flood Protection Plan* and is being developed at the local and regional level with partial funding from DWR. The *Regional Flood Management Plan* establishes the flood management vision for the region and identifies a list of regional actions including improvements to existing flood management facilities. Proposed improvements were generally evaluated at pre-feasibility levels, with preliminary engineering, costs, and financing improvements completed for the majority of the proposed projects. DWR will consider these regional improvements in their basin-wide feasibility studies, assessing their consistency with refined system improvements and other aspects of the SSIA.

Other applicable regional and local plans, policies, and regulations related to minimum flows for water rights and water quality standards are described in Chapter 5 and public safety hazards in Chapter 11.

4.3 Environmental Consequences

This section describes the environmental consequences associated with the Project alternatives and the No Action Alternative. This section presents the assessment methods used to analyze the effects on flood control, hydraulics, and hydrology; the thresholds of significance that determine the significance of effects; and the potential environmental consequences and mitigation measures as they relate to each Project alternative. Detailed descriptions of the alternatives evaluated in this section are provided in Chapter 2, *Description of Alternatives*.

4.3.1 Methods for Analysis

An overview of the methods used in the analysis of the potential effects for hydrology, hydraulics and flood control is presented in the following discussion.

4.3.1.1 Models Used

Several models were used to evaluate the effects of the project alternatives on flood control, hydraulics, and hydrology.

4.3.1.1.1 HEC-RAS

The 1-dimensional Central Valley Floodplain Evaluation and Delineation (CVFED) Hydrologic Engineering Center River Analysis System (HEC-RAS) hydraulic model of the SRFCP (DWR 2014) was used to evaluate changes in peak WSE throughout the Yolo Bypass and the Sacramento River.

The CVFED HEC-RAS model geometry was modified to represent assumed future hydraulic features for each of the alternatives. Hydrology was scaled down from the Central Valley Hydrology Study's (CVHS) 1997 storm pattern to represent a storm with a peak flow at Fremont Weir close to 343,000 cfs, the capacity of the Yolo Bypass. The resulting hydrograph was routed through the HEC-RAS model to find peak WSE. Resulting peak WSE from the alternatives were compared against the resulting peak WSE from existing geometry. HEC-RAS model simulations were developed assuming current sea level rise for existing conditions. Alternatives 1, 2, 3, 5, and 6 were each run for one simulation, assuming current sea level rise, for comparison against the HEC-RAS model simulation for existing conditions. Alternative 4 was modeled in TUFLOW with the same peak flow hydrograph as the other alternatives.

The main model limitation of the HEC-RAS model is the level of detail of its geometry, particularly at low flows. Results are averaged across cross-sections and represent the floodplain in more coarse spatial detail than the two-dimensional TUFLOW model, discussed below and in Section 4.4.1.1.2. The HEC-RAS model is calibrated to represent peak WSE during flood flows and is not calibrated to represent low flows.

4.3.1.1.2 TUFLOW

TUFLOW is a finite difference two-dimensional hydrodynamic modeling engine used to simulate the hydraulics within the Yolo Bypass. The two-dimensional capabilities of the engine allow for the comparison of the spatial distribution of flow, velocity, and depth, with or without assumed future hydraulic features. The Yolo Bypass application of the TUFLOW model extends along the Sacramento River from RM 118 to RM 12 near Rio Vista and includes the entire Yolo Bypass. Historic flows from the year 1997 to 2012 were simulated for several channel and weir configurations on a five- to 10-second timestep as a part of the initial alternatives evaluation (see Appendix D, *Hydrodynamic Modeling Report*). Neither sea level rise or climate change were included in the TUFLOW modeling.

The two-dimensional TUFLOW model is more spatially detailed than the HEC-RAS model and is calibrated for low flows as well as high flows.

4.3.1.1.3 CalSim II

CalSim II is the application of the Water Resources Integrated Modeling System software to the Central Valley Project (CVP) and State Water Project (SWP). This application was jointly developed by Reclamation and DWR for planning studies relating to CVP/SWP operations. The primary purpose of CalSim II is to evaluate the water supply reliability of the CVP and SWP at current and/or future levels of development (e.g., 2005, 2030), with and without various assumed future facilities and with different modes of facility operations. Geographically, the model covers the drainage basin of the Delta and CVP/SWP exports to the San Francisco Bay Area, San Joaquin Valley, Central Coast, and Southern California. CalSim II models a complex and extensive set of regulatory standards and operations criteria. Descriptions of both are contained in Appendix E, *CalSimII Assumptions*.

CalSim II typically simulates system operations for an 82-year-period using a monthly timestep. The model assumes that facilities, land use, water supply contracts, and regulatory requirements are constant over this period, representing a fixed level of development (e.g., 2030, 2070). The historical flow record of October 1921 to September 2003, adjusted for the influences of land use changes and upstream flow regulation, is used to represent the possible range of water supply conditions. Major Central Valley rivers, reservoirs, and CVP/SWP facilities are represented by a network of arcs and nodes. CalSim II uses a mass balance approach to route water through this network. Simulated flows are mean flows for the month; reservoir storage volumes correspond to end-of-month storage.

The hydrologic analysis conducted for this Environmental Impact Statement (EIS)/Environmental Impact Report (EIR) modified the standard historically based CalSim II input hydrology to represent 2030 and 2070-level climate change based on the CWC Climate Change Water Storage Investment Program modeling (CWC 2016). Additionally, the CalSim II used for this analysis includes representation of 2030 and 2070-level sea level rise to ensure Delta water quality operations are consistent with expected conditions. While the 2030 hydrology scenarios include existing infrastructure, the 2070 hydrology scenarios also assume reasonably foreseeable actions that could occur in the Project area in the future and do not rely on approval or implementation of the Project, including actions with current authorization, secured funding for design and construction, and environmental permitting and compliance activities that are substantially complete. These reasonably foreseeable actions, in addition to changes in regulatory conditions and water supply demands, would result in differences in flows on the Sacramento River and in the Delta between existing conditions and the No Action Alternative. Possible changes include the following:

- Implementation of the California WaterFix Project
- Full implementation of the Grassland Bypass Project
- Implementation of the South Bay Aqueduct Improvement and Enlargement Project
- San Joaquin River Restoration Program full restoration flows

Although CalSim II is the best available tool for simulating system-wide operations, the model also contains simplifying assumptions in its representation of the real system. CalSim II's predictive capability is limited and cannot be readily applied to hourly, daily, or weekly timesteps for hydrologic conditions. The model, however, is useful for comparing the relative effects of alternative facilities and operations within the CVP/SWP system on a monthly timestep. Modeling of the existing conditions and comparable level of development alternatives assumes a 2030 hydrology and sea level rise with existing infrastructure and regulatory conditions. Modeling of the No Action Alternative and comparable level of development alternatives assumes a 2070 hydrology and sea level rise and reasonably foreseeable infrastructure and regulatory conditions.

A general external review of the methodology, software, and applications of CalSim II was conducted in 2003 (Close et al. 2003). An external review of the San Joaquin River Valley CalSim II model also was conducted (Ford et al. 2006). Several limitations of the CalSim II models were identified in these external reviews. The main limitations of the CalSim II models are as follows:

- Model uses a monthly timestep.
- Accuracy of the inflow hydrology is uncertain for current conditions and future conditions with climate change.
- Model lacks a fully explicit groundwater representation.

In addition, Reclamation, DWR, and external reviewers have identified the need for a comprehensive error and uncertainty analysis for various aspects of the CalSim II model. DWR conducted the CalSim II Model Sensitivity Analysis Study (DWR 2005), and Reclamation has completed a similar sensitivity and uncertainty analysis for the San Joaquin River basin (Reclamation and DWR 2006).

Despite these limitations, monthly CalSim II model results remain useful for comparative purposes. It is important to differentiate between "absolute" or "predictive" modeling applications and "comparative" applications. In absolute applications, the model is run once to predict a future outcome. Errors or assumptions in formulation, system representation, data, or operational criteria all contribute to total error or uncertainty in model results. In comparative applications, the model is run twice, once to represent a base condition (no-action) and a second time with a specific change (action) to assess the change in the outcome because of the input change. In the comparative mode (the mode used for this EIS/EIR), the difference between the two simulations is of principal importance. Most potential errors or uncertainties affecting the "no-action" simulation also affect the "action" simulation in a similar manner. As a result, the effect of errors and uncertainties on the difference between the simulations is reduced. However, not all limitations are fully eliminated by the comparative analysis approach. Small differences between the alternatives and the bases of comparison are not considered to be indicative of an effect of the alternative.

4.3.1.2 Changes in Flows over Fremont Weir into the Yolo Bypass

All the action alternatives include operation of a new gated notch (or notches) at Fremont Weir, as described in Chapter 2, *Description of Alternatives*. The long-term flow patterns into the Yolo Bypass would change based upon the magnitude of flows in the Sacramento River at Fremont Weir, the changes to gate operations, and the changes to the dimensions and elevations of the gates at Fremont Weir, as evaluated quantitatively using CalSim II model output. Assumptions used in the CalSim II model are described in Appendix E, *CalSimII Assumptions*.

The flood control effect of changing the long-term flow patterns into the Yolo Bypass was evaluated by comparing the number of times the monthly average flow exceeded 136,869 cfs in the CalSim II results for each of the alternatives. 136,869 cfs represents the maximum existing conditions modeled monthly average flow of 136,869 cfs at Fremont Weir. The maximum existing conditions modeled monthly average flow was chosen as a threshold for high flows because any increase in occurrences in the highest monthly flow would likely correspond with a change in the highest sub-monthly peak flows.

Any change in occurrences of flows above the specified threshold was selected since that is within the ability of a stream gage to measure flows reliably; the USGS rates gages as "Excellent" rating indicates that about 95 percent of the daily discharges are within 5 percent of the true value (USGS 2006).

4.3.1.3 Changes in Sacramento River Flows at Freeport

All the action alternatives include operation of a new gated notch (or notches) at Fremont Weir, as described in Chapter 2, *Description of Alternatives*, which would affect flows into the Sacramento River downstream from Fremont Weir at Freeport. Historical data were available for the Sacramento River at Freeport, allowing for a flood-frequency analysis of historical flows.

The long-term flow patterns into the Sacramento River would change based upon the magnitude of flows in the Sacramento River at Fremont Weir, the changes to gate operations, and the changes to the dimensions and elevations of the gates at Fremont Weir, as evaluated quantitatively using CalSim II model output. Assumptions used in the CalSim II model are described in Appendix E, *CalSimII Assumptions*.

The flood control effect of changing the long-term flow patterns into the Sacramento River below Freeport was evaluated by comparing the number of times the monthly average flow exceeded 72,231 cfs in the CalSim II results for each of the alternatives. 72,231 cfs represents the maximum existing conditions modeled monthly average flow of 72,231 cfs at Freeport. The maximum existing conditions modeled monthly average flow was chosen as a threshold for high flows because any increase in the highest monthly flow would likely correspond with a change in high sub-monthly peak flows.

4.3.1.4 100-Year Flood Hazard area

Results from the HEC-RAS and CalSim II models were used to assess changes in the 100-year flood hazard area. CalSim II results were used to assess changes in the peak flow exceedance. HEC-RAS results were compared to determine whether the altered peak flows would exceed the bypass capacity and whether increases in maximum water surface elevation within the bypass would occur for the existing peak flow. Since the HEC-RAS model is calibrated to represent WSE at high flows, a comparison of peak WSE is a suitable use of the model.

The differences in preliminary TUFLOW results of similar alternatives were used to confirm the possible range of changes in flood flows for all the EIS/EIR alternatives. For the highest historic flood flow routed in TUFLOW, which occurred during the 1997 event, TUFLOW indicated that some portions of the bypass experienced increases in maximum WSE between 0.02 and 0.05 feet for the alternatives relative to the existing conditions hydrodynamic model, as described in Appendix D, *Hydrodynamic Modeling Report*. This agrees with the general range of changes in WSE between alternatives as modeled in HEC-RAS.

The analyses discussed in Section 4.4.2 do not include graphical comparisons of the 100-year flood hazard area because the flows would remain limited to the bypass and WSE would remain similar under high flows.

4.3.2 Thresholds of Significance – CEQA

A significant effect on the environment means "a substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the Project." (State CEQA Guidelines, Section 15382). The following thresholds of significance were developed based on the guidance provided in Appendix G of the CEQA Guidelines and modified based on thresholds used in the environmental documents for other projects in the region (e.g., the California WaterFix, Shasta Lake Water Resources Investigation). These thresholds also encompass the factors considered under NEPA to determine the context and the intensity of its impacts.

An alternative would result in a significant impact under CEQA on hydrology, hydraulics, and flood control if, relative to existing conditions, it would increase the frequency or severity of damaging flood flows, as indicated by the following:

- Increase the number of occurrences of monthly flows above 136,869 cfs in the Yolo Bypass (136,869 corresponds to the maximum modeled existing conditions monthly flow) in more than one year. The analysis compares the increase in number of occurrences, rather than the magnitude of change, because peak flow magnitudes cannot be characterized on a monthly timestep. Monthly flows were used to assess effects due to the reliance on CalSim II and its monthly timestep to simulate the long-term effects of the project on hydrology and flood control.
- Increase the number of occurrences of monthly flows above 72,231 cfs in the Sacramento River at Freeport (72,231 cfs corresponds to the maximum modeled existing conditions monthly flow) in more than one year. See rationale for using monthly averages above.
- Place housing or other structures within a 100-year flood hazard area as mapped on a Federal flood hazard boundary or Flood Insurance Rate Map or other flood hazard delineation map
- Place structures that would impede or redirect flood flows within a 100-year flood hazard area

As described in Section 4.3.1.4, the Project is not expected to impede or redirect flood flows within the 100-year flood hazard area; flows would remain within the Yolo Bypass.

Effects are determined by comparing against two baselines. For CEQA, the baseline is existing conditions, and for NEPA, the baseline is the No Action alternative, discussed in further detail in Section 4.3.3.1. The No Action Alternative includes future effects such as sea level rise and climate change; existing conditions does not.

4.3.3 Effects and Mitigation Measures

This section provides an evaluation of the direct and indirect effects on flood control, hydraulics, and hydrology from implementing the Project alternatives. This analysis is organized by Project alternative, with specific impact topics numbered sequentially under each alternative.

4.3.3.1 No Action Alternative

Under the No Action Alternative, no additional actions would be taken to increase seasonal floodplain inundation in the lower Sacramento River Basin or to improve fish passage throughout the Yolo Bypass. The Yolo Bypass would continue to be inundated during overtopping events at Fremont Weir. However, additional flows could not pass Fremont Weir when the Sacramento River elevation is below Fremont Weir. Therefore, there would be no construction-related impacts on flood control, hydraulics, and hydrology.

The No Action Alternative assumes reasonably foreseeable actions that could occur in the Project area in the future and do not rely on approval or implementation of the Project, including actions with current authorization, secured funding for design and construction, and environmental permitting and compliance activities that are substantially complete. These reasonably foreseeable actions, in addition to changes in regulatory conditions and water supply demands, would result in differences in flows in the Sacramento River and in the Delta between existing conditions and the No Action Alternative. Appendix E includes more information on the ways that different components of the No Action Alternative contribute to flow changes. Possible changes that could affect flood management (and are included in the modeling) include the following:

- Sea level rise and climate change beyond that in the existing condition;
- Implementation of the California WaterFix Project;
- Full implementation of the Grassland Bypass Project;
- Implementation of the South Bay Aqueduct Improvement and Enlargement Project; and
- San Joaquin River Restoration Program full restoration flows

4.3.3.1.1 Impact HYD-1: Change in occurrence of flows exceeding the maximum existing conditions monthly flow from the Sacramento River into the Yolo Bypass

The CalSim II modeling uses a monthly time step, which is inappropriate for flood control analysis. However, modeling results for the CalSim II period of record indicate that existing conditions flows from Fremont weir into the Yolo Bypass would be less than 136,869 cfs in all years. With additional 2070 assumed climate change, modeling results for the CalSim II period of record indicate that No Action Alternative monthly flows at Fremont Weir greater than 136,869 cfs (the maximum existing conditions monthly flow) would occur in 2 months out of the simulation period. Therefore, the No Action Alternative would increase the number of occurrences of flow above the maximum existing conditions flow, relative to the existing conditions scenario.

CEQA Conclusion

The effect of the No Action Alternative on flows from the Sacramento River into the Yolo Bypass would be **significant** relative to existing conditions because long-term changes in future flow patterns due to climate change, sea level rise, and implementation of the reasonably foreseeable projects would increase the number of occurrences of flows exceeding the maximum existing conditions monthly flow in the Sacramento River at Fremont Weir. However, mitigation is not necessary for the No Action Alternative. The impact would remain **significant and unavoidable**.

4.3.3.1.2 Impact HYD-2: Change in occurrence of flows exceeding the maximum existing conditions monthly flow in the Sacramento River at Freeport

The CalSim II modeling uses a monthly time step, which is inappropriate for flood control analysis. However, modeling results for the CalSim II period of record indicate that existing conditions flows in the Sacramento River at Freeport would be less than 72,231 cfs in all years. With additional 2070 assumed climate change, modeling results for the CalSim II period of record indicate that No Action Alternative monthly flows at Freeport greater than 72,231 cfs (the maximum existing conditions monthly flow) would occur in 2 months out of the simulation period. Therefore, the No Action Alternative would increase the number of occurrences of flow above the maximum existing conditions flow, relative to the existing conditions scenario.

CEQA Conclusion

The effect of the No Action Alternative on flows in the Sacramento River at Freeport would be **significant** relative to existing conditions because long-term changes in future flow patterns due to climate change, sea level rise, and implementation of the reasonably foreseeable projects would increase the number of occurrences of flows exceeding the maximum existing conditions monthly flow in the Sacramento River at Freeport. However, mitigation is not necessary for the No Action Alternative. The impact would remain **significant and unavoidable**.

4.3.3.1.3 Impact HYD-3: Change in 100-year flood hazard area

The No Action Alternative would not locate any new housing or new structures within the 100-year floodplain. In addition, the No Action Alternative would not impede or redirect flood flows within the existing flood hazard area. The physical configuration of Fremont Weir and the channel geometry within the Yolo Bypass would not be altered under the No Action Alternative. However, the No Action Alternative would have higher WSE and a greater inundated area within the Yolo Bypass relative to existing conditions due to future operational changes caused by sea level rise, climate change, and implementation of the reasonably foreseeable projects. In general, TUFLOW and HEC-RAS model results and sensitivity analyses indicate that flows up to the weir capacity, in addition to inflows from bypass tributaries, would remain within the leveed portion of the Yolo Bypass.

Figures 4-2 through 4-6 present the resulting modeled increase in inundated area under future conditions (pink) relative to existing conditions (blue) for 1,000 to 12,000 cfs flows into the Yolo Bypass. The effects of sea level rise on inundated area are greater at lower flows and relatively smaller under higher flows. For example, the inundated area on Figure 4-6 shows a greater increase for the No Action Alternative relative to existing conditions at a 1,000 cfs flow than the increase in inundated area at a 12,000 cfs flow on Figure 4-2.

CEQA Conclusion

The effect of the No Action Alternative on the 100-year flood hazard area would be **less than significant** because no changes would occur to bypass channel geometry, and peak flood flows would not be impeded or redirected.

4.3.3.2 Alternative 1: East Side Gated Notch

Alternative 1, East Side Gated Notch, would allow increased flow from the Sacramento River to enter the Yolo Bypass through a gated notch on the east side of Fremont Weir. The invert of the new notch would be at an elevation of 14 feet, which is approximately 18 feet below the existing Fremont Weir crest. Alternative 1 would allow up to 6,000 cfs to flow through the notch during periods when the river stage is not high enough to go over the crest of Fremont Weir to provide open channel flow for adult fish passage. See Section 2.4 for more details on the alternative features.

Under Alternative 1, larger areas within the bypass would be inundated at low flows. Flood flows would remain limited to the leveed portion of the bypass. Alternative 1 would not locate any new housing or new structures within the 100-year flood hazard area.

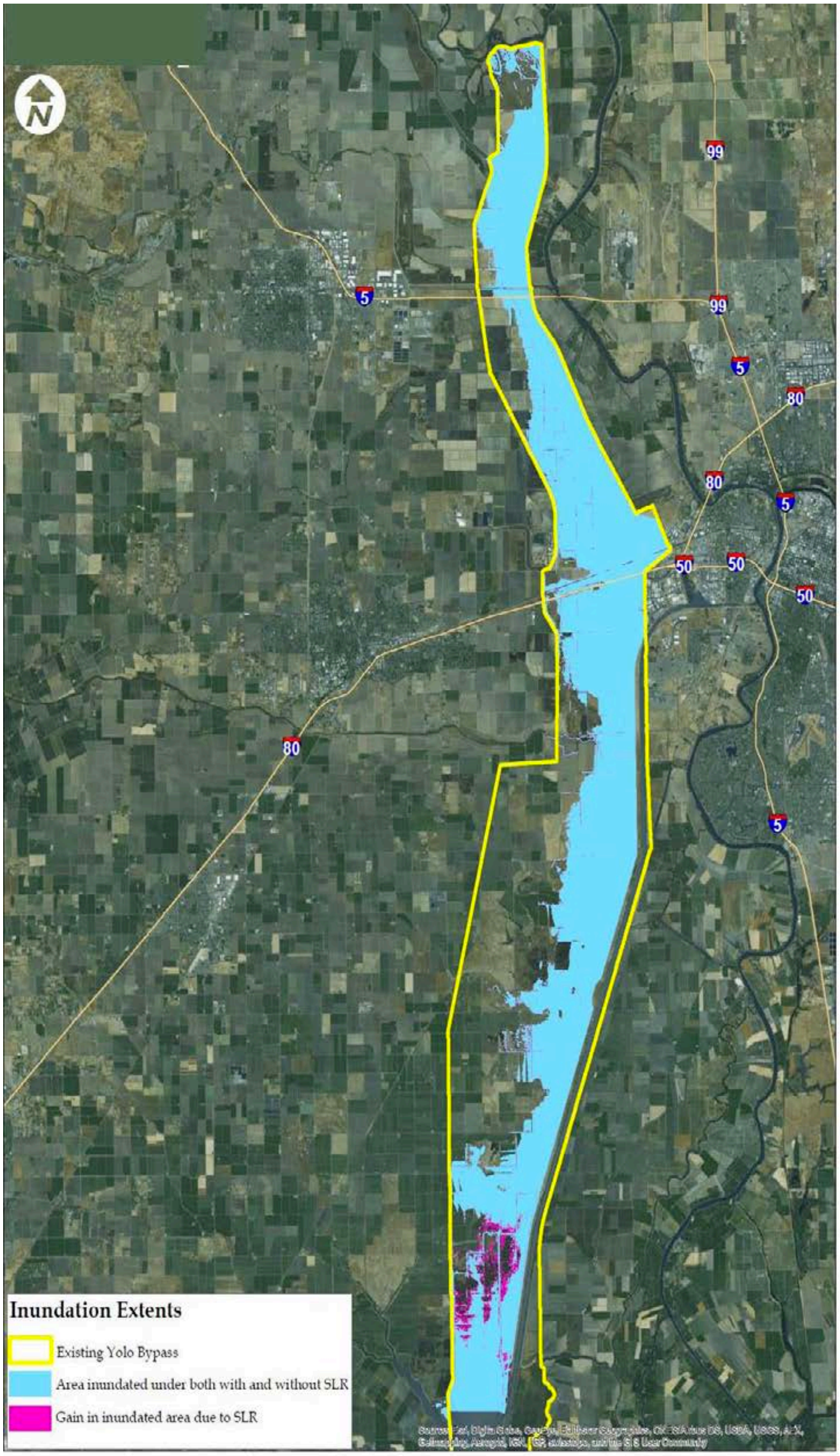

Figure 4-2. Inundation Increase at 12,000 cfs under Future Condition with Sea Level Rise (i.e., No Action Alternative) versus Existing Conditions

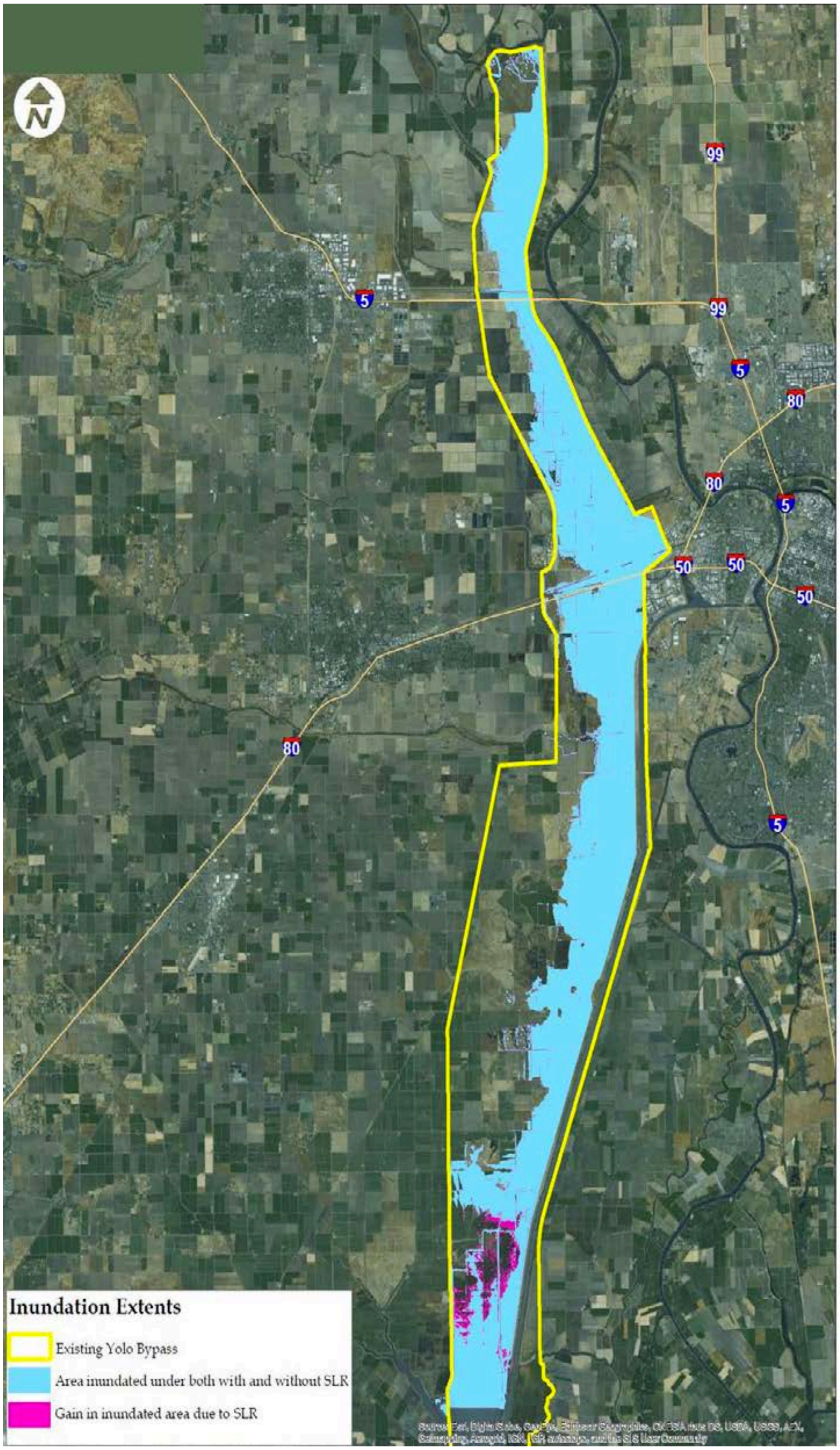

Figure 4-3. Inundation Increase at 9,000 cfs under Future Condition with Sea Level Rise (No Action Alternative) versus Existing Conditions

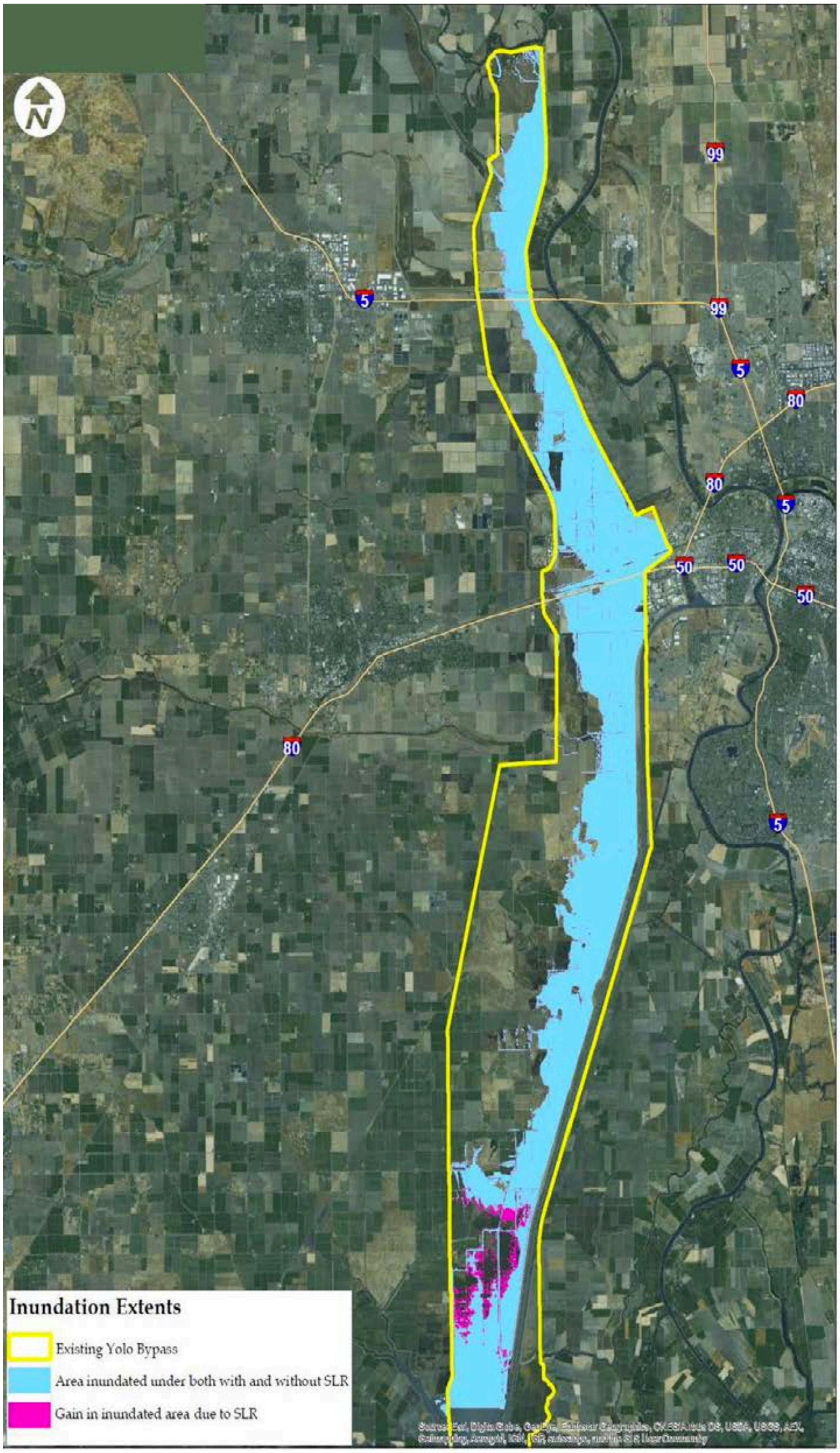

Figure 4-4. Inundation Increase at 6,000 cfs under Future Condition with Sea Level Rise versus Existing Conditions (No Action Alternative)

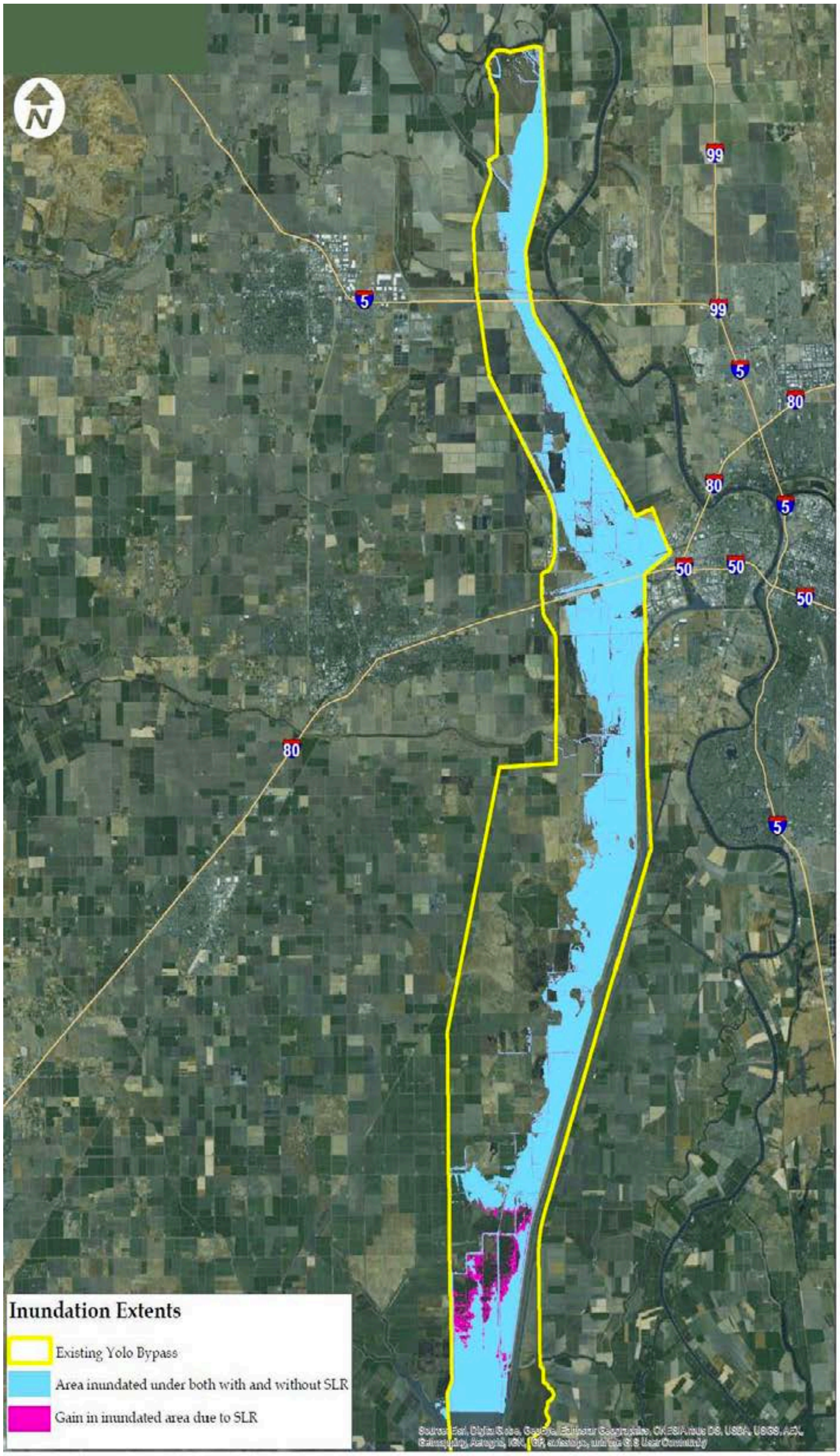

Figure 4-5. Inundation Increase at 3,000 cfs under Future Condition with Sea Level Rise versus Existing Conditions (No Action Alternative)

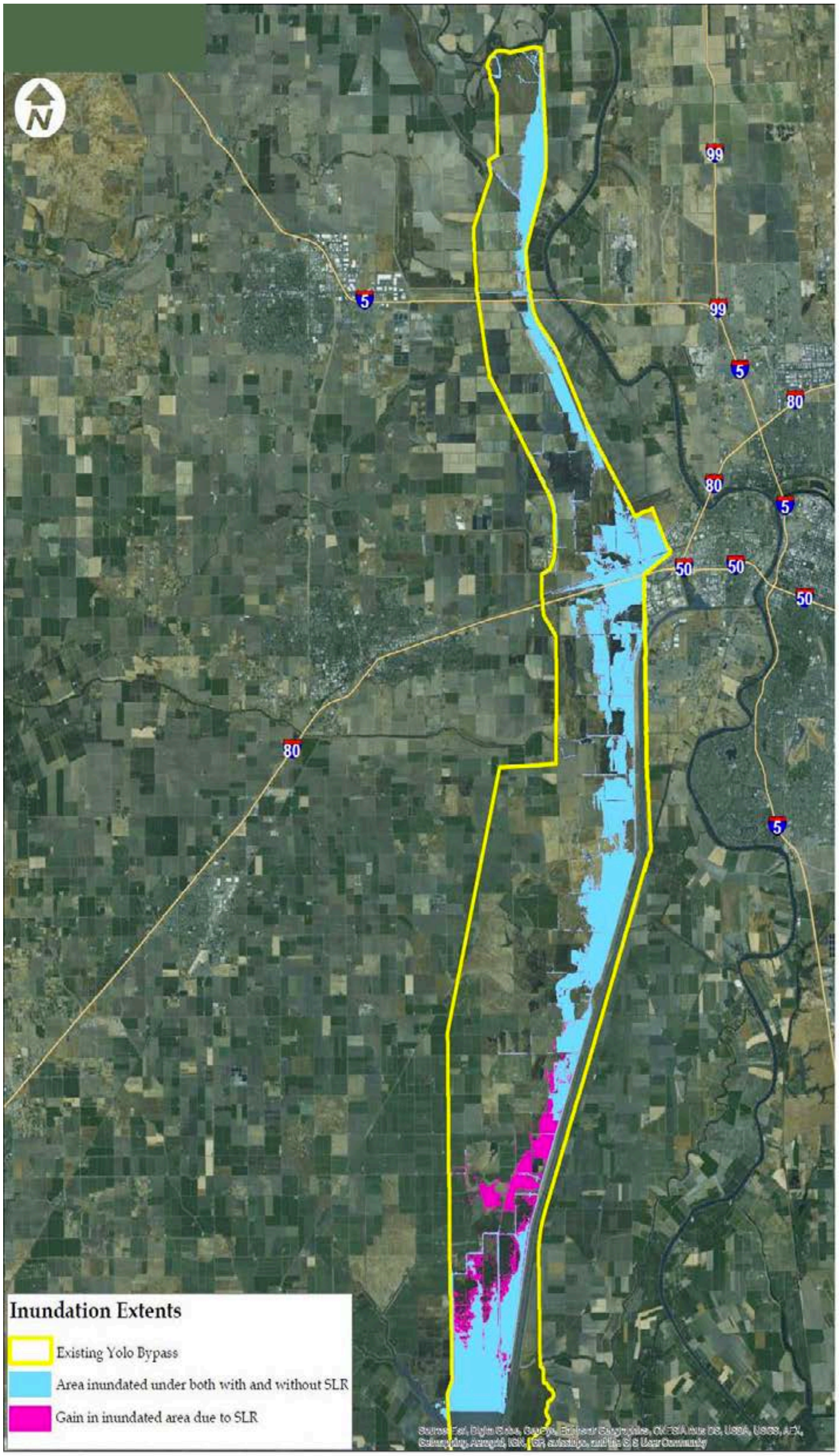

Figure 4-6. Inundation Increase at 1,000 cfs under Future Condition with Sea Level Rise versus Existing Conditions (No Action Alternative)

4.3.3.2.1 Impact HYD-1: Change in occurrence of flows exceeding the maximum existing conditions monthly flow from the Sacramento River into the Yolo Bypass

Alternative 1 compared to Existing Conditions

The CalSim II modeling uses a monthly time step, which is inappropriate for flood control analysis; however, flood management operations at upstream reservoirs would not change for Alternative 1 relative to existing conditions. Although a slight increase in the frequency of high flows in the bypass under Alternative 1 would be possible because of the increased weir capacity at Fremont Weir, Alternative 1 would not increase the occurrence of monthly flows above 136,869 cfs (the maximum existing conditions monthly flow). Based on the CalSim II model results at Fremont Weir with 2030 hydrology and infrastructure, monthly flows at Fremont Weir greater than 136,869 cfs would not occur under either Alternative 1 or existing conditions.

Alternative 1 compared to the No Action Alternative

Based on the CalSim II results at Fremont Weir with 2070 hydrology, infrastructure, and sea level rise, the number of occurrences of flow above 136,869 cfs would remain the same under Alternative 1 relative to the No Action Alternative. Although there would be differences in month-to-month flow in the bypass under Alternative 1 compared to the No Action Alternative, monthly flows at Fremont Weir greater than 136,869 cfs would occur in two months under both Alternative 1 and the No Action Alternative.

CEQA Conclusion

The effect of Alternative 1 on flows from the Sacramento River into the Yolo Bypass would be **less than significant** relative to existing conditions because Alternative 1 would not increase or decrease the number of occurrences of flows exceeding the maximum existing conditions monthly average flow from the Sacramento River into the Yolo Bypass.

4.3.3.2.2 Impact HYD-2: Change in occurrence of flows exceeding the maximum existing conditions monthly flow in the Sacramento River at Freeport

Alternative 1 compared to Existing Conditions

The CalSim II modeling uses a monthly time step, which is inappropriate for flood control analysis; however, flood management operations at upstream reservoirs would not change for Alternative 1 relative to existing conditions. A slight decrease in the frequency of high flows in the Sacramento River at Freeport under Alternative 1 would be possible because of the increased weir capacity at Fremont Weir. Alternative 1 would not increase the occurrence of monthly flows above 72,231 cfs (the maximum existing conditions monthly flow). Based on the CalSim II model results at Freeport with 2030 hydrology and infrastructure, monthly flows at Freeport greater than 72,231 cfs would not occur under either Alternative 1 or existing conditions.

Alternative 1 compared to the No Action Alternative

Based on the CalSim II results at Freeport with 2070 hydrology, infrastructure, and sea level rise, the number of occurrences of flow above 72,231 cfs would remain the same under Alternative 1 relative to the No Action Alternative. Although there would be differences in month-to-month Sacramento River flow at Freeport under Alternative 1 compared to the No Action Alternative, monthly flows at Freeport greater than 72,231 cfs would occur in 2 months under both the No Action Alternative and Alternative 1.

CEQA Conclusion

The effect of Alternative 1 on flows in the Sacramento River at Freeport would be **less than significant** relative to existing conditions because Alternative 1 would not increase or decrease the number of occurrences of flows exceeding the maximum existing conditions monthly average flow at Freeport.

4.3.3.2.3 Impact HYD-3: Change in 100-year flood hazard area

Alternative 1 compared to Existing Conditions

For a given flood or high-flow hydrograph, peak WSE is expected to remain similar to existing conditions. Tables 4-3 and 4-4 show a comparison of maximum WSE for Alternatives 1 through 3 versus the existing conditions along the Sacramento River and the Yolo Bypass, respectively.

Table 4-3. Maximum WSE Changes between Existing Conditions and Alternatives 1, 2, and 3 along the Sacramento River at Key Locations

Locations along the Sacramento River	Maximum WSE (ft. NAVD88)		Difference (ft.)
	Existing Conditions	Alternatives 1, 2, and 3	
Upstream of Fremont Weir	41.02	40.98	-0.04
Natomas Cross Canal	41.24	41.21	-0.03
Verona gage	39.60	39.38	-0.22
Interstate 5	37.27	37.30	0.03
Upstream of Sacramento Weir	33.55	33.54	-0.01
Interstate 80	34.37	34.36	-0.01
Bryte gage	34.38	34.37	-0.01
American River	34.36	34.35	-0.01
I Street Bridge	33.67	33.68	-0.01
Pioneer Memorial Bridge	32.56	32.56	0.00
Freeport bridge	27.72	27.71	-0.01
Snodgrass Slough	22.28	22.21	-0.07
Sutter Slough	19.85	19.84	-0.01
Steamboat Slough	20.54	20.49	-0.05
Walnut Grove gage	17.12	17.12	0.00

Locations along the Sacramento River	Maximum WSE (ft. NAVD88)		Difference (ft.)
	Existing Conditions	Alternatives 1, 2, and 3	
Cache Slough	11.83	11.83	0.00
Rio Vista	11.54	11.54	0.00
3 Mile Slough	5.49	5.49	0.00
Collinsville gage	8.30	8.30	0.00

Source:

HEC-RAS = Hydrologic Engineering Center River Analysis System hydraulic model (HEC-RAS model) 1997 storm pattern scaled to 85 percent, routed through Central Valley Hydrology Study's (CVHS)

WSE = water surface elevation; ft. = feet; NAVD88 = North American Vertical Datum of 1988

Table 4-4. Maximum WSE Changes between the Existing Conditions and Alternatives 1, 2, and 3 along the Yolo Bypass at Key Locations

Locations along the Yolo Bypass	Maximum WSE (ft. NAVD88)		Difference (ft.)
	Existing Conditions	Alternatives 1, 2, and 3	
Fremont Weir	40.2	40.2	0.0
Agricultural Road Crossing 1	37.3	37.3	0.0
Agricultural Road Crossing 2	37.0	37.0	0.0
Knights Landing Ridge Cut	36.4	36.4	0.0
Interstate 5	33.5	33.5	0.0
Road 25 at West Levee	32.0	32.0	0.0
Sacramento Bypass	29.9	29.9	0.0
Agricultural Road Crossing 4	29.8	29.8	0.0
Interstate 80	29.1	29.1	0.0
Putah Creek	27.5	27.5	0.0
Lisbon Gage	25.5	25.5	0.0
North end of Holland Tract	21.3	21.3	0.0
South end of Holland Tract	18.6	18.6	0.0
DWSC at Miner Slough	15.6	15.6	0.0

Source:

DSWC = Deep Water Ship Canal

HEC-RAS = Hydrologic Engineering Center River Analysis System hydraulic model (HEC-RAS model) 1997 storm pattern scaled to 85 percent, routed through Central Valley Hydrology Study's (CVHS)

WSE = water surface elevation; ft. = feet; NAVD88 = North American Vertical Datum of 1988

When Fremont Weir flows at its design capacity of 343,000 cfs (85 percent of the 1997 CVHS hydrograph), the analysis conducted in HEC-RAS indicates that peak WSE within the bypass would not change under Alternative 1 relative to existing conditions. WSE would decrease up to 0.22 feet on the Sacramento River relative to existing conditions.

For the highest historic flood flow routed in TUFLOW, which occurred during the 1997 event, TUFLOW indicated that some portions of the bypass would experience increases in maximum

WSE between 0.02 and 0.05 feet under Alternative 1 relative to the existing conditions hydrodynamic model. TUFLOW results indicated that flows up to the weir capacity would remain within the leveed portion of the Yolo Bypass. Therefore, Alternative 1 would not impede or redirect flood flows within the existing flood hazard area.

Alternative 1 compared to the No Action Alternative

Alternative 1 and the No Action Alternative would be affected by sea level rise. The absolute WSE of Alternative 1 with sea level rise and the absolute WSE of the No Action Alternative would be higher than the absolute WSE of Alternative 1 with current sea levels and the absolute WSE of existing conditions. However, as discussed in Section 4.3.3.1.3, the changes in WSE at higher flows caused by sea level rise are smaller than the differences in WSE at lower flows. Peak WSE is relatively less sensitive to changes due to sea level rise compared to WSE at lower flows.

Because the changes in peak WSE due to sea level rise would be small compared to changes in WSE at low flows due to sea level rise, it is assumed that sea level rise would increase the peak WSE of all alternatives similarly, relative to the alternatives under current sea level conditions. This means that the peak WSE for all alternatives, including Alternative 1 and the No Action Alternative, would be assumed to be increased upward by the same amount.

Therefore, although absolute WSE would change for both the No Action Alternative and Alternative 1, it is assumed that the relative difference in the peak WSE for Alternative 1 compared to the No Action Alternative would remain similar to what is shown in Table 4-4 for Alternative 1 compared to the existing conditions. Similar to the differences presented in Table 4-4, increases in peak WSE in the Yolo Bypass under Alternative 1 with sea level rise compared to the No Action Alternative are expected to be less than one foot. WSE would decrease on the Sacramento River under Alternative 1 with sea level rise compared to the No Action Alternative.

CEQA Conclusion

Impacts to the 100-year flood hazard area would be **less than significant** because the changes to bypass channel geometry under Alternative 1 would not impede or redirect peak flood flows. Increased peak flows from changes to Fremont Weir geometry would remain within the Yolo Bypass. The changes to channel geometry within the Yolo Bypass would increase peak WSE less than one foot. Peak WSE would remain the same or decrease on the Sacramento River. Additionally, increases to the 2-year flood hazard WSE would increase peak WSE less than one foot. Therefore, WSE related impacts, such-as wind-wave erosion, would also be less than significant.

4.3.3.3 Alternative 2: Central Gated Notch

Alternative 2, Central Gated Notch, would provide a similar new gated notch through Fremont Weir as described for Alternative 1. The primary difference between Alternatives 1 and 2 is the location of the notch; Alternative 2 would site the notch near the center of Fremont Weir. This gate would be a similar size but would have an invert elevation that is higher (14.8 feet) because the river is higher at this upstream location, and the gate would allow up to 6,000 cfs through to provide open channel flow for adult fish passage. See Section 2.5 for more details on the alternative features.

Under Alternative 2, larger areas within the bypass would be inundated at low flows; flood flows would remain limited to the leveed portion of the bypass. Alternative 2 would not locate any new facilities within the 100-year flood hazard area.

4.3.3.3.1 Impact HYD-1: Change in occurrence of flows exceeding the maximum existing conditions monthly flow from the Sacramento River into the Yolo Bypass

Flows at Fremont Weir under Alternative 2 would be identical to flows under Alternative 1, and effects would be identical.

CEQA Conclusion

The effect of Alternative 2 on flows from the Sacramento River into the Yolo Bypass would be **less than significant** relative to existing conditions and the future no action scenarios because Alternative 2 would not increase or decrease the number of occurrences of flows exceeding the maximum existing conditions monthly average flow from the Sacramento River into the Yolo Bypass.

4.3.3.3.2 Impact HYD-2: Change in occurrence of flows exceeding the maximum existing conditions monthly flow in the Sacramento River at Freeport

Sacramento River flow at Freeport under Alternative 2 would be identical to flows under Alternative 1, and effects would be identical.

CEQA Conclusion

The effect of Alternative 2 on flows in the Sacramento River at Freeport would be **less than significant** relative to existing conditions and the No Action Scenarios because Alternative 2 would not increase or decrease the number of occurrences of flows exceeding the maximum existing conditions monthly average flow at Freeport.

4.3.3.3.3 Impact HYD-3: Change in 100-year flood hazard area

Tables 4-3 and 4-4 show maximum WSE along the Sacramento River and Yolo Bypass for Alternatives 1, 2, and 3 in comparison to existing conditions. Effects under Alternative 2 relative to existing conditions and the No Action Alternative are expected to be identical to effects under Alternative 1, shown in Table 4-4.

CEQA Conclusion

Impacts to the 100-year flood hazard area would be **less than significant** because the changes to bypass channel geometry under Alternative 2 would not impede or redirect peak flood flows. Increased peak flows from changes to Fremont Weir geometry would remain within the Yolo Bypass. The changes to channel geometry within the Yolo Bypass would increase peak WSE less than one foot. Peak WSE would remain the same or decrease on the Sacramento River. Additionally, increases to the 2-year flood hazard WSE would increase peak WSE less than one foot. Therefore, WSE related impacts, such-as wind-wave erosion, would also be less than significant.

4.3.3.4 Alternative 3: West Side Gated Notch

Alternative 3, West Side Gated Notch, would provide a similar new gated notch through Fremont Weir as described for Alternative 1. The primary difference between Alternatives 1 and 3 is the location of the notch; Alternative 3 would site the notch on the western side of Fremont Weir. This gate would be a similar size but would have an invert elevation that is higher (16.1 feet) because the river is higher at this upstream location. Alternative 3 would allow up to 6,000 cfs through the gated notch to provide open channel flow for adult fish passage. See Section 2.6 for more details on the alternative features.

Under Alternative 3, larger areas within the bypass would be inundated at low flows. Flood flows would remain limited to the leveed portion of the bypass. Alternative 3 would not locate any new facilities within the 100-year flood hazard area.

4.3.3.4.1 Impact HYD-1: Change in occurrence of flows exceeding the maximum existing conditions monthly flow from the Sacramento River into the Yolo Bypass

Flows at Fremont Weir under Alternative 3 would be identical to flows under Alternative 1, and effects would be identical.

CEQA Conclusion

The effect of Alternative 3 on flows from the Sacramento River into the Yolo Bypass would be **less than significant** relative to existing conditions because Alternative 3 would not increase or decrease the number of occurrences of flows exceeding the maximum existing conditions monthly average flow from the Sacramento River into the Yolo Bypass.

4.3.3.4.2 Impact HYD-2: Change in occurrence of flows exceeding the maximum existing conditions monthly flow in the Sacramento River at Freeport

Sacramento River flow at Freeport under Alternative 3 would be identical to flows under Alternative 1, and effects would be identical.

CEQA Conclusion

The effect of Alternative 3 on flows in the Sacramento River at Freeport would be **less than significant** relative to existing conditions because Alternative 3 would not increase or decrease the number of occurrences of flows exceeding the maximum existing conditions monthly average flow at Freeport.

4.3.3.4.3 Impact HYD-3: Change in 100-year flood hazard area

Tables 4-3 and 4-4 show maximum WSE along the Sacramento River and Yolo Bypass for Alternatives 1, 2, and 3 in comparison to existing conditions. Effects under Alternative 3 relative to existing conditions and the No Action Alternative are expected to be identical to effects under Alternative 1.

CEQA Conclusion

Impacts to the 100-year flood hazard area would be **less than significant** because the changes to bypass channel geometry under Alternative 3 would not impede or redirect peak flood flows. Increased peak flows from changes to Fremont Weir geometry would remain within the Yolo Bypass. The changes to channel geometry within the Yolo Bypass would increase peak WSE less than one foot. Peak WSE would remain the same or decrease on the Sacramento River. Additionally, increases to the 2-year flood hazard WSE would increase peak WSE less than one foot. Therefore, WSE related impacts, such-as wind-wave erosion, would also be less than significant.

4.3.3.5 Alternative 4: West Side Gated Notch – Managed Flow

Alternative 4, West Side Gated Notch – Managed Flow, would have a smaller amount of flow entering the Yolo Bypass through the gated notch in Fremont Weir than some other alternatives, but it would incorporate water control structures to maintain inundation for longer periods of time within the northern portion of the Yolo Bypass. Alternative 4 would include the same gated notch and associated facilities as described for Alternative 3; however, it would be operated to limit the maximum inflow to 3,000 cfs. See Section 2.7 for more details on the alternative features.

Alternative 4 would not locate any new housing or new structures within the 100-year floodplain. In addition, Alternative 4 would not impede or redirect flood flows within the existing flood hazard area.

4.3.3.5.1 Impact HYD-1: Change in occurrence of flows exceeding the maximum existing conditions monthly flow from the Sacramento River into the Yolo Bypass

Alternative 4 compared to Existing Conditions

The CalSim II modeling uses a monthly time step, which is inappropriate for flood control analysis; however, flood management operations at upstream reservoirs would not change for Alternative 4 relative to existing conditions. Although a slight increase in the frequency of high flows in the bypass under Alternative 4 would be possible because of the increased weir capacity at Fremont Weir, Alternative 4 would not increase the occurrence of monthly flows above 136,869 cfs (the maximum existing conditions monthly flow). Based on the CalSim II model results at Fremont Weir with 2030 hydrology and infrastructure, monthly flows at Fremont Weir greater than 136,869 cfs would not occur under either Alternative 4 or existing conditions.

Alternative 4 compared to the No Action Alternative

Based on the CalSim II results at Fremont Weir with 2070 hydrology, infrastructure, and sea level rise, the number of occurrences of flow above 136,869 cfs would remain the same under Alternative 4 relative to the No Action Alternative. Although there would be differences in month-to-month flow in the bypass under Alternative 4 compared to the No Action Alternative, monthly flows at Fremont Weir greater than 136,869 cfs would occur in two months under both Alternative 4 and the No Action Alternative.

CEQA Conclusion

The effect of Alternative 4 on flows from the Sacramento River into the Yolo Bypass would be **less than significant** because Alternative 4 would not increase or decrease the number of occurrences of flows exceeding the maximum existing conditions monthly average flow from the Sacramento River into the Yolo Bypass.

4.3.3.5.2 Impact HYD-2: Change in occurrence of flows exceeding the maximum existing conditions monthly flow in the Sacramento River at Freeport

Alternative 4 compared to Existing Conditions

The CalSim II modeling uses a monthly time step, which is inappropriate for flood control analysis; however, flood management operations at upstream reservoirs would not change for Alternative 4 relative to existing conditions. A slight decrease in the frequency of high flows in the Sacramento River at Freeport under Alternative 4 would be possible because of the increased weir capacity at Fremont Weir. Alternative 4 would not increase the occurrence of monthly flows above 72,231 cfs (the maximum existing conditions monthly flow). Based on the CalSim II model results at Freeport with 2030 hydrology and infrastructure, monthly flows at Freeport greater than 72,231 cfs would not occur under either Alternative 4 or existing conditions.

Alternative 4 compared to the No Action Alternative

Based on the CalSim II results at Freeport with 2070 hydrology, infrastructure, and sea level rise, the number of occurrences of flow above 72,231 cfs would remain the same under Alternative 4 relative to the No Action Alternative. Although there would be differences in month-to-month Sacramento River flow at Freeport under Alternative 4 compared to the No Action Alternative, monthly flows at Freeport greater than 72,231 cfs would occur in 2 months under both the No Action Alternative and Alternative 4.

CEQA Conclusion

The effect of Alternative 4 on flows in the Sacramento River at Freeport would be **less than significant** relative to existing because Alternative 4 would not increase or decrease the number of occurrences of flows exceeding the maximum existing conditions monthly average flow in the Sacramento River at Freeport.

4.3.3.5.3 Impact HYD-3: Change in 100-year flood hazard area

Alternative 4 compared to Existing Conditions

For a given flood or high-flow hydrograph, peak WSE is expected to remain similar to existing conditions. Tables 4-5 and 4-6 show a comparison of maximum WSE between Alternative 4 and existing conditions along the Sacramento River and the Yolo Bypass, respectively.

Table 4-5. Maximum WSE Changes between Existing Conditions and Alternative 4 along the Sacramento River at Key Locations

Locations along the Sacramento River	Maximum WSE (ft. NAVD88)		Difference (ft.)
	Existing Conditions	Alternative 4	
Upstream of Fremont Weir	40.39	40.24	-0.15
Natomas Cross Canal	40.22	40.12	-0.10
Verona gage	39.93	39.83	-0.10
Interstate 5	36.11	36.04	-0.07
Upstream of Sacramento Weir	32.23	32.15	-0.08
Interstate 80	32.20	32.16	-0.04
Bryte gage	32.20	32.16	-0.04
American River	32.19	32.17	-0.02
I Street Bridge	31.89	31.86	-0.03
Pioneer Memorial Bridge	31.24	31.21	-0.03
Freeport bridge	26.13	26.1	-0.03
Snodgrass Slough	21.41	21.39	-0.02
Sutter Slough	20.2	20.18	-0.02
Steamboat Slough	18.95	18.93	-0.02
Walnut Grove gage	16.44	16.43	-0.01
Cache Slough	11.16	11.16	0.00

Source:
TUFLOW Hydraulic Impact Analysis. 1997 storm pattern scaled to 85 percent, routed through CVHS HEC-RAS.
WSE = water surface elevation; ft. = feet; NAVD88 = North American Vertical Datum of 1988

Table 4-6. Maximum WSE Changes between Existing Conditions and Alternative 4 along the Yolo Bypass at Key Locations

Locations along the Yolo Bypass	Maximum WSE (ft. NAVD88)		Difference (ft.)
	Existing Conditions	Alternative 4	
Fremont Weir	40.39	40.24	-0.15
Knights Landing Ridge Cut	35.33	35.32	-0.01
Interstate 5	31.04	31.02	-0.02
Sacramento Bypass	29.88	29.86	-0.02
Interstate 80	28.45	28.43	-0.02
Lisbon Gage	26.49	26.47	-0.02
Thomsen Road	25.30	25.28	-0.02
Delhi Road	22.23	22.21	-0.02

Source:
TUFLOW Hydraulic Impact Analysis. 1997 storm pattern scaled to 85 percent, routed through TUFLOW.
WSE = water surface elevation; ft. = feet; NAVD88 = North American Vertical Datum of 1988

When Fremont Weir flows at its design capacity of 343,000 cfs (85 percent of the 1997 CVHS hydrograph), the analysis conducted in HEC-RAS indicates that peak WSE within the bypass would decrease up to 0.15 feet under Alternative 4 in one location relative to existing conditions. WSE would decrease up to 0.15 feet on the Sacramento River relative to existing conditions.

TUFLOW results indicate that flows up to the weir capacity would remain within the leveed portion of Yolo Bypass for all alternatives. Therefore, Alternative 4 would not impede or redirect flood flows within the existing flood hazard area.

Alternative 4 compared to the No Action Alternative

As discussed in Section 4.3.3.2.3, it is assumed that sea level rise would increase the peak WSE of all alternatives equally, relative to the alternatives under 2030 sea level conditions. Therefore, the differences in peak WSE under Alternative 4 with 2070 sea levels relative to the No Action Alternative are expected to be of a similar magnitude to the differences in peak WSE under Alternative 4 with 2030 sea levels relative to existing conditions.

Similar to the differences compared to the existing conditions presented in Table 4-6, Yolo Bypass peak WSE is expected to decrease under Alternative 4 with sea level rise compared to the No Action Alternative. Peak WSE would decrease on the Sacramento River under Alternative 4 with sea level rise compared to the No Action Alternative.

CEQA Conclusion

Impacts to the 100-year flood hazard area would be **less than significant** because the changes to bypass channel geometry under Alternative 4 would not impede or redirect peak flood flows. Increased peak flows from changes to Fremont Weir geometry would remain within the Yolo Bypass. The changes to channel geometry within the Yolo Bypass would increase peak WSE less than one foot. Peak WSE would remain the same or decrease on the Sacramento River. Additionally, increases to the 2-year flood hazard WSE would increase peak WSE less than one foot. Therefore, WSE related impacts, such-as wind-wave erosion, would also be less than significant.

4.3.3.6 Alternative 5: Central Multiple Gated Notches

Alternative 5, Central Multiple Gated Notches, would have a smaller amount of flow entering the Yolo Bypass through the gated notch in Fremont Weir than some other alternatives, but it would incorporate water control structures to maintain inundation for longer periods of time within the northern portion of the Yolo Bypass. Alternative 5 would include the same gated notch and associated facilities as described for Alternative 3; however, it would be operated to limit the maximum inflow to 3,200 cfs. See Section 2.7 for more details on the alternative features.

4.3.3.6.1 Impact HYD-1: Change in occurrence of flows exceeding the maximum existing conditions monthly flow from the Sacramento River into the Yolo Bypass

Alternative 5 compared to Existing Conditions

The CalSim II modeling uses a monthly time step, which is inappropriate for flood control analysis; however, flood management operations at upstream reservoirs would not change for Alternative 5 relative to existing conditions. Although a slight increase in the frequency of high flows in the bypass under Alternative 5 would be possible because of the increased weir capacity at Fremont Weir, Alternative 5 would not increase the occurrence of monthly flows above 136,869 cfs (the maximum existing conditions monthly flow). Based on the CalSim II model results at Fremont Weir with 2030 hydrology and infrastructure, monthly flows at Fremont Weir greater than 136,869 cfs would not occur under either Alternative 5 or existing conditions.

Alternative 5 compared to the No Action Alternative

Based on the CalSim II results at Fremont Weir with 2070 hydrology, infrastructure, and sea level rise, the number of occurrences of flow above 136,869 cfs would remain the same under Alternative 5 relative to the No Action Alternative. Although there would be differences in month-to-month flow in the bypass under Alternative 5 compared to the No Action Alternative, monthly flows at Fremont Weir greater than 136,869 cfs would occur in two months under both Alternative 5 and the No Action Alternative.

CEQA Conclusion

The effect of Alternative 5 on flows from the Sacramento River into the Yolo Bypass would be **less than significant** because Alternative 5 would not increase or decrease the number of occurrences of flows exceeding the maximum existing conditions monthly average flow from the Sacramento River into the Yolo Bypass.

4.3.3.6.2 Impact HYD-2: Change in occurrence of flows exceeding the maximum existing conditions monthly flow in the Sacramento River at Freeport

Alternative 5 compared to Existing Conditions

The CalSim II modeling uses a monthly time step, which is inappropriate for flood control analysis; however, flood management operations at upstream reservoirs would not change for Alternative 5 relative to existing conditions. A slight decrease in the frequency of high flows in the Sacramento River at Freeport under Alternative 5 would be possible because of the increased weir capacity at Fremont Weir. Alternative 5 would not increase the occurrence of monthly flows above 72,231 cfs (the maximum existing conditions monthly flow). Based on the CalSim II model results at Freeport with 2030 hydrology and infrastructure, monthly flows at Freeport greater than 72,231 cfs would not occur under either Alternative 5 or existing conditions.

Alternative 5 compared to the No Action Alternative

Based on the CalSim II results at Freeport with 2070 hydrology, infrastructure, and sea level rise, the number of occurrences of flow above 72,231 cfs would remain the same under Alternative 5 relative to the No Action Alternative. Although there would be differences in month-to-month Sacramento River flow at Freeport under Alternative 5 compared to the No Action Alternative, monthly flows at Freeport greater than 72,231 cfs would occur in 2 months under both the No Action Alternative and Alternative 5.

CEQA Conclusion

The effect of Alternative 5 on flows in the Sacramento River at Freeport would be **less than significant** relative to existing conditions because Alternative 5 would not increase or decrease the number of occurrences of flows exceeding the maximum existing conditions monthly average flow in the Sacramento River at Freeport.

4.3.3.6.3 Impact HYD-3: Change in 100-year flood hazard area

Alternative 5 would change the channel geometry within the Yolo Bypass to improve fish passage and would change the geometry of Fremont Weir to allow higher discharge into the Yolo Bypass than under the existing conditions. Under Alternative 5, larger areas within the bypass would be inundated at low flows. Flood flows would remain limited to the leveed portion of the bypass. Alternative 5 would not locate any new housing or new structures within the 100-year flood hazard area.

Alternative 5 compared to Existing Conditions

For a given flood or high-flow hydrograph, peak WSE under Alternative 5 are expected to remain similar to existing conditions. Tables 4-7 and 4-8 show a comparison of maximum WSE under Alternative 5 compared to existing conditions along the Sacramento River and the Yolo Bypass respectively.

Table 4-7. Maximum WSE Changes between Existing Conditions and Alternative 5 along the Sacramento River at Key Locations

Locations along the Sacramento River	Maximum WSE (ft. NAVD88)		Difference (ft.)
	Existing Conditions	Alternative 5	
Upstream of Fremont Weir	41.02	40.92	-0.10
Natomas Cross Canal	41.24	41.17	-0.07
Verona gage	39.60	39.54	-0.06
Interstate 5	37.27	37.27	0.00
Upstream of Sacramento Weir	33.55	33.53	-0.02
Interstate 80	34.37	34.35	-0.02
Bryte gage	34.38	34.35	-0.03
American River	34.36	34.34	-0.02
I Street Bridge	33.67	33.65	-0.02

Locations along the Sacramento River	Maximum WSE (ft. NAVD88)		Difference (ft.)
	Existing Conditions	Alternative 5	
Pioneer Memorial Bridge	32.56	32.55	-0.01
Freeport bridge	27.72	27.70	-0.02
Snodgrass Slough	22.28	22.20	-0.08
Sutter Slough	19.85	19.83	-0.02
Steamboat Slough	20.54	20.48	-0.06
Walnut Grove gage	17.12	17.11	-0.01
Cache Slough	11.83	11.83	0.00
Rio Vista	11.54	11.54	0.00
3 Mile Slough	5.49	5.49	0.00
Collinsville gage	8.30	8.30	0.00

Source:

HEC-RAS = Hydrologic Engineering Center River Analysis System hydraulic model (HEC-RAS model) 1997 storm pattern scaled to 85 percent, routed through Central Valley Hydrology Study's (CVHS)

WSE= water surface elevation; ft. = feet; NAVD88 = North American Vertical Datum of 1988

Table 4-8. Maximum WSE Changes between Existing Conditions and Alternative 5 along Yolo Bypass at Key Locations

Locations along the Yolo Bypass	Maximum WSE (ft. NAVD88)		Difference (ft.)
	Existing Conditions	Alternative 5	
Fremont Weir	40.2	40.1	-0.1
Agricultural Road Crossing 1	37.3	37.3	0.0
Agricultural crossing 2	37.0	37.0	0.0
Knights Landing Ridge Cut	36.4	36.4	0.0
Interstate 5	33.5	33.5	0.0
Road 25 at West Levee	32.0	32.0	0.0
Sacramento Bypass	29.9	29.9	0.0
Agricultural crossing 4	29.8	29.8	0.0
Interstate 80	29.1	29.1	0.0
Putah Creek	27.5	27.5	0.0
Lisbon Gage	25.5	25.5	0.0
North end of Holland Tract	21.3	21.3	0.0
South end of Holland Tract	18.6	18.6	0.0
DWSC at Miner Slough	15.6	15.6	0.0

Source:

DSWC = Deep Water Ship Canal

HEC-RAS = Hydrologic Engineering Center River Analysis System hydraulic model (HEC-RAS model) 1997 storm pattern scaled to 85 percent, routed through Central Valley Hydrology Study's (CVHS)

WSE= water surface elevation; ft. = feet; NAVD88 = North American Vertical Datum of 1988

When Fremont Weir flows at its design capacity of 343,000 cfs (85 percent of the 1997 CVHS hydrograph), the analysis conducted in HEC-RAS indicates that peak WSE within the bypass would not change for Alternative 5 relative to existing conditions. WSE would decrease up to 0.1 feet on the Sacramento River relative to existing conditions.

For the highest historic flood flow routed in TUFLOW, which occurred during the 1997 event, TUFLOW indicates that some portions of the bypass would experience increases in maximum WSE between 0.02 and 0.05 feet in Alternative 5 relative to the existing conditions hydrodynamic model. TUFLOW results indicate that flows up to the weir capacity would remain within the leveed portion of the Yolo Bypass for all alternatives. Therefore, Alternative 5 would not impede or redirect flood flows within the existing flood hazard area.

Alternative 5 compared to the No Action Alternative

As discussed in Section 4.3.3.2.3, it is assumed that sea level rise would increase the peak WSE of all alternatives equally, relative to the alternatives under 2030 sea level conditions. Therefore, the differences in peak WSE under Alternative 5 with 2070 sea levels relative to the No Action Alternative are expected to be of a similar magnitude to the differences in peak WSE under Alternative 5 with 2030 sea levels relative to existing conditions.

Similar to the differences presented in Table 4-8 for Alternative 5 compared to existing conditions, Yolo Bypass peak WSE is expected to decrease under Alternative 5 with sea level rise compared to the No Action Alternative. Peak WSE would decrease on the Sacramento River under Alternative 5 with sea level rise compared to the No Action Alternative.

CEQA Conclusion

Impacts to the 100-year flood hazard area would be **less than significant** because the changes to bypass channel geometry under Alternative 5 would not impede or redirect peak flood flows. Increased peak flows from changes to Fremont Weir geometry would remain within the Yolo Bypass. The changes to channel geometry within the Yolo Bypass would increase peak WSE less than one foot. Peak WSE would remain the same or decrease on the Sacramento River. Additionally, increases to the 2-year flood hazard WSE would increase peak WSE less than one foot. Therefore, WSE related impacts, such-as wind-wave erosion, would also be less than significant.

4.3.3.6.4 Tule Canal Floodplain Improvements (Program Level)

As described in Section 2.8.1.7, Alternative 5 would include floodplain improvements along Tule Canal, just north of Interstate 80. These improvements would not be constructed at the same time as the remaining facilities. Floodplain improvements are included at a program level of detail to consider all the potential impacts and benefits of Alternative 5. Subsequent consideration of environmental impacts would be necessary before construction could begin.

The Tule Canal Floodplain Improvements would not change the occurrence of flows above the maximum existing conditions monthly flow within the Yolo Bypass or the Sacramento River relative to existing conditions and the No Action Alternative. The improvements would result in changes to WSE within the bypass relative to existing conditions and the No Action Alternative. Weir operations would increase the WSE upstream of Tule Canal for more frequent, lower flows to improve habitat for fish and waterfowl. However, for less frequent, higher flows, such as a one percent AEP monthly flow, the weir would not be operated to increase WSE upstream of Tule Canal. Further, although the floodplain grading would impede flows and redirect flows at lower flows in some areas within the bypass to increase Tule Canal depth, flows through the weir structure would not be allowed to exceed 1,000 cfs (the capacity of Tule Canal).

CEQA Conclusion

The overall capacity of the Yolo Bypass would not be reduced by the Tule Canal Floodplain Improvements relative to existing conditions, and all flows would remain within the existing Yolo Bypass. Therefore, these improvements would have a **less than significant** impact on flood control, hydrology, and hydraulics.

4.3.3.7 Alternative 6: West Side Large Gated Notch

Alternative 6, West Side Large Gated Notch, is a large notch in the western location that would allow flows up to 12,000 cfs. It was designed with the goal of entraining more fish by allowing more flow into the bypass when the Sacramento River is at lower elevations. See Section 2.9 for more details on the alternative features.

4.3.3.7.1 Impact HYD-1: Change in occurrence of flows exceeding the maximum existing conditions monthly flow from the Sacramento River into the Yolo Bypass

Alternative 6 compared to Existing Conditions

The CalSim II modeling uses a monthly time step, which is inappropriate for flood control analysis; however, flood management operations at upstream reservoirs would not change for Alternative 6 relative to existing conditions. Although a slight increase in the frequency of high flows in the bypass under Alternative 6 would be possible because of the increased weir capacity at Fremont Weir, Alternative 6 would not increase the occurrence of monthly flows above 136,869 cfs (the maximum existing conditions monthly flow). Based on the CalSim II model results at Fremont Weir with 2030 hydrology and infrastructure, monthly flows at Fremont Weir greater than 136,869 cfs would not occur under either Alternative 6 or existing conditions.

Alternative 6 compared to the No Action Alternative

Based on the CalSim II results at Fremont Weir with 2070 hydrology, infrastructure, and sea level rise, the number of occurrences of flow above 136,869 cfs would remain the same under Alternative 6 relative to the No Action Alternative. Although there would be differences in month-to-month flow in the bypass under Alternative 6 compared to the No Action Alternative, monthly flows at Fremont Weir greater than 136,869 cfs would occur in two months under both Alternative 6 and the No Action Alternative.

CEQA Conclusion

The effect of Alternative 6 on flows from the Sacramento River into the Yolo Bypass would be **less than significant** because Alternative 6 would not increase or decrease the number of occurrences of flows exceeding the maximum existing conditions monthly average flow from the Sacramento River into the Yolo Bypass.

4.3.3.7.2 Impact HYD-2: Change in occurrence of flows exceeding the maximum existing conditions monthly flow in the Sacramento River at Freeport

Alternative 6 compared to Existing Conditions

The CalSim II modeling uses a monthly time step, which is inappropriate for flood control analysis; however, flood management operations at upstream reservoirs would not change for Alternative 6 relative to existing conditions. A slight decrease in the frequency of high flows in the Sacramento River at Freeport under Alternative 6 would be possible because of the increased weir capacity at Fremont Weir. Alternative 6 would not increase the occurrence of monthly flows above 72,231 cfs (the maximum existing conditions monthly flow). Based on the CalSim II model results at Freeport with 2030 hydrology and infrastructure, monthly flows at Freeport greater than 72,231 cfs would not occur under either Alternative 6 or existing conditions.

Alternative 6 compared to the No Action Alternative

Based on the CalSim II results at Freeport with 2070 hydrology, infrastructure, and sea level rise, the number of occurrences of flow above 72,231 cfs would remain the same under Alternative 6 relative to the No Action Alternative. Although there would be differences in month-to-month Sacramento River flow at Freeport under Alternative 6 compared to the No Action Alternative, monthly flows at Freeport greater than 72,231 cfs would occur in 2 months under both the No Action Alternative and Alternative 6.

CEQA Conclusion

The effect of Alternative 6 on flows from the Sacramento River into the Yolo Bypass would be **less than significant** because Alternative 6 would not increase or decrease the number of occurrences of flows exceeding the maximum existing conditions monthly average flow in the Sacramento River at Freeport

4.3.3.7.3 Impact HYD-3: Change in 100-year flood hazard area

Alternative 6 would change the channel geometry within the Yolo Bypass to improve fish passage and would change the geometry of Fremont Weir to allow higher discharge into the Yolo Bypass than under the existing conditions. Under Alternative 6, larger areas within the bypass would be inundated at low flows. Flood flows would remain limited to the leveed portion of the bypass. Alternative 6 would not locate any new housing or new structures within the 100-year flood hazard area.

Alternative 6 compared to Existing Conditions

For a given flood or high-flow hydrograph, peak WSE is expected to remain similar to existing conditions. Tables 4-9 and 4-10 show a comparison of maximum WSE along the Sacramento River and the Yolo Bypass, respectively.

Table 4-9. Maximum WSE Changes between Existing Conditions and Alternative 6 along the Sacramento River at Key Locations

Locations along the Sacramento River	Maximum WSE (ft. NAVD88)		Difference (ft.)
	Existing Conditions	Alternative 6	
Upstream of Fremont Weir	41.02	40.86	-0.16
Natomas Cross Canal	41.24	41.14	-0.10
Verona gage	39.60	39.50	-0.10
Interstate 5	37.27	37.20	-0.07
Upstream of Sacramento Weir	33.55	33.52	-0.03
Interstate 80	34.37	34.34	-0.03
Bryte gage	34.38	34.34	-0.02
American River	34.36	34.34	-0.02
I Street Bridge	33.67	33.64	-0.03
Pioneer Memorial Bridge	32.56	32.53	-0.03
Freeport bridge	27.72	27.69	-0.03
Snodgrass Slough	22.28	22.19	-0.09
Sutter Slough	19.85	19.83	-0.02
Steamboat Slough	20.54	20.52	-0.02
Walnut Grove gage	17.12	17.11	-0.01
Cache Slough	11.83	11.83	0.00
Rio Vista	11.54	11.54	0.00
3 Mile Slough	5.49	5.49	0.00
Collinsville gage	8.30	8.30	0.00

Source:

HEC-RAS = Hydrologic Engineering Center River Analysis System hydraulic model (HEC-RAS model) 1997 storm pattern scaled to 85 percent, routed through Central Valley Hydrology Study's (CVHS)

WSE= water surface elevation; ft. = feet; NAVD88 = North American Vertical Datum of 1988

Table 4-10. Maximum WSE Changes between Existing Conditions and Alternative 6 along Yolo Bypass at Key Locations

Locations along the Yolo Bypass	Maximum WSE (ft. NAVD88)		Difference (ft.)
	Existing Conditions	Alternative 6	
Fremont Weir	40.2	40.0	-0.2
Agricultural Road Crossing 1	37.3	37.3	0.0
Agricultural crossing 2	37.0	37.0	0.0
Knights Landing Ridge Cut	36.4	36.4	0.0
Interstate 5	33.5	33.5	0.0
Road 25 at West Levee	32.0	32.0	0.0
Sacramento Bypass	29.9	29.9	0.0

Locations along the Yolo Bypass	Maximum WSE (ft. NAVD88)		Difference (ft.)
	Existing Conditions	Alternative 6	
Agricultural crossing 4	29.8	29.8	0.0
Interstate 80	29.1	29.1	0.0
Putah Creek	27.5	27.5	0.0
Lisbon Gage	25.5	25.5	0.0
North end of Holland Tract	21.3	21.3	0.0
South end of Holland Tract	18.6	18.6	0.0
DWSC at Miner Slough	15.6	15.6	0.0

Source:

DSWC = Deep Water Ship Canal

HEC-RAS = Hydrologic Engineering Center River Analysis System hydraulic model (HEC-RAS model) 1997 storm pattern scaled to 85 percent, routed through Central Valley Hydrology Study's (CVHS)

WSE= water surface elevation; ft. = feet; NAVD88 = North American Vertical Datum of 1988

When Fremont Weir flows at its design capacity of 343,000 cfs (85 percent of the 1997 CVHS hydrograph), the analysis conducted in HEC-RAS indicates that peak WSE within the bypass would increase up to 0.2 feet for Alternative 6 relative to existing conditions. WSE would decrease up to 0.16 feet on the Sacramento River relative to existing conditions.

For the highest historic flood flow routed in TUFLOW, which occurred during the 1997 event, TUFLOW indicates that some portions of the bypass would experience increases in maximum WSE between 0.02 and 0.05 feet in Alternative 6 relative to the existing conditions hydrodynamic model. TUFLOW results indicate that flows up to the weir capacity would remain within the leveed portion of the Yolo Bypass for all alternatives. Therefore, Alterative 6 would not impede or redirect flood flows within the existing flood hazard area.

Alternative 6 compared to the No Action Alternative

As discussed in Section 4.3.3.2.3, it is assumed that sea level rise would increase the peak WSE of all alternatives equally, relative to the alternatives under 2030 sea level conditions. Therefore, the differences in peak WSE under Alternative 6 with 2070 sea levels relative to the No Action Alternative are expected to be of a similar magnitude to the differences in peak WSE under Alternative 6 with 2030 sea levels relative to existing conditions.

Similar to the differences presented in Table 4-10 for Alternative 6 compared to existing conditions, increases in Yolo Bypass WSE at peak flows under Alternative 6 with sea level rise compared to the No Action Alternative are expected to be less than one foot. WSE at peak flows would decrease on the Sacramento River under Alternative 6 with sea level rise compared to the No Action Alternative.

CEQA Conclusion

Impacts to the 100-year flood hazard area would be **less than significant** because the changes to bypass channel geometry under Alternative 6 would not impede or redirect peak flood flows. Increased peak flows from changes to Fremont Weir geometry would remain within the Yolo

Bypass. The changes to channel geometry within the Yolo Bypass would increase peak WSE of the bypass by less than one foot. Peak WSE would remain the same or decrease on the Sacramento River. Additionally, increases to the 2-year flood hazard WSE would increase peak WSE less than one foot. Therefore, WSE related impacts, such-as wind-wave erosion, would also be less than significant.

4.3.4 Summary of Impacts

Table 4-11 provides a summary of the identified impacts to flood control, hydraulics, and hydrology within the Project area.

Table 4-11. Summary of Impacts and Mitigation Measures – Flood Control, Hydraulics, and Hydrology

Impact	Alternative	Level of Significance Before Mitigation	Mitigation Measures	Level of Significance after Mitigation
Impact HYD-1: Change in occurrence of flows exceeding the maximum existing conditions monthly flow from the Sacramento River into the Yolo Bypass	No Action	S	--	S
	All Action Alternatives	LTS	--	LTS
Impact HYD-2 Change in occurrence of flows exceeding the maximum existing conditions monthly flow in the Sacramento River at Freeport	No Action	S	--	S
	All Action Alternatives	LTS	--	LTS
Impact HYD-3 Change in 100-year flood hazard area	No Action	LTS	--	LTS
	All Action Alternatives	LTS	--	LTS

Key:
LTS = less than significant
NI = no impact
S = significant
SU = significant and unavoidable
B = beneficial

4.4 Cumulative Impacts Analysis

This section describes the cumulative impacts analysis for flood control, hydrology, and hydraulics. Section 3.3, *Cumulative Impacts*, presents an overview of the cumulative impacts analysis, including the methodology and the projects, plans, and programs included in the cumulative impacts analysis.

4.4.1 Methodology

This evaluation of cumulative impacts considers the effects of the Project and how they might combine with the effects of other past, present, and future projects or actions to create significant impacts on flood control, hydrology, and hydraulics. The area of analysis for these cumulative impacts includes the Yolo Bypass, the Delta, and the larger Sacramento River system. The timeframe for this cumulative impacts analysis includes the past, present, and probable future projects producing related or cumulative impacts that have been identified in the area of analysis.

This cumulative impacts analysis uses the project analysis approach described in detail in Section 3.3, *Cumulative Impacts*.

4.4.2 Cumulative Impacts

Several related and reasonably foreseeable projects and actions (including the Bay-Delta Water Quality Control Plan Update, the Central Valley Flood Management Planning Program, the Central Valley Flood Protection Plan, Folsom Water Control Manual Update, and others as described in Section 3.3) could result in impacts to the occurrence of flows exceeding the maximum existing conditions monthly flow in the Yolo Bypass at Fremont Weir and the maximum existing conditions monthly Sacramento River flow at Freeport. In particular, there may be reduced flows in the Sacramento River and increased flows in the Yolo Bypass due to implementation of the Lower Elkhorn Basin Levee Setback Project (LEBLS). LEBLS would remove all or portions of seven miles of existing levees along the east side of the Yolo Bypass and the north side of the Sacramento Bypass. These levees would be set back, portions of local reclamation district cross levees would be removed, and related infrastructure would be improved or relocated. The project would reduce river levels in the Sacramento River and increase the capacity of the Yolo Bypass near Sacramento and West Sacramento.

Figures 4-7 through 4-11 show the change in inundated area at 1,000, 3,000, 6,000, 9,000, and 12,000 cfs due to implementation of the LEBLS as modeled in HEC-RAS under 2030 conditions. Appendix U includes more detail about this evaluation. The water depth would decrease in some regions of the bypass so that some areas (shaded in pink) are no longer inundated, and the water depth would increase in other regions outside of the existing bypass (shaded in aqua) to inundate additional area.

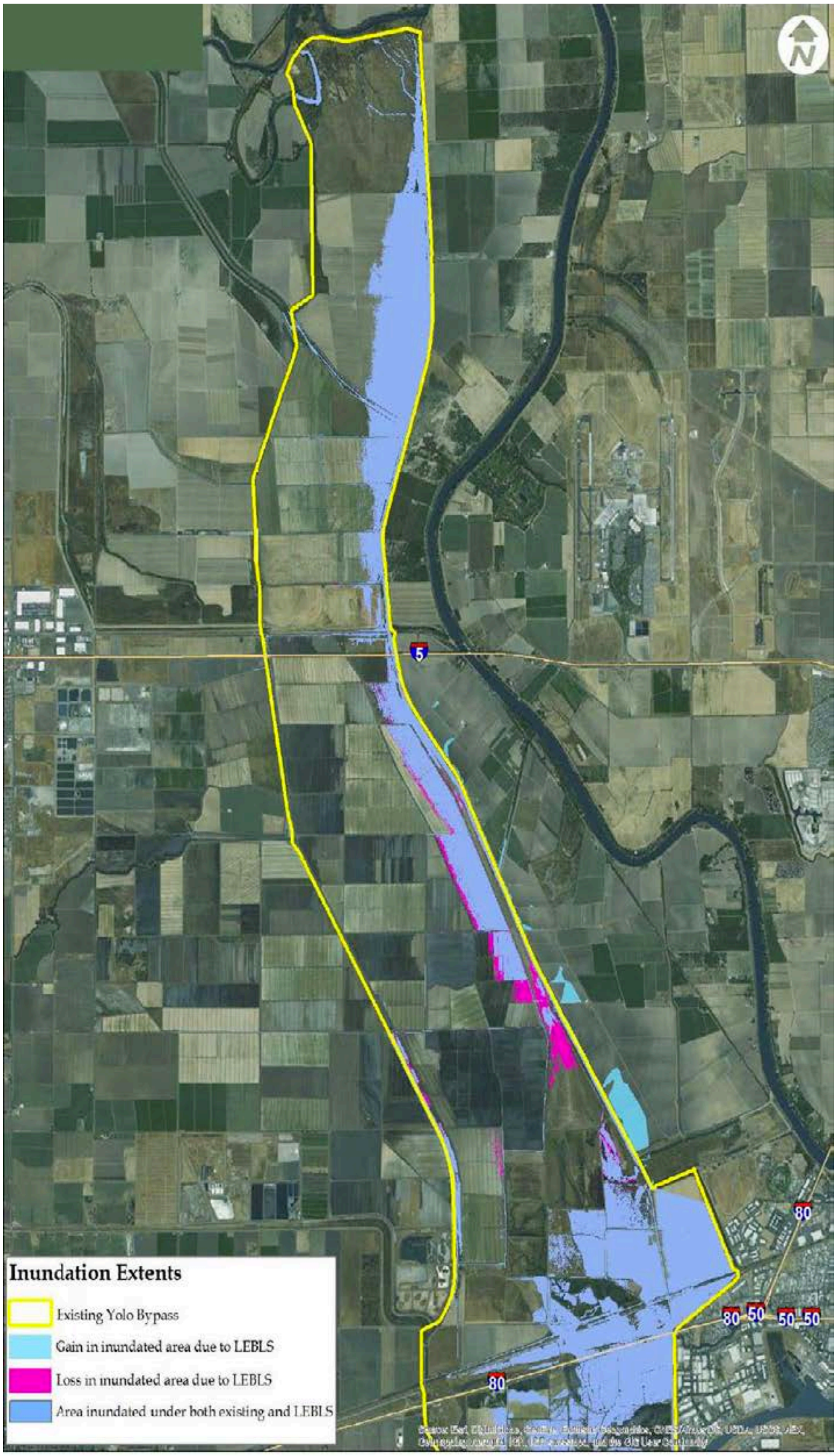

Figure 4-7. Inundation Changes at 1,000 cfs with Lower Elkhorn Basin Levee Setback (LEBLS) Cumulative Impacts versus Inundation under the Alternatives

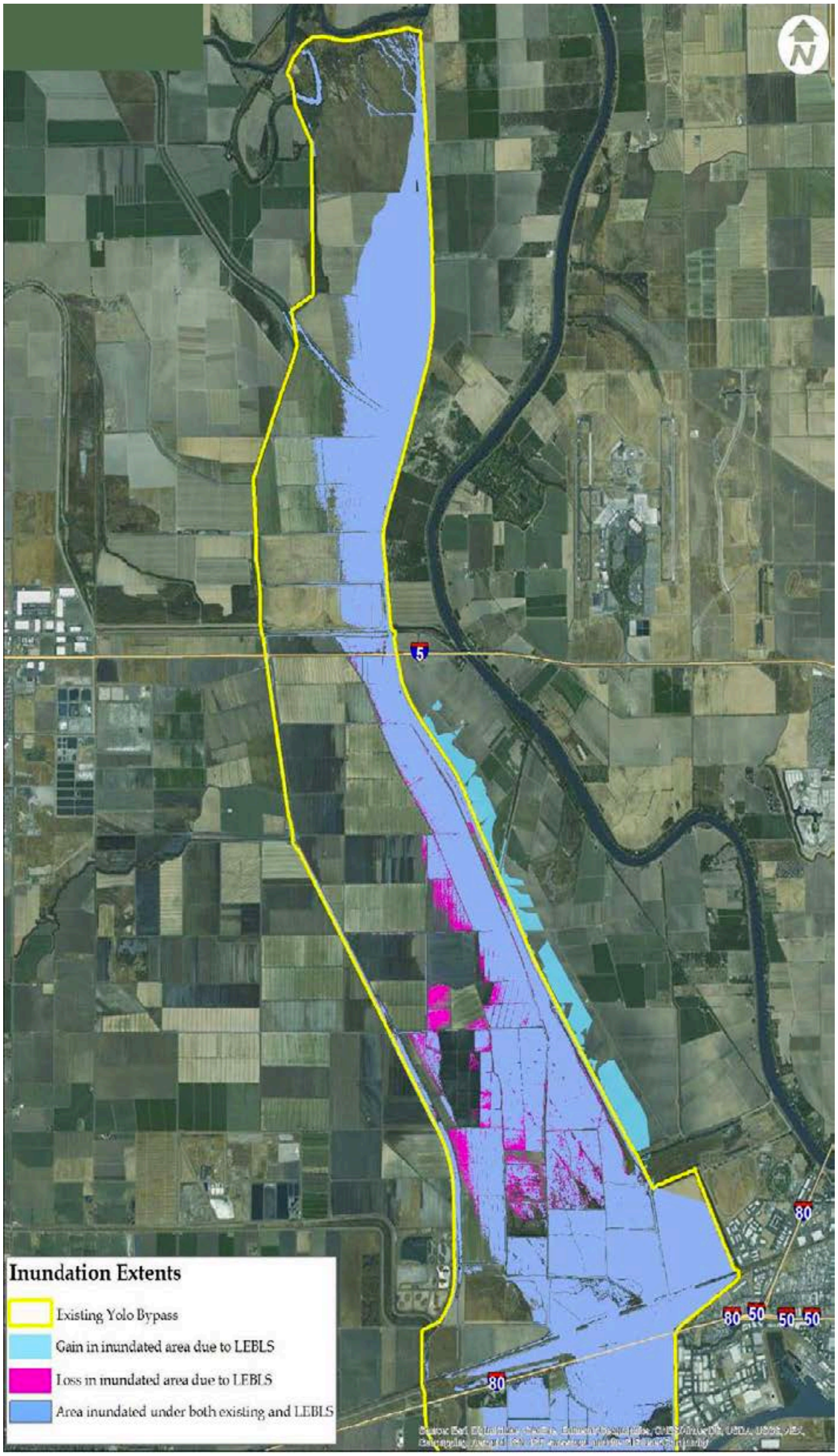

Figure 4-8. Inundation Changes at 3,000 cfs with Lower Elkhorn Basin Levee Setback (LEBLS) Cumulative Impacts versus Inundation under the Alternatives

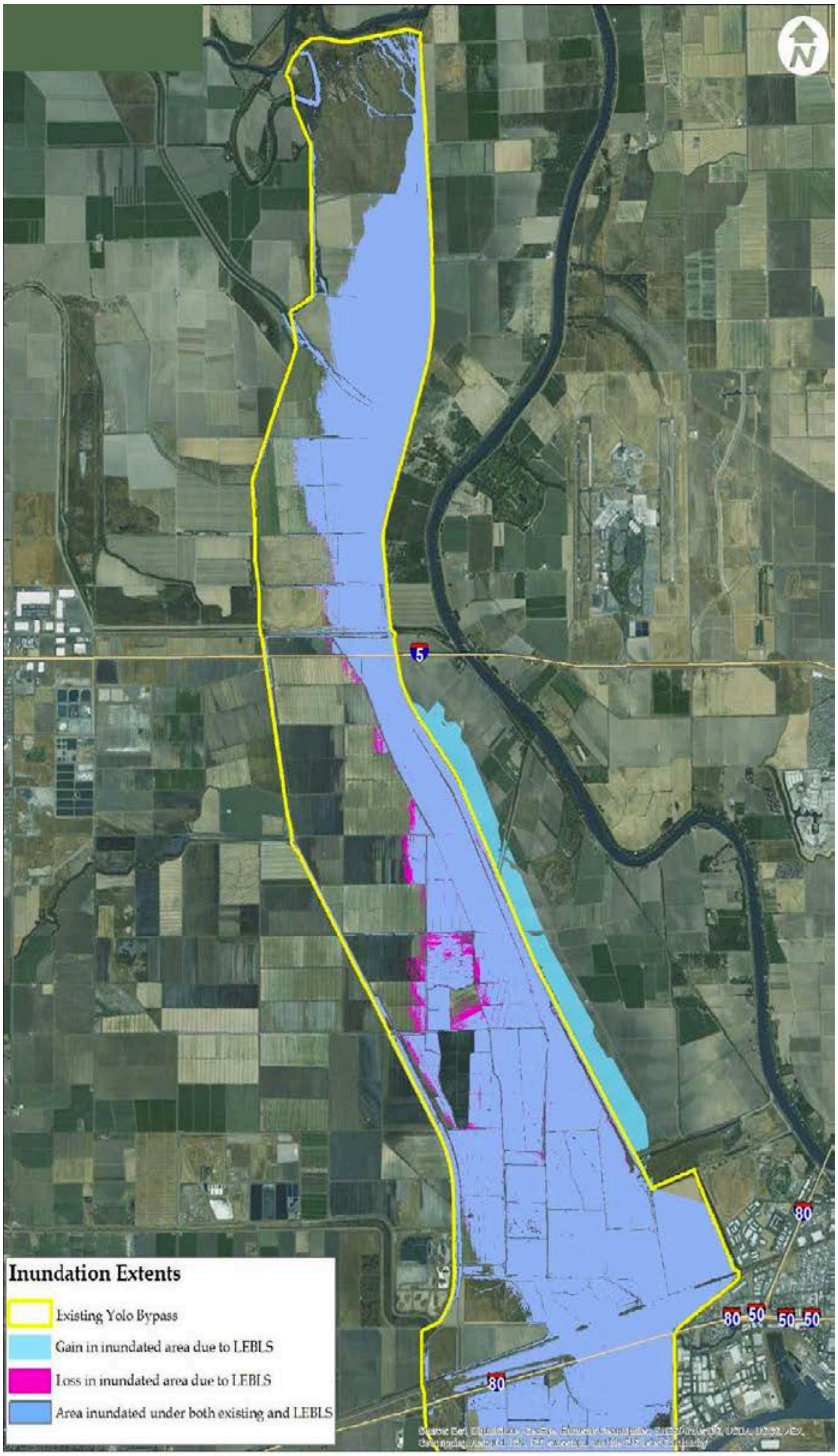

Figure 4-9. Inundation Changes at 6,000 cfs with Lower Elkhorn Basin Levee Setback (LEBLS) Cumulative Impacts versus Inundation under the Alternatives

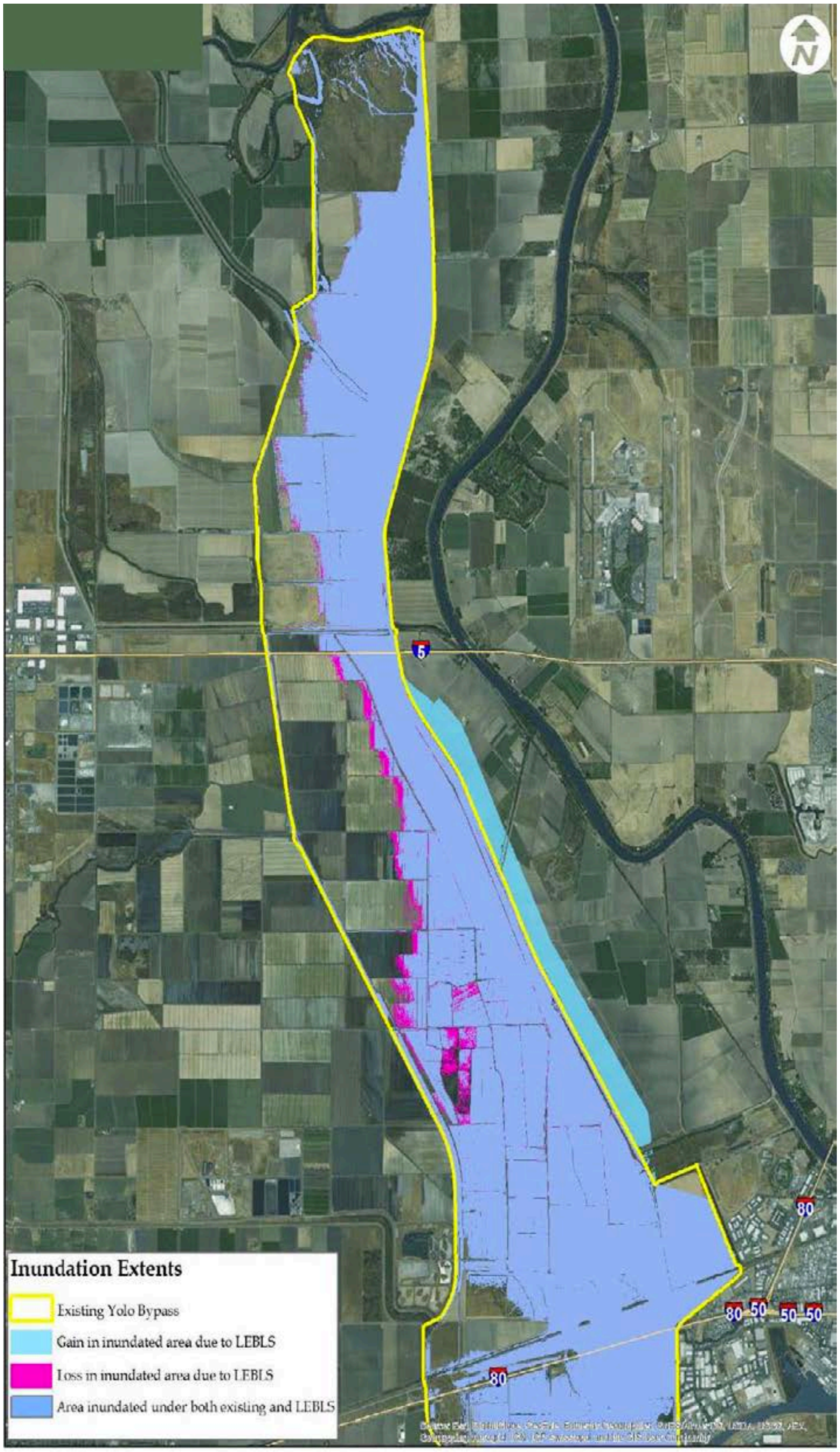

Figure 4-10. Inundation Changes at 9,000 cfs with Lower Elkhorn Basin Levee Setback (LEBLS) Cumulative Impacts versus Inundation under the Alternatives

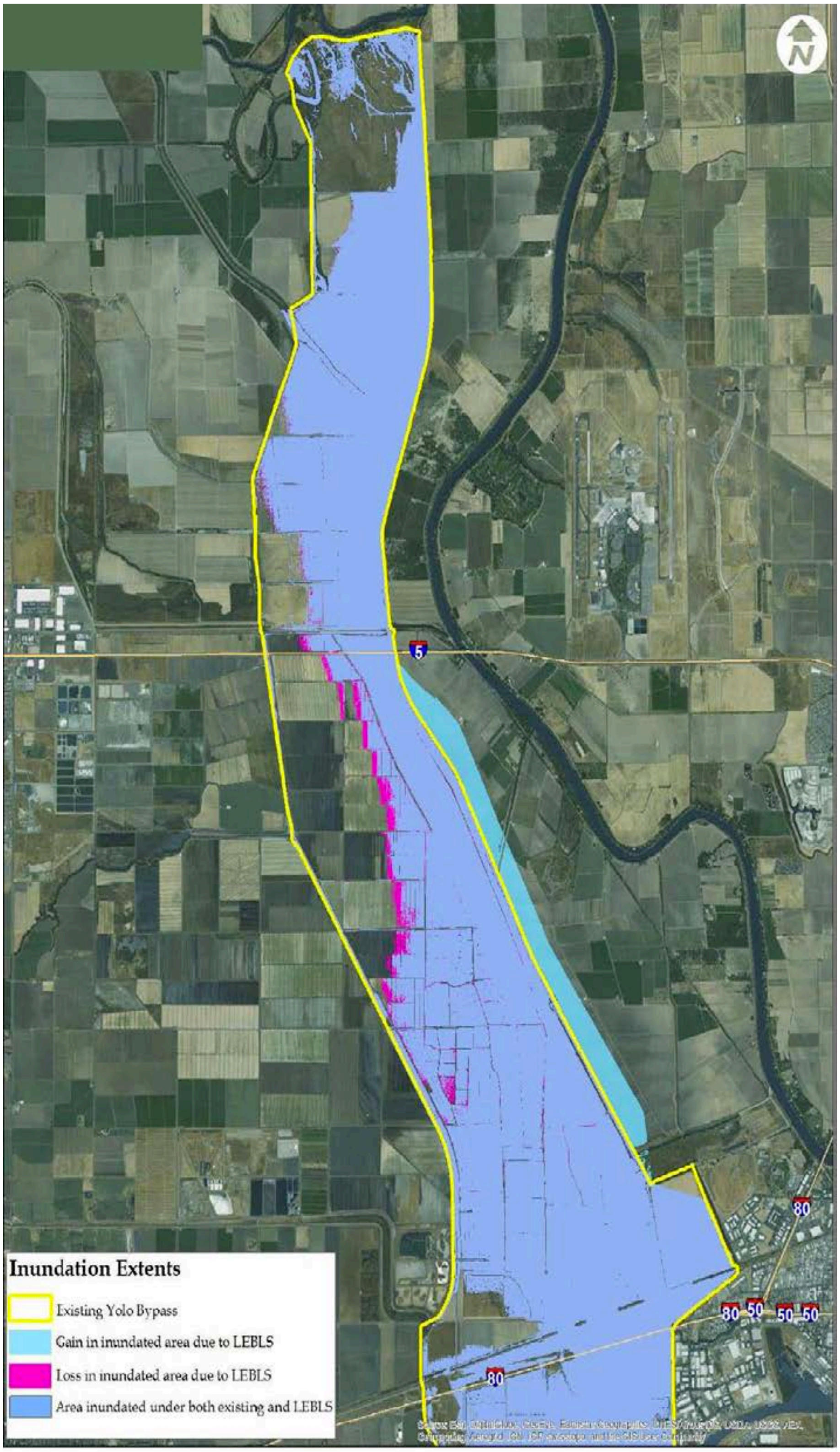

Figure 4-11. Inundation Changes at 12,000 cfs with Lower Elkhorn Basin Levee Setback (LEBLS) Cumulative Impacts versus Inundation under the Alternatives

Figures 4-12 through 4-16 show the LEBLS as modeled in HEC-RAS under 2070 conditions and sea level rise compared to the LEBLS as modeled in HEC-RAS under 2030 conditions. With sea level rise, the inundated area would increase in selected areas, and the inundation depth would increase for 1,000, 3,000, 6,000, 9,000, and 12,000 cfs. Similar to the cumulative impacts under existing conditions, some areas of the bypass would no longer be inundated, and other areas would have increased depth and inundation.

All projects would implement their own mitigation measures to reduce impacts to less than significant levels. Therefore, the cumulative impact on flood control, hydraulics, and hydrology, in both the long term and short term, would be **less than significant**.

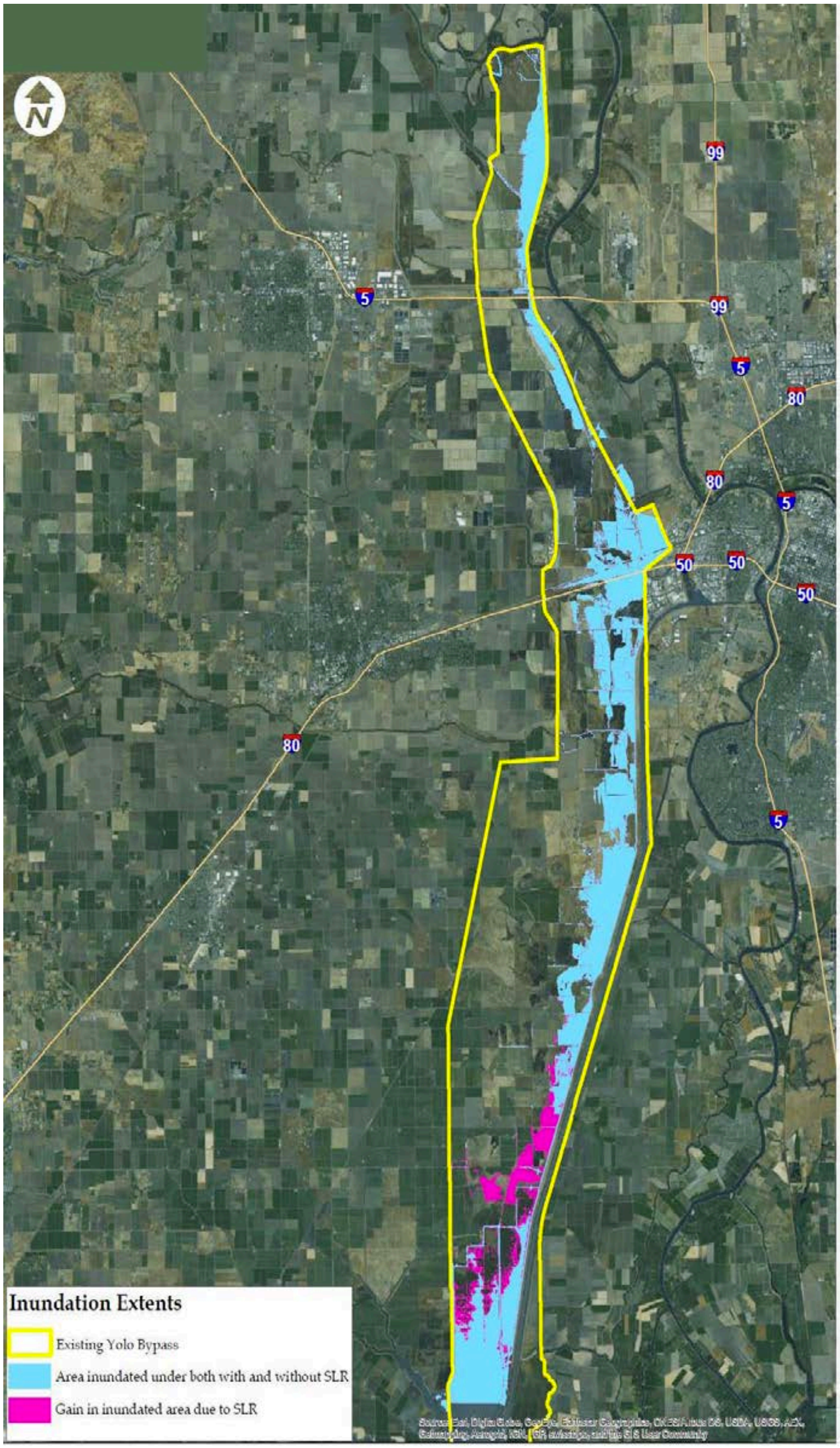

Figure 4-12. Inundation Increase for Lower Elkhorn Basin Levee Setback (LEBLS) Cumulative Impacts at 1,000 cfs with Sea Level Rise versus Inundation with LEBLS Cumulative Impacts at 1,000 cfs without Sea Level Rise

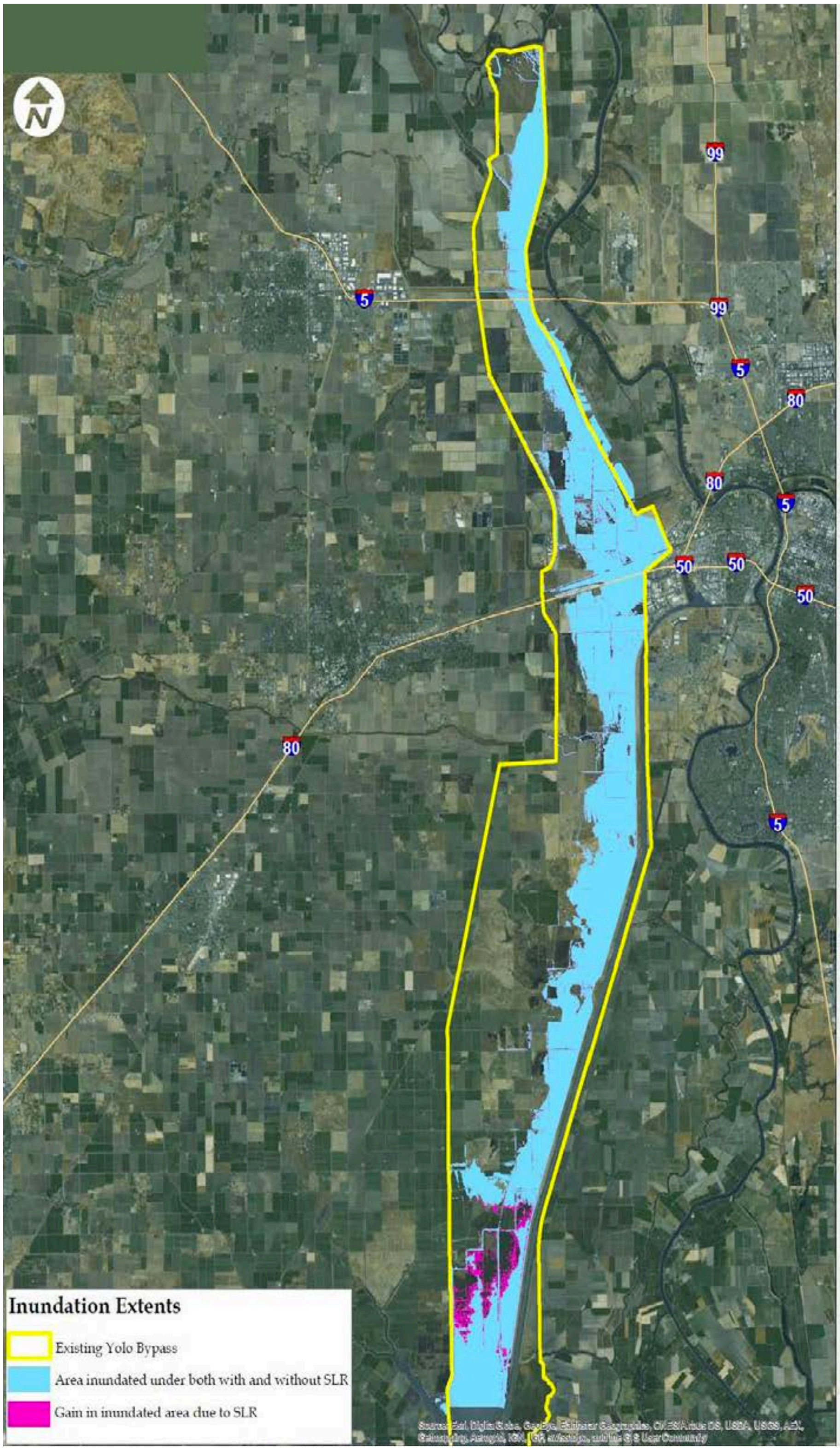

Figure 4-13. Inundation Increase for Lower Elkhorn Basin Levee Setback (LEBLS) Cumulative Impacts at 3,000 cfs with Sea Level Rise versus Inundation with LEBLS Cumulative Impacts at 3,000 cfs without Sea Level Rise

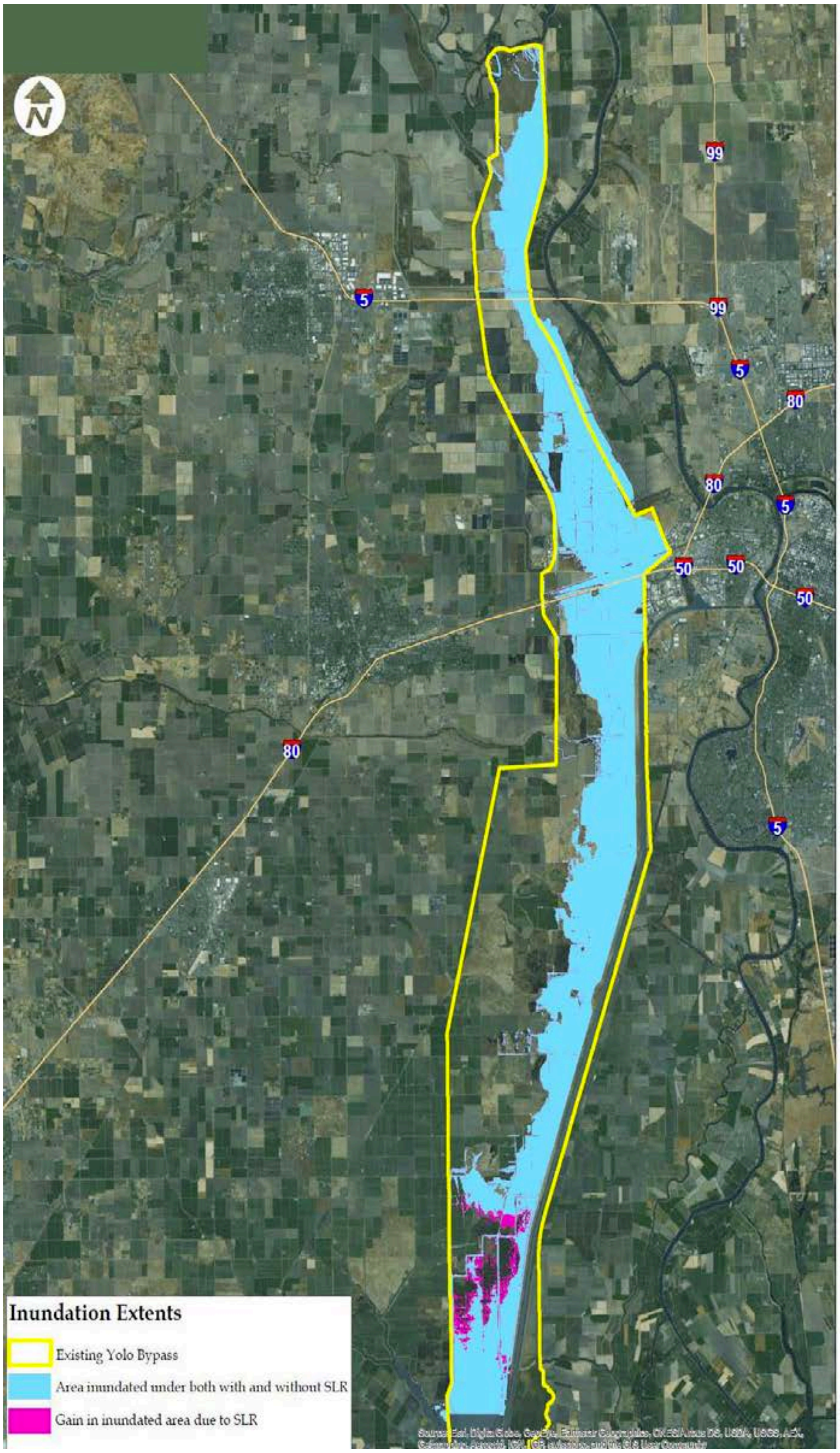

Figure 4-14. Inundation Increase for Lower Elkhorn Basin Levee Setback (LEBLS) Cumulative Impacts at 6,000 cfs with Sea Level Rise versus Inundation with LEBLS Cumulative Impacts at 6,000 cfs without Sea Level Rise

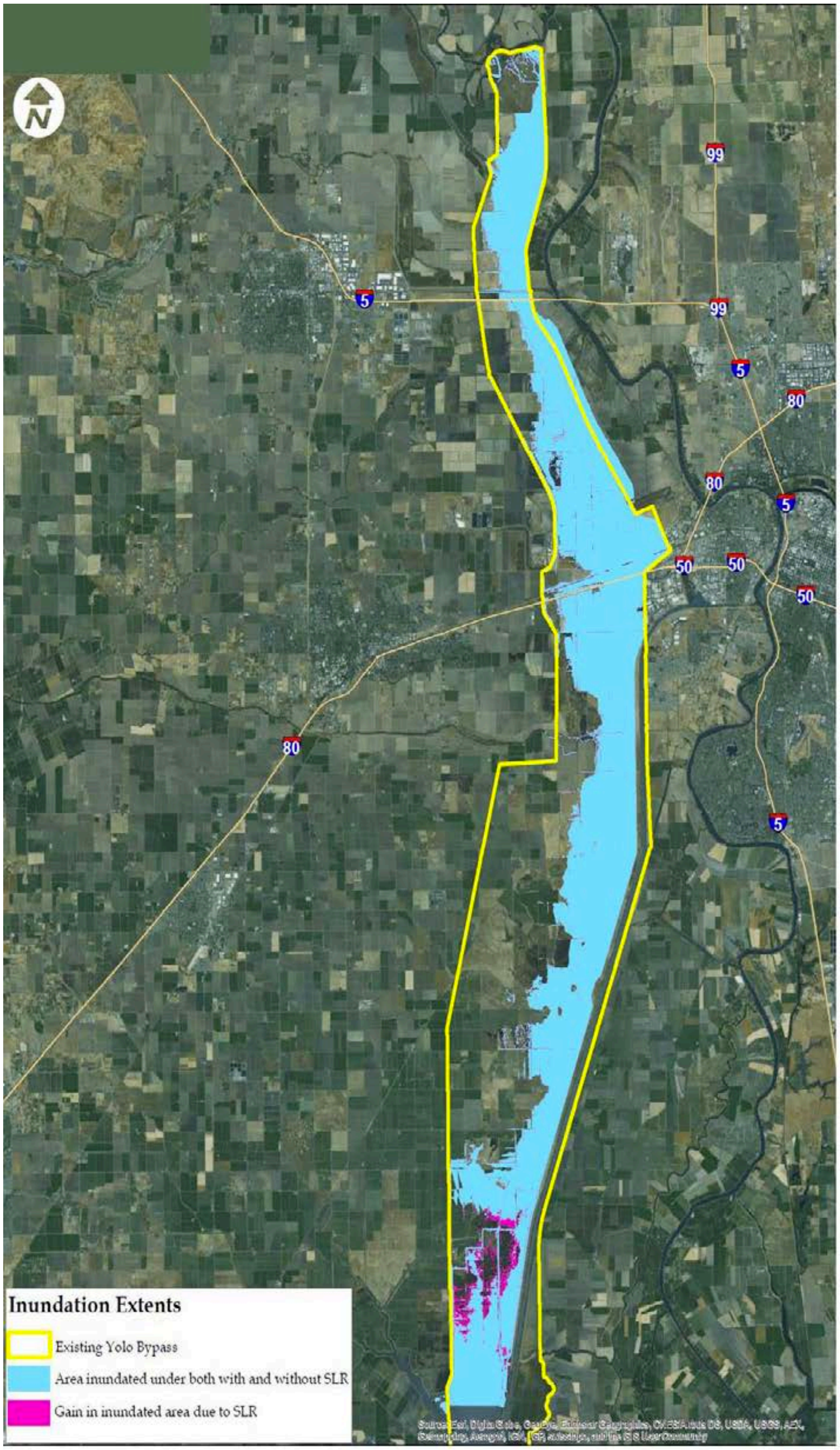

Figure 4-15. Inundation Increase for Lower Elkhorn Basin Levee Setback (LEBLS) Cumulative Impacts at 9,000 cfs with Sea Level Rise versus Inundation with LEBLS Cumulative Impacts at 9,000 cfs without Sea Level Rise

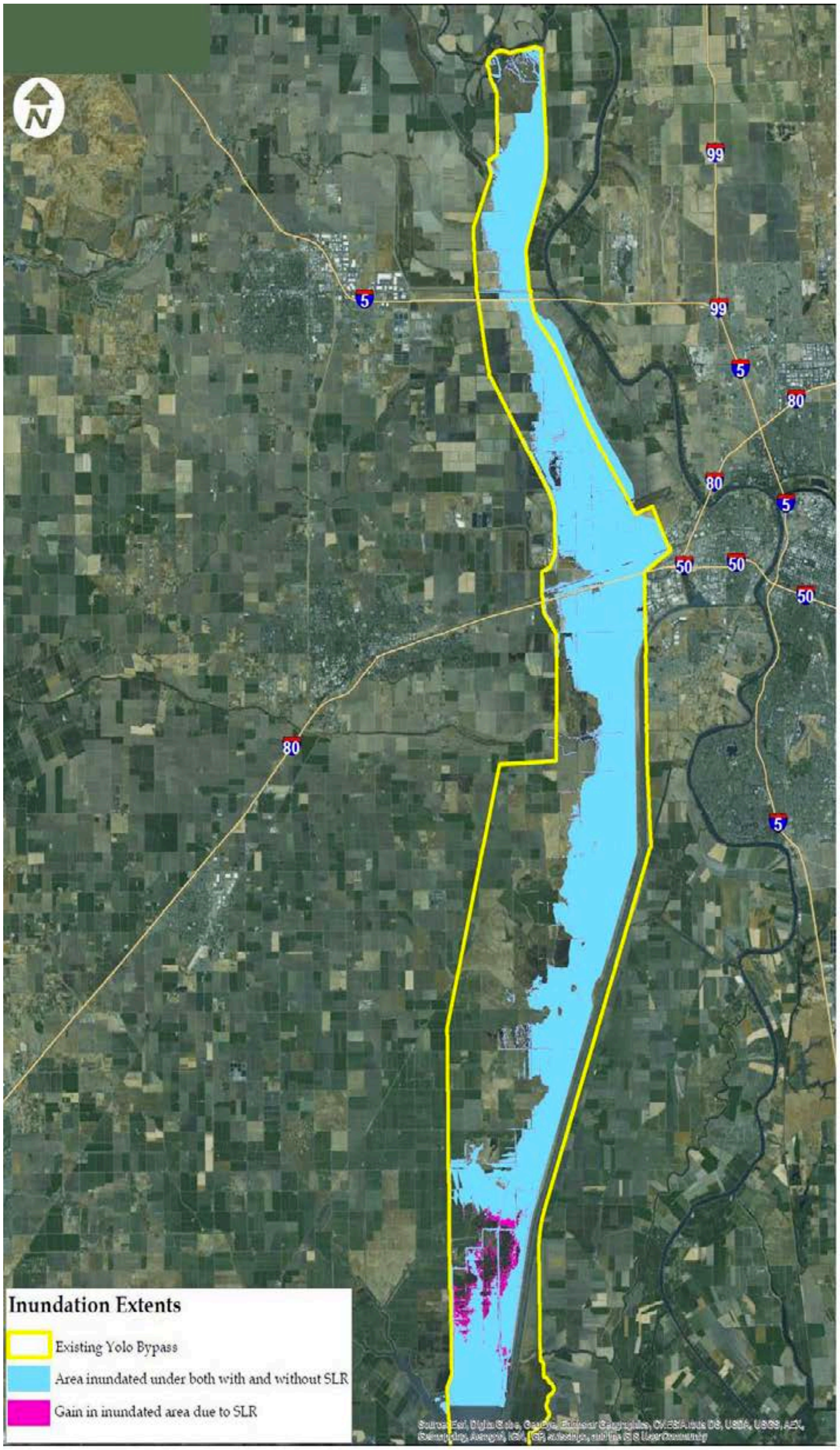

Figure 4-16. Inundation Increase for Lower Elkhorn Basin Levee Setback (LEBLS) Cumulative Impacts at 12,000 cfs with Sea Level Rise versus Inundation with LEBLS Cumulative Impacts at 12,000 cfs without Sea Level Rise

4.5 References

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5 Surface Water Supply

This chapter describes the surface water supply within the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Project) area and identifies potential effects of project implementation on water supply. The analysis provided in this chapter includes a description of existing environmental conditions, methods used to assess environmental effects, potential direct and indirect impacts of project implementation, and mitigation measures recommended to address adverse effects under the National Environmental Policy Act (NEPA) and significant impacts under the California Environmental Quality Act (CEQA). Federal, State of California (State), and local regulations that pertain to surface water supply are summarized.

5.1 Environmental Setting/Affected Environment

The Project area for the water supply analysis includes the Sacramento-San Joaquin Delta (Delta) region, areas upstream of the Delta region that may experience changes in operations as a result of changes in flows in the Yolo Bypass, and the State Water Project (SWP) and Central Valley Project (CVP) Export Service Areas.

Shasta, Folsom, and Oroville reservoirs would not be re-operated to inundate the Yolo Bypass. However, the increase of flows into the Yolo Bypass would reduce flows in the Sacramento River between Fremont Weir and the Delta, which in turn could affect water availability for diversion through the California WaterFix intakes. CVP and SWP service areas are described in greater detail below.

5.1.1 Central Valley Project

5.1.1.1 CVP Facilities

The CVP reaches approximately 400 miles, from the Cascade Mountains near Redding in the north to the Tehachapi Mountains near Bakersfield in the south. It consists of 20 dams and reservoirs, 11 power plants, 500 miles of major canals, conduits, tunnels, and related facilities. The CVP manages approximately 9 million acre-feet (MAF) of water, delivering about 7 MAF of water for municipal, industrial, agricultural, urban, and wildlife use.

The CVP facilities include reservoirs on the Trinity, Sacramento, American, Stanislaus, and San Joaquin rivers. Water from the Trinity River is stored and re-regulated in Trinity Lake, Lewiston Lake, and Whiskeytown Reservoir and diverted through a system of tunnels and power plants into the Sacramento River for the Central Valley.

Water is also stored and reregulated in Shasta Lake and Folsom Lake. Water from these reservoirs and other reservoirs owned and/or operated by the SWP and local water rights holders flows into the Sacramento River. Some CVP contractors divert water directly from or immediately below the dams' outlet works. Other CVP contractors, Sacramento River water rights contractors, and water rights holders divert water directly from the Sacramento and American rivers.

The Sacramento River carries water to the Delta. The C.W. “Bill” Jones (Jones) Pumping Plant at the southern end of the Delta lifts the water into the Delta Mendota Canal. This canal delivers water to CVP contractors and exchange contractors on the San Joaquin River and to water rights contractors on the Mendota Pool. The CVP water is also conveyed to San Luis Reservoir for deliveries to CVP contractors through the San Luis Canal. Water from San Luis Reservoir also can be conveyed through the Pacheco Tunnel to CVP contractors in Santa Clara and San Benito counties.

The CVP also serves water from Friant Dam on the San Joaquin River to CVP contractors located near the Madera and Friant-Kern canals. Water is stored in New Melones Reservoir for water rights holders in the Stanislaus River watershed and CVP contractors in the northern San Joaquin Valley (United States Department of the Interior, Bureau of Reclamation [Reclamation] 2017).

5.1.1.1.1 Shasta and Keswick Dams

Shasta Dam is a curved, gravity-type, concrete structure that rises 533 feet above the streambed with a total height above the foundation of 602 feet. The dam has a crest width of about 41 feet and a length of 3,460 feet. Shasta Lake has a storage capacity of 4.5 MAF and a water surface area at full pool of 29,600 acres. Maximum seasonal flood management storage space in Shasta Lake is 1.3 MAF. Releases from Shasta Dam can be made through the power plant, over the spillway, or through the river outlets. The power plant has a maximum release capacity of nearly 20,000 cubic feet per second (cfs); the river outlets can release a maximum of 81,800 cfs at full pool, and the maximum release over the drum-gated spillway is 186,000 cfs (Reclamation 2013).

Keswick Dam is about nine miles downstream from Shasta Dam. In addition to regulating outflow from the dam, Keswick Dam controls runoff from 45 square miles of drainage area. Keswick Dam is a concrete, gravity-type structure with a spillway over the center of the dam. The spillway has four 50- by 50-foot fixed wheel gates with a combined discharge capacity of 248,000 cfs at full pool elevation (587 feet). Keswick Reservoir storage capacity below the top of the spillway gates at full pool is 23,800 acre-feet (AF). The power plant has a generating capacity of 105,000 kilowatts and can pass about 15,000 cfs at full pool (Reclamation 2013).

5.1.1.1.2 Sacramento Valley Diversion Facilities

Below Keswick Dam, two facilities divert flows from the Sacramento River: the Anderson-Cottonwood Irrigation District Diversion Dam and the Red Bluff Pumping Plant. The primary purpose of these two facilities is to divert water into canals for local agricultural use.

5.1.1.1.3 Folsom and Nimbus Dams

Folsom Dam is a concrete gravity dam on the American River that rises 340 feet above the streambed. The dam has a crest width of about 36 feet and a length of 1,400 feet. Folsom Lake has a storage capacity of 1,087,000 AF and a normal maximum pool of 967,000 AF. The maximum seasonal flood management storage space in Folsom Lake is 600,000 AF. Releases from Folsom Dam can be made from the power plant, through the five main spillway gates, or through river outlets. The spillway capacity is 567,000 cfs; however, the maximum combined release through the river outlets and gated spillway is limited to 115,000 cfs due to downstream channel capacity. The generating capacity of the Folsom power plant is 198,720 kilowatts. An auxiliary spillway with six 23-foot by 34-foot gates was completed in 2017, allowing a maximum total release of 160,000 cfs through the main spillway, auxiliary spillway, and river outlets.

Nimbus Dam, which impounds Lake Natoma, is located seven miles downstream of Folsom Dam on the American River. Nimbus Dam is a 1,093-foot-long and 87-foot-high concrete gravity-type structure with 18 radial gates. The 40-foot by 24-foot gates control flow to two generators with a capacity of 7,763 cfs each (Reclamation 2008).

5.1.1.1.4 C.W. "Bill" Jones Pumping Plant

The CVP Jones Pumping Plant, located about five miles north of Tracy, has a permitted diversion capacity of 4,600 cfs and sits at the end of a 2.5-mile long earth-lined intake channel that extends to Old River (Reclamation 2015). Water diverted at the Jones Pumping Plant is discharged to the CVP Delta-Mendota Canal (DMC), which extends 117 miles to the Mendota Pool. Water from the Jones Pumping Plant may be pumped from the DMC to O'Neill Forebay and then pumped into San Luis Reservoir by the Gianelli Pumping-Generating Plant. The DMC has an initial capacity of 4,600 cfs at the Jones Pumping Plant that decreases to about 3,200 cfs at its terminus (Reclamation 2015).

5.1.1.1.5 O'Neill Forebay and San Luis Reservoir

The O'Neill Pumping-Generating Plant consists of six pump-generating units, with a capacity of 700 cfs each. The O'Neill Forebay is a joint CVP/SWP facility with a storage capacity of about 56,000 AF. In addition to its interactions with the Delta-Mendota Canal via the O'Neill Pumping-Generating Plant, it is a part of the SWP California Aqueduct. The O'Neill Forebay serves as a regulating water body for San Luis Reservoir; the William R. Gianelli Pumping-Generating Plant, also a joint CVP/SWP facility, can pump flows from the O'Neill Forebay into San Luis Reservoir and make releases from San Luis Reservoir to the O'Neill Forebay for diversion to either the DMC or the California Aqueduct. In addition, several water districts receive diversions directly from the O'Neill Forebay. The William R. Gianelli Pumping-Generating Plant consists of eight units, with 1,375 cfs of pumping capacity and 1,640 cfs of generating capacity each, for a total pumping capacity of 11,000 cfs and a generating capacity of 13,120 cfs.

San Luis Reservoir, impounded by the B.F. Sisk Dam, provides offstream storage for excess winter and spring flows diverted from the Delta. It is sized to provide seasonal carryover storage, with a total capacity of over 2 MAF. The CVP share of the storage is less than 1 MAF; the remaining 1 MAF of storage are the SWP share. During spring and summer, water demands and schedules are greater than the capability of Reclamation and the California Department of Water Resources (DWR) to pump water from the Jones Pumping Plant and Harvey O. Banks (Banks) Pumping Plant; water stored in San Luis Reservoir is used to make up the difference. The CVP share of San Luis Reservoir typically is at its lowest in August and September and at its maximum in April. The San Felipe Division of the CVP supplies water to customers in Santa Clara and San Benito counties from San Luis Reservoir (Reclamation 2008).

5.1.1.1.6 Delta Mendota Canal

South of O'Neill Forebay, the DMC terminates in Mendota Pool, about 30 miles west of Fresno. From the DMC, the CVP makes diversions to multiple water users and wildlife refuges. DMC capacity at the terminus is 3,211 cfs (Reclamation 2008).

5.1.1.2 CVP Contractors

At certain times of the year, operations of Shasta Lake are driven by the water supply needs of CVP contractors. The CVP provides water to approximately 145 settlement contractors in the Sacramento Valley, exchange contractors in the San Joaquin Valley, agricultural and municipal and industrial (M&I) water service contractors in both the Sacramento and San Joaquin valleys, and wildlife refuges both north and south of the Delta. Table 5-1 shows the maximum contract quantities for CVP contractors and the contract amounts for agriculture and the historical M&I use.

Table 5-1. Maximum Water Delivery Amounts for CVP Contractors

	Maximum Contract Quantity (AF)
North of Delta CVP Water Service and Water Rights Contracts	
Sacramento River Water Service	468,890
American River	313,750
Sacramento River Settlement Contractors	2,115,620
Subtotal	2,898,260
South of Delta CVP Water Service and Water Rights Contracts	
South of Delta Water Service	2,112,898
South of Delta Water Rights/Exchange Contracts	875,623
Subtotal	2,988,521
Friant Division	2,249,475
In-Delta	195,000
New Melones East Side	755,000
Wildlife Refuges	
North of Delta	151,250
South of Delta	271,001
Subtotal	422,251
Total CVP Contracts	9,508,507

Source: Reclamation March 2016 data

Key: AF= acre-feet; CVP= Central Valley Project

At the beginning of each year, Reclamation evaluates hydrologic conditions throughout California and uses this information to forecast CVP operations and estimate the amount of water to be made available to the Federal water service contractors for the year.

Most of the federal water service contractors have service areas located south of the Delta. In general, allocations to CVP water service contractors south of the Delta are lower than allocations to service contractors in the Sacramento Valley. Because of water rights secured before construction of the CVP, Sacramento Valley settlement contractors and San Joaquin Valley exchange contractors have a higher level of reliability for their supplies except in Shasta-critical years. The critical year is defined as years in which:

- the annual unimpaired inflow into Shasta Lake is less than 3.2 MAF or
- the average inflow for a two-year period is below 4.0 MAF and the total two-year deficiency for deliveries is higher than 0.8 In Shasta-critical years, settlement and exchange contractors receive 75 percent of their contract amounts.

5.1.2 State Water Project

5.1.2.1 SWP Facilities

The SWP's primary storage facility is Oroville Dam. Lake Oroville water is conserved and released to serve three Feather River water contractors, two contractors from the North Bay Aqueduct, and 24 South of Delta contractors from the Banks Pumping Plant.

5.1.2.1.1 Lake Oroville and Thermalito Facilities

Oroville Dam is an earth embankment dam on the Feather River with a total height of 770 feet. The dam is 6,920 feet long with a crest width of 80 feet. Lake Oroville has a storage capacity of 3.5 MAF and water surface area at full pool of 15,805 acres. Maximum seasonal flood management storage space in Lake Oroville is 750,000 AF. Typically, releases from Oroville Dam can be made through the Hyatt power plant, over the spillway, or through the river outlets. The river outlets can release a maximum of 5,400 cfs at full pool. The maximum release over the gated spillway is 150,000 cfs; the Hyatt power plant has a maximum release capacity of nearly 17,000 cfs. In April 2017, construction began to repair damage to the spillway that occurred during high-runoff from a series of storms in January and February 2017. The spillway was partly functional by November 2017. Normal operations resumed in November 2018.

Hyatt Power Plant is on the left when facing downstream of Oroville Dam. Facilities consist of an intake structure, two penstock tunnels, six penstock branches, an underground powerhouse with three turbine units and three reversible turbine-pump units, and two tailrace tunnels and outlet works. Water from the power plant is released through two tunnels into the Feather River just downstream of Oroville Dam.

The Thermalito Diversion Dam, about four miles downstream from Oroville Dam, forms the Thermalito Diversion Pool. The Thermalito Diversion Dam is a concrete, gravity-type structure with a gated spillway outlet. The spillway has fourteen 40- by 23-foot radial gates with a combined discharge capacity of 320,000 cfs at full pool. Thermalito Diversion Pool storage capacity below the top of the spillway gates is 13,350 AF. The power plant at the Thermalito Diversion Dam can pass about 615 cfs at full pool.

From the Thermalito Diversion Dam, flows enter the Thermalito Power Canal and Thermalito Forebay. The Thermalito Forebay is formed by a zoned earthfill dam that provides headwater for the downstream Thermalito Pumping-Generating Plant and tailwater for the upstream Hyatt power plant. The maximum storage of the Thermalito Forebay is 11,768 AF. Flows are conveyed to the Thermalito Pumping-Generating Plant, which operates in tandem with the Hyatt Power plant to provide 17,400 cfs of generating flow and 9,120 cfs of pump-back flow capacities.

Thermalito Afterbay is an offstream reservoir that provides pump-back storage, regulates the power system, and controls flow in the Feather River downstream from Oroville. Thermalito Afterbay Dam, a 39-foot-high earthfill dam, has a crest width of 30 feet and a length of 42,000 feet. The maximum storage of Thermalito Afterbay is 57,040 AF. The controlled maximum flow from the five Thermalito Afterbay eight-foot by eight-foot radial gates into the Feather River is 17,000 cfs. Thermalito Afterbay also has 12 irrigation outlets: five eight-foot by eight-foot radial gates, three six-foot by six-foot radial gates, and four five-foot by six-foot radial gates.

5.1.2.1.2 Harvey O. Banks Pumping Plant and Clifton Court Forebay

The nominal capacity of the Banks Pumping Plant is 10,300 cfs. Permits issued by the United States Army Corps of Engineers regulate the rate of diversion of water into Clifton Court Forebay (CCF). This diversion rate is normally restricted to 6,680 cfs as a three-day average inflow to CCF and 6,993 cfs as a one-day average inflow to CCF. CCF diversions may be greater than these rates between December 15 and March 15 when the inflow into CCF may be augmented by one-third of the San Joaquin River flow at Vernalis when those flows are equal to or greater than 1,000 cfs (Reclamation 2015).

The CCF is a 31,000 AF reservoir that provides storage for off-peak pumping and moderates the effect of the pumps on the fluctuation of flow and stage in adjacent Delta channels (Reclamation 2015).

5.1.2.1.3 O’Neill Forebay and San Luis Reservoir

O’Neill Forebay and San Luis Reservoir are joint CVP/SWP facilities and are discussed in Section 5.1.1.1.5. The SWP share of San Luis Reservoir’s storage is 1.067 MAF; the remaining 0.972 MAF are the CVP share.

5.1.2.1.4 California Aqueduct

South of the Banks Pumping Plant, California Aqueduct flows enter Bethany Reservoir, a 5,000-AF forebay for the South Bay Pumping Plant. Exiting Bethany Forebay, California Aqueduct flows go through a series of checks to the aforementioned O’Neill Forebay and are either pumped into San Luis Reservoir or released to San Luis Canal.

Parallel to the DMC, the San Luis Canal-California Aqueduct is a joint-use facility for the CVP and SWP. It begins on the southeast edge of O’Neill Forebay and extends about 101.5 miles southeasterly to a point near Kettleman City. Water from the canal serves the San Luis Federal service area, mostly for agricultural purposes and for some M&I uses. The canal has a capacity ranging from 8,350 to 13,100 cfs.

5.1.2.2 SWP Contractors

The SWP operates under long-term contracts with public water agencies throughout California. These agencies, in turn, deliver water to wholesalers or retailers or deliver it directly to agricultural and M&I water users (DWR 2017). The SWP contracts between DWR and individual state water contractors define several classifications of water available for delivery under specific circumstances.

5.1.2.3 SWP Contracts

The SWP delivers water to its contractors in accordance with long-term water supply contracts and other agreements. The contractors' maximum contract amounts, known as "Table A" amounts, are shown in Table 5-2.

Table 5-2. Maximum Annual Table A Water Delivery Amounts for SWP Contractors

Contractor	**Maximum Table A Delivery Amounts (AF)**
Feather River Area Contractors	
Butte County	27,500
Yuba City	9,600
Plumas County Flood Control and Water Conservation District	2,700
Subtotal	39,800
North Bay Area Contractors	
Napa County Flood Control and Water Conservation District	29,025
Solano County Water Agency	47,506
Subtotal	76,531
South Bay Area Contractors	
Alameda County Flood Control and Water Conservation District, Zone 7	80,619
Alameda County Water District	42,000
Santa Clara Valley Water District	100,000
Subtotal	222,619
San Joaquin Valley Area Contractors	
Dudley Ridge Water District	50,343
Empire West Side Irrigation District	2,000
Kern County Water Agency	982,730
Kings County	9,305
Oak Flat-Water District	5,700
Tulare Lake Basin Water Storage District	88,922
Subtotal	1,139,000
Central Coastal Area Contractors	
San Luis Obispo County Flood Control and Water Conservation District	25,000
Santa Barbara County Flood Control and Water Conservation District	45,486

Contractor	Maximum Table A Delivery Amounts (AF)
Subtotal	70,486
Southern California Area Contractors	
Antelope Valley–East Kern Water Agency	141,400
Castaic Lake 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	82,800
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
Subtotal	2,623,100
TOTAL TABLE A AMOUNTS	**4,171,536**

Source: State Water Project Final Delivery Capability Report 2015
Key: AF= acre-feet

SWP contractors can also participate in the Article 21 program, which provides water supplies to SWP contractors when water exceeding the current SWP need is available. Under Article 21 of the SWP's long-term water supply contracts, contractors may receive additional water deliveries only under the following specific conditions:

- Such deliveries do not interfere with SWP Table A allocations and SWP operations
- Excess water is available in the Delta
- Capacity is not being used for SWP purposes or scheduled SWP deliveries
- Contractors can use the SWP Article 21 water directly or can store it in their own system (i.e., the water cannot be stored in the SWP system)

SWP contractors can also participate in the Turnback Pool, which allows SWP contractors to sell unused Table A water supply to other SWP contractors.

5.1.3 Non-CVP and SWP Water Users

There are hundreds of non-CVP and SWP water users with water rights junior to the CVP and SWP that divert from along the Feather and Sacramento rivers, within the Yolo Bypass, and in the Delta. These water rights holders are subject to water availability and are only allowed to divert non-CVP or SWP water during periods when there is unstored water from contributing tributaries in excess of the needs of the CVP and SWP.

There are also hundreds of non-CVP and SWP water users with water rights along the Feather and Sacramento rivers, within the Yolo Bypass, and in the Delta, as well as water users with contracts or agreements with DWR and Reclamation. Effects on these water users are not further discussed in this document because DWR and Reclamation would continue to honor all water rights along with existing contracts and agreements.

5.2 Regulatory Setting

5.2.1 Federal Plans, Policies, and Regulations

5.2.1.1 2008 USFWS Biological Opinion

In 2008, the United States Fish and Wildlife Service (USFWS) issued a biological opinion (BO) for the coordinated long-term operations of the CVP and SWP (USFWS 2008). The USFWS determined that continued CVP and SWP operations were likely to jeopardize the existence of delta smelt and destroy or adversely modify its critical habitat. The USFWS BO included a reasonable and prudent alternative (RPA) that identifies a number of habitat improvements and monitoring requirements. RPA actions in the BO are intended to improve survival and habitat conditions for delta smelt, mainly through flow and Delta salinity conditions, through implementation of the following water operations (USFWS 2008; Reclamation 2015):

- Old and Middle River reverse flow limits of no more than -1,500 to -5,000 cfs during periods when delta smelt could be subject to entrainment at the pumps[1]
- X2 location[2] limits during the fall

Details on how these RPA actions were included in the modeling and subsequent analyses are included in Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis*.

5.2.1.2 2009 NMFS BO

In 2009, the National Oceanic and Atmospheric Administration National Marine Fisheries Service (NMFS) issued a *Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and the State Water Project* (NMFS BO) The NMFS BO determined that continued CVP and SWP operations were likely to jeopardize the existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and the Southern Distinct Population Segment of North American green sturgeon (NMFS 2009). The NMFS BO included RPA actions that specify a number of actions, including forming operation groups; implementing habitat improvements; complying with monitoring requirements; and achieving objectives for fish passage, flow, and temperature. The RPA actions related to flow and temperature in the Sacramento River, American River, and

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[1] The flow standard on Old and Middle rivers is expressed as a negative value since Old and Middle Rivers have the potential to run in reverse of their natural direction when the CVP and SWP pumps are running.

[2] X2 is the location of the two parts per thousand salinity contour (isohaline), one meter off the bottom of the estuary, as measured in kilometers upstream from the Golden Gate Bridge (State Water Resources Control Board 2000). X2 is further described in Section 5.2.2.2.3.

Delta that would directly affect project water operations are described below (Reclamation 2015).

5.2.1.2.1 Sacramento River Division

The 2009 NMFS BO included several RPA actions that directly affect Sacramento River Division operations. Those RPA actions include:

- Clear Creek flow and temperature objectives
- Reclamation deliverable water forecast procedures
- End-of-year (September 30) Shasta target storage
- Shasta cold-water management operations
- Sacramento River temperature objectives between Keswick Dam and Bend Bridge
- Restoration of lower Sacramento floodplain-rearing habitat

5.2.1.2.2 American River Division

The 2009 NMFS BO included one RPA action, lower American River temperature objectives, that directly affects American River Division operations

5.2.1.2.3 Delta Division

The 2009 NMFS BO included several RPA actions that directly affect Delta Division operations. Those RPA actions include:

- Delta Cross Channel gate operation
- San Joaquin River inflow to export ratio objectives
- Old and Middle rivers negative or reverse flow objectives

5.2.1.3 Central Valley Project Improvement Act

Following passage by Congress, Reclamation's evolving mission was written into law on October 30, 1992 and signed by President George H. W. Bush. Public Law 102-575, the Reclamation Projects Authorization and Adjustment Act of 1992, included Title 34, the Central Valley Project Improvement Act (CVPIA) (Reclamation 1999). 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 having equal priority with power generation. Among the changes mandated by the CVPIA are the following:

- Dedicating 800,000 AF annually to fish, wildlife, and habitat restoration
- Authorizing water transfers outside the CVP service area
- Implementing the Anadromous Fish Restoration Program
- Creating a restoration fund financed by water and power users

- Installing the Shasta Dam temperature control device
- Implementing fish passage measures at the Red Bluff Diversion Dam
- Planning to increase the CVP yield
- Mandating firm water supplies for Central Valley wildlife refuges

The CVPIA is being implemented on a broad front. The Final Programmatic Environmental Impact Statement (EIS) (Reclamation 1999) for the CVPIA analyzed projected conditions in 2022, 30 years from the CVPIA's adoption in 1992. The Final Programmatic EIS was released in October 1999, and the CVPIA Record of Decision was signed on January 9, 2001.

The CVPIA directs the Secretary of the Interior to develop and implement a program that makes all reasonable efforts to double natural production of anadromous fish in Central Valley streams (Section 3406(b)(1)). The program is known as the Anadromous Fish Restoration Program. Operations of the CVP reflect provisions of the CVPIA, particularly Sections 3406 (b)(1), (b)(2), and (b)(3). The United States Department of the Interior Decision on Implementation of Section 3406 (b)(2) of the CVPIA, October 5, 1999, provides the basis for implementing upstream and Delta actions with CVP delivery capability. The Anadromous Fish Restoration Program assumed Sacramento River water would be acquired under Section 3406 (b)(2).

5.2.1.4 CVP Long-Term Water Service Contracts

In accordance with CVPIA Section 3404(c), Reclamation is renegotiating long-term water service contracts. As many as 113 CVP water service contracts in the Central Valley may be renewed during this process. Reclamation issued a Notice of Intent for long-term contract renewal in October 1998. Environmental documentation was prepared on a regional basis. In February 2005, Reclamation issued decisions (a Record of Decision or Finding of No Significant Impact) for renewing contracts of the Sacramento River, San Luis, and Delta-Mendota Canal divisions, the Sacramento River settlement contracts, and several individual contracts.

5.2.2 State Plans, Policies, and Regulations

5.2.2.1 Water Quality Control Plan for the San Francisco Bay/San Joaquin Delta Estuary

The 1995 San Francisco Bay/Sacramento-San Joaquin Delta (Bay-Delta) Water Quality Control Plan (WQCP) (State Water Resources Control Board [SWRCB] 1995) established water quality control objectives for the protection of beneficial uses in the Delta. The 1995 WQCP identified 1) beneficial uses of the Delta to be protected, 2) water quality objectives for the reasonable protection of beneficial uses, and 3) a program of implementation for achieving the water quality objectives. Because these new beneficial objectives and water quality standards were more protective than those of the previous SWRCB Water Right Decision 1485, the new objectives were adopted in 1995 through a water right order for operation of the CVP and SWP. Key features of the 1995 WQCP include estuarine habitat objectives for Suisun Bay and the western Delta (consisting of salinity measurements at several locations), export/inflow (E/I) ratios intended to reduce entrainment of fish at the export pumps, Delta Cross Channel gate closures, and San Joaquin River electrical conductivity (EC) and flow standards. The SWRCB adopted a new Bay-Delta WQCP on December 13, 2006. However, this new WQCP made only minor changes to the 1995 WQCP.

The SWRCB is in the process of updating the Bay-Delta WQCP. On September 15, 2016, the SWRCB released a draft revised Bay-Delta WQCP and Substitute Environmental Document, which outlines proposed changes to the Bay-Delta WQCP, including revised southern Delta salinity objectives and San Joaquin River flow objectives. Draft changes to the Bay-Delta WQCP will become final upon approval by the SWRCB at a public meeting, which will be held in 2017.

5.2.2.2 State Water Resources Control Board Revised Water Right Decision 1641

The 1995 Bay-Delta WQCP contains water quality objectives. SWRCB Revised Decision 1641 (RD-1641) (SWRCB 2000) and Water Right Order 2001-05 contain the water right requirements as of June 2017 to implement the 1995 WQCP. RD-1641 incorporates water right settlement agreements between Reclamation and DWR and certain water users in the Delta and upstream watersheds regarding contributions of flows to meet water quality objectives. However, the SWRCB imposed terms and conditions on water rights held by Reclamation and DWR that require these two agencies, in some circumstances, to meet many of the water quality objectives established in the 1995 WQCP. RD-1641 authorizes the CVP and SWP to use joint points of diversion (JPOD) in the south Delta and recognizes the CALFED Bay-Delta Program Operations Coordination Group process for operational flexibility in applying or relaxing certain protective standards.

5.2.2.2.1 Delta Outflow Requirement

Delta outflow (inflow that is not exported or diverted) is the primary factor controlling water quality in the Delta. When Delta outflow is low, seawater can intrude farther into the Delta, impacting water quality at drinking water intakes. RD-1641 specifies minimum monthly Delta outflow objectives to maintain a reasonable range of salinity in the estuarine aquatic habitat based on the Net Delta Outflow Index (NDOI). The NDOI is a measure of the freshwater outflow and is determined from a water balance that considers river inflows, precipitation, agricultural consumptive demand, and project exports. The NDOI does not consider the semi-diurnal and spring-neap tidal cycles. The monthly minimum values of the NDOI specified in RD-1641 depend on the water year type. Minimum flows are specified for the months of January and July to December. The outflow objectives from February to June are determined based on the X2 objective.

5.2.2.2.2 Delta Salinity Objectives

RD-1641 salinity standards for the Delta are stated in terms of EC (for protection of agricultural and fish and wildlife beneficial uses) and chloride (for protection of M&I uses). Compliance values vary with water year and month. The salinity objectives at Emmaton on the Sacramento River and at Jersey Point on the San Joaquin River often control Delta outflow requirements during the irrigation season from April through August, requiring additional releases from upstream CVP and SWP reservoirs.

5.2.2.2.3 X2 Objective

RD-1641 includes an objective for X2. The location of X2 is used as a surrogate measure of ecosystem health in the Delta. The X2 objective requires specific daily surface criteria to be met for a certain number of days each month from February through June. Compliance can also be achieved by meeting a 14-day running average salinity or three-day average outflow equivalent. These requirements were designed to provide improved shallow water habitat for fish species in the spring. Because of the relationship between seawater intrusion and interior Delta water quality, the X2 objective also improves water quality at Delta drinking water intakes.

5.2.2.2.4 Maximum Export/Inflow Ratio

RD-1641 includes a maximum E/I ratio standard to limit the fraction of Delta inflows that are exported. This requirement was developed to protect fish species and reduce entrainment losses. Delta exports are defined as the combined pumping of water at Banks and Jones pumping plants. Delta inflows are the gaged or estimated river inflows. The maximum E/I ratio is 0.35 for February through June and 0.65 for the remainder of the year. If the January eight-river runoff index is less than 1.0 MAF, the February E/I ratio is increased to 0.45. The CVP and SWP have agreed to share the allowable exports equally if the E/I ratio is limiting exports.

5.2.2.2.5 Joint Point of Diversion

The JPOD refers to the CVP and SWP use of each other’s pumping facilities in the south Delta to export water from the Delta. The CVP and SWP historically have coordinated use of Delta export pumping facilities to assist with deliveries and aid each other during times of facility failures. In 1978, by agreement with DWR and with authorization from the SWRCB, the CVP began using the SWP Banks Pumping Plant for replacement pumping (195,000 AF) for pumping capacity lost at Jones Pumping Plant because of striped bass pumping restrictions in SWRCB Water Right Decision 1485. In 1986, Reclamation and DWR formally agreed that “either party may make use of its facilities available to the other party for pumping and conveyance of water by written agreement” and that the SWP would pump CVP water to make up for striped bass protection measures (Reclamation and DWR 1986). Reclamation filed a number of temporary petitions with the SWRCB to use Banks Pumping Plant for purposes other than replacement pumping and CVP deliveries that contractually relied on SWP conveyance. In RD-1641, SWRCB conditionally approved the use of the JPOD in three separate stages:

- Stage 1 – for water service to Cross Valley Canal contractors, Tracy Veterans Cemetery, and Musco Olive and to recover export reductions taken to benefit fish
- Stage 2 – for any purpose authorized under the current project water right permits
- Stage 3 – for any purpose authorized up to the physical capacity of the diversion facilities

Each stage of JPOD has regulatory terms and conditions that must be satisfied to implement JPOD.

All stages require a response plan to ensure water levels in the southern Delta will not be lowered to the injury of local riparian water users (Water Level Response Plan). All stages require 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 (Reclamation 2008).

5.2.2.2.6 Sacramento Valley Index Water Year-Type Definitions

The Sacramento Valley Index (SVI) for unimpaired runoff for the current water year (October 1 of the preceding calendar year through September 30 of the current calendar year), as published in DWR Bulletin 120, is a forecast of the sum of the unimpaired runoff at the following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River at Smartsville; and American River, total inflow to Folsom Reservoir. Preliminary determinations of year classification shall be made in February, March, and April, with final determination in May. Each of these determinations is based on hydrologic conditions to date plus forecasts of future runoff, assuming normal precipitation for the remainder of the water year.

The SVI is calculated according to the equation, Index = 0.4 * X + 0.3 * Y + 0.3 * Z, where X is the current year's April to July combined Sacramento Valley unimpaired runoff, Y is the current water year's October to March combined Sacramento Valley unimpaired runoff, and Z is the previous year's SVI value.

The SVI defines five water year-types as follows:

- Wet: if the SVI is greater than or equal to 9.2 MAF
- Above Normal: If the SVI is greater than 7.8 MAF and less than 9.2 MAF
- Below Normal: If the SVI is greater than 6.6 MAF and less than or equal to 7.8 MFA
- Dry: If the SVI is greater than 5.4 MAF and less than or equal to 6.5 MAF
- Critical: If the SVI is less than or equal to 5.4 MAF

5.2.2.3 Coordinated Operations Agreement

The Coordinated Operations Agreement (COA) (Reclamation and DWR 1986) defines how Reclamation and DWR share their joint responsibility to meet Delta water quality standards and the water demands of senior water right holders and how the two agencies share surplus flows. The COA defines the Delta as being in either "balanced water conditions" or "excess water conditions." Balanced water conditions are periods when Delta inflows are just sufficient to meet water user demands within the Delta, outflow requirements for water quality and flow standards, and export demands. Under excess water conditions, Delta outflow exceeds the flow required to meet the water quality and flow standards. Typically, the Delta is in balanced water conditions from June to November and in excess water conditions from December through May. However, depending on the volume and timing of winter runoff, excess or balanced water conditions may extend throughout the year.

With the goal of using coordinated management of surplus flows in the Delta to improve Delta export and conveyance capability, the COA received Congressional approval in 1986 and became Public Law 99-546. The COA, as modified by interim agreements, coordinates operations between the CVP and SWP and provides for the sharing of surplus water supply. The COA requires that the CVP and SWP operate in conjunction to meet State water quality objectives in the Bay-Delta estuary, except as specified. Under this agreement, the CVP and SWP can each contract from the other for the purchase of surplus water supplies, potentially increasing the efficiency of water operations.

Since 1986, the COA principles have been modified to reflect changes in regulatory standards, facilities, and operating conditions. At its inception, the COA water quality standards were those of the 1978 WQCP; these were subsequently modified in the 1991 WQCP. The adoption of the 1995 WQCP by SWRCB superseded those requirements. Evolution of the Clean Water Act over time has also impacted implementation of the COA. Furthermore, terms of the COA were re-negotiated between Reclamation and DWR in 2018.

5.2.2.4 SWRCB Standard Permit Term 91

The CVP and SWP are required to release stored water to meet water quality standards in the Delta (including flow and salinity standards) where natural flows are insufficient. The obligation was originally placed on the CVP and SWP as an interim measure, pending future studies of how the obligation to meet water quality standards would be shared with other appropriators. In return for resolving CVP and SWP protests on subsequent applications to appropriate water, SWRCB Standard Permit Term 91 (Term 91) was developed and made a condition to Sacramento Valley water right permits issued after 1965. Term 91 prohibits diversions by these permittees when natural and abandoned flows to the Delta are insufficient to meet the water quality standards and the CVP and SWP are supplementing such flows with previously stored water to meet the standards.

Term 91 is initiated when two conditions occur simultaneously (SWRCB Decision 1594, page 13)—the Delta is in “balanced condition,” as defined by COA and supplemental water is being released to meet water quality objectives (when releases from storage plus imports from the Trinity River are greater than combined exports from CVP and SWP Delta facilities, plus carriage water[3] requirements). As such, Term 91 is a measure designed to share the responsibility for meeting the water quality standards with specified junior diverters. Without Term 91, these diverters could take water that was otherwise being used to meet standards, thereby forcing the CVP and SWP to release more stored water. Thus, it serves to preclude post-1965 appropriators from interfering with the CVP and SWP’s obligation to meet the standards and in practical effect requires such appropriators to share in meeting the water quality standards (SWRCB 2012).

5.2.2.5 Delta Plan

Signed by the governor of California in 2009, the Sacramento-San Joaquin Delta Reform Act (Water Code Section 85000 et seq.) created a new Delta Stewardship Council (DSC) and gave this body broad oversight of Delta planning and resource management. DSC was tasked with developing and implementing a long-term, comprehensive management plan (Delta Plan) that emphasizes the coequal goals of “providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem” (Water Code Section 85300[a]) as the foundation for State decisions regarding Delta management.

Among other things, the Reform Act contains three specific mandates for the DSC:

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[3] Carriage water is the extra water necessary to carry a unit of water across the Delta for export while maintaining existing water quality conditions or regulatory standards within the Delta.

- Include measures in the Delta Plan to promote statewide water conservation, water use efficiency, sustainable use of water, and improvements to water conveyance/storage and operation, to achieve the coequal goals.
- Include measures in the Delta Plan that attempt to reduce risks to people, property, and State interests in the Delta by promoting effective emergency preparedness, appropriate land uses, and strategic levee investments.
- Determine whether State or local agency projects are consistent with the Delta Plan.

In addition, the Reform Act requires the Delta Plan to cover five topic areas and goals:

- Increased water supply reliability
- Restoration of the Delta ecosystem
- Improved water quality
- Reduced risks of flooding in the Delta
- Protection and enhancement of the Delta

The final Delta Plan was adopted on May 16, 2013, and DSC is still preparing the associated EIR. Following adoption of the Delta Plan, covered actions are required to be consistent with that plan.

5.2.2.6 Delta Protection Commission's Land Use and Resource Management Plan

The Delta Protection Commission (DPC) was created by the State legislature in 1992 with the goal of developing regional policies for the Delta to protect and enhance the existing land uses (agriculture, wildlife habitat, and recreation) in the primary zone. The DPC adopted the *Land Use and Resource Management Plan for the Primary Zone of the Delta* initially in 1995 and amended it most recently in 2010. A large portion of the YBWA is within the Primary Zone of the Delta. The DPC's *Land Use and Resource Management Plan for the Primary Zone of the Delta* states the following goal related to water (DPC 2010): Protect and enhance long-term water quality in the Delta for agriculture, municipal, industrial, water-contact recreation, and fish and wildlife habitat uses, as well as all other beneficial uses.

The DPC's *Land Use and Resource Management Plan for the Primary Zone of the Delta* also includes the following policies related to water:

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

5.2.3 Regional and Local Plans, Policies, and Regulations

There are no regional or local plans, policies or regulations associated with surface water supply relevant to the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project.

5.3 Environmental Consequences

This section describes the environmental consequences associated with the Project alternatives and the No Action Alternative. This section presents the assessment methods used to analyze the effects on surface water supply, the thresholds of significance that determine the significance of effects, and the potential environmental consequences and mitigation measures as they relate to each Project alternative. Detailed descriptions of the alternatives evaluated in this section are provided in Chapter 2, *Description of Alternatives*.

5.3.1 Methods for Analysis

Under NEPA, water supply effects were determined by comparing the effect of each proposed alternative to the effects of the No Action Alternative (the NEPA baseline). Under CEQA, water supply effects were determined by comparing the effects of each proposed alternative to Existing Conditions (the CEQA baseline).

5.3.1.1 Models Used

Potential impacts to water supply were assessed using a combination of DWR/Reclamation’s CalSim II operations model and post-processing spreadsheets.

5.3.1.1.1 CalSim II

The primary model used to assess effects on surface water supply was CalSim II. CalSim II simulates operations of the CVP and SWP under different conditions. More information about the CalSim II model, including assumptions, inputs, and model limitations, is provided in Section 4.3.1.1.3 and Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis*.

5.3.1.1.2 Post-Processing Spreadsheets

Evaluation of Delta excess versus balanced conditions and Term 91 was completed using a post-processing spreadsheet developed by DWR, called “Operations Control_BST_102511.xlsm.” The specific version being used was provided via email by Erik Reyes from DWR’s Bay-Delta Office on February 5, 2013. The spreadsheet reads data from the CalSim II output files and computes the controlling factor (i.e., flood management, minimum flows) for each CVP and SWP facility represented in CalSim II.

5.3.1.2 Methodology for Determining Changes in CVP/SWP Deliveries

Changes in CVP and SWP operations as a result of each alternative are analyzed using the CalSim II model. CalSim II models a complex and extensive set of regulatory standards and operations criteria. Descriptions of both are contained in Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis*. The hydrologic analysis conducted for this EIS/EIR used CalSim II models with 2030 and 2070 conditions from the California Water Commission Climate Change Water Supply Improvement Project modeling to approximate system-wide changes in storage, flow, salinity, and reservoir system reoperation associated with the alternatives. Although CalSim II is the best available tool for simulating system-wide operations, the model also contains simplifying assumptions in its representation of the real system. CalSim

II's predictive capability is limited and cannot be readily applied to hourly, daily, or weekly time steps for hydrologic conditions. The model, however, is useful for comparing the relative effects of alternative facilities and operations within the CVP/SWP system on a monthly time step. Reclamation's CalSim II modeling of Existing Conditions and the comparable level of development alternatives assumes 2030 conditions. Future conditions in the CalSim II modeling for the No Action Alternative and future conditions-level of development alternatives assume 2070 conditions, including estimates of climate change and sea level rise.

Deliveries to CVP and SWP water users located south of the Delta do not necessarily correspond to the same volume as the Delta export patterns because a portion of the exported water is stored in San Luis Reservoir and released on a different pattern than Delta exports, possibly even in another water year, so effects on exports are not included in the water supply analysis.

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

5.3.1.3 Methodology for Determining Changes in Delta Conditions

As used for this analysis, the Operations Control spreadsheet described in Section 5.3.1.1.2 computes how much of Delta outflow was used to meet Delta water quality requirements and how much is in excess of the flow required to meet water quality and outflow requirements. When the computed Surplus Delta Outflow is greater than zero cfs for a month, that month is determined to be in excess conditions. If the Surplus Delta Outflow is zero cfs, the month is determined to be in balanced conditions.

5.3.1.4 Methodology for Determining Changes in Water Supply to Non-CVP/SWP Water Users

Non-CVP/SWP water users with water rights junior to the CVP and SWP could be affected by changes in the application of Term 91. If Term 91 was not applied for the basis of comparison (either Existing Conditions or No Action Alternative) but was for the alternative, there could be an impact on a non-CVP/SWP water users' ability to divert water.

As described in Section 5.2.2.4, two conditions are required to initiate Term 91; the first is the Delta must be in balanced condition, as determined using the approach described in Section 5.3.1.3. The second is that the projects must be releasing supplemental water to meet Delta standards. The method for calculating when supplemental water exists beyond Term 91 was developed in Order 81-15 (SWRCB 1981) and D-1594 (SWRCB 1984):

$$SW = SR - (EX + CW)$$

"SR" is the net storage release from Shasta, Oroville, and Folsom reservoirs plus imports to the Sacramento Valley from the Trinity River CVP facilities, minus exports from the Folsom South Canal. "EX" is the sum of CVP and SWP export diversions at Clifton Court Forebay, Jones Pumping Plant, North Bay Aqueduct, and Contra Costa Canal Intake. "CW" is the project carriage water (i.e., the additional outflow required to maintain water quality standards in the Delta while project exports are occurring). The carriage water term is zero when flow objectives, rather than salinity objectives, control CVP and SWP Delta operations. Reclamation's Central Valley Operations Office publishes daily accounts of project supplemental water (http://www.usbr.gov/mp/cvo).

For this analysis, CalSim II output and data from the Operations Control spreadsheet were used to determine if Term 91 had been initiated for a month for a scenario and if there was a change in the frequency of the application of Term 91 between scenarios that could affect water supply for non-CVP/SWP water users.

5.3.1.5 Methodology for Determining Temporary Impacts during Construction

Temporary impacts to water supply include those of short duration related to the construction of the Project alternatives. Because all the Project alternatives would be constructed when water levels are below the proposed Fremont Weir invert elevations, there would be no temporary changes or temporary effects to water supply outside of the Yolo Bypass. Construction within the Yolo Bypass (such as at Agricultural Road Crossing 1) would include temporary measures to ensure water supply was maintained throughout the construction period. The analysis in this chapter, therefore, does not include a discussion of temporary impacts to water supply.

5.3.2 Thresholds of Significance – CEQA

A significant effect on the environment means "a substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project" (State CEQA Guidelines, Section 15382).

An alternative would result in a significant impact under CEQA on water supply if, relative to Existing Conditions, it would:

- Substantially reduce water supply deliveries to CVP or SWP contractors during operation, including:
  - North of Delta CVP contractors or wildlife refuges
  - South of Delta CVP contractors or wildlife refuges
  - SWP contractors north of the Delta
  - SWP contractors south of the Delta
- Substantially reduce water supply availability for non-CVP or SWP contractors along the Sacramento River and in the Delta during operation by increasing the incidence of Term 91 being initiated

The following thresholds of significance were developed based on the guidance provided in Appendix G to the CEQA guidelines. These thresholds also encompass the factors considered under NEPA to determine the context and the intensity of its impacts.

5.3.2.1 Impact Indicator for Changes in Water Supply Deliveries to CVP or SWP Contractors

Changes in water supply deliveries to CVP and SWP contractors could be represented by changes either to long-term annual water supply or to monthly water supply. Impact indicators for both conditions are described below.

5.3.2.1.1 Significance Threshold for Changes in Long-Term Average Annual Deliveries

For this analysis, a substantial reduction in long-term reliability is defined as a five percent or greater reduction in average annual or average dry and critical year reliability. This amount is assumed to represent a reduction that could not be replaced reliably from other sources such as groundwater pumping or water transfers. Furthermore, the SWP and CVP generally make their allocations to their contractors in five percent increments, whereas CalSim II computes allocations with much higher precision. Changes in long-term average deliveries and dry and critical year deliveries would be indicative of a systematic change in deliveries due to operation of the project. There are much greater stressors on the system during dry and critical years (as defined by the Sacramento Valley Index described in RD-1641), and reductions in water supply in dry and critical years are much more likely to result in impacts to the contractors due to a lack of ability to secure water supply from other sources.

5.3.2.1.2 Significance Threshold for Changes in Monthly Deliveries

Some flexibility would exist to adjust for changes in surface water supply from month to month. For example, temporarily increased groundwater pumping could be used to make up for a single month’s reduction in supply, but long-term changes in monthly supply could have a significant impact. For this analysis, a substantial reduction in monthly reliability is defined as a greater than 10 percent reduction in average monthly water supply. This amount is assumed to represent a reduction that could not be replaced reliably from other sources such as groundwater pumping or water transfers.

Temporary impacts to water supply include those of short duration related to the construction of the Project alternatives. Because all the Project alternatives would be constructed when water levels are below the proposed Fremont Weir invert elevations, there would be no temporary changes or temporary effects to water supply outside of the Yolo Bypass. Construction within the Yolo Bypass (such as at Agricultural Road Crossing 1) would include temporary measures to ensure water supply was maintained throughout the construction period. The analysis in this chapter, therefore, does not include a discussion of temporary impacts to water supply.

5.3.2.2 Impact Indicators for Increase in Incidence of Term 91 Being Initiated

Non-CVP and SWP water users would potentially be impacted if Term 91 was initiated under an alternative when it had not been initiated under the basis of comparison. If Term 91 is indicated more frequently, or in periods when it was not otherwise indicated for an alternative relative to the basis of comparison, non-CVP and SWP water users would be restricted from diverting and could incur reductions in water supply relative to the basis of comparison. For this analysis, changes in incidences of Term 91 initiation would be considered significant if the following conditions occur:

- Under the basis of comparison, Term 91 is not in effect.
- Under the alternatives, Term 91 is in effect.

5.3.3 Effects and Mitigation Measures

This section provides an evaluation of the direct and indirect effects on surface water supply from implementing the Project alternatives. This analysis is organized by Project alternative, with specific impact topics numbered sequentially under each alternative.

Changes in flow at Fremont Weir could change CVP and SWP operations. Increases in flow at Fremont Weir into the Yolo Bypass and corresponding decreases in flow in the Sacramento River between Fremont Weir and the California WaterFix North-Delta Diversion could lead to decreases in diversions in the North Delta Diversion under future conditions, which could lead to decreases in CVP and SWP exports from the Jones and Banks pumping plants. In turn, decreases in Jones and Banks exports could lead to decreases in San Luis Reservoir storage and, ultimately, a decrease in CVP and SWP deliveries to water service contractors south of the Delta.

Modeling of Existing Conditions and the comparable-level of development alternatives assumes a 2030 hydrology and sea level rise with existing infrastructure and regulatory conditions. Modeling of the No Action Alternative and the comparable-level of development alternatives assumes a 2070 hydrology and sea level rise and reasonably foreseeable infrastructure and regulatory conditions.

5.3.3.1 No Action Alternative

Under the No Action Alternative, no additional actions would be taken to increase seasonal floodplain inundation in the lower Sacramento River Basin or improve fish passage throughout the Yolo Bypass. The Yolo Bypass would continue to be inundated during overtopping events at Fremont Weir, and additional flows would not pass through Fremont Weir when the Sacramento River is below Fremont Weir. Therefore, there would be no construction-related impacts on water supply.

As described in Section 4.3.1.1.3, the No Action Alternative assumes reasonably foreseeable actions in addition to changes in hydrology and sea-level rise relative to Existing Conditions. These reasonably foreseeable actions, in addition to changes in regulatory conditions and water supply demands, would result in differences in flows on the Sacramento River and at the Delta between Existing Conditions and the No Action Alternative. The Appendix E discussion of the California Water Commission (CWC) scenarios (used as the basis for this project’s modeling) show that the majority of the differences between Existing Conditions and the No Action Alternative are based on changes in hydrology and sea-level rise.

The California WaterFix Project, included for 2070-level scenarios, could have a notable influence on the effects of the No Action Alternative and its comparable alternatives relative to the Existing Conditions. A change in diversion through the California WaterFix Project intakes could affect storage in San Luis Reservoir and subsequent deliveries to CVP and SWP contractors south of the Delta. Changes in San Luis Reservoir storage could also result in changes to operations of north-of-Delta reservoirs, such as Shasta, Folsom, and Oroville, to move water supply to fill the reduced San Luis Reservoir storage.

5.3.3.1.1 Impact WS-1: Changes in CVP Water Supply Deliveries North of Delta

Table 5-3 shows changes that would occur in CVP deliveries to North of Delta contractors under the No Action Alternative compared to Existing Conditions.

Table 5-3. Simulated Monthly Average Water Supply Deliveries and Percent Change in Deliveries to North of Delta Central Valley Project Contractors and Wildlife Refuges under the No Action Alternative Compared to Existing Conditions

Month	Average All Years		Dry and Critical Years[1]	
	Existing Conditions (cfs)	No Action Alternative Change (cfs [%])	Existing Conditions (cfs)	No Action Alternative Change (cfs [%])
October	1,506	-33 (-2)	1,559	-80 (-5)
November	726	-22 (-3)	770	-49 (-6)
December	389	-7 (-2)	402	-15 (-4)
January	234	-10 (-4)	232	-11 (-5)
February	244	-8 (-3)	248	-14 (-6)
March	337	-14 (-4)	415	-24 (-6)
April	5,113	-98 (-2)	5,464	-134 (-2)
May	5,599	-172 (-3)	5,274	-43 (-1)
June	7,987	-225 (-3)	7,382	-41 (-1)
July	7,932	-327 (-4)	7,252	-201 (-3)
August	5,983	-231 (-4)	5,381	-62 (-1)
September	2,046	-102 (-5)	1,798	-73 (-4)
Total (TAF)	2,310	-76 (-3)	2,193	-45 (-2)

Source: CalSim II Output for DEL_CVP_TOTAL_N

Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

[1]Dry and Critical Years as defined by RD1641 Sacramento Valley Index

Under the No Action Alternative, changes in long-term average water supply deliveries to North of Delta CVP contractors and wildlife refuges would be less than five percent in all months and for the year relative to Existing Conditions. In dry and critical years, average monthly decreases in deliveries would be as high as six percent, but the annual change would only be two percent.

CEQA Conclusion

Because the changes in annual and monthly long-term average and dry and critical year deliveries to North of Delta CVP contractors and wildlife refuges would change by less than 10 percent for monthly deliveries and five percent for annual deliveries, changes in deliveries to North of Delta CVP contractors under the No Action Alternative would be **less than significant**.

5.3.3.1.2 Impact WS-2: Changes in CVP Water Supply Deliveries South of Delta

Table 5-4 shows changes that would occur in deliveries to South of Delta CVP contractors and wildlife refuges under the No Action Alternative compared to Existing Conditions.

Table 5-4. Simulated Monthly Average Water Supply Deliveries and Percent Change in Deliveries to South of Delta CVP Contractors and Wildlife Refuges under the No Action Alternative Compared to Existing Conditions

Month	Average All Years		Dry and Critical Years[1]	
	Existing Conditions (cfs)	No Action Alternative Change (cfs [%])	Existing Conditions (cfs)	No Action Alternative Change (cfs [%])
October	2,670	-129 (-5)	2,580	-140 (-5)
November	1,585	-102 (-6)	1,517	-111 (-7)
December	1,151	-138 (-12)	1,068	-143 (-13)
January	1,274	-230 (-18)	1,142	-234 (-20)
February	1,718	-283 (-16)	1,554	-284 (-18)
March	2,083	-184 (-9)	1,667	-40 (-2)
April	2,592	-317 (-12)	1,984	-86 (-4)
May	3,755	-405 (-11)	2,871	-109 (-4)
June	5,447	-671 (-12)	4,008	-184 (-5)
July	5,876	-771 (-13)	4,205	-230 (-5)
August	5,010	-489 (-10)	3,790	-115 (-3)
September	3,413	-200 (-6)	2,921	-45 (-2)
Total (TAF)	2,214	-237 (-11)	1,773	-104 (-6)

Source: CalSim II Output for DEL_CVP_TOTAL_S

Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

[1]Dry and Critical Years as defined by RD1641 Sacramento Valley Index

Long-term average annual deliveries to CVP South of Delta water service contractors and wildlife refuges would be decreased under the No Action Alternative relative to Existing Conditions, with average annual decreases of 11 percent and up to 18 percent in some months. The No Action Alternative would result in a decrease in average annual CVP South of Delta deliveries of six percent in dry and critical years and a decrease in average monthly CVP South of Delta deliveries by as much as 20 percent in January of dry and critical years relative to Existing Conditions. These changes are primarily due to changes in hydrology associated with climate change.

CEQA Conclusion

Since long-term average annual and monthly deliveries to South of Delta CVP contractors and wildlife refuges under the No Action Alternative, relative to Existing Conditions, would change by more than 10 percent and dry and critical year annual deliveries would be reduced by more than five percent, changes in deliveries to South of Delta CVP contractors would result in a **significant** effect compared to Existing Conditions. Neither NEPA nor CEQA require mitigation measures for the No Action Alternative.

5.3.3.1.3 Impact WS-3: Changes in SWP Water Supply Deliveries North of Delta

Table 5-5 shows changes that would occur in deliveries to North of Delta SWP contractors under the No Action Alternative compared to Existing Conditions.

Table 5-5. Simulated Monthly Average Water Supply Deliveries and Percent Change in Deliveries to North of Delta State Water Project Contractors under the No Action Alternative Compared to Existing Conditions

Month	Average All Years		Dry and Critical Years[1]	
	Existing Conditions (cfs)	No Action Alternative Change (cfs [%])	Existing Conditions (cfs)	No Action Alternative Change (cfs [%])
October	1,449	-66 (-5)	1,476	-201 (-14)
November	1,463	-69 (-5)	1,422	-213 (-15)
December	935	-41 (-4)	924	-130 (-14)
January	345	-17 (-5)	377	-43 (-11)
February	14	-1 (-10)	11	-2 (-17)
March	92	-3 (-3)	145	-13 (-9)
April	2,122	-117 (-5)	2,302	-243 (-11)
May	2,685	-106 (-4)	2,457	-142 (-6)
June	3,217	-125 (-4)	2,925	-179 (-6)
July	3,169	-125 (-4)	2,883	-178 (-6)
August	2,515	-101 (-4)	2,264	-143 (-6)
September	1,874	-68 (-4)	1,611	-154 (-10)
Total (TAF)	1,205	-51 (-4)	1,139	-99 (-9)

Source: CalSim II Output for DEL_SWP_TOTAL_N

Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

[1]Dry and Critical Years as defined by RD1641 Sacramento Valley Index

Long-term average annual deliveries to SWP North of Delta contractors would be decreased by approximately four percent under the No Action Alternative relative to Existing Conditions. The No Action Alternative would result in a decrease in annual SWP North of Delta deliveries of nine percent on average in dry and critical years and a decrease in average monthly SWP North of Delta deliveries by as much as 17 percent in February of dry and critical years relative to Existing Conditions. These changes are primarily due to changes in hydrology associated with climate change.

CEQA Conclusion

Since changes to long-term average annual and monthly SWP North of Delta deliveries under the No Action Alternative, relative to Existing Conditions, would be approximately four percent, with monthly reductions as high as 10 percent, and changes to dry and critical year annual deliveries would be reduced by nine percent, with reductions in monthly dry and critical year deliveries potentially as much as 17 percent, changes in deliveries to North of Delta SWP contractors would result in a **significant** effect compared to Existing Conditions. Neither NEPA nor CEQA require mitigation measures for the No Action Alternative. These changes are primarily due to changes in hydrology associated with climate change.

5.3.3.1.4 Impact WS-4: Changes in SWP Water Supply Deliveries South of Delta

Table 5-6 shows changes that would occur in deliveries to South of Delta SWP contractors under the No Action Alternative compared to Existing Conditions.

Table 5-6. Simulated Monthly Average Water Supply Deliveries and Percent Change in Deliveries to South of Delta SWP Contractors under the No Action Alternative Compared to Existing Conditions

Month	Average All Years		Dry and Critical Years	
	Existing Conditions (cfs)	No Action Alternative Change (cfs [%])	Existing Conditions (cfs)	No Action Alternative Change (cfs [%])
October	4,044	-1 (0)	3,692	-129 (-4)
November	3,416	-432 (-13)	3,055	-325 (-11)
December	3,459	137 (4)	3,152	-197 (-6)
January	465	7 (1)	112	-10 (-8)
February	782	58 (7)	171	-7 (-4)
March	1,284	248 (19)	322	266 (83)
April	2,414	128 (5)	960	148 (15)
May	3,688	125 (3)	2,063	36 (2)
June	5,146	19 (0)	3,430	-70 (-2)
July	5,640	-105 (-2)	4,181	-177 (-4)
August	5,790	-84 (-1)	4,071	-112 (-3)
September	4,893	-64 (-1)	3,435	-48 (-1)
Total (TAF)	2,486	3 (0)	1,739	-38 (-2)

Source: CalSim II Output for DEL_SWP_TOTAL_S
Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Long-term average annual deliveries to SWP South of Delta contractors would be increased, with monthly reductions as high as 13 percent under the No Action Alternative relative to Existing Conditions. The No Action Alternative would result in a decrease in annual SWP South of Delta deliveries of two percent on average in dry and critical years and a decrease in average monthly SWP South of Delta deliveries as much as 11 percent in November of dry and critical years relative to Existing Conditions. Other months, such as March, April, and May, would have increases in dry and critical years under the No Action Alternative. These changes are primarily due to changes in hydrology associated with climate change.

CEQA Conclusion

While long-term average annual and monthly deliveries to South of Delta SWP contractors under the No Action Alternative, relative to Existing Conditions, would increase, dry and critical year annual deliveries would be reduced by two percent, and reductions in monthly dry and critical year deliveries could be as much as 11 percent. These changes in deliveries to South of Delta SWP contractors would result in a **significant** effect compared to existing conditions. Neither NEPA nor CEQA require mitigation measures for the No Action Alternative. These changes are primarily due to changes in hydrology associated with climate change.

5.3.3.1.5 Impact WS-5: Increase in Incidence of Term 91 Being Initiated

Table 5-7 shows a comparison of the number of years Term 91 would be initiated for each month under Existing Conditions but not under the No Action Alternative, or vice versa.

Table 5-7. Comparison of the Number of Years Term 91 would be Initiated Under Existing Conditions but not Under the No Action Alternative, or Vice Versa

Month	Incidents of Term 91 Initiation under Existing Conditions but Not Under the No Action Alternative	Incidents of Term 91 Initiation under the No Action Alternative but not under Existing Conditions
January	0	1
February	1	0
March	0	9
April	1	14
May	3	21
June	21	3
July	10	2
August	38	7
September	7	19
October	17	7
November	17	1
December	0	0
Total	115	84

When compared to Existing Conditions, there were 84 incidents when Term 91 had not been initiated under Existing Conditions but was initiated under the No Action Alternative. These changes are primarily due to changes in hydrology associated with climate change.

CEQA Conclusion

There would be 115 incidents when Term 91 would be initiated under Existing Conditions but not under the No Action Alternative, indicating a potential benefit to non-CVP/SWP water users under the No Action Alternative. However, there would be 84 incidents when Term 91 would be initiated under the No Action Alternative but not under Existing Conditions. This would result in a **significant** effect compared to Existing Conditions. Neither NEPA nor CEQA require mitigation measures for the No Action Alternative. These changes are primarily due to changes in hydrology associated with climate change.

5.3.3.2 Alternative 1: East Side Gated Notch

Alternative 1, East Side Gated Notch, would allow increased flow from the Sacramento River to enter the Yolo Bypass through a gated notch on the east side of Fremont Weir. The invert of the new notch would be at an elevation of 14 feet, which is approximately 18 feet below the existing Fremont Weir crest. Alternative 1 would allow up to 6,000 cfs to flow through the notch during periods when the river levels are not high enough to go over the crest of Fremont Weir to provide open channel flow for adult fish passage. See Section 2.4 for more details on the alternative features.

5.3.3.2.1 Impact WS-1: Changes in CVP Water Supply Deliveries North of Delta

Table 5-8 shows the long-term average changes and dry and critical year changes that would occur in CVP deliveries to North of Delta contractors and wildlife refuges under Alternative 1 compared to Existing Conditions.

Table 5-8. Simulated 2030-Level Monthly Average Water Supply Deliveries and Percent Change in Deliveries to North of Delta CVP Contractors and Wildlife Refuges under Existing Conditions Compared to Alternative 1

Month	Long-Term Average		Dry and Critical Average	
	Existing Conditions (cfs)	Alternative 1 Change (cfs [%])	Existing Conditions (cfs)	Alternative 1 Change (cfs [%])
October	1,506	0 (0)	1,559	0 (0)
November	726	0 (0)	770	0 (0)
December	389	0 (0)	402	0 (0)
January	234	0 (0)	232	0 (0)
February	244	0 (0)	248	0 (0)
March	337	0 (0)	415	0 (0)
April	5,113	0 (0)	5,464	0 (0)
May	5,599	0 (0)	5,274	0 (0)
June	7,987	0 (0)	7,382	0 (0)
July	7,932	0 (0)	7,252	0 (0)
August	5,983	0 (0)	5,381	0 (0)
September	2,046	0 (0)	1,798	0 (0)
Total (TAF)	2,310	0 (0)	1,559	0 (0)

Source: CalSim II Output for DEL_CVP_TOTAL_N
Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Table 5-9 shows the long-term average changes and dry and critical year changes that would occur in CVP deliveries to North of Delta contractors and wildlife refuges under Alternative 1 compared to the No Action Alternative.

Table 5-9. Simulated 2070-Level Monthly Average Water Supply Deliveries and Percent Change in Deliveries to North of Delta CVP Contractors and Wildlife Refuges under the No Action Alternative Compared to Alternative 1

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 1 Change (cfs [%])	No Action Alternative (cfs)	Alternative 1 Change (cfs [%])
October	1,473	0 (0)	1,479	0 (0)
November	705	0 (0)	722	0 (0)
December	382	0 (0)	387	0 (0)

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 1 Change (cfs [%])	No Action Alternative (cfs)	Alternative 1 Change (cfs [%])
January	224	0 (0)	221	0 (0)
February	236	-1 (0)	234	0 (0)
March	323	0 (0)	391	0 (0)
April	5,015	0 (0)	5,330	0 (0)
May	5,427	0 (0)	5,231	0 (0)
June	7,762	0 (0)	7,341	0 (0)
July	7,605	8 (0)	7,051	20 (0)
August	5,752	0 (0)	5,319	0 (0)
September	1,944	0 (0)	1,726	0 (0)
Total (TAF)	2,234	0 (0)	2,147	1 (0)

Source: CalSim II Output for DEL_CVP_TOTAL_N
Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Alternative 1 vs Existing Conditions

For 2030-level scenarios, deliveries to CVP North of Delta water service contractors and wildlife refuges would be similar for the long-term average and similar in dry and critical years under Alternative 1 compared to Existing Conditions. Average monthly and annual Alternative 1 deliveries would change less than one percent in each month and over the year relative to Existing Conditions for both long-term average and dry and critical years. An additional analysis was modeled in CalSim II to assess impacts under the new 2018 COA agreement and findings remain unchanged. More information is provided in Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis.*

Alternative 1 vs No Action Alternative

For 2070-level scenarios, deliveries to CVP North of Delta water service contractors and wildlife refuges would be similar over the long-term average and similar in dry and critical years under Alternative 1 compared to the No Action Alternative. Average monthly and annual Alternative 1 deliveries would change less than one percent in each month and over the year relative to the No Action Alternative for both long-term average and dry and critical years.

CEQA Conclusion

Changes in CVP deliveries to North of Delta contractors and wildlife refuges under Alternative 1 would be **less than significant** because changes to monthly and annual long-term and dry and critical year averages would be less than one percent relative to Existing Conditions.

5.3.3.2.2 Impact WS-2: Changes in CVP Water Supply Deliveries South of Delta

Table 5-10 shows the long-term average changes and dry and critical year changes that would occur in CVP deliveries to South of Delta contractors and wildlife refuges under Alternative 1 compared to Existing Conditions.

Table 5-10. Simulated 2030-Level Monthly Average Deliveries and Percent Change in Deliveries to South of Delta CVP Contractors and Wildlife Refuges under Existing Conditions Compared to Alternative 1

Month	Long-Term Average		Dry and Critical Average	
	Existing Conditions (cfs)	Alternative 1 Change (cfs [%])	Existing Conditions (cfs)	Alternative 1 Change (cfs [%])
October	2,670	0 (0)	2,580	0 (0)
November	1,585	0 (0)	1,517	0 (0)
December	1,151	0 (0)	1,068	0 (0)
January	1,274	0 (0)	1,142	0 (0)
February	1,718	0 (0)	1,554	0 (0)
March	2,083	0 (0)	1,667	0 (0)
April	2,592	0 (0)	1,984	0 (0)
May	3,755	0 (0)	2,871	0 (0)
June	5,447	0 (0)	4,008	0 (0)
July	5,876	0 (0)	4,205	0 (0)
August	5,010	0 (0)	3,790	0 (0)
September	3,413	0 (0)	2,921	0 (0)
Total (TAF)	2,214	0 (0)	1,773	0 (0)

Source: CalSim II Output for DEL_CVP_TOTAL_S
Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Table 5-11 shows the long-term average changes and dry and critical year changes that would occur in CVP deliveries to South of Delta contractors and wildlife refuges under Alternative 1 compared to the No Action Alternative.

Table 5-11. Simulated 2070-Level Monthly Average Water Supply Deliveries and Percent Change in Deliveries to South of Delta CVP Contractors and Wildlife Refuges under the No Action Alternative Compared to Alternative 1

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 1 Change (cfs [%])	No Action Alternative (cfs)	Alternative 1 Change (cfs [%])
October	2,541	0 (0)	2,441	0 (0)
November	1,483	0 (0)	1,406	0 (0)
December	1,013	0 (0)	925	0 (0)
January	1,043	0 (0)	908	0 (0)
February	1,435	0 (0)	1,270	0 (0)
March	1,900	0 (0)	1,627	0 (0)

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 1 Change (cfs [%])	No Action Alternative (cfs)	Alternative 1 Change (cfs [%])
April	2,274	0 (0)	1,897	0 (0)
May	3,350	-1 (0)	2,761	-1 (0)
June	4,776	-1 (0)	3,824	-1 (0)
July	5,105	-1 (0)	3,975	0 (0)
August	4,521	-1 (0)	3,674	-1 (0)
September	3,213	0 (0)	2,876	0 (0)
Total (TAF)	1,977	0 (0)	1,669	0 (0)

Source: CalSim II Output for DEL_CVP_TOTAL_S
Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Alternative 1 vs Existing Conditions

For 2030-level scenarios, deliveries to CVP South of Delta water service contractors and wildlife refuges would be similar for the long-term average and similar in dry and critical years under Alternative 1 compared to Existing Conditions. Average monthly and annual Alternative 1 deliveries would change less than one percent on average in each month and over the year relative to Existing Conditions for both the long-term average and the dry and critical year average. An additional analysis was modeled in CalSim II to assess impacts under the new 2018 COA agreement and findings remain unchanged. More information is provided in Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis.*

Alternative 1 vs No Action Alternative

For 2070-level scenarios, deliveries to CVP South of Delta water service contractors and wildlife refuges would be similar for the long-term average and similar in dry and critical years under Alternative 1 compared to the No Action Alternative. Average monthly and annual Alternative 1 deliveries would change less than one percent on average in each month and over the year relative to the No Action Alternative for both long-term average and dry and critical year average.

CEQA Conclusion

Changes in CVP South of Delta deliveries under Alternative 1would be **less than significant** because changes to monthly and annual long-term and dry and critical year averages would be less than one percent relative to Existing Conditions.

5.3.3.2.3 Impact WS-3: Changes in SWP Water Supply Deliveries North of Delta

Table 5-12 shows the long-term average changes and dry and critical year changes that would occur in SWP deliveries to North of Delta contractors under Alternative 1 compared to Existing Conditions.

Table 5-12. Simulated 2030-Level Monthly Average Deliveries and Percent Change in Deliveries to North of Delta SWP Contractors under Existing Conditions Compared to Alternative 1

Month	Long-Term Average		Dry and Critical Average	
	Existing Conditions (cfs)	Alternative 1 Change (cfs [%])	Existing Conditions (cfs)	Alternative 1 Change (cfs [%])
October	1,449	0 (0)	1,476	0 (0)
November	1,463	0 (0)	1,422	0 (0)
December	935	0 (0)	924	0 (0)
January	345	0 (0)	377	0 (0)
February	14	0 (0)	11	0 (0)
March	92	0 (0)	145	0 (0)
April	2,122	0 (0)	2,302	0 (0)
May	2,685	0 (0)	2,457	0 (0)
June	3,217	0 (0)	2,925	0 (0)
July	3,169	0 (0)	2,883	0 (0)
August	2,515	0 (0)	2,264	0 (0)
September	1,874	0 (0)	1,611	0 (0)
Total (TAF)	1,205	0 (0)	1,139	0 (0)

Source: CalSim II Output for DEL_SWP_TOTAL_N

Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Table 5-13 shows the long-term average changes and dry and critical year changes that would occur in SWP deliveries to North of Delta contractors under Alternative 1 compared to the No Action Alternative.

Table 5-13. Simulated 2070-Level Monthly Average Water Supply Deliveries and Percent Change in Deliveries to North-of-Delta SWP Contractors under the No Action Alternative Compared to Alternative 1

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 1 Change (cfs [%])	No Action Alternative (cfs)	Alternative 1 Change (cfs [%])
October	1,383	4 (0)	1,275	0 (0)
November	1,394	5 (0)	1,210	0 (0)
December	894	3 (0)	794	0 (0)
January	328	0 (0)	334	0 (0)
February	13	0 (0)	9	0 (0)
March	89	0 (0)	133	0 (0)
April	2,005	0 (0)	2,059	0 (0)
May	2,578	0 (0)	2,315	0 (0)
June	3,092	0 (0)	2,746	0 (0)
July	3,044	0 (0)	2,706	0 (0)

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 1 Change (cfs [%])	No Action Alternative (cfs)	Alternative 1 Change (cfs [%])
August	2,413	0 (0)	2,121	0 (0)
September	1,806	0 (0)	1,457	0 (0)
Total (TAF)	1,154	1 (0)	1,040	0 (0)

Source: CalSim II Output for DEL_SWP_TOTAL_N
Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Alternative 1 vs Existing Conditions

For 2030-level scenarios, deliveries to SWP North of Delta water service contractors would be similar for the long-term average and similar in dry and critical years under Alternative 1 compared to Existing Conditions. Average monthly and annual Alternative 1 deliveries would change less than one percent on average in each month and over the year relative to Existing Conditions for both long-term average and dry and critical year average. An additional analysis was modeled in CalSim II to assess impacts under the new 2018 COA agreement and findings remain unchanged. More information is provided in Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis.*

Alternative 1 vs No Action Alternative

For 2070-level scenarios, deliveries to SWP North of Delta water service contractors would be similar for the long-term average and similar in dry and critical years under Alternative 1 compared to the No Action Alternative. Average monthly and annual Alternative 1 deliveries would change less than one percent on average in each month and over the year relative to the No Action Alternative for both long-term average and dry and critical year average.

CEQA Conclusion

Changes in SWP deliveries to North of Delta contractors under Alternative 1 would be **less than significant** because changes to monthly and annual long-term and dry and critical year averages would be less than one percent relative to Existing Conditions.

5.3.3.2.4 Impact WS-4: Changes in SWP Water Supply Deliveries South of Delta

Table 5-14 shows the long-term average changes and dry and critical year changes that would occur in SWP deliveries to South of Delta contractors under Alternative 1 compared to Existing Conditions.

Table 5-14. Simulated 2030-Level Monthly Average Water Supply Deliveries and Percent Change in Deliveries to South of Delta SWP Contractors under Existing Conditions Compared to Alternative 1

Month	Long-Term Average		Dry and Critical Average	
	Existing Conditions (cfs)	Alternative 1 Change (cfs [%])	Existing Conditions (cfs)	Alternative 1 (cfs [%])
October	4,044	0 (0)	3,692	0 (0)
November	3,416	0 (0)	3,055	0 (0)
December	3,459	0 (0)	3,152	0 (0)
January	465	0 (0)	112	0 (0)
February	782	0 (0)	171	0 (0)
March	1,284	0 (0)	322	0 (0)
April	2,414	0 (0)	960	0 (0)
May	3,688	0 (0)	2,063	0 (0)
June	5,146	0 (0)	3,430	0 (0)
July	5,640	0 (0)	4,181	0 (0)
August	5,790	0 (0)	4,071	0 (0)
September	4,893	0 (0)	3,435	0 (0)
Total (TAF)	2,486	0 (0)	1,739	0 (0)

Source: CalSim II Output for DEL_SWP_TOTAL_S

Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Table 5-15. shows the long-term average changes and dry and critical year changes that would occur in SWP deliveries to South of Delta contractors under Alternative 1 compared to the No Action Alternative.

Table 5-15. Simulated 2070-Level Monthly Average Water Supply Deliveries and Percent Change in Deliveries to South of Delta SWP Contractors under the No Action Alternative Compared to Alternative 1

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 1 Change (cfs [%])	No Action Alternative (cfs)	Alternative 1 (cfs [%])
October	4,043	-3 (0)	3,562	-3 (0)
November	2,984	-4 (0)	2,730	-5 (0)
December	3,596	-16 (0)	2,956	-5 (0)
January	472	-3 (0)	103	0 (0)
February	840	0 (0)	164	-1 (0)
March	1,531	-4 (0)	587	-2 (0)
April	2,542	-5 (0)	1,108	-8 (-1)
May	3,813	-7 (0)	2,098	-14 (-1)
June	5,165	-9 (0)	3,361	-18 (-1)
July	5,535	-8 (0)	4,005	-14 (0)
August	5,706	-9 (0)	3,960	-15 (0)

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 1 Change (cfs [%])	No Action Alternative (cfs)	Alternative 1 (cfs [%])
September	4,829	-10 (0)	3,387	-19 (-1)
Total (TAF)	2,489	-5 (0)	1,701	-6 (0)

Source: CalSim II Output for DEL_SWP_TOTAL_S
Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Alternative 1 vs Existing Conditions

For 2030-level scenarios, deliveries to SWP South of Delta water service contractors would be similar for the long-term average and similar in dry and critical years under Alternative 1 compared to Existing Conditions. Average monthly and annual Alternative 1 deliveries would change less than one percent on average in each month and over the year relative to Existing Conditions for both long-term average and average dry and critical average. An additional analysis was modeled in CalSim II to assess impacts under the new 2018 COA agreement and findings remain unchanged. More information is provided in Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis.*

Alternative 1 vs No Action Alternative

For 2070-level scenarios, deliveries to SWP South of Delta water service contractors would be similar for the long-term average and similar in dry and critical years under Alternative 1 compared to the No Action Alternative. Average monthly and annual Alternative 1 deliveries would change less than one percent on average in each month and over the year relative to the No Action Alternative for both long-term average and dry and critical average.

CEQA Conclusion

Changes in SWP deliveries to South of Delta contractors under Alternative 1 would be **less than significant** because changes to monthly and annual long-term and dry and critical year averages would be less than one percent relative to Existing Conditions.

5.3.3.2.5 Impact WS-5: Increase in Incidence of Term 91 Being Initiated

A comparison of the incidents of Term 91 being initiated was made between Existing Conditions and Alternative 1 for 2030-level scenarios and the No Action Alternative and Alternative 1 for 2070-level scenarios. Table 5-16 compares the number of incidents by month that Term 91 would have been initiated under Alternative 1 to Existing Conditions and the No Action Alternative.

Table 5-16. Comparison of the Simulated Number of Incidents Term 91 Would Have Been Initiated under Existing Conditions or the No Action Alternative but Not under Alternative 1

Month	2030-Level Conditions		2070-Level Conditions	
	Term 91 Initiated Under Existing Conditions but Not Under Alternative 1 (Years)	Term 91 Initiated Under Alternative 1 but Not Under Existing Conditions (Years)	Term 91 Initiated Under No Action Alternative but Not Under Alternative 1 (Years)	Term 91 Initiated Under Alternative 1 but Not Under No Action Alternative (Years)
October	0	0	0	0
November	0	0	0	0
December	0	0	0	0
January	0	0	1	0
February	0	0	0	0
March	0	0	0	0
April	0	0	0	0
May	0	0	0	0
June	0	0	0	0
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
Total	0	0	1	0

Source: Term 91 Calculation

Alternative 1 vs Existing Conditions

For 2030-level scenarios, there would be no changes in the number of times Term 91 is initiated under Alternative 1 relative to Existing Conditions. An additional analysis was modeled in CalSim II to assess impacts under the new 2018 COA agreement and findings remain unchanged. More information is provided in Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis.*

Alternative 1 vs No Action Alternative

For 2070-level scenarios, there would be one month that Term 91 would be initiated under the No Action Alternative but not under Alternative 1.

CEQA Conclusion

There would be no impact from increases in the incidents of Term 91 being initiated under Alternative 1 since there would be no differences in the incidents of Term 91 being initiated compared to Existing Conditions.

5.3.3.3 Alternative 2: Central Gated Notch

Alternative 2, Central Gated Notch, would provide a similar new gated notch through Fremont Weir as described for Alternative 1. The primary difference between Alternatives 1 and 2 is the location of the notch; Alternative 2 would site the notch near the center of Fremont Weir. This gate would be a similar size but would have an invert elevation that is higher (14.8 feet) because the river is higher at this upstream location, and the gate would allow up to 6,000 cfs through to provide open channel flow for adult fish passage. See Section 2.5 for more details on the alternative features.

Because Alternative 2 would affect water flow and movement in the same way as described for Alternative 1, impacts under Alternative 2 would be identical to those discussed for Alternative 1.

5.3.3.4 Alternative 3: West Side Gated Notch

Alternative 3, West Side Gated Notch, would provide a similar new gated notch through Fremont Weir as described for Alternative 1. The primary difference between Alternatives 1 and 3 is the location of the notch; Alternative 3 would site the notch on the western side of Fremont Weir. This gate would be a similar size but would have an invert elevation that is higher (16.1 feet) because the river is higher at this upstream location. Alternative 3 would allow up to 6,000 cfs through the gated notch to provide open channel flow for adult fish passage. See Section 2.6 for more details on the alternative features.

Because Alternative 3 would affect water flow and movement in the same way as described for Alternative 1, impacts under Alternative 3 would be identical to those discussed for Alternative 1.

5.3.3.5 Alternative 4: West Side Gated Notch – Managed Flow

Alternative 4, West Side Gated Notch – Managed Flow, would have a smaller amount of flow entering the Yolo Bypass through the gated notch in Fremont Weir than some other alternatives, but it would incorporate water control structures to maintain inundation for longer periods of time within the northern portion of the Yolo Bypass. Alternative 4 would include the same gated notch and associated facilities as described for Alternative 3; however, it would be operated to limit the maximum inflow to 3,000 cfs. See Section 2.7 for more details on the alternative features. Implementation of Alternative 4 would result in direct and indirect effects on water supply.

5.3.3.5.1 Impact WS-1: Changes in CVP Water Supply Deliveries North of Delta

Table 5-17 shows the long-term average changes and dry and critical year changes that would occur in CVP deliveries to North of Delta contractors and wildlife refuges under Alternative 4 compared to Existing Conditions.

Table 5-17. Simulated 2030-Level Monthly Average Deliveries and Percent Change in Deliveries to North of Delta CVP Contractors and Wildlife Refuges under Existing Conditions Compared to Alternative 4

Month	Long-Term Average		Dry and Critical Average	
	Existing Conditions (cfs)	Alternative 4 Change (cfs [%])	Existing Conditions (cfs)	Alternative 4 Change (cfs [%])
October	1,506	0 (0)	1,559	0 (0)
November	726	0 (0)	770	0 (0)
December	389	0 (0)	402	0 (0)
January	234	0 (0)	232	0 (0)
February	244	0 (0)	248	0 (0)
March	337	0 (0)	415	0 (0)
April	5,113	0 (0)	5,464	0 (0)
May	5,599	0 (0)	5,274	0 (0)
June	7,987	0 (0)	7,382	0 (0)
July	7,932	0 (0)	7,252	0 (0)
August	5,983	0 (0)	5,381	0 (0)
September	2,046	0 (0)	1,798	0 (0)
Total (TAF)	2,310	0 (0)	2,193	0 (0)

Source: CalSim II Output for DEL_CVP_TOTAL_N

Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Table 5-18 shows the long-term average changes and dry and critical year changes that would occur in CVP deliveries to North of Delta contractors and wildlife refuges under Alternative 4 compared to the No Action Alternative.

Table 5-18. Simulated 2070-Level Monthly Average Water Supply Deliveries and Percent Change in Deliveries to North of Delta CVP Contractors and Wildlife Refuges under the No Action Alternative Compared to Alternative 4

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 4 Change (cfs [%])	No Action Alternative (cfs)	Alternative 4 Change (cfs [%])
October	1,473	0 (0)	1,479	0 (0)
November	705	1 (0)	722	0 (0)
December	382	0 (0)	387	0 (0)
January	224	0 (0)	221	0 (0)
February	236	-1 (0)	234	0 (0)
March	323	0 (0)	391	0 (0)
April	5,015	0 (0)	5,330	0 (0)
May	5,427	0 (0)	5,231	0 (0)
June	7,762	0 (0)	7,341	0 (0)
July	7,605	0 (0)	7,051	0 (0)
August	5,752	0 (0)	5,319	0 (0)

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 4 Change (cfs [%])	No Action Alternative (cfs)	Alternative 4 Change (cfs [%])
September	1,944	0 (0)	1,726	0 (0)
Total (TAF)	2,234	0 (0)	2,147	0 (0)

Source: CalSim II Output for DEL_CVP_TOTAL_N
Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Alternative 4 vs Existing Conditions

For 2030-level scenarios, deliveries to CVP North of Delta water service contractors and wildlife refuges would be similar for the long-term average and similar in dry and critical years under Alternative 4 compared to Existing Conditions. Average monthly and annual Alternative 4 deliveries would change less than one percent on average in each month and over the year relative to Existing Conditions for both long-term average and dry and critical year average. An additional analysis was modeled in CalSim II to assess impacts under the new 2018 COA agreement and findings remain unchanged. More information is provided in Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis.*

Alternative 4 vs No Action Alternative

For 2070-level scenarios, deliveries to CVP North of Delta water service contractors and wildlife refuges would be similar for the long-term average and similar in dry and critical years under Alternative 4 compared to the No Action Alternative. Average monthly and annual Alternative 4 deliveries would change less than one percent on average in each month and over the year relative to the No Action Alternative for both long-term average and dry and critical year average.

CEQA Conclusion

Changes in CVP deliveries to North of Delta contractors and wildlife refuges under Alternative 4 would be **less than significant** because changes to monthly and annual long-term and dry and critical year averages would be less than one percent relative to Existing Conditions.

5.3.3.5.2 Impact WS-2: Changes in CVP Water Supply Deliveries South of Delta

Table 5-19 shows the long-term average changes and dry and critical year changes that would occur in CVP deliveries to South of Delta contractors and wildlife refuges under Alternative 4 compared to Existing Conditions.

Table 5-19. Simulated 2030-Level Monthly Average Deliveries and Percent Change in Deliveries to South of Delta CVP Contractors and Wildlife Refuges under Existing Conditions Compared to Alternative 4

Month	Long-Term Average		Dry and Critical Average	
	Existing Conditions (cfs)	Alternative 4 Change (cfs [%])	Existing Conditions (cfs)	Alternative 4 Change (cfs [%])
October	2,670	0 (0)	2,580	0 (0)
November	1,585	0 (0)	1,517	0 (0)
December	1,151	0 (0)	1,068	0 (0)
January	1,274	0 (0)	1,142	0 (0)
February	1,718	0 (0)	1,554	0 (0)
March	2,083	0 (0)	1,667	0 (0)
April	2,592	0 (0)	1,984	0 (0)
May	3,755	0 (0)	2,871	0 (0)
June	5,447	0 (0)	4,008	0 (0)
July	5,876	0 (0)	4,205	0 (0)
August	5,010	0 (0)	3,790	0 (0)
September	3,413	0 (0)	2,921	0 (0)
Total (TAF)	2,214	0 (0)	1,773	**0 (0)**

Source: CalSim II Output for DEL_CVP_TOTAL_S

Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Table 5-20 shows the long-term average changes and dry and critical year changes that would occur in CVP deliveries to South of Delta contractors and wildlife refuges under Alternative 4 compared to the No Action Alternative.

Table 5-20. Simulated 2070-Level Monthly Average Water Supply Deliveries and Percent Change in Deliveries to South of Delta CVP Contractors and Wildlife Refuges under the No Action Alternative Compared to Alternative 4

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 4 Change (cfs [%])	No Action Alternative (cfs)	Alternative 4 Change (cfs [%])
October	2,541	0 (0)	2,441	0 (0)
November	1,483	0 (0)	1,406	0 (0)
December	1,013	0 (0)	925	0 (0)
January	1,043	0 (0)	908	0 (0)
February	1,435	0 (0)	1,270	0 (0)
March	1,900	0 (0)	1,627	-1 (0)
April	2,274	0 (0)	1,897	-1 (0)
May	3,350	-1 (0)	2,761	-1 (0)
June	4,776	-1 (0)	3,824	-1 (0)
July	5,105	-1 (0)	3,975	-1 (0)
August	4,521	-1 (0)	3,674	-1 (0)

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 4 Change (cfs [%])	No Action Alternative (cfs)	Alternative 4 Change (cfs [%])
September	3,213	0 (0)	2,876	0 (0)
Total (TAF)	1,977	0 (0)	1,669	**0 (0)**

Source: CalSim II Output for DEL_CVP_TOTAL_S
Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Alternative 4 vs Existing Conditions

For 2030-level scenarios, deliveries to CVP South of Delta water service contractors and wildlife refuges would be similar for the long-term average and similar in dry and critical years under Alternative 4 compared to Existing Conditions. Average monthly and annual Alternative 4 deliveries would change less than one percent on average in each month and over the year relative to Existing Conditions for both long-term average and dry and critical year average. An additional analysis was modeled in CalSim II to assess impacts under the new 2018 COA agreement and findings remain unchanged. More information is provided in Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis.*

Alternative 4 vs No Action Alternative

For 2070-level scenarios, deliveries to CVP South of Delta water service contractors and wildlife refuges would be similar for the long-term average and similar in dry and critical years under Alternative 4 compared to the No Action Alternative. Average monthly and annual Alternative 4 deliveries would change less than one percent on average in each month and over the year relative to the No Action Alternative for both long-term average and dry and critical year average.

CEQA Conclusion

Changes in CVP Deliveries South of Delta under Alternative 4 would be **less than significant** because changes to monthly and annual long-term and dry and critical year averages would be less than one percent relative to Existing Conditions.

5.3.3.5.3 Impact WS-3: Changes in SWP Water Supply Deliveries North of Delta

Table 5-21 shows the long-term average changes and dry and critical year changes that would occur in SWP deliveries to North of Delta contractors under Alternative 4 compared to Existing Conditions.

Table 5-21. Simulated 2030-Level Monthly Average Water Supply Deliveries and Percent Change in Deliveries to North of Delta SWP Contractors under Existing Conditions Compared to Alternative 4

Month	Long-Term Average		Dry and Critical Average	
	Existing Conditions (cfs)	Alternative 4 Change (cfs [%])	Existing Conditions (cfs)	Alternative 4 Change (cfs [%])
October	1,449	0 (0)	1,476	0 (0)
November	1,463	0 (0)	1,422	0 (0)
December	935	0 (0)	924	0 (0)
January	345	0 (0)	377	0 (0)
February	14	0 (0)	11	0 (0)
March	92	0 (0)	145	0 (0)
April	2,122	0 (0)	2,302	0 (0)
May	2,685	0 (0)	2,457	0 (0)
June	3,217	0 (0)	2,925	0 (0)
July	3,169	0 (0)	2,883	0 (0)
August	2,515	0 (0)	2,264	0 (0)
September	1,874	0 (0)	1,611	0 (0)
Total (TAF)	1,205	0 (0)	1,139	0 (0)

Source: CalSim II Output for DEL_SWP_TOTAL_N
Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Table 5-22 shows the long-term average changes and dry and critical year changes that would occur in SWP deliveries to North of Delta contractors under Alternative 4 compared to the No Action Alternative.

Table 5-22. Simulated 2070-Level Monthly Average Water Supply Deliveries and Percent Change in Deliveries to North of Delta SWP Contractors under the No Action Alternative Compared to Alternative 4

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 4 Change (cfs [%])	No Action Alternative (cfs)	Alternative 4 Change cfs [%])
October	1,383	4 (0)	1,275	-1 (0)
November	1,394	5 (0)	1,210	0 (0)
December	894	3 (0)	794	-1 (0)
January	328	-1 (0)	334	-2 (-1)
February	13	0 (0)	9	0 (0)
March	89	0 (0)	133	0 (0)
April	2,005	0 (0)	2,059	0 (0)
May	2,578	0 (0)	2,315	0 (0)
June	3,092	0 (0)	2,746	0 (0)
July	3,044	0 (0)	2,706	0 (0)
August	2,413	0 (0)	2,121	0 (0)
September	1,806	0 (0)	1,457	0 (0)
Total (TAF)	1,154	1 (0)	1,040	0 (0)

Source: CalSim II Output for DEL_SWP_TOTAL_N
Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Alternative 4 vs Existing Conditions

For 2030-level scenarios, deliveries to SWP North of Delta water service contractors would be similar for the long-term average and similar in dry and critical years under Alternative 4 compared to Existing Conditions. Average monthly and annual Alternative 4 deliveries would change less than one percent on average in each month and over the year relative to Existing Conditions for both long-term average and dry and critical year average. An additional analysis was modeled in CalSim II to assess impacts under the new 2018 COA agreement and findings remain unchanged. More information is provided in Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis.*

Alternative 4 vs No Action Alternative

For 2070-level scenarios, deliveries to SWP North of Delta water service contractors would be similar for the long-term average and similar in dry and critical years under Alternative 4 compared to the No Action Alternative. Average monthly and annual Alternative 4 deliveries would change less than one percent on average in each month and over the year relative to the No Action Alternative for both long-term average and dry and critical year average.

CEQA Conclusion

Changes in SWP Deliveries North of Delta under Alternative 4 would be **less than significant** because changes to monthly and annual long-term and dry and critical year averages would be less than one percent relative to Existing Conditions.

5.3.3.5.4 Impact WS-4: Changes in SWP Water Supply Deliveries South of Delta

Table 5-23 shows the long-term average changes and dry and critical year changes that would occur in SWP deliveries to South of Delta contractors under Alternative 4 compared to Existing Conditions.

Table 5-23. Simulated 2030-Level Monthly Average Deliveries and Percent Change in Deliveries to South of Delta SWP Contractors under Existing Conditions Compared to Alternative 4

Month	Long-Term Average		Dry and Critical Average	
	Existing Conditions (cfs)	Alternative 4 Change (cfs [%])	Existing Conditions (cfs)	Alternative 4 (cfs [%])
October	4,044	0 (0)	3,692	0 (0)
November	3,416	0 (0)	3,055	0 (0)
December	3,459	0 (0)	3,152	0 (0)
January	465	0 (0)	112	0 (0)
February	782	0 (0)	171	0 (0)
March	1,284	0 (0)	322	0 (0)
April	2,414	0 (0)	960	0 (0)
May	3,688	0 (0)	2,063	0 (0)
June	5,146	0 (0)	3,430	0 (0)
July	5,640	0 (0)	4,181	0 (0)
August	5,790	0 (0)	4,071	0 (0)
September	4,893	0 (0)	3,435	0 (0)

Month	Long-Term Average		Dry and Critical Average	
	Existing Conditions (cfs)	Alternative 4 Change (cfs [%])	Existing Conditions (cfs)	Alternative 4 (cfs [%])
Total (TAF)	2,486	0 (0)	1,739	0 (0)

Source: CalSim II Output for DEL_SWP_TOTAL_S

Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Table 5-24 shows the long-term average changes and dry and critical year changes that would occur in SWP deliveries to South of Delta contractors under Alternative 4 compared to the No Action Alternative.

Table 5-24. Simulated 2070-Level Monthly Average Water Supply Deliveries and Percent Change in Deliveries to South of Delta SWP Contractors under the No Action Alternative Compared to Alternative 4

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 4 Change (cfs [%])	No Action Alternative (cfs)	Alternative 4 (cfs [%])
October	4,043	0 (0)	3,562	-7 (0)
November	2,984	-4 (0)	2,730	-8 (0)
December	3,596	-14 (0)	2,956	-7 (0)
January	472	-3 (-1)	103	0 (0)
February	840	-1 (0)	164	1 (1)
March	1,531	-3 (0)	587	-1 (0)
April	2,542	-7 (0)	1,108	-14 (-1)
May	3,813	-8 (0)	2,098	-16 (-1)
June	5,165	-6 (0)	3,361	-9 (0)
July	5,535	-2 (0)	4,005	1 (0)
August	5,706	-3 (0)	3,960	-2 (0)
September	4,829	-4 (0)	3,387	-3 (0)
Total (TAF)	2,489	-3 (0)	1,701	-4 (0)

Source: CalSim II Output for DEL_SWP_TOTAL_S

Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Alternative 4 vs Existing Conditions

For 2030-level scenarios, deliveries to SWP South of Delta water service contractors would be similar for the long-term average and similar in dry and critical years under Alternative 4 compared to Existing Conditions. Average monthly and annual Alternative 4 deliveries would change less than one percent on average in each month and over the year relative to Existing Conditions for both long-term average and dry and critical year average. An additional analysis was modeled in CalSim II to assess impacts under the new 2018 COA agreement and findings remain unchanged. More information is provided in Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis.*

Alternative 4 vs No Action Alternative

For 2070-level scenarios, deliveries to SWP South of Delta water service contractors would be similar for the long-term average and similar in dry and critical years under Alternative 4 compared to the No Action Alternative. Average monthly and annual Alternative 4 deliveries would change less than one percent on average in each month and over the year relative to the No Action Alternative for both long-term average and dry and critical year average

CEQA Conclusion

Changes in SWP Deliveries South of Delta under Alternative 4 would be **less than significant** because changes to monthly and annual long-term and dry and critical year averages would be less than one percent relative to Existing Conditions.

5.3.3.5.5 Impact WS-5: Increase in Incidence of Term 91 Being Initiated

A comparison of the incidents of Term 91 being initiated was made between Existing Conditions and Alternative 4 for 2030-level scenarios and the No Action Alternative and Alternative 4 for 2070-level scenarios. Table 5-25 shows a comparison of the incidents of Term 91 being initiated, by month, for Alternative 4 and Existing Conditions and the No Action Alternative.

Table 5-25. Comparison of the Simulated Number of Incidents Term 91 Would Have Been Initiated under Existing Conditions or the No Action Alternative but Not under Alternative 4

Month	2030-Level Conditions		2070-Level Conditions	
	Term 91 Initiated Under Existing Conditions but Not Under Alternative 4 (Years)	Term 91 Initiated Under Alternative 4 but Not Under Existing Conditions (Years)	Term 91 Initiated Under No Action Alternative but Not Under Alternative 4 (Years)	Term 91 Initiated Under Alternative 4 but Not Under No Action Alternative (Years)
October	0	0	0	0
November	0	0	0	0
December	0	0	0	0
January	0	0	0	0
February	0	0	0	0
March	0	0	0	0
April	0	0	0	0
May	0	0	1	0
June	0	0	1	0
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
Total	0	0	2	0

Source: Term 91 Calculation

Alternative 4 vs Existing Conditions

For 2030-level scenarios, there would be no changes in the initiation of Term 91 between Existing Conditions and Alternative 4. An additional analysis was modeled in CalSim II to assess impacts under the new 2018 COA agreement and findings remain unchanged. More information is provided in Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis.*

Alternative 4 vs No Action Alternative

For 2070-level scenarios, there would be two months that Term 91 was initiated under the No Action Alternative but not under Alternative 4.

CEQA Conclusion

There would be no impact from increases in the incidents of Term 91 being initiated under Alternative 4 since there would be no differences in the incidents of Term 91 being initiated compared to Existing Conditions.

5.3.3.6 Alternative 5: Central Multiple Gated Notches

Alternative 5, Central Multiple Gated Notches, would have a smaller amount of flow entering the Yolo Bypass through the gated notch in Fremont Weir than some other alternatives, but it would incorporate water control structures to maintain inundation for longer periods of time within the northern portion of the Yolo Bypass. Alternative 5 would include the same gated notch and associated facilities as described for Alternative 3; however, it would be operated to limit the maximum inflow to 3,200 cfs. See Section 2.7 for more details on the alternative features. Implementation of Alternative 5 would result in direct and indirect effects on water supply.

5.3.3.6.1 Impact WS-1: Changes in CVP Water Supply Deliveries North of Delta

Table 5-26 shows the long-term average changes and dry and critical year changes that would occur in CVP deliveries to North of Delta contractors and wildlife refuges under Alternative 5 compared to Existing Conditions.

Table 5-26. Simulated 2030-Level Monthly Average Water Supply Deliveries and Percent Change in Deliveries to North of Delta CVP Contractors and Wildlife Refuges under Existing Conditions Compared to Alternative 5

Month	Long-Term Average		Dry and Critical Average	
	Existing Conditions (cfs)	Alternative 5 Change (cfs [%])	Existing Conditions (cfs)	Alternative 5 Change (cfs [%])
October	1,506	0 (0)	1,559	0 (0)
November	726	0 (0)	770	0 (0)
December	389	0 (0)	402	0 (0)
January	234	0 (0)	232	0 (0)
February	244	0 (0)	248	0 (0)
March	337	0 (0)	415	0 (0)

Month	Long-Term Average		Dry and Critical Average	
	Existing Conditions (cfs)	Alternative 5 Change (cfs [%])	Existing Conditions (cfs)	Alternative 5 Change (cfs [%])
April	5,113	0 (0)	5,464	0 (0)
May	5,599	0 (0)	5,274	0 (0)
June	7,987	0 (0)	7,382	0 (0)
July	7,932	0 (0)	7,252	0 (0)
August	5,983	0 (0)	5,381	0 (0)
September	2,046	0 (0)	1,798	0 (0)
Total (TAF)	2,310	0 (0)	2,193	0 (0)

Source: CalSim II Output for DEL_CVP_TOTAL_N
Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Table 5-27 shows the long-term average changes and dry and critical year changes that would occur in CVP deliveries to North of Delta contractors and wildlife refuges under Alternative 5 compared to the No Action Alternative.

Table 5-27. Simulated 2070-Level Monthly Average Water Supply Deliveries and Percent Change in Deliveries to North of Delta CVP Contractors and Wildlife Refuges under the No Action Alternative Compared to Alternative 5

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 5 Change (cfs [%])	No Action Alternative (cfs)	Alternative 5 Change (cfs [%])
October	1,473	0 (0)	1,479	0 (0)
November	705	0 (0)	722	0 (0)
December	382	1 (0)	387	0 (0)
January	224	0 (0)	221	0 (0)
February	236	-1 (0)	234	0 (0)
March	323	0 (0)	391	0 (0)
April	5,015	0 (0)	5,330	0 (0)
May	5,427	0 (0)	5,231	0 (0)
June	7,762	0 (0)	7,341	0 (0)
July	7,605	0 (0)	7,051	0 (0)
August	5,752	0 (0)	5,319	0 (0)
September	1,944	0 (0)	1,726	0 (0)
Total (TAF)	2,234	0 (0)	2,147	0 (0)

Source: CalSim II Output for DEL_CVP_TOTAL_N
Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Alternative 5 vs Existing Conditions

For 2030-level scenarios, deliveries to CVP North of Delta water service contractors and wildlife refuges would be similar for the long-term average and similar in dry and critical years under

Alternative 5 compared to Existing Conditions. Average monthly and annual Alternative 5 deliveries would change less than one percent on average in each month and over the year relative to Existing Conditions for both long-term average and dry and critical year average. An additional analysis was modeled in CalSim II to assess impacts under the new 2018 COA agreement and findings remain unchanged. More information is provided in Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis.*

Alternative 5 vs No Action Alternative

For 2070-level scenarios, deliveries to CVP North of Delta water service contractors and wildlife refuges would be similar for the long-term average and similar in dry and critical years under Alternative 5 compared to the No Action Alternative. Average monthly and annual Alternative 5 deliveries would change less than one percent on average in each month and over the year relative to the No Action Alternative for both long-term average and dry and critical year average.

CEQA Conclusion

Changes in deliveries to CVP North of Delta water service contractors and wildlife refuges under Alternative 5 would be **less than significant** because changes to monthly and annual long-term and dry and critical year averages would be less than one percent relative to Existing Conditions.

5.3.3.6.2 Impact WS-2: Changes in CVP Water Supply Deliveries South of Delta

Table 5-28 shows the long-term average changes and dry and critical year changes that would occur in CVP deliveries to South of Delta contractors and wildlife refuges under Alternative 5 compared to Existing Conditions.

Table 5-28. Simulated 2030-Level Monthly Average Deliveries and Percent Change in Deliveries to South of Delta CVP Contractors and Wildlife Refuges under Existing Conditions Compared to Alternative 5

Month	Long-Term Average		Dry and Critical Average	
	Existing Conditions (cfs)	Alternative 5 Change (cfs [%])	Existing Conditions (cfs)	Alternative 5 Change (cfs [%])
October	2,670	0 (0)	2,580	0 (0)
November	1,585	0 (0)	1,517	0 (0)
December	1,151	0 (0)	1,068	0 (0)
January	1,274	0 (0)	1,142	0 (0)
February	1,718	0 (0)	1,554	0 (0)
March	2,083	0 (0)	1,667	0 (0)
April	2,592	0 (0)	1,984	0 (0)
May	3,755	0 (0)	2,871	0 (0)
June	5,447	0 (0)	4,008	0 (0)
July	5,876	0 (0)	4,205	0 (0)
August	5,010	0 (0)	3,790	0 (0)

Month	Long-Term Average		Dry and Critical Average	
	Existing Conditions (cfs)	Alternative 5 Change (cfs [%])	Existing Conditions (cfs)	Alternative 5 Change (cfs [%])
September	3,413	0 (0)	2,921	0 (0)
Total (TAF)	2,214	0 (0)	1,773	0 (0)

Source: CalSim II Output for DEL_CVP_TOTAL_S
Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Table 5-29 shows the long-term average changes and dry and critical year changes that would occur in CVP deliveries to South of Delta contractors and wildlife refuges under Alternative 5 compared to the No Action Alternative.

Table 5-29. Simulated 2070-Level Monthly Average Water Supply Deliveries and Percent Change in Deliveries to South of Delta CVP Contractors and Wildlife Refuges under the No Action Alternative Compared to Alternative 5

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 5 Change (cfs [%])	No Action Alternative (cfs)	Alternative 5 Change (cfs [%])
October	2,541	0 (0)	2,441	0 (0)
November	1,483	0 (0)	1,406	0 (0)
December	1,013	0 (0)	925	0 (0)
January	1,043	0 (0)	908	-1 (0)
February	1,435	0 (0)	1,270	-1 (0)
March	1,900	0 (0)	1,627	1 (0)
April	2,274	0 (0)	1,897	0 (0)
May	3,350	0 (0)	2,761	0 (0)
June	4,776	-1 (0)	3,824	0 (0)
July	5,105	-1 (0)	3,975	0 (0)
August	4,521	0 (0)	3,674	0 (0)
September	3,213	0 (0)	2,876	0 (0)
Total (TAF)	1,977	0 (0)	1,669	0 (0)

Source: CalSim II Output for DEL_CVP_TOTAL_S
Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Alternative 5 vs Existing Conditions

For 2030-level scenarios, deliveries to CVP South of Delta water service contractors and wildlife refuges would be similar for the long-term average and similar in dry and critical years under Alternative 5 compared to Existing Conditions. Average monthly and annual Alternative 5 deliveries would change less than one percent on average in each month and over the year relative to Existing Conditions for both long-term average and dry and critical year average. An additional analysis was modeled in CalSim II to assess impacts under the new 2018 COA agreement and findings remain unchanged. More information is provided in Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis.*

Alternative 5 vs No Action Alternative

For 2070-level scenarios, deliveries to CVP South of Delta water service contractors and wildlife refuges would be similar for the long-term average and similar in dry and critical years under Alternative 5 compared to the No Action Alternative. Average monthly and annual Alternative 5 deliveries would change less than one percent on average in each month and over the year relative to the No Action Alternative for both long-term average and dry and critical year average.

CEQA Conclusion

Changes in deliveries to CVP South of Delta water service contractors and wildlife refuges under Alternative 5 would be **less than significant** because changes to monthly and annual long-term and dry and critical year averages would be less than one percent relative to Existing Conditions.

5.3.3.6.3 Impact WS-3: Changes in SWP Water Supply Deliveries North of Delta

Table 5-30 shows the long-term average changes and dry and critical year changes that would occur in SWP deliveries to North of Delta contractors under Alternative 5 compared to Existing Conditions.

Table 5-30. Simulated 2030-Level Monthly Average Water Supply Deliveries and Percent Change in Deliveries to North of Delta SWP Contractors under Existing Conditions Compared to Alternative 5

Month	Long-Term Average		Dry and Critical Average	
	Existing Conditions (cfs)	Alternative 5 Change (cfs [%])	Existing Conditions (cfs)	Alternative 5 Change (cfs [%])
October	1,449	0 (0)	1,476	0 (0)
November	1,463	0 (0)	1,422	0 (0)
December	935	0 (0)	924	0 (0)
January	345	0 (0)	377	0 (0)
February	14	0 (0)	11	0 (0)
March	92	0 (0)	145	0 (0)
April	2,122	0 (0)	2,302	0 (0)
May	2,685	0 (0)	2,457	0 (0)
June	3,217	0 (0)	2,925	0 (0)
July	3,169	0 (0)	2,883	0 (0)
August	2,515	0 (0)	2,264	0 (0)
September	1,874	0 (0)	1,611	0 (0)
Total (TAF)	1,205	0 (0)	1,139	0 (0)

Source: CalSim II Output for DEL_SWP_TOTAL_N
Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Table 5-31 shows the long-term average changes and dry and critical year changes that would occur in SWP deliveries to North of Delta contractors under Alternative 5 compared to the No Action Alternative.

Table 5-31. Simulated 2070-Level Monthly Average Water Supply Deliveries and Percent Change in Deliveries to North of Delta SWP Contractors under the No Action Alternative Compared to Alternative 5

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 5 Change (cfs [%])	No Action Alternative (cfs)	Alternative 5 Change (cfs [%])
October	1,383	0 (0)	1,275	-11 (-1)
November	1,394	-1 (0)	1,210	-15 (-1)
December	894	0 (0)	794	-9 (-1)
January	328	-2 (-1)	334	-5 (-1)
February	13	0 (0)	9	0 (0)
March	89	0 (0)	133	0 (0)
April	2,005	0 (0)	2,059	0 (0)
May	2,578	0 (0)	2,315	0 (0)
June	3,092	0 (0)	2,746	0 (0)
July	3,044	0 (0)	2,706	0 (0)
August	2,413	0 (0)	2,121	0 (0)
September	1,806	0 (0)	1,457	0 (0)
Total (TAF)	1,154	0 (0)	1,040	-3 (0)

Source: CalSim II Output for DEL_SWP_TOTAL_N

Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Alternative 5 vs Existing Conditions

For 2030-level scenarios, deliveries to SWP North of Delta water service contractors would be similar for the long-term average and similar in dry and critical years under Alternative 5 compared to Existing Conditions. Average monthly and annual Alternative 5 deliveries would change less than one percent on average in each month and over the year relative to Existing Conditions for both long-term average and dry and critical year average. An additional analysis was modeled in CalSim II to assess impacts under the new 2018 COA agreement and findings remain unchanged. More information is provided in Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis.*

Alternative 5 vs No Action Alternative

For 2070-level scenarios, deliveries to SWP North of Delta water service contractors would be similar for the long-term average and similar in dry and critical years under Alternative 5 compared to the No Action Alternative. Average monthly and annual Alternative 5 deliveries would change less than one percent on average in each month and over the year relative to the No Action Alternative for both long-term average and dry and critical year average.

CEQA Conclusion

Changes in deliveries to SWP North of Delta contractors under Alternative 5 would be **less than significant** because changes to monthly and annual long-term and dry and critical year averages would be less than one percent relative to Existing Conditions.

5.3.3.6.4 Impact WS-4: Changes in SWP Water Supply Deliveries South of Delta

Table 5-32 shows the long-term average changes and dry and critical year changes that would occur in SWP deliveries to South of Delta contractors under Alternative 5 compared to Existing Conditions.

Table 5-32. Simulated 2030-Level Monthly Average Deliveries and Percent Change in Deliveries to South of Delta SWP Contractors under Existing Conditions Compared to Alternative 5

Month	Long-Term Average		Dry and Critical Average	
	Existing Conditions (cfs)	Alternative 5 Change (cfs [%])	Existing Conditions (cfs)	Alternative 5 (cfs [%])
October	4,044	0 (0)	3,692	0 (0)
November	3,416	0 (0)	3,055	0 (0)
December	3,459	0 (0)	3,152	0 (0)
January	465	0 (0)	112	0 (0)
February	782	0 (0)	171	0 (0)
March	1,284	0 (0)	322	0 (0)
April	2,414	0 (0)	960	0 (0)
May	3,688	0 (0)	2,063	0 (0)
June	5,146	0 (0)	3,430	0 (0)
July	5,640	0 (0)	4,181	0 (0)
August	5,790	0 (0)	4,071	0 (0)
September	4,893	0 (0)	3,435	0 (0)
Total (TAF)	2,486	0 (0)	1,739	0 (0)

Source: CalSim II Output for DEL_SWP_TOTAL_S

Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Table 5-33 shows the long-term average changes and dry and critical year changes that would occur in SWP deliveries to South of Delta contractors under Alternative 5 compared to the No Action Alternative.

Table 5-33. Simulated 2070-Level Monthly Average Water Supply Deliveries and Percent Change in Deliveries to South of Delta SWP Contractors under the No Action Alternative Compared to Alternative 5

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 5 Change (cfs [%])	No Action Alternative (cfs)	Alternative 5 (cfs [%])
October	4,043	-1 (0)	3,562	-5 (0)

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 5 Change (cfs [%])	No Action Alternative (cfs)	Alternative 5 (cfs [%])
November	2,984	-4 (0)	2,730	-7 (0)
December	3,596	-15 (0)	2,956	-7 (0)
January	472	-3 (-1)	103	0 (0)
February	840	-2 (0)	164	-2 (-1)
March	1,531	-9 (-1)	587	-2 (0)
April	2,542	-10 (0)	1,108	-16 (-1)
May	3,813	-9 (0)	2,098	-19 (-1)
June	5,165	-8 (0)	3,361	-13 (0)
July	5,535	-4 (0)	4,005	-4 (0)
August	5,706	-6 (0)	3,960	-6 (0)
September	4,829	-6 (0)	3,387	-7 (0)
Total (TAF)	2,489	-5 (0)	1,701	-5 (0)

Source: CalSim II Output for DEL_SWP_TOTAL_S
Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Alternative 5 vs Existing Conditions

For 2030-level scenarios, deliveries to SWP South of Delta water service contractors would be similar for the long-term average and similar in dry and critical years under Alternative 5 compared to Existing Conditions. Average monthly and annual Alternative 5 deliveries would change less than one percent on average in each month and over the year relative to Existing Conditions for both long-term average and dry and critical year average. An additional analysis was modeled in CalSim II to assess impacts under the new 2018 COA agreement and findings remain unchanged. More information is provided in Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis.*

Alternative 5 vs No Action Alternative

For 2070-level scenarios, deliveries to SWP South of Delta water service contractors would be similar for the long-term average and similar in dry and critical years under Alternative 5 compared to the No Action Alternative. Average monthly and annual Alternative 5 deliveries would change less than one percent on average in each month and over the year relative to the No Action Alternative for both long-term average and dry and critical year average.

CEQA Conclusion

Changes in deliveries to SWP South of Delta contractors under Alternative 5 would be **less than significant** because changes to monthly and annual long-term and dry and critical year averages would be less than one percent relative to Existing Conditions.

5.3.3.6.5 Impact WS-5: Increase in Incidence of Term 91 Being Initiated

A comparison of the number of incidents of Term 91 being initiated was made between Existing Conditions and Alternative 5 for 2030-level scenarios and the No Action Alternative and Alternative 5 for 2070-level scenarios. Table 5-34 shows a comparison of the incidents of Term 91 being initiated, by month, for Alternative 5 and Existing Conditions and the No Action Alternative.

Table 5-34. Comparison of the Simulated Number of Incidents Term 91 Would Have Been Initiated under Existing Conditions or the No Action Alternative but Not under Alternative 5

Month	2030-Level Conditions		2070-Level Conditions	
	Term 91 Initiated Under Existing Conditions but Not Under Alternative 5 (Years)	Term 91 Initiated Under Alternative 5 but Not Under Existing Conditions (Years)	Term 91 Initiated Under No Action Alternative but Not Under Alternative 5 (Years)	Term 91 Initiated Under Alternative 5 but Not Under No Action Alternative (Years)
October	0	0	0	0
November	0	0	0	0
December	0	0	0	0
January	0	0	0	0
February	0	0	0	0
March	0	0	0	0
April	0	0	0	0
May	0	0	1	0
June	0	0	1	0
July	0	0	0	0
August	0	0	0	0
September	0	0	1	0
Total	0	0	3	0

Source: Term 91 Calculation

Alternative 5 vs Existing Conditions

For 2030-level scenarios, there would be no changes in the initiation of Term 91 between Existing Conditions and Alternative 5. An additional analysis was modeled in CalSim II to assess impacts under the new 2018 COA agreement and findings remain unchanged. More information is provided in Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis.*

Alternative 5 vs No Action Alternative

For 2070-level scenarios, there would be three months that Term 91 was initiated under the No Action Alternative but not under Alternative 5.

CEQA Conclusion

There would be no impact from increases in the number of Term 91 being initiated under Alternative 5 since there would be no differences in the number of incidents of Term 91 being initiated compared to Existing Conditions.

5.3.3.6.6 Tule Canal Floodplain Improvements (Program Level)

As described in Section 2.8.1.7, Alternative 5 would include floodplain improvements along Tule Canal, just north of Interstate 80. These improvements would not be constructed at the same time as the remaining facilities. They are included at a program level of detail to consider all the potential impacts and benefits of Alternative 5. Subsequent consideration of environmental impacts would be necessary before construction could begin.

The Tule Canal Floodplain improvements would not affect the timing of flows within the Yolo Bypass and would not increase or decrease the amount of flow within the Yolo Bypass in any months; therefore, these improvements would have no impact on water supply.

5.3.3.7 Alternative 6: West Side Large Gated Notch

Alternative 6, West Side Large Gated Notch, is a large notch in the western location that would allow flows up to 12,000 cfs. It was designed with the goal of entraining more fish by allowing more flow into the bypass when the Sacramento River is at lower elevations. See Section 2.9 for more details on the alternative features.

5.3.3.7.1 Impact WS-1: Changes in CVP Water Supply Deliveries North of Delta

Table 5-35 shows the long-term average changes and dry and critical year changes that would occur in CVP deliveries to North of Delta contractors and wildlife refuges under Alternative 6 compared to Existing Conditions.

Table 5-35. Simulated 2030-Level Monthly Average Deliveries and Percent Change in Deliveries to North of Delta CVP Contractors and Wildlife Refuges under Existing Conditions Compared to Alternative 6

Month	Long-Term Average		Dry and Critical Average	
	Existing Conditions (cfs)	Alternative 6 Change (cfs [%])	Existing Conditions (cfs)	Alternative 6 Change (cfs [%])
October	1,506	0 (0)	1,559	0 (0)
November	726	0 (0)	770	0 (0)
December	389	0 (0)	402	0 (0)
January	234	0 (0)	232	0 (0)
February	244	0 (0)	248	0 (0)
March	337	0 (0)	415	0 (0)
April	5,113	0 (0)	5,464	0 (0)
May	5,599	0 (0)	5,274	0 (0)
June	7,987	0 (0)	7,382	0 (0)
July	7,932	0 (0)	7,252	0 (0)

Month	Long-Term Average		Dry and Critical Average	
	Existing Conditions (cfs)	Alternative 6 Change (cfs [%])	Existing Conditions (cfs)	Alternative 6 Change (cfs [%])
August	5,983	0 (0)	5,381	0 (0)
September	2,046	0 (0)	1,798	0 (0)
Total (TAF)	2,310	0 (0)	2,193	0 (0)

Source: CalSim II Output for DEL_CVP_TOTAL_N
Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Table 5-36 shows the long-term average changes and dry and critical year changes that would occur in CVP deliveries to North of Delta contractors and wildlife refuges under Alternative 6 compared to the No Action Alternative.

Table 5-36. Simulated 2070-Level Monthly Average Water Supply Deliveries and Percent Change in Deliveries to North of Delta CVP Contractors and Wildlife Refuges under the No Action Alternative Compared to Alternative 6

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 6 Change (cfs [%])	No Action Alternative (cfs)	Alternative 6 Change (cfs [%])
October	1,473	0 (0)	1,479	0 (0)
November	705	1 (0)	722	0 (0)
December	382	1 (0)	387	0 (0)
January	224	0 (0)	221	0 (0)
February	236	0 (0)	234	0 (0)
March	323	0 (0)	391	0 (0)
April	5,015	0 (0)	5,330	0 (0)
May	5,427	0 (0)	5,231	0 (0)
June	7,762	0 (0)	7,341	0 (0)
July	7,605	0 (0)	7,051	0 (0)
August	5,752	0 (0)	5,319	0 (0)
September	1,944	0 (0)	1,726	0 (0)
Total (TAF)	2,234	0 (0)	2,147	0 (0)

Source: CalSim II Output for DEL_CVP_TOTAL_N
Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Alternative 6 vs Existing Conditions

For 2030-level scenarios, deliveries to CVP North of Delta water service contractors and wildlife refuges would be similar for the long-term average and similar in dry and critical years under Alternative 6 compared to Existing Conditions. Average monthly and annual Alternative 6 deliveries would change less than one percent on average in each month and over the year relative to Existing Conditions for both long-term average and dry and critical year average. An additional analysis was modeled in CalSim II to assess impacts under the new 2018 COA agreement and findings remain unchanged. More information is provided in Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis.*

Alternative 6 vs No Action Alternative

For 2070-level scenarios, deliveries to CVP North of Delta water service contractors and wildlife refuges would be similar for the long-term average and similar in dry and critical years under Alternative 6 compared to the No Action Alternative. Average monthly and annual Alternative 6 deliveries would change less than one percent on average in each month and over the year relative to the No Action Alternative for both long-term average and dry and critical year average.

CEQA Conclusion

Changes in deliveries to CVP North of Delta contractors and wildlife refuges under Alternative 6 would be **less than significant** because changes to monthly and annual long-term and dry and critical year averages would be less than one percent relative to Existing Conditions.

5.3.3.7.2 Impact WS-2: Changes in CVP Water Supply Deliveries South of Delta

Table 5-37 shows the long-term average changes and dry and critical year changes that would occur in CVP deliveries to South of Delta contractors and wildlife refuges under Alternative 6 compared to Existing Conditions.

Table 5-37. Simulated 2030-Level Monthly Average Deliveries and Percent Change in Deliveries to South of Delta CVP Contractors and Wildlife Refuges under Existing Conditions Compared to Alternative 6

Month	Long-Term Average		Dry and Critical Average	
	Existing Conditions (cfs)	Alternative 6 Change (cfs [%])	Existing Conditions (cfs)	Alternative 6 Change (cfs [%])
October	2,670	0 (0)	2,580	0 (0)
November	1,585	0 (0)	1,517	0 (0)
December	1,151	0 (0)	1,068	0 (0)
January	1,274	0 (0)	1,142	0 (0)
February	1,718	0 (0)	1,554	0 (0)
March	2,083	0 (0)	1,667	0 (0)
April	2,592	0 (0)	1,984	0 (0)
May	3,755	0 (0)	2,871	0 (0)
June	5,447	0 (0)	4,008	0 (0)
July	5,876	0 (0)	4,205	0 (0)
August	5,010	0 (0)	3,790	0 (0)
September	3,413	0 (0)	2,921	0 (0)
Total (TAF)	2,214	0 (0)	1,773	0 (0)

Source: CalSim II Output for DEL_CVP_TOTAL_N

Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Table 5-38 shows the long-term average changes and dry and critical year changes that would occur in CVP deliveries to South of Delta contractors and wildlife refuges under Alternative 6 compared to the No Action Alternative.

Table 5-38. Simulated 2070-Level Monthly Average Water Supply Deliveries and Percent Change in Deliveries to South of Delta CVP Contractors and Wildlife Refuges under the No Action Alternative Compared to Alternative 6

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 6 Change (cfs [%])	No Action Alternative (cfs)	Alternative 6 Change (cfs [%])
October	2,541	0 (0)	2,441	0 (0)
November	1,483	0 (0)	1,406	0 (0)
December	1,013	0 (0)	925	0 (0)
January	1,043	0 (0)	908	-1 (0)
February	1,435	0 (0)	1,270	-1 (0)
March	1,900	1 (0)	1,627	2 (0)
April	2,274	0 (0)	1,897	0 (0)
May	3,350	0 (0)	2,761	0 (0)
June	4,776	1 (0)	3,824	0 (0)
July	5,105	1 (0)	3,975	0 (0)
August	4,521	1 (0)	3,674	0 (0)
September	3,213	0 (0)	2,876	0 (0)
Total (TAF)	1,977	0 (0)	1,669	0 (0)

Source: CalSim II Output for DEL_CVP_TOTAL_S
Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Alternative 6 vs Existing Conditions

For 2030-level scenarios, deliveries to CVP South of Delta water service contractors and wildlife refuges would be similar for the long-term average and similar in dry and critical years under Alternative 6 compared to Existing Conditions. Average monthly and annual Alternative 6 deliveries would change less than one percent on average in each month and over the year relative to Existing Conditions for both long-term average and dry and critical year average. An additional analysis was modeled in CalSim II to assess impacts under the new 2018 COA agreement and findings remain unchanged. More information is provided in Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis.*

Alternative 6 vs No Action Alternative

For 2070-level scenarios, deliveries to CVP South of Delta water service contractors and wildlife refuges would be similar for the long-term average and similar in dry and critical years under Alternative 6 compared to the No Action Alternative. Average monthly and annual Alternative 6 deliveries would change less than one percent on average in each month and over the year relative to the No Action Alternative for both long-term average and dry and critical year average.

CEQA Conclusion

Changes in deliveries to CVP South of Delta contractors and wildlife refuges under Alternative 6 would be **less than significant** because changes to monthly and annual long-term and dry and critical year averages would be less than one percent relative to Existing Conditions.

5.3.3.7.3 Impact WS-3: Changes in SWP Water Supply Deliveries North of Delta

Table 5-39 shows the long-term average changes and dry and critical year changes that would occur in SWP deliveries to North of Delta contractors under Alternative 6 compared to Existing Conditions.

Table 5-39. Simulated 2030-Level Monthly Average Deliveries and Percent Change in Deliveries to North of Delta SWP Contractors under Existing Conditions Compared to Alternative 6

Month	Long-Term Average		Dry and Critical Average	
	Existing Conditions (cfs)	Alternative 6 Change (cfs [%])	Existing Conditions (cfs)	Alternative 6 Change (cfs [%])
October	1,449	0 (0)	1,476	0 (0)
November	1,463	0 (0)	1,422	0 (0)
December	935	0 (0)	924	0 (0)
January	345	0 (0)	377	0 (0)
February	14	0 (0)	11	0 (0)
March	92	0 (0)	145	0 (0)
April	2,122	0 (0)	2,302	0 (0)
May	2,685	0 (0)	2,457	0 (0)
June	3,217	0 (0)	2,925	0 (0)
July	3,169	0 (0)	2,883	0 (0)
August	2,515	0 (0)	2,264	0 (0)
September	1,874	0 (0)	1,611	0 (0)
Total (TAF)	1,205	0 (0)	1,139	0 (0)

Source: CalSim II Output for DEL_SWP_TOTAL_N
Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Table 5-40 shows the long-term average changes and dry and critical year changes that would occur in SWP deliveries to North of Delta contractors under Alternative 6 compared to the No Action Alternative.

Table 5-40. Simulated 2070-Level Monthly Average Water Supply Deliveries and Percent Change in Deliveries to North of Delta SWP Contractors under the No Action Alternative Compared to Alternative 6

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 6 Change (cfs [%])	No Action Alternative (cfs)	Alternative 6 Change (cfs [%])
October	1,383	0 (0)	1,275	0 (0)
November	1,394	3 (0)	1,210	0 (0)
December	894	0 (0)	794	0 (0)

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 6 Change (cfs [%])	No Action Alternative (cfs)	Alternative 6 Change (cfs [%])
January	328	-1 (0)	334	0 (0)
February	13	0 (0)	9	0 (0)
March	89	0 (0)	133	0 (0)
April	2,005	0 (0)	2,059	0 (0)
May	2,578	0 (0)	2,315	0 (0)
June	3,092	0 (0)	2,746	0 (0)
July	3,044	0 (0)	2,706	0 (0)
August	2,413	0 (0)	2,121	0 (0)
September	1,806	0 (0)	1,457	0 (0)
Total (TAF)	1,154	0 (0)	1,040	0 (0)

Source: CalSim II Output for DEL_SWP_TOTAL_N

Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Alternative 6 vs Existing Conditions

For 2030-level scenarios, deliveries to SWP North of Delta water service contractors would be similar for the long-term average and similar in dry and critical years under Alternative 6 compared to Existing Conditions. Average monthly and annual Alternative 6 deliveries would change less than one percent on average in each month and over the year relative to Existing Conditions for both long-term average and dry and critical year average. An additional analysis was modeled in CalSim II to assess impacts under the new 2018 COA agreement and findings remain unchanged. More information is provided in Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis.*

Alternative 6 vs No Action Alternative

For 2070-level scenarios, deliveries to SWP North of Delta water service contractors would be similar for the long-term average and similar in dry and critical years under Alternative 6 compared to the No Action Alternative. Average monthly and annual Alternative 6 deliveries would change less than one percent on average in each month and over the year relative to the No Action Alternative for both long-term average and dry and critical year average.

CEQA Conclusion

Changes in deliveries to SWP North of Delta contractors under Alternative 6 would be **less than significant** under Alternative 6 because changes to monthly and annual long-term and dry and critical year averages would be less than one percent relative to Existing Conditions.

5.3.3.7.4 Impact WS-4: Changes in SWP Water Supply Deliveries South of Delta

Table 5-41 shows the long-term average changes and dry and critical year changes that would occur in SWP deliveries to South of Delta contractors under Alternative 6 compared to Existing Conditions.

Table 5-41. Simulated 2030-Level Monthly Average Deliveries and Percent Change in Deliveries to South of Delta SWP Contractors under Existing Conditions Compared to Alternative 6

Month	Long-Term Average		Dry and Critical Average	
	Existing Conditions (cfs)	Alternative 6 Change (cfs [%])	Existing Conditions (cfs)	Alternative 6 (cfs [%])
October	4,044	0 (0)	3,692	0 (0)
November	3,416	0 (0)	3,055	0 (0)
December	3,459	0 (0)	3,152	0 (0)
January	465	0 (0)	112	0 (0)
February	782	0 (0)	171	0 (0)
March	1,284	0 (0)	322	0 (0)
April	2,414	0 (0)	960	0 (0)
May	3,688	0 (0)	2,063	0 (0)
June	5,146	0 (0)	3,430	0 (0)
July	5,640	0 (0)	4,181	0 (0)
August	5,790	0 (0)	4,071	0 (0)
September	4,893	0 (0)	3,435	0 (0)
Total (TAF)	2,486	0 (0)	1,739	0 (0)

Source: CalSim II Output for DEL_SWP_TOTAL_S

Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Table 5-42 shows the long-term average changes and dry and critical year changes that would occur in SWP deliveries to South of Delta contractors under Alternative 6 compared to the No Action Alternative.

Table 5-42. Simulated 2070-Level Monthly Average Water Supply Deliveries and Percent Change in Deliveries to South of Delta SWP Contractors under the No Action Alternative Compared to Alternative 6

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 6 Change (cfs [%])	No Action Alternative (cfs)	Alternative 6 (cfs [%])
October	4,043	-4 (0)	3,562	-11 (0)
November	2,984	-8 (0)	2,730	-14 (-1)
December	3,596	-20 (-1)	2,956	-18 (-1)
January	472	-4 (-1)	103	0 (0)
February	840	-4 (0)	164	-5 (-3)
March	1,531	-13 (-1)	587	-1 (0)
April	2,542	-14 (-1)	1,108	-20 (-2)
May	3,813	-14 (0)	2,098	-24 (-1)
June	5,165	-12 (0)	3,361	-16 (0)
July	5,535	-9 (0)	4,005	-6 (0)
August	5,706	-11 (0)	3,960	-9 (0)
September	4,829	-10 (0)	3,387	-8 (0)
Total (TAF)	2,489	-7 (0)	1,701	-8 (0)

Source: CalSim II Output for DEL_SWP_TOTAL_S

Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Alternative 6 vs Existing Conditions

For 2030-level scenarios, deliveries to SWP South of Delta water service contractors would be similar for the long-term average and similar in dry and critical years under Alternative 6 compared to Existing Conditions. Average monthly and annual Alternative 6 deliveries would change less than two percent on average in each month and over the year relative to Existing Conditions for both long-term average and dry and critical year average. An additional analysis was modeled in CalSim II to assess impacts under the new 2018 COA agreement and findings remain unchanged. More information is provided in Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis.*

Alternative 6 vs No Action Alternative

For 2070-level scenarios, supplies would generally decrease by less than one percent compared to the No Action Alternative, but these decreases could be larger during dry and critical years under Alternative 6 compared to the No Action Alternative. Several months during dry and critical years show average decreases up to three percent.

CEQA Conclusion

Changes in deliveries to SWP South of Delta contractors under Alternative 6 would be **less than significant** because changes to monthly and annual long-term and dry and critical year averages would be less than two percent compared to Existing Conditions relative to Existing Conditions.

5.3.3.7.5 Impact WS-5: Increase in Incidence of Term 91 Being Initiated

A comparison of the incidents of Term 91 being initiated was made between Existing Conditions and Alternative 6 for 2030-level scenarios and the No Action Alternative and Alternative 5 for 2070-level scenarios. Table 5-43 shows a comparison of the incidents of Term 91 being initiated, by month, for Alternative 6 and Existing Conditions and the No Action Alternative.

Table 5-43. Comparison of the Simulated Number of Incidents Term 91 Would Have Been Initiated under Existing Conditions or the No Action Alternative but Not under Alternative 6

Month	2030-Level Conditions		2070-Level Conditions	
	Term 91 Initiated Under Existing Conditions but Not Under Alternative 6 (Years)	Term 91 Initiated Under Alternative 6 but Not Under Existing Conditions (Years)	Term 91 Initiated Under No Action Alternative but Not Under Alternative 6 (Years)	Term 91 Initiated Under Alternative 6 but Not Under No Action Alternative (Years)
October	0	0	0	0
November	0	0	0	0
December	0	0	0	0
January	0	0	0	0
February	0	0	0	0
March	0	0	0	0
April	0	0	0	0

Month	2030-Level Conditions		2070-Level Conditions	
	Term 91 Initiated Under Existing Conditions but Not Under Alternative 6 (Years)	Term 91 Initiated Under Alternative 6 but Not Under Existing Conditions (Years)	Term 91 Initiated Under No Action Alternative but Not Under Alternative 6 (Years)	Term 91 Initiated Under Alternative 6 but Not Under No Action Alternative (Years)
May	0	0	1	0
June	0	0	1	0
July	0	0	0	0
August	0	0	0	0
September	0	0	1	0
Total	0	0	3	0

Source: Term 91 Calculation

Alternative 6 vs Existing Conditions

For 2030-level scenarios, there would be no changes in the initiation of Term 91 between Existing Conditions and Alternative 6. An additional analysis was modeled in CalSim II to assess impacts under the new 2018 COA agreement and findings remain unchanged. More information is provided in Appendix E, *CalSim II Assumptions and 2018 COA Sensitivity Analysis.*

Alternative 6 vs No Action Alternative

For 2070-level scenarios, there would be three months that Term 91 was initiated under the No Action Alternative but not under Alternative 6.

CEQA Conclusion

There would be no impact from increases in the number of Term 91 being initiated under Alternative 6 since there would be no differences in the number of incidents of Term 91 being initiated compared to Existing Conditions.

5.3.4 Summary of Impacts

Table 5-44 provides a summary of the identified impacts to surface water supply within the Project area.

Table 5-44. Summary of Impacts and Mitigation Measures for Surface Water Supply

Impact	Alternative	Level of Significance Before Mitigation	Mitigation Measures	Level of Significance After Mitigation
Impact WS-1: Changes in CVP Water Supply Deliveries North of Delta	No Action	LTS	--	LTS

Impact	Alternative	Level of Significance Before Mitigation	Mitigation Measures	Level of Significance After Mitigation
	1, 2, 3, 4, 5 (Project), 6	LTS	---	LTS
	5 (Program)	NI	---	NI
Impact WS-2: Changes in CVP Water Supply Deliveries South of Delta	No Action	S	--	S
	1, 2, 3, 4, 5 (Project), 6	LTS	---	LTS
	5 (Program)	NI	---	NI
Impact WS-3: Changes in SWP Water Supply Deliveries North of Delta	No Action	S	--	S
	1, 2, 3, 4, 5 (Project), 6	LTS	---	LTS
	5 (Program)	NI	---	NI
Impact WS-4: Changes in SWP Water Supply Deliveries South of Delta	No Action	S	--	S
	1, 2, 3, 4, 5 (Project), 6	LTS	--	LTS
	5 (Program)	NI	---	NI
Impact WS-5: Increase in Incidents of Term 91 Being Initiated	No Action	S	--	S
	All Action Alternatives	NI	---	NI

Key:
LTS = less than significant; NI = no impact; S = significant

5.4 Cumulative Impacts Analysis

This section describes the cumulative impacts analysis for surface water supply. Section 3.3, *Cumulative Impacts,* presents an overview of the cumulative impacts analysis, including the methodology and the projects, plans, and programs included in the cumulative impacts analysis.

5.4.1 Methodology

This evaluation of cumulative impacts for surface water supply considers the effects of the Project and how they might combine with the effects of other past, present, and future projects or actions to create significant impacts on specific resources. The area of analysis for these cumulative impacts includes the Yolo Bypass, the Delta, and the larger Sacramento River system. The timeframe for this cumulative impacts analysis includes the past, present, and probable future projects that could produce related or cumulative impacts in the area of analysis.

This cumulative impacts analysis uses the project analysis approach described in detail in Section 3.3, *Cumulative Impacts*.

5.4.2 Cumulative Impacts

Given that the Project would not result in a change in recurrence of Delta excess conditions, the Lead Agencies do not anticipate that the Project would contribute to cumulative impacts to Delta excess conditions. Several related and reasonably foreseeable projects and actions could result in impacts to CVP and SWP deliveries North and South of the Delta. The Bay-Delta Water Quality Control Plan Update and the Sacramento-San Joaquin Delta Estuary Total Maximum Daily Load for Methylmercury are ongoing activities and final determinations of the updates have not yet been made. However, all projects would implement their own mitigation measures to reduce impacts to less than significant levels.

Several of the local projects being analyzed serve to improve water supply within the region. The cumulative benefit of these projects, including the Delta Plan, the Sites Reservoir Project, the Shasta Lake Water Resources Investigation, and the North Bay Aqueduct Alternative Intake Project, also would serve to, at least in part, offset the water supply impacts associated with the projects described above.

Therefore, the cumulative impact of water supply, in both the long and short term, would be **less than significant**.

5.5 References

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6 Water Quality

This chapter presents existing water quality conditions and the regulatory setting for water quality in the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Project) area as well as environmental consequences and mitigation as they pertain to implementation of the Project alternatives.

6.1 Environmental Setting/Affected Environment

The water quality area of analysis includes waterbodies that could be affected by development of the Project alternatives, which would be constructed within the Yolo Bypass. Project alternatives would divert water from the Sacramento River into the Yolo Bypass, which would affect both the bypass (increased flow) and the river (decreased flow). Diverting more flow into the bypass may also have an impact downstream after water flow from the bypass and river are combined and enter the river delta.

The Yolo Bypass is a 59,300-acre contiguous floodplain area of the lower Sacramento River and conveys floodwaters from the Sacramento, American, and Feather rivers and their tributary watersheds. When flows in the lower Sacramento River exceed approximately 56,270 cubic feet per second (cfs), they begin to spill over Fremont Weir and enter the bypass (California Data Exchange Center [CDEC] 2017). Additionally, water from both the Sacramento and American rivers can enter the bypass via Sacramento Weir. These flood events affect the San Francisco Estuary and its two component regions, the Sacramento-San Joaquin Delta (Delta) and downstream water bodies, including Suisun, San Pablo, and San Francisco bays (Sommer et al. 2001). The Yolo Bypass also receives flow during flood and non-flood conditions from several westside tributaries, including Cache and Putah creeks, Willow Slough, and the Knights Landing Ridge Cut from the Colusa Basin. Figure 6-1 presents the Yolo Bypass and its tributaries, which form the water quality area of analysis.

6.1.1 Constituents of Concern

Various waterbodies that flow into the Yolo Bypass have been identified as impaired for certain constituents of concern on the 2012 303(d) list under the Clean Water Act (CWA). Water from these sources define existing water quality in the bypass.

CWA Section 303(d) requires states to identify waterbodies that do not meet applicable water quality standards after the application of certain technology-based controls on point source discharges. As defined in the CWA and Federal regulations, water quality standards include the designated beneficial uses of a waterbody, the adopted water quality criteria necessary to protect those uses, and an anti-degradation policy. As defined in the Porter-Cologne Water Quality Act (Porter-Cologne Act), water quality standards are associated with designated beneficial uses of a waterbody, the established water quality objectives (both narrative and numeric), and California's non-degradation policy (State Water Resources Control Board [SWRCB] Resolution No. 68-16). Section 6.2.1.1 contains a description of the CWA and the 303(d) listing process.

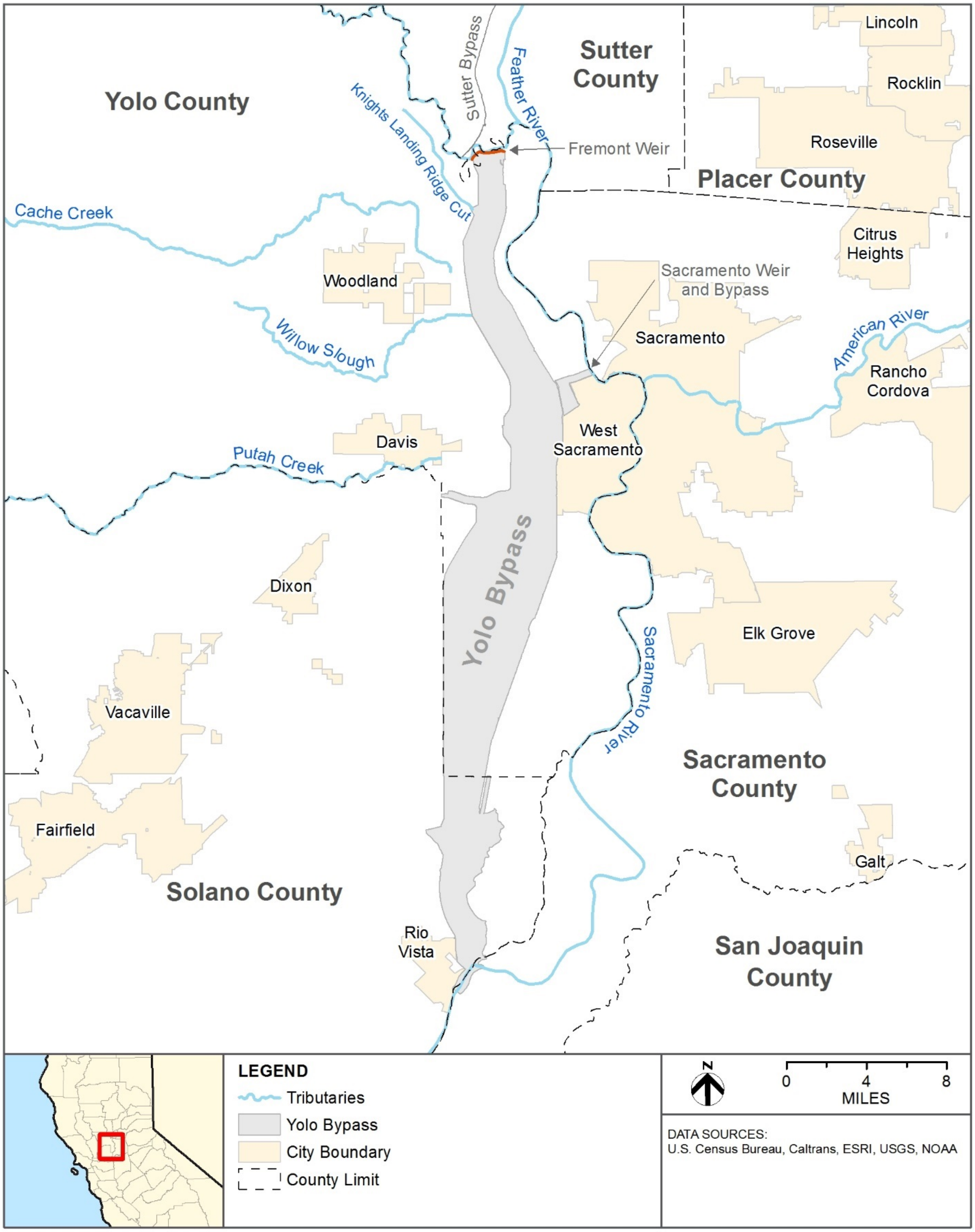


Figure 6-1. Water Quality Area of Analysis includes the Yolo Bypass and Tributaries.

Impaired waterbodies listed under 303(d) that deliver flow to the bypass or receive flow from the bypass, along with information concerning constituents that contribute to their impaired water quality are provided in Table 6-1.

Table 6-1. 303(d) Listed Waterbodies that deliver flow to the Yolo Bypass Area of Analysis and Their Associated Constituents of Concern

Name	Constituent	Potential Sources	Estimated Area Affected [1]	Proposed TMDL Completion Year	Region
Delta Waterways (northern portion)	Chlorpyrifos DDT Diazinon Invasive Species PCBs Mercury Toxicity	Source Unknown Source Unknown Source Unknown Source Unknown Source Unknown Agriculture/Atmospheric Deposition/Other Runoff/Industrial and Municipal Wastewater/Natural Sources/Resource Extraction Source Unknown	6,795 acres 6,795 acres 6,795 acres 6,795 acres 6,795 acres 6,795 acres 6,795 acres		Central Valley
Cache Creek, Lower	Boron Mercury Toxicity	Source Unknown Resource Extraction Source Unknown	96 miles 96 miles 96 miles	2021 2007 2019	Central Valley
Knights Landing Ridge Cut	Dissolved Oxygen Salinity	Source Unknown Source Unknown	13 miles 13 miles	2021 2021	Central Valley
Putah Creek	Mercury	Resource Extraction/ Source Unknown	27 miles	2017	Central Valley
Sacramento River (Red Bluff to Knights Landing Ridge Cut)	DDT Dieldrin Mercury PCBs Toxicity	Source Unknown Source Unknown Source Unknown Source Unknown Source Unknown	82 miles 82 miles 82 miles 82 miles 82 miles	2021 2021 2021 2021 2019	Central Valley
Sacramento River (Knights Landing Ridge Cut to the Delta)	Chlordane DDT Dieldrin Mercury PCBs Toxicity	Source Unknown Source Unknown Source Unknown Source Unknown Source Unknown Source Unknown	16 miles 16 miles 16 miles 16 miles 16 miles 16 miles	2021 2021 2022 2021 2021 2019	Central Valley
Tule Canal	Boron Indicator Bacteria Salinity	Source Unknown Source Unknown Source Unknown Source Unknown	11 miles 11 miles 11 miles 11 miles	2021 2021 2021 2021	Central Valley
Willow Slough	Boron Toxicity	Source Unknown Source Unknown	10 miles 10 miles	2021	Central Valley

Name	Constituent	Potential Sources	Estimated Area Affected [1]	Proposed TMDL Completion Year	Region
Willow Slough Bypass	Boron	Source Unknown	6 miles	2021	Central Valley
	Chlorpyrifos	Agriculture	6 miles	2021	
	Diuron	Agriculture	6 miles	2021	
	Indicator Bacteria	Source Unknown	6 miles		
	Malathion	Source Unknown	6 miles		
	Selenium	Source Unknown	6 miles		
	Specific Conductivity	Source Unknown	6 miles		
	Toxicity	Source Unknown	6 miles		

Source: SWRCB 2016.

Key: DDT = dichlorodiphenyltrichloroethane; E. coli = Escherichia coli; PCB = polychlorinated biphenyl; TMDL = Total Maximum Daily Load

[1] Estimated area affected is given as the surface area (acres) of lakes or estuaries or length (river miles) for river systems.

6.1.2 Beneficial Uses

Application of water quality objectives (i.e., standards) to protect designated beneficial uses is critical to water quality management in the State of California (State). State law defines beneficial uses to include (but not be limited to) "...domestic; municipal; agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves" (Water Code Section 13050(f)). Protection and enhancement of existing and potential beneficial uses are primary goals of water quality planning. Important points concerning the concept of beneficial uses are:

1. All water quality problems can generally be stated in terms of whether there is water of sufficient quantity or quality to protect or enhance beneficial uses (Central Valley Regional Water Quality Control Board [RWQCB] 2016).
2. Beneficial uses do not include all the reasonable uses of water. For example, disposal of wastewaters is not included as a beneficial use. Such disposal of wastewaters is not a prohibited use; it is merely a use that cannot be satisfied to the detriment of beneficial uses. Similarly, the use of water for the dilution of salts is not a beneficial use although it may, in some cases, be a reasonable and desirable use of water (Central Valley RWQCB 2016).
3. The protection and enhancement of beneficial uses require that certain quality and quantity objectives be met for surface and ground waters (Central Valley RWQCB 2016).
4. Fish, plants, other wildlife, and humans use water beneficially.

Beneficial uses designated for waters within the area of analysis are presented in Table 6-2. Beneficial uses designated for any specifically identified waterbody generally also apply to its tributary streams. In some cases, a beneficial use may not be applicable to the entire body of water. In these cases, RWQCB judgment is applied. Waterbodies within the basins that do not have beneficial uses designated are assigned municipal and domestic supply designations in accordance with the provisions of SWRCB Resolution No. 88-63. These municipal and domestic supply designations in no way affect the presence or absence of other beneficial uses in these waterbodies.

The Porter Cologne Water Quality Control Act defines water quality objectives as, "… the limits or levels of water quality constituents or characteristics which are established for the reasonable protections of the beneficial uses of water or the preventions of nuisance within a specified area" (Water Code Section 13050(h)). Basin Plans present water quality objectives in numerical or narrative format for specified waterbodies or for protection of specified beneficial uses throughout a specific basin or region.

6.1.3 Existing Conditions

The following sections summarize water quality for each of the waterbodies evaluated in the area of analysis and that deliver water to the bypass. The descriptions cover land use for each waterbody because land use can affect the quality of runoff that the waterbody receives and therefore the water quality of the waterbody itself. Where available, data describing general water quality parameters are presented.

6.1.3.1 Yolo Bypass

Inundation of Yolo Bypass occurs to some extent in approximately 70 percent of years (Nurmi 2017). From 1939-2011, an event lasting for at least one to two days with flows greater than 6,000 cfs occurred in about 70 percent of years (USGS 11453000 YOLO BYPASS NR WOODLAND CA). . The frequency, timing, extent, and duration of flood inundation is dependent on regional weather and climate. The bypass is designed to hold flows up to 500,000 cfs (Smalling et al. 2005) and inundate up to approximately 59,000 acres.

Table 6-2. Beneficial Uses of Waterbodies in the Yolo County Region[1]

Beneficial Use Designation	Yolo Bypass	Cache Creek (Clear Lake to the Yolo Bypass)	Putah Creek (Lake Berryessa to the Yolo Bypass)	Sacramento-San Joaquin Delta	Sacramento River (Colusa Basin to "I" Street Bridge)
Municipal and Domestic Supply (MUN)		X	X	X	X
Agricultural Supply – Irrigation (AGR)	X	X	X	X	X
Agricultural Supply – Stock Watering (AGR)	X	X	X	X	
Industrial Process Supply (PROC)		X		X	
Industrial Service Supply (IND)		X		X	
Water Contact Recreation (REC-1)	X	X	X	X	X
Canoeing and Rafting Recreation (REC-1)		X	X		X
Non-contact Water Recreation (REC-2)	X	X	X	X	X
Wildlife Habitat (WILD)	X	X	X	X	X
Navigation (NAV)				X	X

Beneficial Use Designation	Yolo Bypass	Cache Creek (Clear Lake to the Yolo Bypass)	Putah Creek (Lake Berryessa to the Yolo Bypass)	Sacramento-San Joaquin Delta	Sacramento River (Colusa Basin to "I" Street Bridge)
Cold Freshwater Habitat (COLD)	X	X	X	X	X
Warm Freshwater Habitat (WARM)	X	X	X	X	X
Cold Migration (MIGR)	X			X	X
Warm Migration (MIGR)	X			X	X
Cold Spawning (SPWN)		X			X
Warm Spawning (SPWN)	X	X	X	X	X

Source: Central Valley RWQCB 2016.

[1] Beneficial uses are taken from the most recent Water Quality Control Plan (July 2016) and do not include the recently adopted (May 2017) beneficial uses of Tribal Tradition and Culture (CUL), Tribal Subsistence Fishing (T-SUB), and Subsistence Fishing by other communities or individuals (SUB) because they have not yet been designated within this area.

The floodplain historically has been inundated as early as October and as late as June, with a typical peak period of inundation during January through March (Sommer et al. 2001). The primary input to the bypass is through Fremont Weir in the north, which conveys floodwaters from the Sacramento and Feather rivers. This occurs when the combined flow of the Sutter Bypass and Sacramento and Feather rivers cause river elevations at Fremont Weir to exceed 32 feet North American Vertical Datum of 1988 (NAVD 88) (CDEC 2017). In major storm events, additional water from the American and Sacramento rivers enter from the east via Sacramento Weir. Flows also enter from several small, impaired streams along the west side of the Yolo Bypass, including Knights Landing Ridge Cut, Cache Creek, Willow Slough Bypass, and Putah Creek. Inflows from these western streams are generally small in comparison to floodwater discharges over Fremont Weir; however, they are often the greatest source of freshwater to the floodplain in fall, spring, and during dry years when Sacramento River water does not spill over the weirs (Schemel et al. 2002). Inputs from these tributaries can be identified as bands in aerial photographs of the basin and can substantially augment the Sacramento basin floodwaters or cause localized floodplain inundation prior to Fremont Weir inputs (Sommer et al. 2001). Additionally, urban stormwater runoff and wastewater treatment facility discharges come from the University of California, Davis campus and cities of Davis and Woodland, 2.5 and 6.8 million gallons per day, respectively (City of Woodland 2005). The mean depth of the floodplain does not exceed three meters, except in extreme flood events (Sommer et al. 2001).

The basin empties to the Delta through the Toe Drain channel, and the waters continue to drain after floodwaters stop entering the bypass. Under high flooding events, the basin may also drain through Shag Slough and Liberty Cut. During drier months, the Toe Drain channel is the primary source of tidally influenced perennial water.

The Yolo Bypass Wildlife Area is in the central part of the Yolo Bypass, primarily south of I-80, and could be affected by increased inundation by Project alternatives. Several high priority pollutants of concern have been identified in the Yolo Bypass Wildlife Area Management Plan (California Department of Fish and Game [CDFG] 2008). These include mercury, other toxic chemicals, salinity, bacteria, selenium, and boron. Several of these pollutants have been identified in the contributing waterbodies to the Yolo Bypass as part of the 303(d) program. A brief discussion of some of the primary pollutants of concern is provided below, with information specific to each contributing waterbody in the sections that follow.

6.1.3.1.1 Mercury

Mercury (Hg) is a toxic pollutant that readily transports through the environment and accumulates in fish tissue in both contaminated and seemingly pristine aquatic ecosystems (Cabana et al. 1994). Methylmercury (MeHg), the organic form of the metal that accumulates in the food web, is a potent neurotoxin that can impair reproduction and fetal development (Ratcliffe et al. 1996, Weiner et al. 2002). It can also impair the smoltification and subsequent outward migration behavior in juvenile salmon.

Hg is an important contaminant in the Sacramento River watershed. Mercury released during gold mining operations in the Sierra Nevada and mercury mining along the eastern edge of the Central Valley from south of Paso Robles to north of the Bay Area are primary sources of Hg to rivers and lakes, including the Sacramento River and Yolo Bypass. Many of the more than 500 mercury mines in California have not been remediated and many continue to release mercury to the environment (CDFW 2017).

This section provides a summary of mercury environmental chemistry and toxicology, and a discussion of implications of project alternatives on MeHg production and bioaccumulation in the bypass.

Overview of Mercury Environmental Chemistry

Mercury occurs naturally as a mineral and is globally distributed throughout the environment by both natural and anthropogenic processes. Mercury exists in solid, liquid, and vapor forms at typical temperatures, which facilitate its widespread occurrence. Global cycling of mercury involves release of mercury to the atmosphere, subsequent transport by winds, and deposition of mercury to land and surface water. Some deposited mercury adheres to soil and sediment, and some is re-released as vapor to air completing the cycle (Agency for Toxic Substances and Disease Registry [ATSDR] 1999).

Human activity has added considerable mercury to the global cycle. Major anthropogenic sources of mercury releases to the environment include chlor-alkali production facilities; combustion of fossil fuels, primarily coal; production of cement; medical and municipal waste incinerators; and industrial/commercial boilers (USEPA 1996b).

In some cases, mercury is released directly to soils or surface waters without intervening atmospheric transport. In the Sacramento River watershed, such sources include elemental mercury used in placer mining for gold in the Sierra Nevada, and mercury mines in coastal ranges along the eastern edge of the Central Valley. Mining in the Cache Creek watershed (e.g., Sulfur Bank and Turkey Run) created mines that are still releasing mercury to Cache Creek and eventually to the Yolo Bypass. Discharge from the creek into the bypass was and is a major source of mercury now found in sediments in the bypass (Domagalski et al. 2004, Brown et al. 2015).

Cinnabar (HgS) is the only important ore of mercury and was the target for mines along the creek. The mineral is known for is bright red color and was used historically as a pigment. HgS is essentially insoluble, with a solubility product of about 10^{-52}. Under reducing conditions, HgS is quite stable. In the presence of oxygen, sulfur can be oxidized to sulfur oxyanions, releasing elemental mercury and mercury as Hg(I) and Hg(II) cations. In fact, processing of cinnabar involves heating the ore in the presence of oxygen (retorting) to convert Hg in cinnabar to elemental Hg vapor. The vapor is then cooled to condense Hg into its elemental, liquid form.

Historical mining of mercury thus converted stable, reduced ore bodies of HgS to cationic and elemental forms, which are far more mobile in the environment (ATSDR 1999). Some of these more mobile mercury forms enter global mercury cycling as fugitive vapors from ore processing, erosion and runoff from mine wastes, and release of process water.

In addition, some Hg that is released to surface water is bound to sediments, particularly HgS which erodes from mine wastes. Hg bound to particulates in sediments can be transformed by microbes into organic species, particularly MeHg. This process is most efficient in anaerobic (reducing) conditions. HgS is stable under these conditions. However, as mentioned above, HgS can be oxidized to ionic and elemental forms in aerobic conditions. These forms of mercury are available for methylation during periods of low oxygen concentrations (ATSDR 1999, Weiner et al. 2002, Marvin-DiPasquale et al. 2009).

Given this chemistry, methylation of mercury as HgS is efficient in aquatic systems where aerobic and anaerobic conditions alternate (e.g., Marvin-DiPasquale 2009, Henry et al. 2010). During drier seasons, mercury in surface sediments may be exposed to atmosphere and oxidized. Subsequently, in periods of inundation, microbial decomposition of organic matter in sediments can create anaerobic conditions that favor methylation. If periods of inundation are accompanied by deposition of additional HgS, MeHg production can continue seasonally for extended periods.

MeHg production in the bypass is ongoing and will continue regardless of whether any of the Alternatives is constructed. The focus of this the following discussion is what may happen when larger areas of flooded more often and, hence, subject to cyclical oxidative and reductive conditions. Since all areas of the bypass are currently subject to periodic flooding, soils throughout the bypass contain Hg that can be methylated. More frequent flooding will add Hg via deposition of suspended sediments to the existing inventory.

Further, MeHg produced at the sediment surface readily diffuses and enriches overlying waters, whereas MeHg produced deeper in the sediment diffuses through a layer of surface sediments and is less likely to reach the overlying water (Gill et al. 1999). Thus, situations where mercury is continually being deposited on the sediment surface, oxidized during dry periods, then subject to inundation and anaerobic conditions can be anticipated to result in substantial MeHg that is available for uptake into the food web.

MeHg production can be enhanced with freshly flooded soils. In a study of freshwater reservoirs, newly flooded soils took up to 10 to 20 years before MeHg production fell to levels similar to those found in other more established reservoirs (Bodaly et al. 2007). The study found that peak MeHg production in the sediment occurred within several years after permanent inundation; however, the lag in accumulation within the piscivorous species pushes the effects in the food web out to the 10- to 20-year mark. These time frames are likely to vary across sites and are not intended to represent what will occur if Hg sources to the bypass are eliminated. The time frames do provide an illustration of the extended periods of time that may be required for the mass of mercury available for methylation in sediments to be naturally attenuated.

MeHg is highly toxic (see below), soluble, and efficiently enters the food web. It accumulates in organisms that feed higher in the web and is a major source of mercury exposure for people and piscivorous mammals and birds that consume seafood (e.g., tuna) and freshwater fish. Piscivorous mammals (e.g., dolphins, whales, seals) also accumulate mercury in their tissues, at times to high levels, even in seemingly pristine environments such as the arctic (Wagemann et al. 1998).

Environmental Toxicology of Mercury

Mercury toxicity is complex, and the literature on this subject is voluminous. Included below is a summary of some of the key issues and hazards associated with MeHg production in sediments, particularly as they pertain to the Yolo Bypass. The discussion includes information on how mercury is taken into biota and how it is distributed, metabolized, and excreted in, to and from different tissues, as well as information on the adverse effects of mercury.

Toxicokinetics (absorption, distribution, metabolism, and excretion)

As noted above, mercury occurs in several of forms in the environment. Different forms of mercury vary in their impacts to human health and ecological receptors. Since the major issue for the Yolo Bypass, and, indeed, the Sacramento watershed, is the production and impacts of MeHg. This discussion of impacts focuses briefly on this aspect of mercury toxicology. A great deal of additional information on mercury toxicology can be found in the toxicology profile for this element produced by ATSDR (1999) for human toxicity and in Weiner et al. (2002) for impacts to wildlife.

When consumed (e.g., with a meal of seafood), about 95 percent of MeHg is absorbed from the gastrointestinal tract into the blood stream and is rapidly distributed to other parts of the body. MeHg that enters the brain and/or crosses the placenta into a developing child is of greatest concern. Ecologically, a similar concern arises for MeHg in the brain of predators and/or in developing offspring in utero or in eggs. MeHg can be changed in the brain and other tissues to inorganic mercury, typically Hg(II). In the brain, Hg(II) is trapped for extended periods. If exposure to mercury continues, inorganic mercury will accumulate to toxic levels. MeHg is excreted primarily in feces with a half-life of several months in most species. The limiting factor appears to be conversion to inorganic mercury in tissues other than brain. MeHg also exists in in breast milk, resulting in exposure of nursing young.

Toxicity

The nervous system is very sensitive to mercury toxicity, and kidneys are an important secondary target organ. In poisoning incidents that occurred in other countries, some people who ate fish contaminated with large amounts of MeHg or seed grains treated with MeHg or other organic mercury compounds developed permanent damage to the brain and kidneys (ATSDR 1999). Likewise, salmonids may suffer non-lethal neurological damage and reproductive effects in response to MeHg exposure (Weis 2009, Crump and Trudeau 2009). This toxicity can interfere with smoltification and migration behavior among other effects.

In utero, exposure caused severe mental dysfunction and associated birth defects in children whose mothers consumed contaminated seafood or grains. Less dramatic, but still severe and permanent, effects of MeHg exposure include personality changes (irritability, shyness, nervousness), tremors, changes in vision (constriction or narrowing of the visual field), deafness, muscle incoordination, loss of sensation, and difficulties with memory. Animal studies indicate that some similar effects have been observed following mercury exposure.

Mercury accumulates in the kidneys, making these organs also sensitive to the toxic effects of mercury. All forms of mercury can cause kidney damage if large enough amounts enter the body. Mercury produces similar kidney damage in non-mammals and birds. This damage slows urine production and can, with sufficiently long and intense exposure, cause complete and irreversible loss of kidney function. In salmonids, damage to kidneys can inhibit smoltification processes by impairing the ability of kidneys to excrete the larger salt loads that accompany migration to marine conditions (Niimi, AJ and Kissoon, GP. 1994, Depew et al. 2012).

In addition to the nervous system and kidneys, mercury can also cause damage to other internal organs. Such effects occur at higher levels of exposure, and additional information can be found in ATSDR (1999).

Mercury in the Yolo Bypass

Mercury is a prominent contaminant in sediments in the Yolo Bypass. Much of this mercury is apparently due to erosion and runoff from historical mercury mines in upstream watersheds during rainfall events, as evidenced by notably lower mercury loading during drought years (Domagalski et al. 2004).

Mercury in the form of HgS and Hg(II) in mine wastes (calcines) and elemental Hg released during ore processing were historically transported to Cache Creek and other streams via erosion and runoff during precipitation events and perhaps other mechanisms such as dumping, resulting in Hg bound to sediment particles in the Cache Creek stream bed. Downstream, floodwaters historically filled the Yolo Basin, adding Hg-contamination to basin sediment before construction of the bypass. This process continued after the construction of weirs and levees designed to control floodwaters in the Sacramento area using the bypass as a buffer. Release of mercury from mine wastes in the Cache Creek and other watersheds continues currently (CDFW 2017).

Sediment transport from Cache Creek to the bypass was reduced after 1938 by construction of the Cache Creek settling basin. This basin was intended to reduce sediment loading to the bypass. It also had the effect of reducing the load of mercury entering the bypass. The basin does capture substantial amounts of sediment. Brown, et al. (2015) indicated that sediment load entering the bypass is reduced by about 55 percent from load entering the settling basin. The basin is reasonably effective at reducing sediment (hence, Hg loading) to the bypass. Still, almost half of sediment load under flood conditions enters the bypass; perhaps a similar percentage of mercury load also enters along with this sediment. Importantly, periodic flood events mean that parts of the bypass are inundated only seasonally and exposed to atmosphere for at least part of the year. These areas undergo cyclic dry and wet periods conducive to MeHg formation.

The bypass is essentially a seasonal wetland, with periodic flows of shallow, slow -moving water over vegetated soils. In an analysis of a suite of wetlands managed for either agriculture or wildlife, the presence of shallow slow-moving[1] water, flooding and drying cycles, and the presence of plant matter, overall enhanced the production of MeHg (Windham-Myers et al. 2014). This evaluation also concluded that increased MeHg concentration in the shallow water column fostered higher uptake into aquatic organisms, ultimately, leading to elevated fish body burdens.

Mercury in bypass sediments is metabolized by sediment microbes, particularly sulfur- and iron-reducing bacteria, to MeHg. This mercury is taken up into the aquatic food web. Henry et al. (2010) found that mercury uptake is higher for smoltifying salmon in the bypass than uptake in the Sacramento River. Fish in the bypass also grew more rapidly than their counterparts in the River, and both MeHg production and greater consumption of contaminated food may play a role in observed higher tissue concentrations in fish from the bypass. This conclusion is supported by the lack of greater growth and MeHg accumulation in caged fish which would be unable to pursue food items over a wide area.

Further, it is not clear from available information whether mercury in tissues of juvenile salmon from the bypass may cause adverse effects. Juvenile salmon in the bypass appear to grow more rapidly than their counterparts in the adjacent river, suggesting that habitat in the bypass is more favorable than river habitat. Studies in the literature suggest that non-lethal neurological effects might occur when fish tissue concentrations exceed 0.1 to 0.3 ng MeHg/g (wet weight) (Beckvar 2005, Depew et al. 2012, Eagle-Smith 2016, Niime and Kissoon 1994). Juvenile salmon from the bypass recently showed MeHg concentrations in tissue 1/5th to 1/10th of these thresholds (Henry et al. 2010).

Shallow, slow moving water is an important habitat characteristic for juvenile salmon during their growth and smoltification stage of their migration to the Pacific (Suchanek 1984). Thus, the same factors that may promote MeHg production may also provide the benefits anticipated for implementation of Project alternatives.

Mercury Release to the Delta

Because of both natural and anthropogenic sources in the environment, mercury continually cycles in the aquatic environments of the Sacramento River basins and the Delta, with historical gold and mercury mining as primary anthropogenic sources in this region. Mercury mines in the Cache Creek and Putah Creek watersheds in the coastal ranges supplied much of the elemental mercury used for gold placer mining in the Sierra Nevada. The Cache Creek watershed in particular is implicated as the major source of Hg loading to the Delta and San Francisco Bay. Cache Creek has its mouth at the Yolo Bypass, and mercury from the creek must move through the bypass to reach the Delta (Domagalski et al. 2004, Brown et al. 2015).

When the Yolo Bypass is not flooded, the Sacramento and San Joaquin rivers are the largest sources of MeHg to the Delta, accounting for 60 percent of mercury entering the estuary (Central Valley RWQCB 2017). When the Yolo Bypass is flooded, it becomes the dominant source of MeHg to the Delta, and mass balance studies show that 40 percent of all MeHg exported from the Sacramento Basin is produced in the bypass even though it is typically flooded only two

[1] Flows in the bypass vary considerably with season and location. The intention here is to recognize that at some times and places water moves slowly enough for anaerobic conditions to develop, favoring the production of MeHg. No particular flow rate(s) is implied.

months of the year (Foe et al. 2008). Slotton (2007) observed that concentrations of MeHg in fish tissue increase following several months of Yolo Bypass flood flows, demonstrating that in-bypass flooding directly affects MeHg production and MeHg concentrations in fish tissue.

Research in the Delta and its tributaries indicates that sediment MeHg concentrations, mercury methylation and demethylation, uptake and bioaccumulation in the aquatic food web, and mass flux of MeHg from the sediment to overlying water and direct uptake by aquatic biota are all highly dynamic processes. Important factors affecting these processes include land use/community type (e.g., wetlands/marsh, agriculture, open water), location in the region, and other factors (e.g., hydrologic factors, salinity, pH, temperature, nutrients, sulfate, organic matter, and temporal-seasonal conditions [CDFG 2008; Benoit et al. 2003]).

Understanding of chemistry and impacts of MeHg production and subsequent uptake into the food web are dependent on site-specific information to bolster more general knowledge of sediment mercury contamination. Important gaps in understanding of bypass-specific issues exist that limit the evaluation of Project alternatives. A number of ongoing studies on various aspects of mercury in the bypass will eventually fill some of these gaps (Central Valley RWQCB 2017), and these efforts are considered as part of the cumulative effects analysis.

6.1.3.1.2 Organic Chemicals

Toxic chemicals, including pesticides, are included as 303(d) listed constituents of concern primarily in the Sacramento River. Due to agricultural land uses, pesticides are found throughout the waters and sediments of the bypass (CDFG 2008). The major pesticides that have been used on rice in this region are molinate, thiobencarb, and carbofuran. Molinate and thiobencarb are applied to control aquatic grasses and weeds on flooded rice fields, while carbofuran is applied to control insects. These chemicals have been shown in the past to be acutely toxic to fish and were attributed to objectionable taste issues in drinking water in the City of Sacramento (Domagalski et al. 2000). Over the past 15 years, molinate use has declined by nearly half while thiobencarb use has more than doubled, and carbofuran has been eliminated and partially replaced by the pyrethroid pesticide lambda-cyhalothrin (Orlando and Kuivila 2004).

A management program is currently in place that requires rice-field water to be retained on fields for one month following pesticide application to allow concentrations in water to be reduced through mechanisms such as volatilization, biological processes, or photo-degradation (Domagalski et al. 2000). The *Central Valley Basin Plan*, explained in Section 6.2.3.1, contains the following rice pesticide performance goals applicable to all waters designated as freshwater habitat: carbofuran (0.4 micrograms per liter [µg/L]), malathion (0.1 µg/L), methyl parathion (0.13 µg/L), molinate (10 µg/L) and thiobencarb (1.5 µg/L). The Basin Plan also contains a water quality objective of one µg/L for thiobencarb in waters designated for municipal and domestic supply (Central Valley RWQCB 2010). Additionally, pesticides such as DDT, which are no longer used, can still be detected in streambed sediments and in the tissues of aquatic organisms because of their persistent chemical characteristics.

A study published in 2007 to evaluate the potential sources of pesticides to the Yolo Bypass found that 13 current-use pesticides were detected in water samples collected in 2004 from the bypass, with the highest concentrations observed at input sites during high flows. Additionally, 13 current-use pesticides, along with residual DDT and its metabolites, were detected in bed and suspended sediments. Results indicate soil samples were dominated by DDT and its degradation products, but also contained a variety of current-use pesticides at lower concentrations (Smalling et al. 2007).

6.1.3.1.3 Salinity

High salt content is a concern for the entire bypass area (City of Woodland 2005). Salinity can reduce the productivity of bypass agricultural fields and may create problems for seasonal wetlands, including stress on microorganisms, plants, and animals. Urban water uses increase salts content in wastewater discharges and irrigation practices and leaching increases salt content of agricultural return flows. A water quality assessment completed as part of the *Yolo Bypass Water Quality Management Plan Report* (City of Woodland 2005) indicates that of 12 measured sample sites within the bypass region, salinity (measured as EC) within the agricultural drains of the Knights Landing Ridge Cut and Willow Slough Bypass had exceeded potentially acceptable EC criteria of 700 uS/cm. Readings at the Toe Drain averaged less than 500 uS/cm (City of Woodland 2005).

In-bypass salinity increases downstream through Tule Canal, but salinity at the farthest downstream site is lower than all other contributing sites, except the floodwaters (City of Woodland 2005).

6.1.3.1.4 Total Suspended Solids (TSS)

Sediment suspended in the water column is not a contaminant *per se* but is discussed because many contaminants bind to fine particulates and are transported, deposited, and resuspended along with sediment. Sediment enters the bypass as TSS in water from the Sacramento River at flood stage, and continuously in water from westside tributaries such as Cache and Putah Creeks. Project alternatives will increase water flow and, hence, sediment transport into the bypass by lowering the elevation where Sacramento River water spills over the Fremont Weir and enters the bypass. Contaminants bound to sediment from the river will therefore have a greater influence on sediment quality in the bypass after the weir is notched.

As discussed above, water entering the bypass comes largely from waterbodies listed as impaired for one or more toxic constituents. The Yolo Bypass is also listed as impaired partly as a result of transport of contamination from these waterbodies. Current use of agricultural pesticides in the bypass is a second source of contaminants in water and sediment and is subject to mitigation measures to reduce their impact.

Introducing additional Sacramento River sediment into the bypass may have several effects in the bypass. Some constituents of concern (e.g. Hg) may be diluted in sediments in some areas of the bypass as a result of mixing of river sediment with sediment from tributaries carrying sediment with higher Hg concentrations. The total load of constituents of concern for the river may increase in the bypass as a result of deposition of river sediment. Deposition of contaminated sediments may increase in some areas of the bypass where inundation is currently less frequent, but which will be inundated more often under Project alternatives. Total load of some constituents, particularly current-use pesticides, may increase as a result of both greater flow and inundation of greater areas in the bypass.

6.1.3.1.5 Temperature

One of the consequences of increased withdrawal of river water for human uses is an increase in water temperature due to lowered volume both in the withdrawn water and remaining water in the river. Increase of river temperatures from their natural levels can have far-reaching effects on local ecology, including alteration of community processes and facilitating invasion by exotic species (UC Davis 2017).

Native salmonid species are of great ecological, economic, and cultural importance to local communities. They also serve as strong indicators of habitat quality and integrity in river systems, particularly with regard to water temperature, sediment load, and barriers to passage. They are well-studied, including behavioral and physiological responses to temperature extremes. The Central Valley spring-run Chinook salmon is listed as a threatened species under the Endangered Species Act (ESA), giving them a high priority for restoration. The main threats to the remaining populations are loss and degradation of habitat.

Maximum water temperature is a critical part of habitat quality for salmonids. Temperature affects every aspect of salmonid biology, from feeding and growth rates to migration and spawning, and stress levels and survival. Rainbow trout, for example, are more severely impacted by temperatures in excess of 20°C than by fishing pressure.

Temperature is discussed at length in Section 8, *Aquatic Resources and Fisheries* and is not further evaluated under water quality.

6.1.3.2 Sacramento River

The Sacramento River from Red Bluff to Knights Landing is listed on the Section 303(d) list for DDT, dieldrin, mercury, PCBs, and unknown toxicity. The Sacramento River from Knights Landing Ridge Cut to the Delta is on the Section 303(d) list for chlordane, DDT, dieldrin, mercury, PCBs, and unknown toxicity. Table 6-3 provides an overview of general water quality data collected at three-month intervals from 2010-2016 as reported by the California DWR for the Sacramento River below Knights Landing (Figure 6-2). Also from this data set, Figure 6-3 presents total mercury samples collected below Knights Landing from 2012 through 2016 (2010-2012 not available). As seen in Figure 6-2, total mercury concentrations fall well below the California Toxics Rule threshold of 50 nanograms per liter (ng/L) total mercury in water for consumption of water and aquatic organisms (SWRCB 2017).

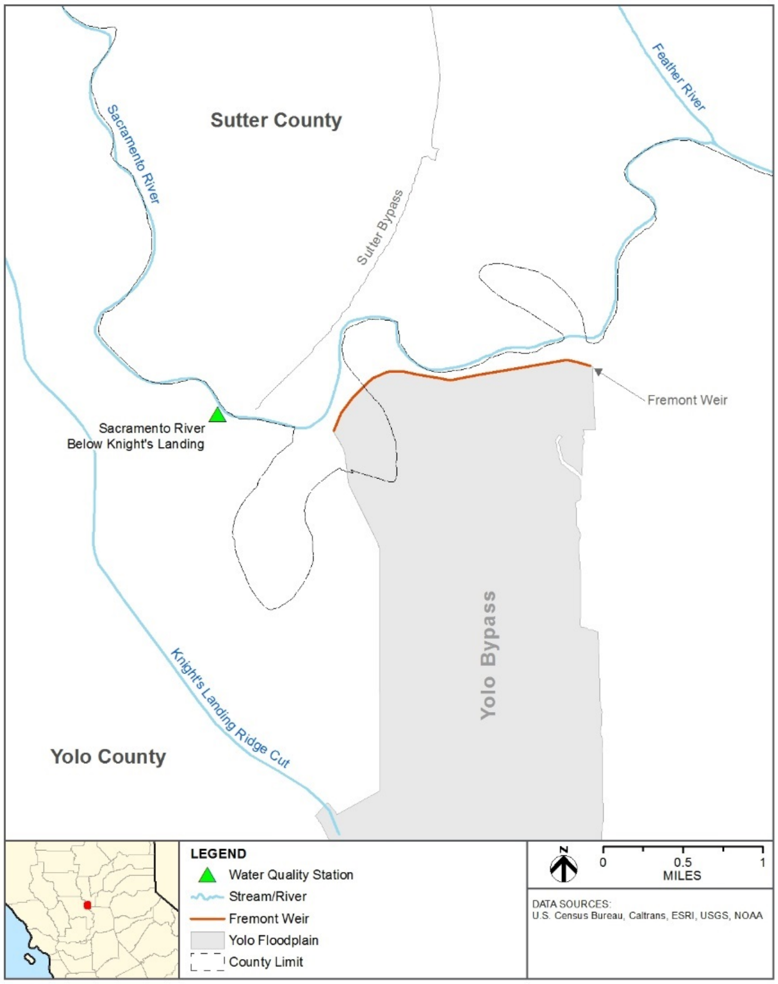
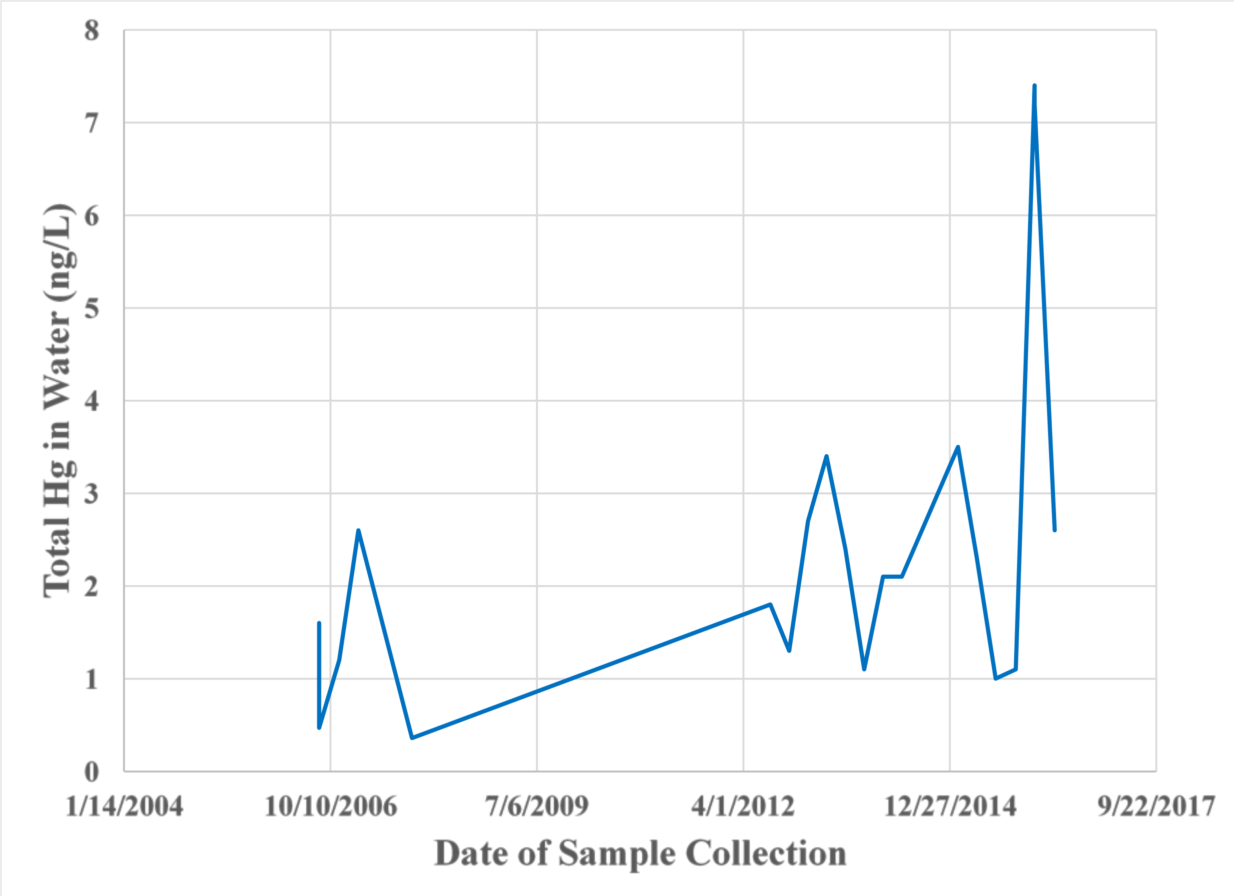


Figure 6-2. Sacramento River below Knights Landing Water Quality Monitoring Station

Table 6-3. Water Quality Parameters Sampled[1] on the Sacramento River below Knights Landing

Water Quality Parameter	Minimum	Maximum	Average
pH (standard units)	7.4	8.4	7.9
Turbidity (NTU)	4.3	64	13.3
Dissolved Oxygen (mg/L)	6.5	11.7	9.2
Total Organic Carbon (mg/L)	1.2	4.5	2.0
Total Nitrogen (mg/L)	0.02	0.94	0.16
Total Phosphorus (mg/L)	0.01	0.1	0.05
Electrical Conductivity (µS/cm)	140	462	235

Source: California Department of Water Resources (DWR) 2017
[1] Samples Collected 2/2010 – 11/2016
Key: mg/L = milligrams per liter; NTU = nephelometric turbidity units; µS/cm = microSiemens per centimeter



Source: California Department of Water Resources (DWR) 2017

Figure 6-3. Total Mercury in Water in the Sacramento River below Knights Landing

6.1.3.3 Western Stream Inputs

Inflows from western streams, including the Knights Landing Ridge Cut, Cache Creek, Willow Slough, and Putah Creek, are generally small in comparison to the Sacramento River floodwater influxes through Fremont Weir. However, these small streams serve as the primary source of freshwater to the floodplain in the fall and spring, and in dry years when the Sacramento River does not spill over the weir (Schemel et al. 2002). Water from Cache and Putah creeks is affected by upstream reservoirs, historical mining operations, agricultural return flows, and stormwater runoff. Water from each of these creeks is diverted for irrigation as it enters the bypass and eventually drains into the Toe Drain (Smalling et al. 2005). Willow Slough carries stormwater runoff and possibly agricultural and other discharges, as it principally drains agricultural areas west of the bypass and also conveys effluent from the City of Davis's wastewater treatment plant (Smalling et al. 2005). The Knights Landing Ridge Cut carries water from the Colusa Basin Drain to the Yolo Bypass. The Ridge Cut is an artificial overflow channel that connects the Colusa Basin Drain to the bypass. Under low-flow conditions, the Colusa Basin Drain discharges directly to the Sacramento River, but under high-flow conditions, water in the drain is directed through the Ridge Cut to the Yolo Bypass. Aerial observations suggest that inflows from the Knights Landing Ridge Cut and Cache Creek are the largest of the four western streams (Schemel et al. 2002).

Since much of the Yolo Bypass area is surrounded by and includes agricultural land use, inputs of pesticides, which could affect critical life stages of native fish, are a concern. A study completed in 2005 by the United States Geological Service assessed pesticide concentrations in water and sediment samples from six source watersheds to the bypass and three sites within the bypass during both dry and wet water years (Smalling et al 2005). Thirteen current-use pesticides and three insecticides were detected in surface water and sediment samples collected during the study. Suspended sediments had higher pesticide concentrations compared to bed sediments, indicating the potential for pesticide transport throughout the bypass, especially during high-flow events or during the first rainfall of the season as sediments move from the fields to the creeks (Smalling et al 2005).

6.1.3.4 Sacramento-San Joaquin Delta

Changes in inflows from the Sacramento River and Yolo Bypass could cause flow changes within the Delta.

Water quality in the Delta is highly variable temporally (timing) and spatially (location) and is a function of complex circulation patterns that are affected by inflows from the Sacramento River system, daily tidal inflows and outflows through the San Francisco Bay, pumping for Delta agricultural operations and exports, and operation of flow control structures. Existing water quality problems of the Delta system are of particular concern for portions of the Delta that are impaired by the presence of metals and pesticides. The relative concentrations of these constituents over time is closely related to the hydrodynamic conditions.

The Delta hydrodynamic conditions are primarily measured using the parameters of inflow and outflow as well as X2. X2 represents the geographic location of the 2 parts per thousand near-bottom salinity isohaline in the Delta, which is measured in distance upstream from the Golden Gate Bridge. The change in position of X2 is directly controlled by the other parameters (Delta inflow, river flows, and Delta exports). Given this connection, changes in the position of the X2 can be used to characterize likely changes in the other parameters. In the Bay-Delta Plan, a salinity value--or EC value--of 2.64 millimhos/centimeter (mmhos/cm) is used to represent the X2 location. The Bay-Delta Plan X2 objective requires specific daily or 14-day surface EC criteria, or 3-day averaged outflow requirements to be met for a certain number of days each month, February through June, at specific locations.

6.2 Regulatory Setting

This section describes the laws related directly to water quality. Several regulatory authorities at the Federal, State, and local level control the flow, quality, and supply of water in California. The Project is one of several efforts that individually and collectively seek to improve conditions in the bypass and/or meet the mercury TMDL. Coordination among these projects is necessary since actions such as proposed for the Project may need to be adjusted to be consistent with other actions considered for reducing mercury levels in water.

6.2.1 Federal Plans, Policies, and Regulations

Federal laws and regulations pertaining to surface water quality are discussed below.

6.2.1.1 Federal Clean Water Act

Growing public awareness and concern for controlling water pollution led to enactment of the Federal Water Pollution Control Act Amendments of 1972. As amended in 1977, this law became commonly known as the Clean Water Act. The CWA established the basic structure for regulating discharges of pollutants into the waters of the United States. It gave USEPA the authority to implement pollution control programs such as setting wastewater standards for industrial and municipal dischargers. The CWA also continued requirements to set water quality standards for all known contaminants in surface waters. The CWA made it unlawful for any person to discharge any pollutant from a point source into navigable waters unless a permit was obtained under its provisions (USEPA 2002).

Section 303(d) of the 1972 CWA requires states, territories, and authorized tribes to develop a list of water quality-impaired segments of waterways. The 303(d) list includes waterbodies that do not meet water quality standards for the specified beneficial uses of that waterway even after point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that these jurisdictions establish priority rankings for waterbodies on their 303(d) lists and implement a process, called Total Maximum Daily Loads (TMDLs), to meet water quality standards (USEPA 2002).

The TMDL process is a tool for implementing water quality standards and is based on the relationship between pollution sources and in-stream water quality conditions. The TMDL establishes the maximum allowable loadings of a pollutant that can be assimilated by a waterbody while still meeting applicable water quality standards. The TMDL provides the basis for the establishment of water quality-based controls. These controls should provide the pollution reduction necessary for a waterbody to meet water quality standards. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The TMDL’s allocation calculation for each waterbody must include a margin of safety to ensure the waterbody can be used for the State-designated uses. Additionally, the calculation must also account for seasonal variation in water quality (USEPA 2002).

TMDLs are intended to address all significant stressors that cause or threaten to cause waterbody beneficial use impairments, including point sources (e.g., wastewater treatment plant discharges), nonpoint sources (e.g., runoff from fields, streets, range, or forest land), and naturally occurring sources (e.g., runoff from undisturbed lands). TMDLs may be based on readily available information and studies. In some cases, complex studies or models are needed to understand how stressors are causing waterbody impairment. In many cases, simple analytical efforts provide an adequate basis for stressor assessment and implementation planning. TMDLs are developed to provide an analytical basis for planning and implementing pollution controls, land management practices, and restoration projects needed to protect water quality. States are required to include approved TMDLs and associated implementation measures in State water quality management plans. Within California, TMDL implementation is through regional Basin Plans.

The CWA also establishes the basic structure for regulating discharges of pollutants into the waters of the United States and gives USEPA the authority to implement pollution control programs such as setting wastewater standards for industries (USEPA 2002). In certain states such as California, USEPA has delegated authority to State agencies.

Water quality of waters of the United States subjected to a discharge of dredged or fill material is regulated under Section 404 of the CWA. These actions must not violate Federal or State water quality standards. Specifically, in the State of California, the RWQCB administers Section 401 and either issues or denies water quality certifications, depending upon whether the proposed discharge or fill material complies with applicable State and Federal laws.

In addition to complying with State and Federal water quality standards, all point sources that discharge into waters of the United States must obtain a National Pollutant Discharge Elimination System (NPDES) permit under provisions of Section 402 of the CWA. In California, SWRCB and RWQCBs are responsible for the implementation of the NPDES permitting process at the State and regional levels, respectively.

The NPDES permit process also provides a regulatory mechanism for the control of nonpoint source pollution created by runoff from construction and industrial activities and general and urban land use, including runoff from streets. Projects involving construction activities (e.g., clearing, grading, or excavation) involving land disturbance greater than one acre must file a Notice of Intent with the applicable RWQCB to indicate their intent to comply with the State General Permit for Stormwater Discharges Associated with Construction Activity (General Permit). The State General Permit specifies Best Management Practices (BMPs) to achieve compliance as well as numeric action levels to achieve Federal standards to minimize sediment and pollutant loadings. The General Permit requires preparation and implementation of a Stormwater Pollution Prevention Plan (SWPPP) as well as a Rain Event Action Plan prior to construction. The SWPPP and Rain Event Action Plan are intended to help identify the sources of sediment and other pollutants and assess the effectiveness of BMPs in preventing or reducing pollutants in storm water discharges and authorized non-storm water discharges. The CWA also requires that a permit be obtained from USEPA and United States Army Corps of Engineers when discharge of dredged or fill material into wetlands and waters of the United States occurs. Section 404 of the CWA requires USEPA and United States Army Corps of Engineers to issue individual and general permits for these activities.

6.2.2 State Plans, Policies, and Regulations

State laws and regulations pertaining to surface water quality are discussed below.

6.2.2.1 California Porter-Cologne Water Quality Control Act

The Porter-Cologne Act was enacted in 1969 and established the SWRCB. The Porter-Cologne Act defines water quality objectives as the limits or levels of water constituents that are established for reasonable protection of beneficial uses. Unlike the CWA, the Porter-Cologne Act applies to both surface and groundwater. The Porter-Cologne Act requires the nine semi-autonomous RWQCBs to establish water quality objectives while acknowledging that water quality may be changed to some degree without unreasonably affecting beneficial uses. Beneficial uses, together with the corresponding water quality objectives, are defined as standards, per Federal CWA regulations. Therefore, the regional plans provide the regulatory framework for meeting State and Federal requirements for water quality control. Changes in water quality are only allowed if the change is consistent with the most restrictive beneficial use designation identified by the State, does not unreasonably affect the present or anticipated beneficial uses, and does not result in water quality less than that prescribed in the water quality control plans (WQCP) (Central Valley RWQCB 2016).

A State of California General Permit for Discharges of Stormwater Associated with Construction Activity Construction General Permit Order 2009-0009-DWQ (as amended in 2010 and 2012) will be required prior to any ground disturbance that is greater than one acre or is part of a common plan of development greater than one acre. A Notice of Intent and SWPPP must be developed and electronically submitted to the Storm Water Multiple Application and Report Tracking System, an online database maintained by SWRCB. A qualified SWPPP Developer must prepare the SWPPP. The SWPPP, other permit-required documents, and monitoring data must be maintained on the construction site. A Qualified SWPPP Practitioner must implement the SWPPP during construction, including installation, inspection, and maintenance of BMPs required by the General Permit.

The General Permit requires dischargers to determine the relative risk levels at each construction site. The risk factors are based on the potential for sedimentation and impacts to downstream receiving waters.

Based on the site's risk level, the SWPPP must list BMPs the discharger will use to protect stormwater runoff as well as the placement of those BMPs. These measures may include but would not be limited to revegetation, silt fences, turbidity fences, mulching of unstabilized areas, dewatering structures, stormwater drainage system, and construction fencing. The SWPPP will require a visual monitoring program, a chemical monitoring program for the "non-visual" pollutants to be implemented if there is a failure of BMPs, and a sediment monitoring plan if the site discharges directly to a waterbody listed on the 303(d) list for sediment. This monitoring program will assess compliance with numeric action levels appropriate to the project. The SWPPP should also contain a site map(s), showing the construction site perimeter; existing and proposed buildings, lots, roadways, stormwater collection and discharge points; general topography both before and after construction; and drainage patterns across the project. At higher risk sites, Rain Event Action Plans must be developed to ensure active construction sites have adequate erosion and sediment controls implemented prior to forecasted storm events.

6.2.2.2 Water Quality Control Plans

The California Water Code (Section 13240) requires the preparation and adoption of WQCPs (Basin Plans), and the Federal CWA (Section 303) supports this requirement. According to Section 13050 of the California Water Code, Basin Plans consist of a designation or establishment for the waters within a specified area of beneficial uses to be protected, water quality objectives to protect those uses, and an implementation program needed for achieving the objectives. State law also requires that Basin Plans conform to the policies set forth in the Water Code, beginning with Section 13000, and any State policy for water quality control. The Basin Plans are regulatory references for meeting the State and Federal requirements for water quality control (40 Code Federal Regulations 131.20). One significant difference between the State and Federal programs is that California's basin plans also establish standards for groundwater in addition to surface water (Central Valley RWQCB 2016).

Basin Plans are adopted and amended by nine regional water boards under a structured process involving full public participation and State environmental review. Basin Plans and amendments do not become effective until approved by SWRCB. Regulatory provisions must be approved by the Office of Administrative Law. Adoption or revision of surface water standards is subject to the approval of USEPA.

Basin Plans complement other WQCPs adopted by the SWRCB such as the WQCP for Temperature Control and Ocean Waters. The SWRCB and the regional water boards maintain each Basin Plan in an updated and readily available edition that reflects the current water quality control programs.

The fourth edition of the Basin Plan for the Central Valley RWQCB pertains to the Sacramento and San Joaquin River basins. The Sacramento River Basin covers 27,210 square miles in the entire drainage area of the Sacramento River. It also includes the drainage sub-basins of Cache and Putah creeks.

In addition to specific plans to control water quality, the Water Quality Control Plan for the San Francisco Bay / Sacramento-San Joaquin Delta Estuary (SWRCB 2006) includes an objective to maintain water quality and other watershed conditions sufficient to achieve a doubling goal of natural production of Chinook salmon from the average production of 1967-1991.

6.2.2.2.1 Delta Mercury Control Program (Basin Plan Amendment)

The Delta Mercury Control Program (DMCP) was adopted by the Regional Board in April 2010 and approved by the USEPA in October 2011. The DMCP includes fish-tissue objectives for the Delta and MeHg load allocations for NPDES facilities, municipal storm water, agricultural lands, wetlands, and open water in the Delta and Yolo Bypass. The DMCP uses an adaptive management approach that contains two phases. Phase I (spanning from October 2011 through approximately October 2020) emphasizes studies and pilot projects to develop and evaluate management practices to control MeHg as well as the development of upstream mercury control programs for major tributaries, the development and implementation of a mercury exposure reduction program to protect humans, and the development of a mercury offset program. Phase II, beginning after Phase I ends, requires dischargers to implement MeHg control programs and continuation of mercury reduction programs. This phased approach is designed to protect people eating one meal per week of trophic levels 3 and 4 Delta fish, plus some non-Delta fish.

The program provides MeHg load and waste load allocations for each Delta subarea (Central Valley RWQCB 2011) (see Table 6-4, Sacramento River, Yolo Bypass, and Tributaries only).

Table 6-4. Methylmercury load allocations

Delta Subarea or Tributary	Current Load (g/yr)	Allocation (g/yr)
Sacramento River		
Agricultural drainage	36	20
Atmospheric wet deposition	5.6	5.6
Open water	140	78
Tributary Inputs	**2,034**	1,129
Wetlands	94	52
Yolo Bypass		
Agricultural drainage	19	4.1
Atmospheric wet deposition	4.2	4.2
Open water	100	22
Tributary Inputs	**462**	100
Wetlands	480	103
Cache Creek	-	30
Dixon Area	-	0.77
Fremont Weir	-	39
Knights Landing Ridge Cut	-	22
Putah Creek @ Mace Boulevard	-	2.4
Willow Slough	-	3.9

Source: Central Valley RWQCB 2011
Key: g/yr= grams per year
Bolded values emphasize the contribution of tributaries to mercury loads in the Sacramento River and Yolo Bypass

6.2.2.2.2 Cache Creek, North Fork Cache Creek, Bear Creek, and Harley Gulch Basin Plan Amendment

In October 2005, the Central Valley RWQCB adopted a Basin Plan amendment for methylmercury in Cache Creek, North Fork Cache Creek, Bear Creek, and Harley Gulch. The amendment was subsequently approved by the SWRCB and USEPA. The amendment added a beneficial use designation for Commercial and Sport Fishing on these waterways, and included water quality objectives for methylmercury in the waterways and in fish tissue (USEPA 2007).

6.2.2.2.3 Central Valley Pesticide and TMDL Basin Plan Amendment

In March 2014, the Central Valley RWQCB adopted Resolution RS-2014-0041 for control of diazinon and chlorpyrifos discharges. This amendment applies to the Sacramento and San Joaquin River basins in response to diazinon and chlorpyrifos concentrations, which exceed applicable water quality objectives. These contaminants are most often found in waterbodies because of application as a pesticide in agricultural areas. The aquatic life beneficial use is the most sensitive to both diazinon and chlorpyrifos. Maximum concentrations and averaging periods for each contaminant are listed in Table 6-5.

Table 6-5. Maximum concentrations and averaging periods for control of diazinon and chlorpyrifos discharges

Pesticide	Maximum Concentration (µg/L)	Averaging Period
Chlorpyrifos – acute	0.025	1-hour average
Chlorpyrifos – chronic	0.015	4-day average
Diazinon – acute	0.16	1-hour average
Diazinon – chronic	0.10	4-day average

Source: California Environmental Protection Agency 2014
Key: µg/L= micrograms per liter
Not to be exceeded more than once in a three-year period

6.2.2.2.4 Central Valley Diuron TMDL and Basin Plan Amendment

The Central Valley RWQCB is developing a proposed amendment to the water quality control plan to establish water quality objectives, TMDLs, and a program of implementation to control discharges of the herbicide diuron. Diuron is the most widely used herbicide in California for both agricultural and non-agricultural uses to control annual broadleaf and grassy weeds. Alternatives proposed for water quality objectives include the most recently used evaluation guideline of 1.3 µg/L, a guideline of 0 µg/L, indicating no detectable concentration in surface would be allowed, or an acute criterion of 170 µg/L and chronic criterion of 1.3 µg/L (Central Valley RWQCB 2012).

6.2.2.2.5 Central Valley Organochlorine Pesticide TMDL and Basin Plan Amendment

The Central Valley RWQCB is working toward a proposed amendment to the water quality control plan for the control of organochlorine pesticides, including DDTs and Group A pesticides, which have the ability to concentrate in sediments and fish. These pesticides historically have been used in urban, residential, and agricultural settings. Evaluation of targets is currently being completed (Central Valley RWQCB 2010b).

6.2.2.2.6 Central Valley Pyrethroid Pesticides TMDL and Basin Plan Amendment

In January 2017, the Central Valley RWQCB released proposed amendments to the water quality control plan for the control of pyrethroid pesticides discharges into selected surface waters in the Sacramento and San Joaquin river basins. Pyrethroids are currently widely used for structural pest control in urban and residential areas, in various consumer use pest control products, and in agriculture in the Central Valley, and have been found at levels of concern in the Sacramento and San Joaquin river basins since the early 2000s. The aquatic life beneficial use is the most sensitive pyrethroids. The proposed amendment offers a phased approach designed to monitor concentrations while moving toward water quality improvement. To determine appropriate levels for the pyrethroid concentration goals, the Central Valley RWQCB is currently recommending a methodology that directs use of the fifth percentile of the statistical species sensitivity distribution, unless a more sensitive species falls below that value. These criteria are all substantially lower than the concentrations currently observed in impaired waters, indicating reductions will need to be taken to attain water quality standards (Central Valley RWQCB 2017).

6.2.3 Regional and Local Plans, Policies, and Regulations

Regional and local plans and policies pertaining to surface water quality are discussed below.

6.2.3.1 Central Valley RWQCB Rice Pesticides Program

The Basin Plan states that the discharge of irrigation return flows containing carbofuran, malathion, methyl parathion, molinate, and thiobencarb is prohibited unless the discharger is following management practices approved by the Central Valley RWQCB. The plan further states that implementation of these management practices must be expected to result in compliance with the performance goals. The Basin Plan contains the following rice pesticide performance goals applicable to all waters designated as freshwater habitat: carbofuran (0.4 µg/L), malathion (0.1 µg/L), methyl parathion (0.13 µg/L), molinate (10 µg/L), and thiobencarb (1.5 µg/L). The Basin Plan also contains a water quality objective of one µg/L for thiobencarb in waters designated for municipal and domestic supply (Central Valley RWQCB 2010). As a result of 2009 thiobencarb monitoring, hold time requirements and outreach efforts were revised and continue to be in effect (Central Valley RWQCB 2016b).

6.2.3.2 Delta Protection Commission Land Use and Resource Management Plan for the Primary Zone of the Delta

The Delta Protection Commission (DPC) was created by the State legislature in 1992 with the goal of developing regional policies for the Delta to protect and enhance the existing land uses (agriculture, wildlife habitat, and recreation) in the primary zone. The DPC adopted the *Land Use and Resource Management Plan for the Primary Zone of the Delta* initially in 1995 and amended it most recently in 2010. A large portion of the Yolo Bypass is within the Primary Zone of the Delta. The DPC's *Land Use and Resource Management Plan for the Primary Zone of the Delta* states the following goal related to water quality (DPC 2010):

- Protect and enhance long-term water quality in the Delta for agriculture, municipal, industrial, water-contact recreation, and fish and wildlife habitat uses, as well as all other beneficial uses.

In addition, the plan includes two policies applicable to water quality (DPC 2010):

- State, federal, and local agencies shall be strongly encouraged to preserve and protect the water quality of the Delta both for in-stream purposes and for human use and consumption.

6.3 Ensure, for the sake of the environment and water quality, the provision of appropriate restroom, pump-out and other sanitation and waste management facilities at new and existing recreation sites.Environmental Consequences

This section describes the environmental consequences associated with the Project alternatives, and the No Action Alternative, on water quality. This section presents the assessment methods used to analyze the effects on water quality, the thresholds of significance that determine the significance of effects, and the potential environmental consequences and mitigation measures as they relate to each Project alternative. Detailed descriptions of the alternatives evaluated in this chapter are provided in Chapter 2, *Description of Alternatives*.

6.3.1 Methods for Analysis

This section describes the approach for the analysis of water quality in the Project area. The evaluation of impacts on water quality considers the potential for increased degradation of water quality and flow regimes in the Yolo Bypass region and receiving waterbodies such that it would cause violations of water quality standards or negatively impact assigned beneficial uses.

Note that a quantitative evaluation the impact of the action alternatives' mercury methylation is not currently possible. Modeling of impacts to mercury methylation is challenging because of seasonal variability in mercury release, deposition of mercury in sediment and subsequent formation of methylmercury, and uptake and accumulation of methylmercury in the food web. Information is currently insufficient to develop a functional tool to quantify methylmercury impacts. Impacts are discussed and evaluated at a qualitative level based on flow changes identified through the CalSim operational model (see Appendices E and G6 for more information).

Impacts to water quality are determined relative to existing conditions (for California Environmental Quality Act [CEQA]) and the No Action Alternative (for the National Environmental Policy Act [NEPA]). However, the No Action Alternative would be similar to existing conditions because water quality is not anticipated to experience substantive changes in the area of analysis. Therefore, the analysis compares the impacts of the action alternatives only to existing conditions.

6.3.2 Thresholds of Significance – CEQA

The thresholds of significance for impacts are based on the environmental checklist in Appendix G of the State CEQA Guidelines, as amended. These thresholds also encompass the factors considered under NEPA to determine the significance of an action in terms of its context and the intensity of its impacts. An impact resulting from the implementation of an alternative would be significant if it would:

- Result in the degradation of surface water quality such that it would exceed regulatory standards or would substantially impair beneficial uses of surface water

6.3.3 Effects and Mitigation Measures

This section provides an evaluation of the direct and indirect effects on water quality from implementing the Project alternatives. This analysis is organized by Project alternative, with specific impact topics numbered sequentially under each alternative.

6.3.3.1 No Action Alternative

Under the No Action Alternative, the Project would not be implemented, and none of the Project components would be developed. No Project-related construction activities or alteration of the Yolo Bypass region would occur. In addition to no changes in pesticides, herbicides, MeHg, TSS and salinity related to Project components, TMDL programs for MeHg, pesticides, and herbicides, as mentioned in Section 6.2.3, would continue in the region and would be likely to improve water quality.

CEQA Conclusion

Because no construction or alteration of the bypass under the existing conditions would occur, **no impact** to water quality in the area of analysis would ensue.

6.3.3.2 Alternative 1: East Side Gated Notch

Alternative 1, East Side Gated Notch, would allow increased flow from the Sacramento River to enter the Yolo Bypass through a gated notch on the east side of Fremont Weir. The invert of the new notch would be at an elevation of 14 feet, which is approximately 18 feet below the existing Fremont Weir crest. Alternative 1 would allow up to 6,000 cfs to flow through the notch, during periods when the river levels are not high enough to go over the crest of Fremont Weir, to provide open channel flow for adult fish passage. See Section 2.4 for more details on the alternative features.

6.3.3.2.1 Impact WQ-1: Construction- or maintenance-related degradation of surface water quality such that it would exceed regulatory standards or would substantially impair beneficial uses of surface water

Construction activities under Alternative 1 would involve demolition of a portion of the existing Fremont Weir; construction of a headworks structure, intake channel and outlet channel; and grading of the transport channel. These activities could affect water quality temporarily during the construction period. Possibilities include mobilizing sediment and associated contaminants during excavation and grading, release of construction-related chemicals such as oils, fuels, cement, solvents, etc. from improper handling or accidents.

Maintenance activities would include sediment removal every five years from the proposed transport channel and Tule Pond/Tule Canal within the Fremont Weir Wildlife Area using construction equipment to load and haul it from the bypass; these maintenance activities have the potential to affect water quality in the Yolo Bypass in the same ways as construction activities at the beginning of the project. Maintenance activities would not include dredging in the Sacramento River.

Contamination of the Sacramento River as well as its riverbanks and bed soils downstream of the Yolo Bypass could also occur during construction from leakage or accidental spills of petroleum products and other pollutants during construction. Improper handling, storage, or disposal of these materials could cause degradation of water quality the Sacramento River as well as the bypass.

CEQA Conclusion

Because Alternative 1 could increase downstream sedimentation and turbidity relative to existing conditions and might mobilize sediment-associated contaminants, the impact of construction and maintenance could be **significant** and any impact would depend on how well construction and maintenance are planned.

Mitigation Measure MM-HAZ-1: Implement a Construction Risk Management Plan (CRMP) to serve as a contingency plan for hazardous materials and waste operations, if encountered during construction, and construction near abandoned well sites.

The Lead Agencies and the contractor will prepare a CRMP that will include procedures to follow to identify soil contamination during excavation activities and the handling and disposal of any contaminated soil. The CRMP will also require DWR to obtain an opinion through the California Department of Conservation, Division of Oil, Gas, and Geothermal Resources Well Review Program prior to working near the sites. The CRMP will also identify procedures to follow for removal, handling, and disposal if underground storage tanks or other hazardous materials are found during construction of the site. The CRMP will be included in the final plans and specifications for project implementation.

Mitigation Measure MM-WQ-1: Implement a spill prevention, control, and countermeasure plan.

The Lead Agencies or their construction contractor shall develop and implement a Spill Prevention, Control, and Countermeasure Plan (SPCCP) to minimize the potential for, and effects from, spills of hazardous, toxic, and petroleum substances during construction and maintenance. The SPCCP shall be completed before construction activities begin. Implementation of this measure shall comply with State and Federal water quality regulations. The SPCCP shall describe spill sources and spill pathways in addition to the actions that shall be taken in the event of a spill (e.g., an oil spill from engine refueling shall be cleaned up immediately with oil absorbents) or the exposure of an undocumented hazard. The SPCCP shall outline descriptions of containment facilities and practices such as double-walled tanks, containment berms, emergency shut-offs, drip pans, fueling procedures, and spill response kits. It shall also describe how and when employees are trained in proper handling procedures and spill prevention and response procedures.

The Lead Agencies shall review and approve the SPCCP before the onset of construction activities and shall routinely inspect the construction area to verify that the measures specified in the SPCCP are properly implemented and maintained. The Lead Agencies shall notify its contractors immediately if there is a noncompliance issue and shall require compliance.

If a spill is reportable, the construction contractor's superintendent shall notify the Lead Agencies, and the Lead Agencies shall take action to contact the appropriate safety and cleanup crews to ensure the SPCCP is followed. A written description of reportable releases shall be submitted to the Central Valley RWQCB and the California Department of Toxic Substances Control. This submittal shall contain a description of the release, including the type of material and an estimate of the amount spilled, the date of the release, an explanation of why the spill occurred, and a description of the steps taken to prevent and control future releases. The releases shall be documented on a spill report form.

Mitigation Measure MM-WQ-2: Implement a stormwater pollution and prevention plan.

Prior to initiating construction and maintenance activities, the construction contractor shall prepare an SWPPP that describes BMPs that shall be implemented to control accelerated erosion, sedimentation, and other pollutants during and after Project construction. Specific BMPs that shall be incorporated into the SWPPP shall be site-specific and shall be prepared in accordance with the regional water board field manual. The SWPPP shall include, but not be limited to, the following standard erosion- and sediment-control BMPs:

- **Timing of construction.** All construction and ongoing operations and maintenance activities shall occur from April 15 through November 1 to avoid ground disturbance in the rainy season.
- **Stabilize grading spoils.** Grading spoils generated during construction may be temporarily stockpiled in staging areas located within two miles of Yolo Bypass. Such staging areas shall not contain native or sensitive vegetation communities and shall not support sensitive plant or animal species. Silt fences, non-monofilament fiber rolls, or similar devices shall be installed around the base of the temporary stockpiles to intercept runoff and sediment during storm events. If necessary, temporary stockpiles may be covered with a geotextile material to increase protection from wind and water erosion. Materials used for stabilizing spoils will be selected to be non-injurious to wildlife
- **Permanent site stabilization.** The construction contractor shall install structural or vegetative methods to permanently stabilize all graded or disturbed areas once construction is complete. Structural methods could include installing biodegradable fiber rolls or erosion-control blankets. Vegetative methods could include applying organic mulch and tackifiers, and/or an erosion-control native seed mix.
- **Staging of construction equipment and materials.** Equipment and materials shall be staged in designated staging areas that meet the requirements identified above regarding stabilizing grading spoils.
- **Minimize soil and vegetation disturbance.** The construction contractor shall minimize ground disturbance and the disturbance and/or destruction of existing vegetation. This shall be accomplished, in part, through establishing designated equipment staging areas, ingress and egress corridors, equipment exclusion zones and protecting existing trees before beginning any grading operations.
- **Install sediment barriers.** The construction contractor shall install silt fences, fiber rolls, or similar devices to prevent sediment-laden water from leaving the construction area to the extent feasible in areas where construction is occurring in saturated soils.

Mitigation Measure MM-WQ-3: Develop a turbidity monitoring program.

The Basin Plan for the Sacramento River and San Joaquin River basins (Fourth Edition) (Central Valley RWQCB 2016) contains turbidity objectives. Specifically, the plan states that where natural turbidity is between five and 50 NTUs, turbidity levels may not be elevated by 20 percent above ambient conditions; where ambient conditions are between 50 and 100 NTUs, conditions may not be increased by more than 10 NTUs; and where natural turbidity is greater than 100 NTUs, increases shall not exceed 10 percent. A sampling plan shall be developed and implemented based on specific site conditions and in consultation with the Central Valley RWQCB. If turbidity limits exceed basin plan standards, construction-related earth-disturbing activities shall slow to a point that would alleviate the problem.

Implementation of the CRMP, SPCCP, SWPPP, construction BMPs, and turbidity monitoring plan included in MM-HAZ1 and MM-WQ-1 through MM-WQ-3, respectively, would minimize all water quality risks, and, therefore, the impact would be reduced to **less than significant**.

6.3.3.2.2 Impact WQ-2: Operation-related degradation of surface water quality such that it would exceed regulatory standards or would substantially impair beneficial uses of surface water

Alternative 1 will result in inundation of the Yolo Bypass seasonally during times when water would not flow over the Fremont Weir under existing conditions. Agricultural land constitutes the majority of the area within the bypass, followed by wetlands and fallow land. Crop types and land use are further discussed in Chapter 11, *Land Use and Agricultural Resources*. Past and current application of pesticides and herbicides within the bypass have led to listing of many of these chemicals as pollutants of concern in the *Yolo Bypass Wildlife Area Land Management Plan* (CDFG 2008) as well as the *Central Valley Region Basin Plan* and *Yolo Bypass Water Quality Management Plan Report* (City of Woodland 2005). Changes to flows into the Yolo Bypass have the potential to affect water quality within the Yolo Bypass or downstream in the Delta.

Alternative 1, East Side Gated Notch, would allow increased flow from the Sacramento River to enter the Yolo Bypass through a gated notch. The bottom of the notch (the “invert”) would be at an elevation of 14 feet, which is approximately 18 feet below the existing Fremont Weir crest. Water would be able to flow through the proposed notch during periods when the river levels are not high enough to go over the crest of Fremont Weir. The additional flow from the gated notch would add water to the bypass from the Sacramento River during flows that would be considered non-flood events under existing conditions. The increased frequency of inundation from the Sacramento River due to the gated notch would allow greater areas within the bypass to be inundated seasonally. Since water quality in the Sacramento River would not be affected by the alternative, constituents of concern (see Table 6-1) entering the bypass would not be expected to change in comparison to existing conditions. However, the total load of contaminants would increase, depending in large measure on TSS in the river. Key contaminants such as Hg are mainly transported bound to sediment particles and the amount of sediment in water entering the bypass will be a critical determinant of the load of contaminants. The highest sediment loads in the river typically occur during periods of high runoff. When flood-conditions are not present, TSS may be lower and concentrations of sediment-bound contaminants such as Hg would be lower.

One water quality variable of particular concern in the Yolo Bypass is MeHg. Historical mining on Cache Creek and Putah Creek results in substantial contributions of inorganic mercury to the Yolo Bypass, and mercury methylation causes this mercury to enter the foodweb. Wetlands support the methylation process, and MeHg levels are increased in seasonal wetlands. Elevated MeHg uptake in aquatic biota and subsequent MeHg export to the Delta have been observed as a result of flooding in the Yolo Bypass, in particular the flooding of formerly dry or mostly dry soils (Slotton et al. 2007; Foe et al. 2008).

Additional inundation of the bypass (i.e. greater areas subject to periodic flooding) under Alternative 1 would likely increase net methylation, which could in turn increase the total amount of MeHg entering the foodweb within the bypass. It is not clear, however, whether increased total MeHg production would increase the amount of MeHg in fish tissues, or instead support growth and smoltification of juvenile salmon over a greater area where MeHg production is similar to production under existing conditions. MeHg production on a per unit area basis may not change substantially because notching would not affect water quality of sources of water to the bypass. Thus, Alternative 1 may expand conditions for juvenile salmon in a manner that resembles existing conditions, rather than increase the impact of MeHg production on uptake of MeHg into fish.

Total production of MeHg is likely to increase under Alternative 1 due to seasonal inundation of greater areas within the bypass. Most mercury methylation in an aquatic ecosystem occurs within the sediments and then diffuses out into the overlying water. Larger areas of inundation compared to existing conditions where efficient MeHg production may take place would increase export of total MeHg from the bypass to the Delta.

Increased total MeHg production might not increase, however, since mercury sources to the bypass would not be affected by construction of Alternative 1. Instead, MeHg concentrations might remain similar to existing conditions, with the main impact being expansion of the MeHg producing areas. With available information and data, determining the direction and magnitude of changes in MeHg production in the bypass and its uptake into the food web is quite difficult. However, since impacts to juvenile salmon are driven by concentrations rather than total load, bioaccumulation in these fish may not change substantively with implementation of Alternative 1.

Export of MeHg from the Yolo Bypass is best described in terms of load. Much of the Hg that exits the bypass is bound to sediment particles and deposits onto sediment in the low energy waters of the Delta and bays. Increasing the total load of Hg in sediments across the same area may allow increase of total MeHg available for transport out of the bypass. The major impact of implementing Alternative 1 could be on MeHg entering the Delta from the bypass rather than on juvenile salmon in the bypass.

Pesticides and herbicides from agricultural use are also contaminants of concern to water quality and are found in low concentrations throughout the waters and bottom sediments of the Yolo Bypass. The more persistent legacy organochlorine pesticides (e.g., DDT, dieldrin) are generally found at higher levels than the less persistent organophosphate compounds (e.g., diazinon). As discussed in Section 6.1.3.1.2, *Toxic Chemicals,* among pesticides detected, soil/sediment samples taken from the bypass have been dominated by DDT and its degradation products, DDE and DDD.

Increased flow into the bypass at the Fremont Weir could mobilize sediment and associated pesticides and PCB and deliver them to the Delta. Such occurrence would likely be temporary as the current inventory of pesticides in bypass sediments equilibrates with input from increased inflow from the Sacramento River. Moreover, the gradient in the bypass is shallow which discourages mass sediment mobilization under non-flood conditions. As indicated above, impacts would not be noticeable during non-flood conditions.

Current-use pesticides tend to be more mobile and less stable in the environment. The load of these pesticides entering the bypass at the Fremont Weir and the amount of these same chemicals in the outflow to the Sacramento River will decrease by dilution and degradation. However, some pesticides may be mobilized in agricultural fields where their use continues and which will be inundated more often under Project considerations. Currently, a program to reduce pesticide residues by leaving fields dry and fallow for a time sufficient for pesticide degradation is being implemented.

Increased salinity in water in the bypass could adversely affect productivity of agricultural crops and upset aquatic fresh water communities. Increased flow from the Sacramento River would not cause a general increase in salinity above what is seen under existing conditions, where flows enter the Yolo Bypass from the same sources. As discussed in Section 6.1.3.1.3, while monitoring has shown high salinity in western tributaries inputs, salinity at the furthest downstream sample site in the bypass is lower than all contributing sites except for floodwaters. One data point from the Sacramento River above the Fremont Weir was 482 uS/cm, well within the range of typical drinking water (DWR 2017).

Further, changes in inflows from the Sacramento River and Yolo Bypass could change flow conditions within the Delta, and potentially affect the X2 position. Tables 6-6 and 6-7 Delta inflow and outflow, respectively, for Alternative 1 compared to existing conditions and the No Action Alternative. As shown in the table, flow changes would be small and focused during wetter conditions where adequate water is moving through the Delta to maintain water quality conditions. (More information about the CalSim II model, including assumptions, inputs, results and model limitations, is provided in Sections 4.3.1.1.3, 5.3.3 and Appendix E, *CalSim II Assumptions*.) Because these flow changes are small, they would not likely adversely affect water quality in the Delta.

Table 6-6. Simulated Sacramento River Delta Inflow and Percent Change in Inflow under the No Action Alternative Compared to Alternative 1

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 1 Change (cfs [%])	No Action Alternative (cfs)	Alternative 1 Change (cfs [%])
October	11,300	0 (0)	9,786	0 (0)
November	15,746	-128 (-1)	10,989	-9.5 (0)
December	24,309	-503 (-2)	13,126	-55 (-1)
January	34,221	-921 (-3)	16,324	-262 (-2)
February	41,784	-1,041 (-2)	22,587	-611 (-3)
March	35,394	-480 (-1)	18,719	-220 (-1)
April	22,062	0 (0)	11,121	0 (0)

Month	Long-Term Average		Dry and Critical Average	
	No Action Alternative (cfs)	Alternative 1 Change (cfs [%])	No Action Alternative (cfs)	Alternative 1 Change (cfs [%])
May	13,364	0 (0)	9,061	-0.5 (0)
June	12,597	0 (0)	11,165	0 (0)
July	19,584	8 (0)	14,763	0 (0)
August	13,697	0 (0)	9,946	0 (0)
September	16,482	0 (0)	9,383	0 (0)
Total (TAF)	15,659	-183 (-1)	9,446	-68 (-1)

Source: CalSim II Output (see Appendix G6)

Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

Table 6-7. Simulated Sacramento River Delta Outflow under Existing Conditions Compared to Alternative 1

Month	Long-Term Average		Dry and Critical Average	
	Existing Conditions (cfs)	Alternative 1 Change (cfs [%])	Existing Conditions (cfs)	Alternative 1 Change (cfs [%])
October	6,909	0 (0)	4,979	0 (0)
November	11,530	0 (0)	6,498	0 (0)
December	25,386	0 (0)	7,615	0 (0)
January	48,782	0 (0)	13,632	0 (0)
February	63,791	0 (0)	22,893	0 (0)
March	48,782	0 (0)	18,063	0 (0)
April	30,013	0 (0)	11,131	0 (0)
May	16,104	0 (0)	7,504	0 (0)
June	7,983	0 (0)	6,555	0 (0)
July	8,482	0 (0)	4,651	0 (0)
August	4,062	0 (0)	4,013	0 (0)
September	9,331	0 (0)	3,140	0 (0)
Total (TAF)	16,820	0 (0)	6,628	0 (0)

Source: CalSim II Output (see Appendix G6)

Key: cfs = cubic feet-per-second; TAF = thousands of acre-feet

CEQA Conclusion

Additional Project-related flow through the bypass may result in a **significant** impact because increased shallow inundation could increase MeHg production in bypass sediments, resulting in greater uptake of MeHg into both fish tissue and increased loading of MeHg in outflow from the bypass. Alternative 1 would not likely increase pesticide loading or concentration or salinity within the Yolo Bypass or downstream. Implementation of the water quality mitigation and monitoring program included in MM-WQ-4 could reduce the impact of the Project. However, sources of Hg, such as Cache and Putah Creeks, continue to release Hg to the bypass, which can be anticipated to sustain production of MeHg in bypass sediments. Mitigation efforts will need to be adaptively managed in response to information obtained from monitoring efforts but may not be able to fully address a change in mercury methylation in the Yolo Bypass. Therefore, this impact would be **significant and unavoidable.**

Mitigation Measure MM-WQ-4: Develop a water quality mitigation and monitoring program.

The Lead Agencies shall develop and implement a program to reduce, minimize, or eliminate increases in water quality constituents. This mitigation measure will be focused on mercury and methylmercury since other water quality parameters are not likely to be adversely affected.

The program shall develop a monitoring plan, including frequent sampling and reporting, particularly for existing constituents of concern. The Lead Agencies shall coordinate with the implementation of the current TMDLs to share monitoring information and contribute to the efforts to reduce constituents of concern within the Yolo Bypass. Monitoring efforts could include collection of water quality (through the water column), soil, and fish and invertebrate tissue monitoring within the Yolo Bypass and the Delta. If monitoring levels are found to be above water quality objectives, Lead Agencies will consider means to reduce discharges throughout the bypass region.

As an example, monitoring information may identify time periods where increased inundation is associated with sharp increases in methylmercury production. In these cases, operations of the gated notch could be managed to limit the inundation associated with increased methylmercury production.

6.3.3.3 Alternative 2: Central Gated Notch

Alternative 2, Central Gated Notch, would provide a similar new gated notch through Fremont Weir as described for Alternative 1. The primary difference between Alternatives 1 and 2 is the location of the notch; Alternative 2 would site the notch near the center of Fremont Weir. This gate would be a similar size but would have an invert elevation that is higher (14.8 feet) because the river is higher at this upstream location, and the gate would allow up to 6,000 cfs through to provide open channel flow for adult fish passage. See Section 2.5 for more details on the alternative features.

Impacts under Alternative 2 would be identical to those discussed for Alternative 1.

6.3.3.4 Alternative 3: West Side Gated Notch

Alternative 3, West Side Gated Notch, would provide a similar new gated notch through Fremont Weir as described for Alternative 1. The primary difference between Alternatives 1 and 3 is the location of the notch; Alternative 3 would site the notch on the western side of Fremont Weir. This gate would be a similar size but would have an invert elevation that is higher (16.1 feet) because the river is higher at this upstream location. Alternative 3 would allow up to 6,000 cfs through the gated notch to provide open channel flow for adult fish passage. See Section 2.6 for more details on the alternative features.

Impacts under Alternative 3 would be substantively the same as impacts discussed for Alternative 1.

6.3.3.5 Alternative 4: West Side Gated Notch – Managed Flow

Alternative 4, West Side Gated Notch – Managed Flow, would have a smaller amount of flow entering the Yolo Bypass through the gated notch in Fremont Weir than some other alternatives, but it would incorporate water control structures to maintain inundation for longer periods of time within the northern portion of the Yolo Bypass. Alternative 4 would include the same gated notch and associated facilities as described for Alternative 3; however, it would be operated to limit the maximum inflow to 3,000 cfs. See Section 2.7 for more details on the alternative features.

6.3.3.5.1 Impact WQ-1: Construction- or maintenance-related degradation of surface water quality such that it would exceed regulatory standards or would substantially impair beneficial uses of surface water

Similar to Alternative 1, Alternative 4 includes excavation activities that could lead to potential contamination of the area waterbodies as well as the riverbanks and bed soils from leakage or accidental spills of petroleum products and other pollutants during construction. Alternative 4 also includes construction of two water control structures on Tule Canal, fish passage and bypass channels, and improvements to Agricultural Road Crossing 1 and the downstream channel. Maintenance activities would include sediment removal every five years from the proposed transport channel and Tule Pond/Tule Canal within the Fremont Weir Wildlife Area using construction equipment and removing it from the bypass; these actions have the potential to affect water quality in the Yolo Bypass in the same way as the construction at the beginning of the project. Construction and maintenance activities would not include dredging in the Sacramento River. These activities could result in moderate ground disturbance within the area of analysis, contributing to downstream sedimentation and resulting in increased turbidity.

CEQA Conclusion

Construction and maintenance activities could result in moderate ground disturbance within the area of analysis, contributing to downstream sedimentation and resulting in increased turbidity. Although these impacts would be temporary, they could be **significant**.

Implementation of the CRMP, SPCCP, SWPPP, construction BMPs, and turbidity monitoring plan included in MM-HAZ-1 as well as MM-WQ-1 through MM-WQ-3, respectively, would ensure that all water quality risks would be minimized.

The impact would be reduced to **less than significant** due to the implementation of MM-HAZ-1 and MM-WQ-1 through MM-WQ-3.

6.3.3.5.2 Impact WQ-2: Operation-related degradation of surface water quality such that it would exceed regulatory standards or would substantially impair beneficial uses of surface water

Alternative 4 would have a smaller amount of flow entering the Yolo Bypass through the gated notch in Fremont Weir than some other alternatives, but it would uniquely incorporate water control structures to maintain inundation for longer periods of time while allowing a maximum flow of 3,000 cfs.

The reduction in flow compared to Alternative 1 would result in changes in flow the Delta region that would be less than those outlined under Alternative 1. As such, flow related potential impacts to the Delta region are expected to be less than those noted under Alternative 1.

This longer inundation time and reduction in flow, as compared to Alternatives 1, 2, and 3, would result in additional sedimentation when faster moving water from upstream meets slower moving water within the Yolo Bypass. Alternative 4 would increase sediment entering the bypass to an estimated 701,000 cubic yards on an average annual basis. The increased sedimentation could deposit additional pollutants into the bypass.

The longer timeframe for inundation would also give additional time for the waters of the Sacramento River to mix with waters from Cache and Putah Creeks. This mixing could sequentially add additional mercury from the creeks to the outflow into the Sacramento River, although such effect may be diminished by sedimentation of TSS in creek water. Mixing might also reduce overall Hg concentrations in the water column and result in less Hg per unit area after sediment-bound Hg is deposited in the bypass. The longer inundation time combined with a larger cyclical inundated area also would likely increase the in-situ production of MeHg in the Yolo Bypass. Greater MeHg production could result in increased uptake of MeHg into fish tissue and result in non-lethal toxicity to juvenile salmon. This result is predicated on increased *concentrations* of MeHg rather than an overall increase in MeHg production. The latter could occur without increasing concentrations, for example, if the rate of MeHg remained steady, but the area over which this production occurred increased. Habitat suitability for juvenile salmon would also at least partially determine if and how much increasing the area of inundation would affect uptake into the food web. Any lack of correspondence between where MeHg is produced and where fish prefer to feed may affect bioaccumulation.

CEQA Conclusion

Because increased inundation time and reduced flows could sequentially add additional mercury from the creeks to the outflow into the Sacramento River and because the longer inundation time would likely increase the in-situ production of MeHg in the Yolo Bypass, impacts to water quality could be **significant** under Alternative 4. This judgment applies to water quality, but not necessarily to impacts on juvenile salmon or aquatic communities in the Delta and bays. As included in the impact discussion for Alternative 1, data are insufficient to determine if and by how much fish tissue concentrations may be affected.

Implementation of the water quality mitigation and monitoring program included in MM-WQ-4 would reduce the level of significance. However, mitigation would not be likely to lessen the effects of increased inundation, and any impact would be **significant and unavoidable.**

6.3.3.6 Alternative 5: Central Multiple Gated Notches

Alternative 5, Central Multiple Gated Notches, would increase the number of outmigrating juvenile fish that enter the Yolo Bypass by using multiple gates and intake channels to allow more flow to enter the bypass when the river is at lower elevations. Flows would move to other gates when the river is higher to control inflows. Alternative 5 incorporates multiple gated notches in the central location on the existing Fremont Weir that would allow combined flows of up to 3,400 cfs. See Section 2.8 for more details on the alternative features.

6.3.3.6.1 Impact WQ-1: Construction- or maintenance-related degradation of surface water quality such that it would exceed regulatory standards or would substantially impair beneficial uses of surface water

Similar to Alternative 1, Alternative 5 includes excavation activities that could lead to potential contamination of the area waterbodies as well as the riverbanks and bed soils from leakage or accidental spills of petroleum products and other pollutants during construction. Alternative 5 includes construction of multiple gates at Fremont Weir, with four sets of gates rather than one set in Alternative 1. While Alternative 5 has additional structures that would be constructed, the types of impacts from construction would be the same as discussed for Alternative 1. Maintenance activities would include sediment removal every five years from the proposed transport channel and Tule Pond/Tule Canal within the Fremont Weir Wildlife Area using construction equipment and removing it from the bypass; these actions have the potential to affect water quality in the Yolo Bypass in the same way as the construction at the beginning of the project. Construction and maintenance activities would not include dredging in the Sacramento River. These activities could result in moderate ground disturbance within the area of analysis, contributing to downstream sedimentation and resulting in increased turbidity.

CEQA Conclusion

Construction and maintenance activities could result in moderate ground disturbance within the area of analysis, contributing to downstream sedimentation and resulting in increased turbidity. Although these impacts would be temporary, they could be **significant**.

Implementation of the CRMP, SPCCP, SWPPP, construction BMPs, and turbidity monitoring plan included in MM-HAZ-1 and MM-WQ-1 through MM-WQ-3, respectively, would ensure that all water quality risks would be minimized.

The impact would be reduced to **less than significant** due to the implementation of MM-HAZ-1 and MM-WQ-1 through MM-WQ-3.

6.3.3.6.2 Impact WQ-2: Operation-related degradation of surface water quality such that it would exceed regulatory standards or would substantially impair beneficial uses of surface water

Possible impacts for Alternative 5 would be similar to impacts for Alternative 4, Maximum flows over the Fremont Weir would be somewhat greater than flows for Alternative 4 (3400 cfs versus 3000 cfs), but smaller than maximum flow entering the Yolo Bypass under Alternatives 1, 2, and 3. Similar to Alternative 4, the changes in flows entering the bypass are expected to have miniscule impacts to the Delta region. Alternative 5 would increase sediment entering the bypass to an estimated 701,000 cubic yards on an average annual basis. The increased sedimentation could deposit additional pollutants into the bypass. The longer inundation time could increase the in-situ production of MeHg in the Yolo Bypass and subsequently increase the accumulation in the food web and subsequent export of MeHg to the Delta.

CEQA Conclusion

Because the longer inundation time could increase the in-situ production of MeHg in the Yolo Bypass under Alternative 5, this impact could be **significant**.

Implementation of the water quality mitigation and monitoring program included in MM-WQ-4 would reduce the level of significance. However, mitigation would not be likely to lessen the effects of additional inundation of the bypass, and this impact would be **significant and unavoidable.**

6.3.3.6.3 Tule Canal Floodplain Improvements (Program Level)

As described in Section 2.8.1.7, Alternative 5 would include floodplain improvements along Tule Canal, just north of Interstate 80. These improvements would not be constructed at the same time as the remaining facilities. They are included at a program level of detail to consider all of the potential impacts and benefits of Alternative 5. Subsequent consideration of environmental impacts would be necessary before construction could begin.

Impact WQ-1: Construction-related degradation of surface water quality such that it would exceed regulatory standards or would substantially impair beneficial uses of surface water

Construction activities associated with development of a series of secondary channels to branch off from Tule Canal include excavation, which could lead to potential contamination of the area waterbodies as well as the riverbanks and bed soils from leakage or accidental spills of petroleum products and other pollutants during construction. In addition to construction of channels A, B, and C, these improvements also include construction of a fish bypass channel. These activities could result in moderate ground disturbance within the area of analysis, contributing to downstream sedimentation and resulting in increased turbidity.

CEQA Conclusion

These impacts would only occur during construction but could be **significant** because construction could increase downstream sedimentation and turbidity.

Implementation of the CRMP, SPCCP, SWPPP, construction BMPs, and turbidity monitoring plan included in MM-HAZ-1 and MM-WQ-1 through MM-WQ-3, respectively, would ensure that all water quality risks would be minimized.

The impact would be reduced to **less than significant** due to the implementation of MM-HAZ-1 and MM-WQ-1 through MM-WQ-3.

Impact WQ-2: Operation-related degradation of surface water quality such that it would exceed regulatory standards or would substantially impair beneficial uses of surface water

Operation of secondary channels would increase inundation of the surrounding areas, which are managed as wetland habitat for waterfowl under existing conditions. Since the area currently experiences inundation as well as wetting and drying periods, increased inundation from the Tule Canal is not expected to cause substantive changes in water quality.

CEQA Conclusion

This impact would be **less than significant** under Alternative 5 because the surrounding areas experience inundation due to operation as managed wetland habitat. The increased inundation from the Tule Canal is not expected to cause substantive changes in water quality.

6.3.3.7 Alternative 6: West Side Large Gated Notch

Alternative 6, Large Gated Notch, is a large notch in the western location that would allow flows up to 12,000 cfs. It was designed with the goal of entraining more fish by allowing more flow into the bypass when the Sacramento River is at lower elevations. See Section 2.9 for more details on the alternative features.

6.3.3.7.1 Impact WQ-1: Construction- or maintenance-related degradation of surface water quality such that it would exceed regulatory standards or would substantially impair beneficial uses of surface water

Similar to Alternative 1, Alternative 6 includes excavation activities that could lead to potential contamination of the area waterbodies as well as the riverbanks and bed soils from leakage or accidental spills of petroleum products and other pollutants during construction. Alternative 6 includes construction of a larger gated notch and associated channels than included in Alternative 1. While Alternative 6 has additional construction activities, the types of impacts from construction would be the same as discussed for Alternative 1. Maintenance activities would include sediment removal every five years from the proposed transport channel and Tule Pond/Tule Canal within the Fremont Weir Wildlife Area using construction equipment and removing it from the bypass; these actions have the potential to affect water quality in the Yolo Bypass in the same way as the construction at the beginning of the project. Construction and maintenance activities would not include dredging in the Sacramento River. These activities could result in moderate ground disturbance within the area of analysis, contributing to downstream sedimentation and resulting in increased turbidity.

CEQA Conclusion

Under Alternative 6, construction and maintenance activities could result in moderate ground disturbance within the area of analysis, contributing to downstream sedimentation and resulting in increased turbidity. These impacts would be temporary but could be **significant**.

Implementation of the CRMP, SPCCP, SWPPP, construction BMPs, and turbidity monitoring plan included in MM-HAZ-1 and MM-WQ-1 through MM-WQ-3, respectively, would ensure that all water quality risks would be minimized.

The impact would be reduced to **less than significant** due to the implementation of MM-HAZ-1 and MM-WQ-1 through MM-WQ-3.

6.3.3.7.2 Impact WQ-2: Operation-related degradation of surface water quality such that it would exceed regulatory standards or would substantially impair beneficial uses of surface water

Alternative 6 would increase the rate or speed at which flooding of the bypass would occur and potentially increase the area of inundation. Alternative 6 would also increase sediment entering the bypass to an estimated 827,000 cubic yards on an average annual basis. This increase in sediment entering the bypass would in turn increase the amount of constituents of concern, including mercury, entering the bypass and potentially increase turbidity. The increase in continuous flow through the bypass would continue to move these pollutants downstream, thus, increasing pollution in the outflow to the Sacramento River and the Delta.

CEQA Conclusion:

This impact would be **significant** under Alternative 6 because the potential increase in the rate and area of inundation would increase the amount of sediment and constituents of concern entering the bypass and potentially moving downstream into the Sacramento River.

Implementation of the water quality mitigation and monitoring program included in MM-WQ-4 would reduce the level of significance. However, mitigation would not be likely to lessen the effects of additional inundation of the bypass, and this impact would be **significant and unavoidable.**

6.3.4 Summary of Impacts

Table 6-8 below provides a summary of the identified impacts to water quality within the Area of Analysis.

Table 6-8. Summary of Impacts and Mitigation Measures – Water Quality

Impact	Alternative	Level of Significance before Mitigation	Mitigation Measures	Level of Significance after Mitigation
Impact WQ-1: Construction- or maintenance-related degradation of surface water quality such that it would exceed regulatory standards or would substantially impair beneficial uses of surface water	No Action	NI	---	---
	All Action Alternatives	S	MM-HAZ-1 MM-WQ-1 MM-WQ-2 MM-WQ-3	LTS
Impact WQ-2: Operation-related degradation of surface water quality such that it would exceed regulatory standards or would substantially impair beneficial uses of surface water	No Action	NI	---	---
	1, 2, 3, 4, 5 (Project), 6	S	MM-WQ-4	SU
	5 (Program)	LTS	---	LTS

Key:
LTS = less than significant
NI = no impact
S = significant
SU = significant and unavoidable

6.4 Cumulative Impacts Analysis

This section describes the cumulative effects analysis for Water Quality. Section 3.3, *Cumulative Impacts*, presents an overview of the cumulative effects analysis, including the methodology and the projects, plans, and programs considered in the cumulative effects analysis.

6.4.1 Methodology

This evaluation of cumulative effects considers the effects of the Project and how they may combine with the effects of other past, present, and future projects or actions to create significant impacts on water quality. The area of analysis for these cumulative effects includes both the Yolo Bypass and the larger Sacramento River system. The timeframe for this cumulative analysis includes the past, present, and probable future projects producing related or cumulative impacts that have been identified around analysis.

Several projects are specifically designed to improve conditions for anadromous salmonids in the Sacramento River system, including the Yolo Bypass and may have long-term beneficial impacts. For example, the Fremont Weir Adult Fish Passage Modification Project is intended to improve upstream passage for adult salmonids and for sturgeon. Construction associated with some of these same projects could also have short-term detrimental impacts. In other cases, projects focused on flood control and/or drinking water supply could have both short-term, construction related and long-term negative impacts (e.g., Central Valley Flood Protection Plan).

Impacts of past, ongoing and planned projects are difficult to determine, for both short- and long-term time frames. A great deal of effort has been and continues to be spent to improve water quality, habitat, contamination, and migration for anadromous salmonids and other fish and wildlife in the Sacramento River watershed. It seems reasonable to anticipate beneficial impacts, at least in the long-term as projects are completed and their effects realized.

In the short-term, it is possible that construction/implementation of other projects could cause temporary cumulative impacts. Long-term impacts could be associated with projects not focused on restoring/improving fisheries.

This cumulative effects analysis utilizes the project analysis approach described in detail in Section 3.3, *Cumulative Impacts*. Several related and reasonably foreseeable projects and actions may result in water quality impacts in the Project area, in particular, levee removal and relocation, other construction-related activities and operational/management changes associated with flood control and drinking water supply:

- Agricultural Road Crossing #4 Fish Passage Improvement Project
- Battle Creek Salmon and Steelhead Restoration Project
- California EcoRestore projects
- California WaterFix
- Central Valley Flood Protection Plan
- Delta Wetlands Project
- EchoWater Project
- Folsom Dam Water Control Manual Update
- Fremont Weir Adult Fish Passage Modification Project
- Lisbon Weir Modification Project
- Lower Cache Creek Flood Risk Management Feasibility Study and the Woodland Flood Risk Reduction Project

- Lower Elkhorn Basin Levee Setback Project
- Lower Putah Creek 2 North America Wetlands Conservation Act Project
- Lower Putah Creek Realignment Project
- Lower Yolo Restoration Project
- North Bay Aqueduct Alternative Intake Project
- North Delta Flood Control and Ecosystem Restoration Project
- North Delta Fish Conservation Bank
- Sacramento River Bank Protection Project
- Sacramento River General Reevaluation Report
- Sacramento-San Joaquin Deltas Estuary Total Maximum Daily Load (TMDL) for Methylmercury
- Shasta Lake Water Resources Investigation
- Sites Reservoir Project
- Upstream Sacramento River Fisheries Projects
- Wallace Weir Fish Rescue Facility Project
- Yolo Habitat Conservation Plan/Natural Communities Conservation Plan
- Yolo Regional Conservation Investment Strategy/Local Conservation Plan.
- Yuba River Development Project Relicensing

These projects may result in additional construction equipment in the area of analysis, possibly introducing additional sedimentation and construction-related contaminants to the river and the Delta. These programs would be expected to utilize proper mitigation measures to prevent contamination and increases in turbidity and would likely coordinate proposed actions within this Project to avoid significant cumulative impacts.

These projects may also be beneficial in improving habitat in the Bypass and Delta and decreasing Hg load from Cache and Putah Creeks.

6.4.2 Cumulative Impacts

Cumulative effects with respect to changes in water quality standards could be associated with the California WaterFix, including evaluation and potential establishment of water quality criteria and flow objectives that protect beneficial uses on tributaries to the Sacramento River under Phase IV. Additionally, the Staff Report for the Delta Mercury Control Program (Central Valley RWQCB 2010c) proposes a number of changes to water management and storage in and upstream of the Delta. Changes to salinity objectives, dredging and dredge materials disposal and reuse, and changes to flood conveyance flows would be subject to the open water MeHg allocations. As a result, MeHg reductions are likely to comply with allocations by 2030.

The Lower Yolo Restoration Project, aimed at restoring tidal flux to 1,100 acres of existing pasture land, would be expected to have water quality impacts similar to the Project. While cumulative changes in flow within the Delta region are not expected to be substantial enough to cause cumulative impacts to flow, this may increase the load of contaminants of concern, including MeHg loads to the Sacramento River.

While the projects that involve construction would be expected to have significant short-term impacts on the area of analysis, it is expected that these potential impacts would be mitigated to a less than significant level. Additionally, changes in water quality standards that could result from implementation of several projects in the cumulative analysis would be expected to improve water quality within the area of analysis. However, impacts associated with MeHg in the Yolo Bypass may continue to be cumulatively significant, and the increased inundation from the Project **could be cumulatively considerable.**

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7 Groundwater

This section presents the existing conditions of groundwater resources within the Project area and discusses potential effects of the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Project) alternatives on groundwater levels, land subsidence, and groundwater quality.

7.1 Environmental Setting/Affected Environment

The alternatives described in this document include actions in the Yolo Bypass, which is in California's Central Valley, in an area north of the Sacramento-San Joaquin Delta (Delta). The project and primary potential impacts to groundwater resources occur in this "North of Delta" region, but the project could also cause indirect impacts for an area south of the Delta. The North of Delta and South of Delta areas are described in this Environmental Setting/Affected Environment section in a level of detail commensurate with the potential impacts in these areas.

7.1.1 North of Delta Area

The Project area is located within the Sacramento Valley Groundwater Basin. The Sacramento Valley Groundwater Basin is bordered by the Red Bluff Arch to the north, the Coast Range to the west, the Sierra Nevada to the east, and the San Joaquin Valley to the south. The California Department of Water Resources (DWR) Bulletin 118 further divides the Sacramento Valley Groundwater Basin into subbasins (DWR 2003, 2016f). The Project area for groundwater resources is limited to the area around the Yolo Bypass and includes portions of the Colusa, Yolo, and Sutter subbasins, as defined in Bulletin 118 and shown in Figure 7-1. Although the southern portion of the Yolo Bypass is in the Solano subbasin, this subbasin was not included in this analysis as it is well away from the portion of the bypass where modifications are proposed. Requests were made to adjust the boundaries of the Colusa subbasin as part of the Sustainable Groundwater Management Act (SGMA). These modifications, finalized and adopted on October 21, 2016, included portions of the southern Colusa subbasin and the northeastern portion of the original Yolo subbasin that are in Yolo County (DWR 2016a). These areas were consolidated into the Yolo subbasin for jurisdictional reasons. DWR evaluated local agency requests for basin boundary modifications and finalized approved modifications in Bulletin 118 (DWR 2016f).

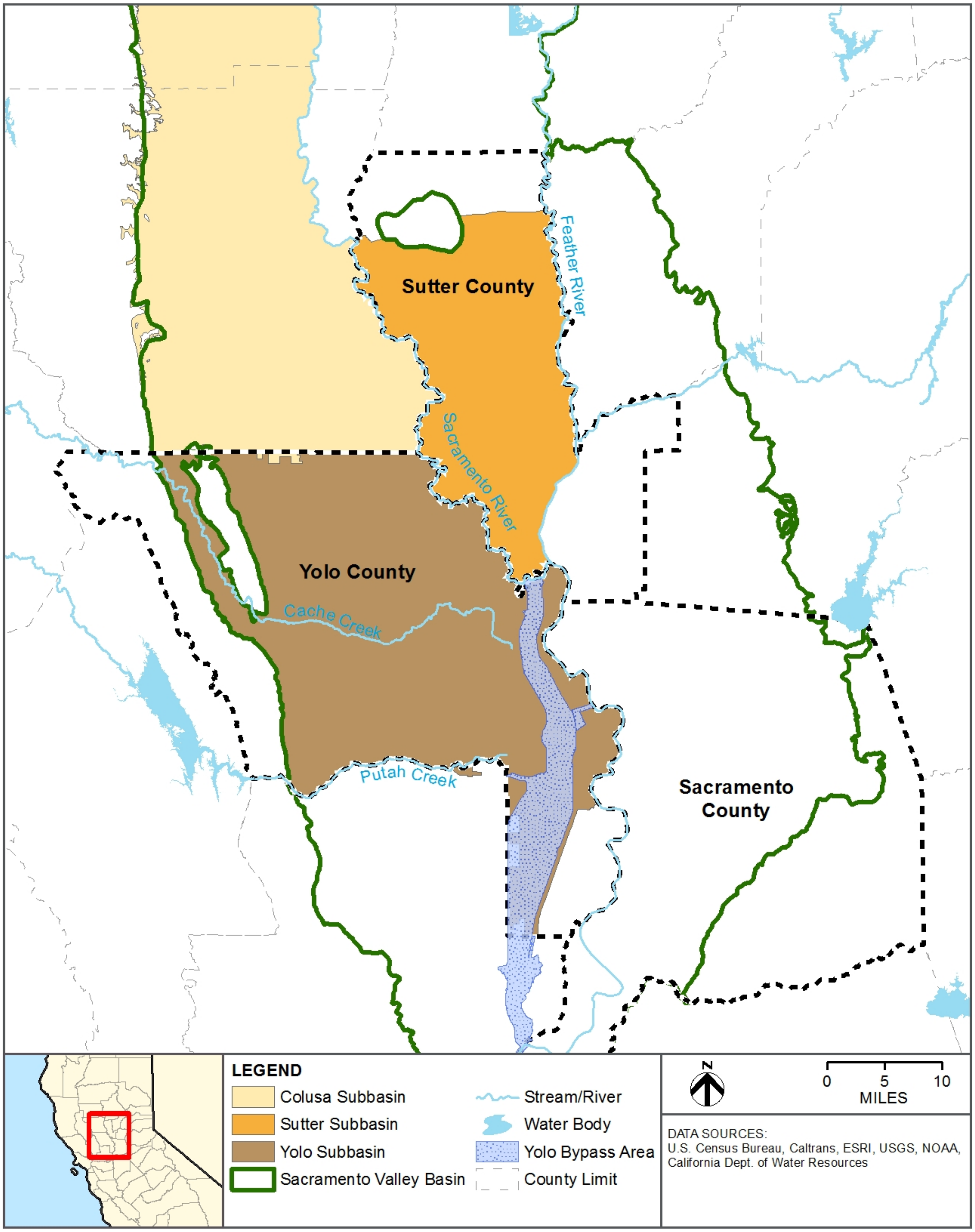


Figure 7-1. Project Area for Groundwater Resources

Table 7-1 summarizes the DWR groundwater basin prioritization ranking pursuant to SGMA and the proposed Groundwater Sustainability Agencies (GSAs) for each groundwater subbasin. Groundwater basins with high and medium priority are subject to regulations and accelerated timelines to which low priority basins are not subject.

Table 7-1. Groundwater Basin Prioritization Ranking and GSAs within the Project Area

Subbasin	DWR Groundwater Basin Prioritization Ranking	Proposed GSA (as of July 10, 2017)
Colusa	Medium	Two local agencies have submitted GSA formation notices for the majority of the Colusa subbasin that falls within the Sacramento River Groundwater Basin.
Yolo	High	Two local agencies have submitted GSA formation notices for the majority of the Yolo Basin that falls within the Sacramento River Groundwater subbasin.
Sutter	Medium	Seven local agencies have submitted GSA formation notices for the majority of the Sutter subbasin that falls within the Sacramento River Groundwater Basin.

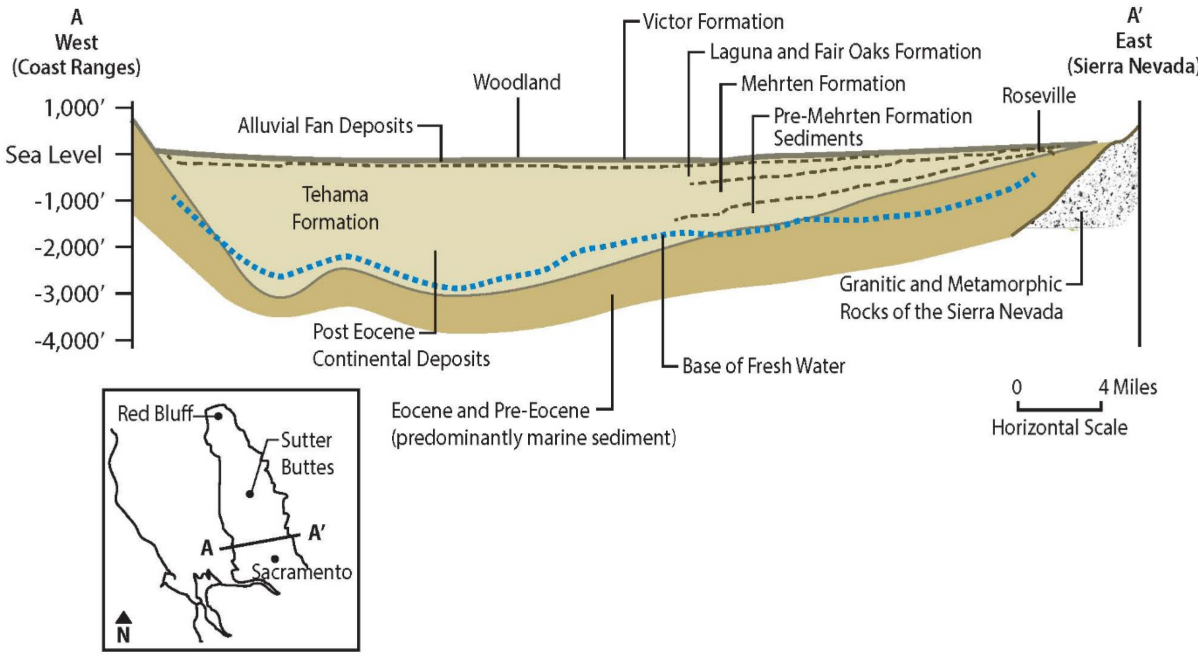
Source: DWR 2015b, DWR 2016b, DWR 2017

Key: DWR = California Department of Water Resources, GSA = Groundwater Sustainability Agency

7.1.1.1 Geology, Hydrogeology, and Hydrology

The Sacramento Valley Groundwater Basin is a north-northwest trending asymmetrical trough filled with both marine and continental rocks and sediment. On the eastern side, the basin overlies basement rock that rises relatively gently to the Sierra Nevada while on the western side the underlying basement rock rises more steeply to form the Coast Range. Overlying the basement rock are marine sandstone, shale, and conglomerate rocks, which generally contain brackish or saline water (DWR 1978). The freshwater-bearing formation in the valley comprises sedimentary and volcanic rocks that can absorb, transmit, and yield fresh water. The depth below ground surface (bgs) to the base of freshwater is approximately 1,600 feet in the southern portion of the Sacramento Valley (DWR 1978) but is shallower toward the edges of the valley.

The western portion of the Sacramento Valley Groundwater Basin, near the Project area (including the Colusa and Yolo subbasins), is predominantly underlain by the Tehama Formation (Figure 7-2). The Tehama Formation is derived from Coast Range sediments. The formation is composed of moderately compacted silt, clay, and fine silty sand that occurs between lenses of sand and gravel, silt and gravel, and cemented conglomerate (DWR 2003). The Tehama Formation ranges in thickness from 1,500 to 2,500 feet. DWR describes the Tehama Formation as a “moderately productive, deep, water-bearing zone” (DWR 2003). The other major formations in this area of the Sacramento Valley Groundwater Basin include the Mehrten and Laguna formations. The Mehrten and Laguna formations are primarily composed of heterogeneous gravel and sand layers.



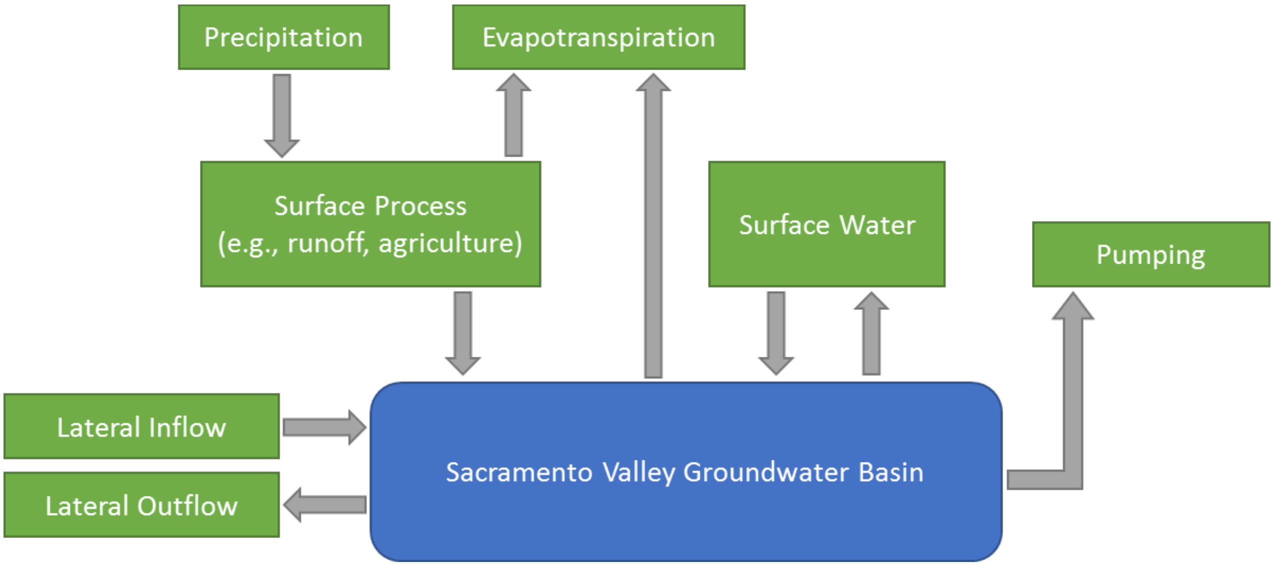
Source: DWR 1978

Figure 7-2. Geologic Cross-Section of the Sacramento Valley Groundwater Basin

These formations are typically overlain by both older and younger alluvial deposits. The younger alluvium primarily consists of silts and clays but can include channel deposits. The younger alluvial deposits can range from zero to 150 feet thick (DWR 2003). The older alluvium can range from 60 to 130 feet thick and consists of moderately compacted silt, silty clay, sand, and gravel deposited in alluvial fans (DWR 2003). The younger alluvium can yield significant quantities of water where it is saturated while the yield from the older alluvium can vary between 50 and 4,000 gallons per minute, depending on the area (DWR 2003).

Freshwater (groundwater) is present primarily in the heterogeneous gravel and sand layers of the Laguna, Mehrten, and Tehama formations. Groundwater is also present in the shallower alluvial deposits.

Groundwater is recharged by percolation from rainfall infiltration, shallow groundwater connectivity with perennial and ephemeral streambeds, lateral inflow along the basin boundaries, and other surface processes such as irrigation and managed aquifer recharge (Figure 7-3). Groundwater discharges primarily include evapotranspiration, discharge to streams, pumping, or other surface features such as marshes.



Source: Adapted from Faunt 2009

Figure 7-3. Generalized Components of the Groundwater Budget

The surface water inflow and outflow arrows in Figure 7-3 are a description of the interaction between groundwater and surface water. These terms reference the movement of water from the perspective of the stream/river. In a "losing" stream condition, the water elevation in the stream is higher than the groundwater elevation under and adjacent to the stream. In this condition, water flows through the riverbed, out of the stream, and into the groundwater system (i.e., the water is "lost" from the surface water). In a "gaining" system, the water elevation in the surface water is lower than the adjacent groundwater elevation. Under this condition, water flows from the groundwater into the surface water system (i.e., the water is "gained" by stream).

Depending on groundwater and stream levels, portions of the same stream system may be gaining while other portions are losing. The gaining/losing condition can also change at different times of the year based on changes in the groundwater level, the surface water level, or both. When the Yolo Bypass is in flood operations, the water levels in the Sacramento River and the bypass are higher than the groundwater level under and adjacent to the bypass, contributing to a "losing" condition. Under a "losing" condition, the water that exits the surface water (i.e., river, bypass) will recharge the shallow groundwater system, potentially resulting in an increase in groundwater levels. Under the reverse condition, a "gaining" condition, the groundwater level may be reduced, or at least not increase as much, as water drains from the shallow groundwater to the surface water feature.

7.1.1.2 Groundwater Production, Levels, and Storage

Bulletin 118 states that an estimated 310,000 acre-feet (AF) of groundwater is pumped for agricultural purposes in the Colusa subbasin. Municipal and industrial and environmental/ wetland pumping is estimated to be 14,000 and 22,000 AF, respectively (DWR 2003). In the Sutter subbasin, DWR estimates pumping for agricultural uses to be 171,400 AF and urban use to be 3,900 AF (DWR 2003). DWR does not provide a groundwater pumping estimate for the Yolo subbasin in Bulletin 118.

The California Water Plan (CWP) provides groundwater well and production information on a county basis. Yolo County, the county where most of the Project area is located, has 1,355 domestic, 828 irrigation, 89 public supply, and 42 industrial production wells as of July 2012 (DWR 2013). The CWP also provides estimates of groundwater use in the region. This use is provided by units called “Planning Areas”. The Project area is located within three different Planning Areas —Colusa Basin, Central Basin West, and Sacramento-San Joaquin Delta. The area of the Yolo Bypass is much smaller than these areas however. The CWP estimates that 522,000 AF of groundwater is used as supply in the Colusa Basin, equating to approximately 25 percent of the supply (DWR 2013). Groundwater is estimated to be 520,000 AF in the Central Basin West (58 percent of supply) and 24,000 AF (4 percent) in the Sacramento-San Joaquin Delta Planning Area (DWR 2013). The CWP estimates that groundwater comprises approximately 30 percent of all the water used in the Sacramento River hydrologic region (totaling approximately 2,700,000 AF) (DWR 2013).

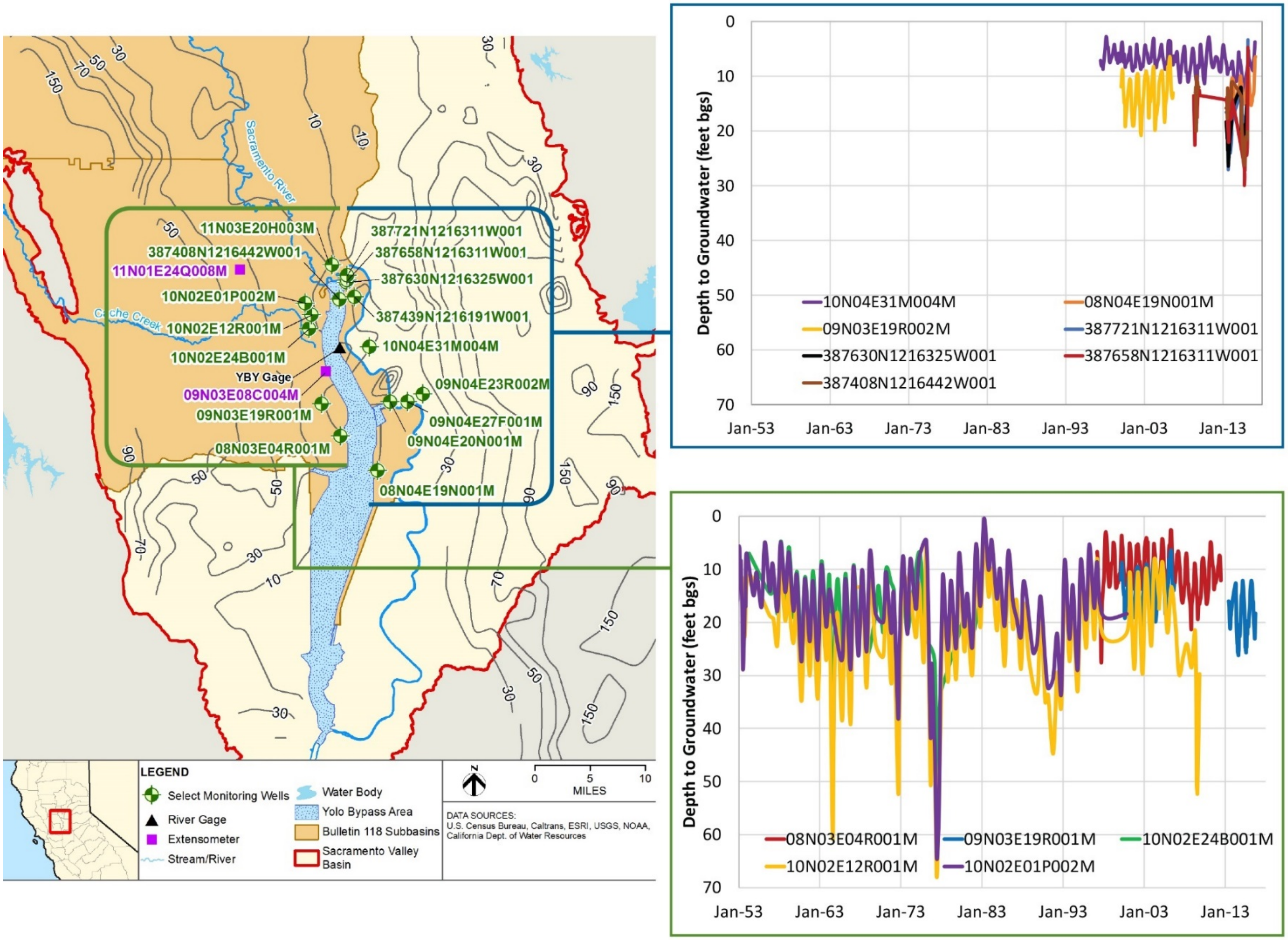
The estimated recharge to the Colusa subbasin due to deep percolation of applied water is 64,000 AF (DWR 2003). In the Sutter subbasin, DWR estimates natural recharge to be 40,000 AF and applied water recharge to be 22,100 AF.

DWR and other monitoring entities monitor groundwater levels in the subbasins. The total depth of monitoring wells ranges from 18 to 1,380 feet bgs within the Yolo, Colusa, and Sutter subbasins (DWR 2003).

Figure 7-4 shows the spring 2016 groundwater contours in the Yolo, Colusa, and Sutter subbasins and the available groundwater level hydrograph data at select monitoring wells within three miles of the Project area since the 1950s. Groundwater levels around the Yolo Bypass are typically shallow and range from as low as five to 70 feet bgs. Groundwater levels typically vary annually, with higher (shallower) levels at the end of the winter and lower (deeper) levels at the end of the summer. The annual fluctuations in water level are typically due to groundwater pumping in the area. The hydrographs in Figure 7-4 also show that the overall groundwater levels vary with wet and dry hydrologic conditions. When flow is present in the Yolo Bypass, additional groundwater recharge likely occurs, which could increase the groundwater elevations under and near the bypass. Groundwater levels along the eastern side of the bypass (between the bypass and the Sacramento River, in the Elkhorn area) vary from 10 to 30 feet bgs. Groundwater levels along the western side of the bypass near Interstate (I) 80 vary from three to 26 feet bgs under existing conditions.

7.1.1.3 Groundwater-Related Land Subsidence

Groundwater-related land subsidence, which is typically not reversible, occurs when groundwater extraction causes groundwater levels to fall below the historic levels. The reduction in water level causes the loss of pore pressure within the soil matrix. This loss in pore pressure can result in collapse (i.e., consolidation, compaction) of soils that may be susceptible to subsidence. Clays are typically the soils most susceptible to subsidence.



Source: DWR 2016c

Figure 7-4. Spring 2016 Groundwater Contours in the Colusa, Yolo, and Sutter Subbasins (depth to water below ground surface)

Historically, land subsidence occurred in the eastern portion of Yolo County and the southern portion of Colusa County because of extensive groundwater pumping in areas that have soils susceptible to subsidence (DWR 2014). The earliest land subsidence studies in the Sacramento Valley occurred in the early 1970s when the United States Geological Survey (USGS), in cooperation with DWR, measured elevation changes along various survey lines.

DWR has prioritized the Colusa and Yolo subbasins as having a high potential for subsidence (DWR 2014). Figure 7-4 shows the locations of two active DWR extensometers in Yolo County (09N03E08C004M and 11N01E24Q008M). As shown in Figure 7-5, these two extensometers have shown measurable subsidence. Extensometer 09N03E08C004M is near the Yolo Bypass and has recorded approximately 0.9 foot of subsidence from 1991 to the present (DWR 2016d). Extensometer 11N01E24Q008M, near the Yolo-Zamora area, has recorded approximately 1.1 feet of subsidence from 1992 to 2016 (DWR 2016d). DWR also measures subsidence trends from 319 continuous global positional system (CGPS) stations across the Central Valley. CGPS station Woodland_CN2004, located in the City of Woodland, has recorded approximately 0.05 feet of subsidence since 2004 (DWR 2016e).

As much as four feet of land subsidence has been measured east of Zamora over the last several decades. The area between Zamora, the Knights Landing Ridge Cut, and Woodland has been most affected (Yolo County 2009). This area is near extensometer 11N01E24Q008M (Figure 7-4).

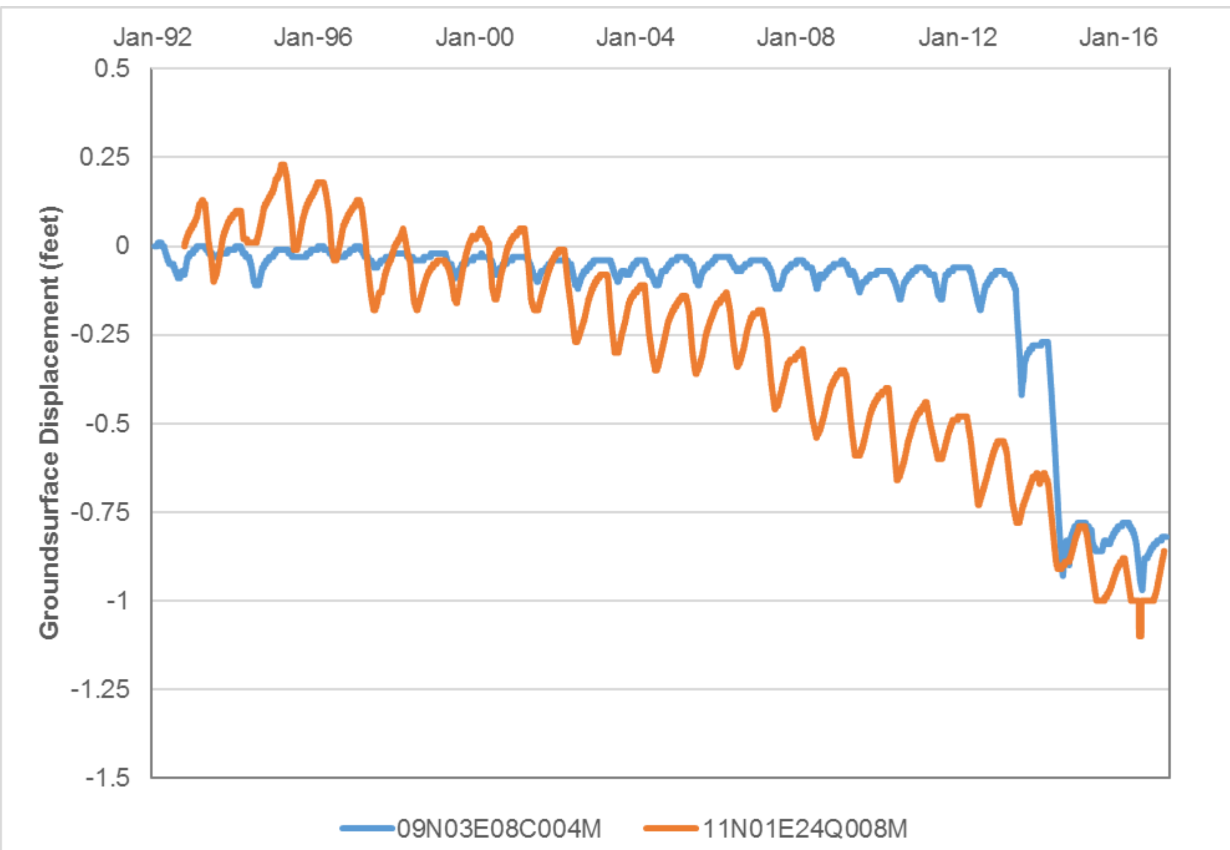


Figure 7-5. Land Subsidence Recorded at Active Extensometers in the Project area

7.1.1.4 Groundwater Quality

Groundwater quality in the Sacramento Valley Groundwater Basin is generally good and of sufficient quality for municipal, agricultural, domestic, and industrial uses. Groundwater quality in the Yolo, Colusa, and Sutter subbasins is generally hard and high in salt content. Groundwater in the Colusa and Yolo subbasins is characterized as the sodium magnesium, calcium magnesium, or magnesium bicarbonate type (DWR 2003).

The California Department of Public Health (CDPH) and United States Environmental Protection Agency's secondary drinking water standard for total dissolved solids (TDS) is 500 milligrams per liter (mg/L), and the agricultural water quality goal for TDS is 450 mg/L. TDS concentrations as high as 1,500 mg/L have been recorded in wells west of the Sacramento River in the Yolo subbasin, between Putah Creek and the confluence of the Sacramento and San Joaquin rivers (Bertoldi 1991). Groundwater in the Colusa subbasin has TDS concentrations that range from 120 to 1,200 mg/L (average 391 mg/L). In the Sutter subbasin, TDS concentrations range from 133 to 1,660 mg/L.

There are also some localized groundwater quality issues in all three subbasins. Localized areas of high electrical conductivity, TDS, adjusted sodium adsorption ratio, nitrate, and magnesium occur within the Project area. Based on the USGS's Groundwater Ambient Monitoring and Assessment (GAMA) program, most constituents that were detected in groundwater samples were found at concentrations below drinking water thresholds. GAMA detected volatile organic compounds (VOCs) in less than one-third and pesticides and pesticide degradates in just over one-half of the wells. These detections were below health-based thresholds. Additionally, the detections of trace elements in samples were below health-based thresholds, with the exceptions of arsenic and boron (USGS 2011a, 2011b).

Elevated levels of boron as high as two to four mg/L have been recorded along Cache Creek. Elevated selenium and nitrate concentrations have occurred in groundwater near the City of Davis (DWR 2003).

Groundwater that receives surface water recharge from streams has the potential to be of better quality. In general, rivers/streams that originate along the edges of the Central Valley have good water quality. As this water flows into the Central Valley basins, it has the potential to recharge the basins with groundwater basin good quality water.

7.1.2 South of Delta Area

The South of Delta area consists of several groundwater basins and subbasins that are in several hydrologic regions.

7.1.2.1 San Joaquin Valley Hydrologic Region

The predominant groundwater basin in the San Joaquin Valley hydrologic region is the San Joaquin Valley Groundwater Basin.

7.1.2.1.1 San Joaquin Valley Groundwater Basin

The San Joaquin Valley Groundwater Basin extends over the southern two-thirds of the Central Valley regional aquifer system and has an area of approximately 13,500 square miles. The San

Joaquin Valley Groundwater Basin extends from just north of Stockton in San Joaquin County to Kern County in the south.

The aquifer system in the San Joaquin Valley Groundwater Basin is mostly comprised of unconsolidated alluvial and lacustrine sediments, derived from parent materials of the Coast Ranges and the Sierra Nevada Mountains. The Valley fill reaches a thickness of about 28,000 feet in the southwestern corner (Page 1986). A significant hydrogeologic feature in the basin is the Corcoran Clay. This clay layer divides the aquifer system into two distinct zones—an upper unconfined to semi-confined aquifer and a lower confined aquifer.

Irrigated agriculture in the northern portion of the San Joaquin Valley Groundwater Basin increased from about one million acres in the 1920s to more than 2.2 million acres by the early 1980s (United States Department of the Interior, Bureau of Reclamation [Reclamation] 1997). Even with the increase in irrigated agriculture, the USGS estimates the cumulative change in groundwater storage for the entire San Joaquin Valley Groundwater Basin to be relatively constant from 1962 through 2003 (Faunt 2009). Groundwater storage typically drops during dry periods and increases during wetter years. Analyses by DWR, using their California Central Valley Simulation Model, showed storage within the San Joaquin Valley has been showing a steady decline since the 1940s. Annual average groundwater production in the basin is estimated to be 0.9 million AF in the CVHM model (Faunt 2009).

Land Subsidence

From the 1920s until the mid-1960s, the use of groundwater for irrigation of crops in the San Joaquin Valley increased rapidly, causing land subsidence throughout the west and southern portions of the valley. DWR has prioritized the western portion of the San Joaquin Valley (Tracy, Delta-Mendota, and Westside subbasins) as having a high potential for subsidence (DWR 2016c). Subsidence has also been observed recently along the San Joaquin River between Los Banos and Madera, with an estimated average subsidence rate of nearly 0.75 feet per year since 2012.

Groundwater Quality

Given the size of the San Joaquin Valley Groundwater Basin, groundwater quality can vary throughout the basin. For example, the western portion of the basin is characterized by mixed sulfates, bicarbonates, and chlorides in the water. There are also localized areas of high iron, fluoride, nitrate, and boron in the subbasin (DWR 2003).

7.1.2.2 San Francisco Bay Hydrologic Region

The predominant groundwater basins in the San Francisco Bay hydrologic region are the Santa Clara Valley and the Gilroy-Hollister Valley groundwater basins.

7.1.2.2.1 Santa Clara Valley Groundwater Basin

The Santa Clara subbasin is the primary portion of the Santa Clara Valley Groundwater Basin and occupies a structural trough parallel to the northwest trending Coast Ranges. The subbasin contains both confined and unconfined aquifer units (Santa Clara Valley Water District [SCVWD] 2001). Groundwater in the basin is managed by SCVWD using active recharge facilities and imposing limits on annual groundwater withdrawal. The operational storage capacity of the Santa Clara Valley subbasin is estimated to be 383,000 AF (SCVWD 2001 and SCVWD 2002 as cited in SCVWD 2012), accounting for available pumping capacity and the avoidance of land subsidence and problems associated with high groundwater levels.

Land Subsidence

Santa Clara County has experienced as much as 13 feet of historic subsidence caused by excessive pumping of groundwater. SCVWD currently manages its groundwater use to avoid subsidence and has established subsidence thresholds equal to the current acceptable rate of 0.01 feet per year (SCVWD 2012). DWR has categorized Santa Clara subbasin as having a low potential for future land subsidence (DWR 2016c).

Groundwater Quality

DWR has prioritized the Santa Clara Valley subbasin as medium priority based on groundwater quality concerns in some wells across the basin (DWR 2016c). Groundwater in the subbasin is suitable for most uses and meets drinking water standards at public supply wells without the use of treatment methods while being considered as “hard” water (SCVWD 2001).

7.1.2.2.2 Gilroy-Hollister Valley Groundwater Basin

The Llagas Area subbasin is a primary portion of the Gilroy-Hollister Groundwater Basin and occupies a northwest trending structural depression. The operational storage capacity of the Llagas Area subbasin is estimated to be between 150,000 and 165,000 AF, with annual average pumping in the subbasin of approximately 20,000 AF (SCVWD 2012).

Land Subsidence

SCVWD manages groundwater in the Llagas Area subbasin and has established subsidence thresholds equal to the current acceptable rate of 0.01 feet per year (SCVWD 2012). DWR has categorized Llagas Area subbasin as having a low potential for future land subsidence (DWR 2016c).

Groundwater Quality

DWR has prioritized the Llagas Area subbasin as high priority based on groundwater quality concerns over a significant number of wells across the subbasin (DWR 2016c). Groundwater is typically hard in the subbasin, but is suitable for most uses and meets drinking water standards at public supply wells without the use of treatment methods. The SCVWD created a Nitrate Management Program in October 1991 to investigate and remediate increasing nitrate concentrations in the subbasin (SCVWD 2001).

7.1.2.3 South Lahontan Hydrologic Region

The predominant groundwater basins in the South Lahontan hydrologic region are the Fremont Valley and the Antelope Valley groundwater basins.

The total storage capacity of these two groundwater basins is approximately 74,800 AF, with 70,000 of that total in the Antelope Valley (DWR 2003). Groundwater pumping was estimated to be between 130,000 and 150,000 AF (Antelope Valley 2013) and approximately 32,000 AF in the Fremont Valley (DWR 2003).

Land Subsidence

DWR has categorized theses basins as having a medium-to-high (Fremont Valley) or a high (Antelope Valley) potential for land subsidence (DWR 2016c). A monitoring station in California City (Fremont Valley) has recorded a little under 0.02 feet of subsidence since 2005. Stations in the Antelope valley have recorded 0.01 to 0.03 feet of recent subsidence (DWR 2016c).

Groundwater Quality

DWR has prioritized the Fremont Valley Groundwater Basin as a low priority basin with some groundwater quality concerns and the Antelope Valley basin as a high priority. The Fremont Valley basin has naturally high TDS. Hardness, high fluoride, boron, and nitrates are contaminants of potential concern in the Antelope Valley basin (DWR 2016c).

7.1.2.4 Colorado River Hydrologic Region

The Colorado River hydrologic region consists of the Ames Valley, Cooper Mountain Valley, Warren Valley, and Coachella Valley groundwater basins.

Groundwater storage in these basins is estimated to be 1,200,000 AF (Ames Valley), 106,000 AF (Warren Valley), and 38.7 million AF (Coachella Valley) (DWR 2003). The Warren Valley Groundwater Basin has been adjudicated since 1997 and is managed by Warren Valley Basin Watermaster.

Land Subsidence

DWR has categorized the Ames Valley, Cooper Mountain Valley, and Warren Valley basins as having low or low-to-medium potential for subsidence (DWR 2016c). The CGPS station north of Yucca Valley in Landers has not recoded any subsidence since installation in 1999 (DWR 2016c). Subsidence monitoring in the Ames and Warren valleys have not recorded any subsidence since they were installed in 1999 and 2000, respectively (DWR 2016c).

Groundwater Quality

There are areas of TDS, fluoride, nitrate, and chloride concentrations within these basins (DWR 2003).

7.1.2.5 South Coast Hydrologic Region

The South Coast hydrologic region consists of several groundwater basins where groundwater use and conditions vary.

7.1.2.5.1 Northwest Metropolitan Area Groundwater Basins

The Northwest Metropolitan Area Groundwater Basin and the subbasins that comprise it are generally east-west trending basins that drain into the Pacific Ocean to their west by the Santa Clara River, Calleguas Creek, and Conejo Creek. The total storage capacity is estimated to be between 3,000,000 to 5,000,00 AF (Metropolitan Water District of Southern California [(MWD] 2007). The natural and operational safe yields are estimated to be approximately 45,000 and 100,000 AF, respectively (MWD 2007). Groundwater pumping between 1995 to 2005 was estimated to be 122,000 AF per year.

Land Subsidence

The Oxnard Plain and Oxnard Forebay areas of the basin are categorized as having a medium to high potential for subsidence, with other areas as having a medium to low priority for subsidence (DWR 2016c). The five subsidence monitoring stations in the basin may show signs of subsidence. One station located in the coastal region recorded up to 0.13 feet of subsidence since 2000 (DWR 2016c).

Groundwater Quality

Water quality issues in the basin include seawater intrusion in the coastal aquifers and nitrate and sulfate concerns in the agricultural areas. TDS concentrations throughout much of the basin exceed 1,000 mg/L.

7.1.2.5.2 San Fernando Valley Groundwater Basin

The total storage capacity of the groundwater basin is estimated to be approximately 3,200,000 AF (MWD 2007). The natural and operational safe yields are estimated to be approximately 43,600 and 96,800 AF, respectively (MWD 2007). The San Fernando Valley groundwater basin has been adjudicated since 1979 (DWR 2016c).

Land Subsidence

DWR has prioritized the basin as having a low to medium potential for land subsidence (DWR 2016c). The three subsidence monitoring points in the basin have not recorded any subsidence since installation in 1999 (DWR 2016c).

Groundwater Quality

Bulletin 118 (DWR 2003) identified groundwater contamination of VOCs, such as trichloroethylene, perchloroethylene, petroleum compounds, chloroform, nitrate, sulfate, and heavy metals, in the basin.

7.1.2.5.3 San Gabriel Valley Groundwater Basin

The total groundwater storage capacity of the groundwater basin is estimated to be approximately 8,600,000 AF (MWD 2007). The natural safe yield is estimated to be approximately 152,700 AF (MWD 2007). The basin has been adjudicated since 1971 (DWR 2016c).

Land Subsidence

DWR has also categorized the basin to have a high potential for subsidence due to subsidence concerns in the adjacent subbasins (DWR 2016c). Two subsidence monitoring locations have shown indications of subsidence, with one location measuring up to 0.03 feet of subsidence since 2000 (DWR 2016c).

Groundwater Quality

DWR has prioritized the groundwater basin as high priority because of water quality concerns (DWR 2016c). Key constituents of concern in the basin include TDS, nitrate, VOCs, perchlorate, and N-Nitrosodimethylamine (MWD 2007).

7.1.2.5.4 Coastal Plain of Los Angeles Groundwater Basin

The total storage capacity of the groundwater basin is estimated to be approximately 13,800,000 AF (MWD 2007). The natural and operational safe yields are estimated to be approximately 125,800 AF and 217,300 AF, respectively (MWD 2007). DWR has prioritized the portions of this groundwater basin as either medium or high priority due to groundwater contamination and/or overdraft concerns. Two subbasins in this groundwater basin, the Central and West coast subbasins, have been adjudicated since 1965 and 1961, respectively (DWR 2016c).

Land Subsidence

Portions of this basin have been categorized as either low or medium-to-high potential for subsidence (DWR 2016c). Two monitoring stations in the Central subbasin have recorded up to 0.11 feet of subsidence since installation in 2000.

Groundwater Quality

Localized areas of poor water quality exist in the subbasin, including areas of VOC contamination. Portions of the shallower and deeper aquifers in the coastal region have been impacted by seawater intrusion.

7.1.2.5.5 Coastal Plain of Orange County Groundwater Basin

The total storage capacity of the groundwater basin is estimated to be approximately 66,000,000 AF, with a natural safe yield of 70,500 AF (MWD 2007).

Land Subsidence

DWR has categorized the basin as having a high potential for subsidence due to measured subsidence in the adjacent Coastal Plain of Los Angeles Groundwater Basin (DWR 2016c).

Groundwater Quality

Seawater intrusion along the coastal area has resulted in DWR prioritizing this groundwater basin as medium priority (DWR 2016c). The shallow aquifer has nitrate and VOC contamination issues. Colored groundwater concerns exist in the basin but are limited to the shallow aquifer near the coast (MWD 2007).

7.2 Regulatory Setting

The following section describes the applicable groundwater laws, rules, regulations, and policies.

7.2.1 Federal Plans, Policies, and Regulations

There are no applicable Federal regulations specific to groundwater use within the Project area.

7.2.2 State Plans, Policies, and Regulations

Groundwater use is subject to statewide regulation; additionally, all water use in California is subject to constitutional provisions that prohibit waste and unreasonable use of water. Some relevant provisions are listed below.

7.2.2.1 Water Code (Section 10750) or Assembly Bill 3030 of 1992

Assembly Bill (AB) 3030, commonly referred to as the Groundwater Management Act, permits local agencies to develop Groundwater Management Plans (GMP). Subsequent legislation has further amended the Water Code to make the adoption of a management program mandatory if an agency is to receive public funding for groundwater projects, creating an incentive for the development and implementation of plans.

7.2.2.2 Water Code (Section 10753.7) or Senate Bill 1938 of 2002

Senate Bill (SB) 1938 requires local agencies seeking State of California (State) funds for groundwater construction or groundwater quality projects to have the following: 1) a developed and implemented GMP that includes basin management objectives (BMOs)[1] and addresses the monitoring and management of groundwater levels, groundwater quality degradation, inelastic land subsidence, and surface water/groundwater interaction; 2) a plan addressing cooperation and working relationships with other public entities; 3) a map showing the groundwater subbasin the project is in, neighboring local agencies, and the area subject to the groundwater management plan; 4) protocols for the monitoring of groundwater levels, groundwater quality, inelastic land subsidence, and groundwater/surface water interaction; and 5) GMPs with the components listed above for local agencies outside the groundwater subbasins delineated by Bulletin 118 (DWR 2003).

7.2.2.3 Water Code (Sections 10920 to 10936 and 12924) or Senate Bill X7 6 of 2009

SB X7 6 established a voluntary statewide groundwater monitoring program and requires that groundwater data collected be made readily available to the public. The bill requires DWR to 1) develop a statewide groundwater level monitoring program to track seasonal and long-term

[1] BMOs are management tools that define the acceptable range of groundwater levels, groundwater quality, and inelastic land subsidence that could occur in a local area without causing significant adverse impacts.

trends in groundwater elevation; 2) conduct an investigation of the State's groundwater basins delineated by Bulletin 118 and report its findings to the governor and legislature no later than January 1, 2012 and thereafter in years ending in five or zero; and 3) work cooperatively with local Monitoring Entities to regularly and systematically monitor groundwater elevation to demonstrate seasonal and long-term trends. AB 1152, Amendment to Water Code Sections 10927, 10932, and 10933, allows local monitoring entities to propose alternate monitoring techniques for basins meeting certain conditions and requires submittal of a monitoring plan to DWR for evaluation. In response to SB X7 6, DWR developed and maintains the California Statewide Groundwater Monitoring (CASGEM) program and database.

7.2.2.4 Sustainable Groundwater Management Act

SGMA, enacted in 2014, is a combination of the Senate and Assembly bills described below.

7.2.2.4.1 Water Code (Sections 10927, 10933, 12924, 10750.1, and 10720) or Senate Bill 1168

SB 1168 requires the establishment of GSAs and adoption of Groundwater Sustainability Plans (GSPs). GSAs must be formed by June 30, 2017. GSAs are new entities that consist of local agency(ies) and include new authority to 1) investigate and determine the sustainable yield of a groundwater basin, 2) regulate groundwater extractions, 3) impose fees for groundwater management, 4) require registration of groundwater extraction facilities, 5) require groundwater extraction facilities to use flow measurement devices, and 6) enforce the terms of a GSP.

Additionally, this bill requires groundwater basins to be ranked as high-, medium-, low-, or very low-priority with respect to groundwater conditions and adverse impacts on local habitat and local stream flow no later than January 31, 2015. DWR has determined that the initial basin prioritization developed in June 2014 would be the priority adopted under this legislation. DWR has identified and finalized 21 basins/subbasins with critical overdraft conditions as of January 2016.

GSPs for groundwater basins/subbasins designated by DWR as high- and medium-priority with critical overdraft conditions (per SB X7 6) are required to be developed by January 31, 2020. GSPs for the remaining high- and medium-priority groundwater basins/subbasins are to be developed by January 31, 2022. GSPs are encouraged to be developed for groundwater basins prioritized as low- or very low-priority. All high- and medium-priority basins must achieve sustainability within 20 years of adopting a GSP.

7.2.2.4.2 Water Code (Sections 10729, 10730, 10732, 10733, and 10735) or Assembly Bill 1739

AB 1739 1) provides the specific authorities to a GSA (as defined by SB 1168); 2) requires DWR to publish best management practices (BMPs) for the sustainable management of groundwater by January 1, 2017; and 3) requires DWR to estimate and report the amount of water available for groundwater replenishment by December 31, 2016. The bill authorizes DWR to approve and periodically review all GSPs.

The bill authorizes the State Water Resources Control Board (SWRCB) to 1) conduct inspections and obtain an inspection warrant; 2) designate a groundwater basin as a probationary groundwater basin; 3) develop interim plans for probationary groundwater basins in consultation with DWR if the local agency fails to remedy a deficiency resulting in the designation of probationary; and 4) issue cease and desist orders or violations of restrictions, limitations, orders, or regulations issued under AB 1739.

7.2.2.4.3 Water Code (Sections 10735.2 and 10735.8) or Senate Bill 1319

SB 1319 authorizes the SWRCB to designate high- and medium-priority basins (defined by SB 1168) as a probationary basin after January 31, 2025. This bill allows the SWRCB to develop interim management plans that may override a local agency. However, if the appointed GSA could demonstrate compliance with sustainability goals for the basin, then the SWRCB must exclude the groundwater basin or a portion of the groundwater basin from probationary status.

Per SB 1319, the local agency or GSA has a 90- to 180-day window to remedy certain deficiencies that caused the SWRCB to designate a basin as probationary. The SWRCB could develop an interim plan for certain probationary basins one year after the designation.

7.2.2.4.4 Water Code (Section 10722.2) or Basin Boundary Emergency Regulation

SB 1168 established a procedure for local agencies to request adjustment of basin boundaries identified in Bulletin 118. Boundary modification could be requested based on geologic or hydrologic criteria (scientific modification) or to promote sustainable groundwater management (jurisdictional modification). The Basin Boundary Emergency Regulation specifies the information a local agency is required to provide for the requested boundary adjustment and the procedure for the modification request and public input (DWR 2015a).

7.2.2.4.5 Water Code (Sections 10722.4 and 10730) or Assembly Bill 939

AB 939 authorizes a GSA to impose fees to fund the GSP and requires the GSA to hold at least one public meeting prior to imposing or increasing the fee. The GSA is required to make the data upon which the proposed fee is based available to the public at least 10 days prior to the public meeting.

7.2.2.4.6 Water Code (Sections 10540, 10721, 10727.4, 10727.8, 10733.4, 10726.5, and 10732.2) or Assembly Bill 617

AB 617 requires measures addressing in lieu use to be included in the groundwater sustainability plan. This bill also requires groundwater sustainability planning to be incorporated into the integrated regional water management plan.

7.2.2.5 Other Groundwater Regulations

Groundwater quality issues are monitored through different legislative acts and are the responsibility of several different State agencies, including:

- SWRCB and nine Regional Water Quality Control Boards – Responsible for protecting water quality for present and future beneficial use

- California Department of Toxic Substances Control – Responsible for protecting public health from improper handling, storage, transport, and disposal of hazardous materials
- California Department of Pesticide Regulation – Responsible for preventing pesticide pollution of groundwater
- CDPH – Responsible for drinking water supplies and standards
- California Integrated Waste Management Board – Oversees non-hazardous solid waste disposal
- California Department of Conservation – Responsible for preventing groundwater contamination due to oil, gas, and geothermal drilling and related activities

7.2.3 Regional and Local Plans, Policies, and Regulations

Local GMPs and county ordinances vary by authority/agency and region but typically involve provisions to limit or prevent groundwater overdraft, regulate transfers, prevent subsidence, and protect groundwater quality.

7.2.3.1 Yolo County

In 2009, Yolo County adopted the *2030 Countywide General Plan Conservation and Open Space Element* (County of Yolo 2009). The General Plan lists several goals related to groundwater resources within the county. Some of the groundwater-related goals pertinent to this project are listed below:

- Policy AG-2.1: Protect areas identified as significantly contributing to groundwater recharge from uses that would reduce their ability to recharge or would threaten the quality of the underlying aquifers.
- Policy CO-5.1: Coordinate with water purveyors and users to manage supplies to avoid long-term overdraft, water quality degradation, land subsidence, and other potential problems.
- Policy CO-5.3: Manage Yolo County's groundwater resources on a sustainable yield basis that can provide water purveyors and individual users with reliable, high quality groundwater to serve existing and planned land uses during prolonged drought periods.
- Policy CO-5.14: Require that proposals to convert land to uses other than agriculture, open space, or habitat demonstrate that groundwater recharge will not be significantly diminished.
- Policy CO-5.23: Support efforts to meet applicable water quality standards for all surface and groundwater resources.

In 2006, Yolo County developed the *Yolo County Groundwater Management Plan* in compliance with AB 3030 and SB 1938. The GMP sets forth groundwater elevation triggers to avoid groundwater overdraft in the basin. When groundwater elevation triggers set forth in the GMP are reached, the county would institute groundwater conservation measures.

7.2.3.2 Sutter County

In 2011, Sutter County adopted the *Sutter County 2030 General Plan*. The General Plan lists the following groundwater related goals pertinent to this project:

- Policy AG 3.6: Support the efforts of the local water agencies to promote groundwater recharge, conjunctive use, conservation of significant recharge areas, and other activities to protect and manage Sutter County's groundwater resources.
- Policy I 2.10: Continue to regulate the siting, design, construction, and operation of wastewater disposal systems in accordance with Sutter County regulations to minimize contamination of groundwater supplies.
- Policy ER 6.4: Require new development to preserve areas that provide important groundwater recharge, stormwater management, and water quality benefits such as undeveloped open spaces, natural habitat, riparian corridors, wetlands, and natural drainage areas.
- Policy ER 6.6: Regulate stormwater collection and conveyance, as necessary, to protect groundwater supplies from contamination.
- Policy ER 6.11: Require new development to protect the quality of water resources and natural drainage systems through site design and use of source controls, stormwater treatment, runoff reduction measures, BMPs, and low impact development.
- Policy ER 6.12: Require new development to integrate natural watercourses and provide buffers between waterways and urban development to minimize disturbance of watercourses and protect water quality.

In 2012, Sutter County developed the *Sutter County Groundwater Management Plan*. The GMP sets forth BMPs to manage groundwater levels to ensure adequate water supplies while avoiding adverse impacts and mitigating them when they do occur. Adverse impacts related to groundwater levels can occur from excessively high or low groundwater levels. What constitutes an excessively high or low groundwater level may change over time, and will vary by land use and hydrologic and climatic conditions. To avoid groundwater level declines or abnormally high groundwater levels, Sutter County promotes conjunctive use, regularly monitoring groundwater levels within the county; participates in integrated regional water management programs; and implements polices listed in the General Plan to preserve and protect the county's groundwater resources (listed above).

7.2.3.3 Sacramento County

The Sacramento Groundwater Authority collectively manages groundwater in the northern portion of the Sacramento region. In 2008, the Sacramento Groundwater Authority adopted the *Sacramento Groundwater Authority Groundwater Management Plan*. The GMP sets the groundwater elevation targets, with the goal of improving groundwater elevations over time. Additionally, the GMP states the groundwater basin should be managed such that the impacts during drier years will be minimized when surface water supplies are curtailed and replaced by increased groundwater supplies.

7.2.3.4 Delta Protection Commission Land Use and Resource Management Plan for the Primary Zone of the Delta

The Delta Protection Commission (DPC) was created by the State legislature in 1992 with the goal of developing regional policies for the Delta to protect and enhance the existing land uses (agriculture, wildlife habitat, and recreation) in the primary zone. The DPC adopted the *Land Use and Resource Management Plan for the Primary Zone of the Delta* initially in 1995 and amended it most recently in 2010. A large portion of the Yolo Bypass is within the Primary Zone of the Delta. The DPC's *Land Use and Resource Management Plan for the Primary Zone of the Delta* states the following policies related to subsidence (DPC 2010):

- Subsidence control shall be a key factor in evaluating land use proposals. Encourage agricultural, land management, recreational, and wildlife management practices that minimize subsidence of peat soils.
- Local governments should utilize studies of agricultural and land management methods that minimize subsidence and should assist in educating landowners and managers as to the value of utilizing these methods.
- The conversion of an agricultural parcel, parcels, and/or an agricultural island for water impoundment, including reservoirs, water conveyance or wetland development may not result in the seepage of water onto or under the adjacent parcel, parcels, and/or island. These conversions shall mitigate the risks and adverse effects associated with seepage, levee stability, subsidence, and levee erosion, and shall be consistent with the goals of this Plan.

7.3 Environmental Consequences

This section describes the environmental consequences associated with the Project alternatives and the No Action Alternative. This section presents the assessment methods used to analyze the effects on groundwater; the thresholds of significance that determine the significance of effects; and the potential environmental consequences and mitigation measures as they relate to each Project alternative. Detailed descriptions of the alternatives evaluated in this section are provided in Chapter 2, *Description of Alternatives*.

7.3.1 Methods for Analysis

Potential changes to groundwater levels, land subsidence, and groundwater quality were assessed qualitatively. Potential impacts to groundwater resources in the North of Delta and South of Delta service areas were estimated based on estimated changes in water supply using results from the CalSim II model (see Appendix E for description of the assumptions and methods used in the CalSim II model). Groundwater quality impacts were assessed by considering known areas of concern and determining whether the expected increase in groundwater pumping could cause those areas to migrate. For land subsidence, the changes in groundwater supply (using the CalSim II results) and drawdown were compared to areas that are susceptible to subsidence and areas with existing subsidence to identify areas that may be impacted. The potential for land subsidence was only considered when expected increases in groundwater pumping would be long-term and/or have the potential to cause groundwater level declines greater than historic minimum levels.

Impacts to groundwater resources are determined relative to existing conditions (for California Environmental Quality Act [CEQA]) and the No Action Alternative (for the National Environmental Policy Act [NEPA]). However, as described below, the No Action Alternative would be the same as existing conditions because groundwater resources are not anticipated to experience substantive changes in the area of analysis. Therefore, the analysis compares the impacts of the action alternatives only to existing conditions.

7.3.2 Thresholds of Significance – CEQA

The thresholds of significance for impacts are based on the environmental checklist in Appendix G of the CEQA Guidelines, as amended. These thresholds also encompass the factors considered under NEPA to determine the context and the intensity of impacts. An impact resulting from the implementation of an alternative would be significant if it would result in:

- A net change in groundwater levels that would deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a lowering of groundwater levels that would impact pre-existing or planned land uses
- Permanent land subsidence caused by significant groundwater level decline
- Degradation in groundwater quality such that it would exceed regulatory standards or substantially impair reasonably anticipated beneficial uses of groundwater

7.3.3 Effects and Mitigation Measures

This section provides an evaluation of the direct and indirect effects on groundwater from implementing the Project alternatives. This analysis is organized by Project alternative, with specific impact topics numbered sequentially under each alternative.

7.3.3.1 No Action Alternative

Under the No Action Alternative, the Project would not be implemented, and none of the Project features would be developed in the Project area. The No Action Alternative would not require any construction and would not affect groundwater.

7.3.3.1.1 Impact GRW-1: Temporary and Short-Term Construction-Related Effects on Groundwater Levels

Under the No Action Alternative, there would be no construction-related impacts in the Project area that could result in a decrease in groundwater levels. Therefore, groundwater levels would not experience short-term construction-related impacts and would be the same as existing conditions.

CEQA Conclusion

The No Action Alternative would have **no impact** on groundwater levels in the Project area because it would include no construction activities to affect groundwater levels.

7.3.3.1.2 Impact GRW-2: Temporary and Short-Term Construction-Related Effects on Groundwater Quality

Under the No Action Alternative, there would be no construction-related impacts to groundwater quality in the Project area. Therefore, groundwater quality would not experience short-term construction-related impacts and would be the same as existing conditions.

CEQA Conclusion

The No Action Alternative would have **no impact** on groundwater quality in the Project area because it would include no construction activities to affect groundwater quality.

7.3.3.1.3 Impact GRW-3: Operational Impacts to Groundwater Recharge Could Cause a Lowering of the Local Groundwater Level that Would Impact Pre-existing or Planned Land Uses in the Area Surrounding the Yolo Bypass

Under the No Action Alternative, there would be no changes to the operation of the Yolo Bypass; therefore, there would be no changes to groundwater recharge adjacent to the bypass.

CEQA Conclusion

The No Action Alternative would have **no impact** on groundwater recharge in the Project area because it would include no changes to the operation of the Yolo Bypass.

7.3.3.1.4 Impact GRW-4: Operational Impacts to Groundwater Quality in the Area Surrounding the Yolo Bypass

Under the No Action Alternative, there would be no changes to the operation of the Yolo Bypass; therefore, there would be no changes to groundwater quality adjacent to the bypass.

CEQA Conclusion

The No Action Alternative would have **no impact** on groundwater recharge in the Project area because it would include no changes to the operation of the Yolo Bypass.

7.3.3.1.5 Impact GRW-5: Long-term Changes to Groundwater Levels due to Decreased Allocation to North of Delta and South of Delta Contractors

Under the No Action Alternative, there would be no changes to the operation of the Yolo Bypass that could have indirect effects on the supplies for North of Delta and South of Delta Contractors; therefore, there would be no changes to groundwater levels in these areas.

CEQA Conclusion

The No Action Alternative would have **no impact** on groundwater levels in the Project area because it would include no changes to the operation of the Yolo Bypass.

7.3.3.1.6 Impact GRW-6: Long-Term Changes to Groundwater Quality due to Decreased Allocation to North of Delta and South of Delta Contractors

Under the No Action Alternative, there would be no changes to the operation of the Yolo Bypass that could have indirect effects on the supplies for North of Delta and South of Delta Contractors; therefore, there would be no changes to groundwater quality in these areas.

CEQA Conclusion

The No Action Alternative would have **no impact** on groundwater recharge in the Project area because it would include no changes to the operation of the Yolo Bypass.

7.3.3.1.7 Impact GRW-7: Increased Potential for Land Subsidence due to Decreased Allocation to North of Delta and South of Delta Contractors

Under the No Action Alternative, there would be no changes to the operation of the Yolo Bypass that could have indirect effects on the supplies for North of Delta and South of Delta Contractors; therefore, there would be no changes to groundwater levels that would result in land subsidence in these areas.

CEQA Conclusion

The No Action Alternative would have **no impact** on land subsidence in the Project area because it would include no changes to the operation of the Yolo Bypass.

7.3.3.2 Alternative 1: East Side Gated Notch

Alternative 1, East Side Gated Notch, would allow increased flow from the Sacramento River to enter the Yolo Bypass through a gated notch on the east side of Fremont Weir. The invert of the new notch would be at an elevation of 14 feet, which is approximately 18 feet below the existing Fremont Weir crest. Alternative 1 would allow up to 6,000 cubic feet per second (cfs) to flow through the notch during periods when the river levels are not high enough to go over the crest of Fremont Weir to provide open channel flow for adult fish passage. See Section 2.4 for more details on the alternative features.

7.3.3.2.1 Impact GRW-1: Temporary and Short-Term Construction-Related Effects on Groundwater Levels

Under Alternative 1, construction activities include excavation related to construction of the intake channel and headworks, transport channel, and downstream facilities. The headworks and intake channels under Alternative 1 would be constructed on the eastern side of Fremont Weir. As discussed in Appendix F of the *Assessment of Groundwater Impact on Project Excavation – Technical Memorandum,* excavation of the intake channel, headworks structure, and an outlet channel would occur within proximity to the Sacramento River and at depths below measured groundwater elevations. The headworks and inlet structure would require excavation down to an elevation of seven feet. Groundwater elevation near the excavation area on the eastern side of the Fremont Weir varies from seven to 15 feet between the spring and fall seasons, respectively. Dewatering efforts would be required to provide relatively dry conditions for construction. The groundwater pumping required for dewatering could cause temporary groundwater level declines in the shallow aquifer in the construction area during construction activities. Construction of the headworks structure, intake channel, and outlet channel would occur concurrently. It would take approximately 12 to 15 weeks to construct the headworks structure. Any dewatering activities would end after construction is complete, allowing groundwater levels to recover.

CEQA Conclusion

Construction-related impacts on groundwater levels under Alternative 1 would be **less than significant** because dewatering activities would be short-term and would end after construction is complete.

7.3.3.2.2 Impact GRW-2: Temporary and Short-Term Construction-Related Effects on Groundwater Quality

As discussed under Impact GRW-1, construction activities would occur below measured groundwater elevations. Construction equipment could cause increased waste discharge through onsite runoff or spills. Additionally, improper storage of construction waste could impact groundwater quality since construction is expected to occur below grade and within proximity to the shallow groundwater aquifer within the Project area. Contamination of surface water due to construction activities would also impact groundwater quality in areas where groundwater and surface water interaction occurs.

CEQA Conclusion

Because construction under Alternative 1 could occur below measured groundwater levels and within proximity to the shallow groundwater aquifer, potential onsite spills or waste discharge runoff during construction would be expected to impact groundwater quality. This impact would be **significant**.

Mitigation Measure MM-HAZ-1: Implement a Construction Risk Management Plan.

As discussed in the effects and mitigation measures of Chapter 19, *Hazardous Materials, Health, and Safety*, construction of the Project shall include implementation of a Construction Risk Management Plan (CRMP) to eliminate accidental releases of hazardous materials.

Mitigation Measure MM-WQ-1: Implement a Spill Prevention, Control, and Countermeasure Plan.

As discussed in mitigation measures of Chapter 6, *Water Quality*, construction activities shall incorporate a Spill Prevention, Control, and Countermeasure Plan (SPCCP).

Mitigation Measure MM-WQ-2: Implement a Stormwater Pollution and Prevention Plan.

As discussed in mitigation measures of Chapter 6, *Water Quality*, construction activities shall incorporate a Stormwater Pollution and Prevention Plan (SWPPP) and construction BMPs.

Mitigation Measure MM-WQ-3: Develop a turbidity monitoring program.

As discussed in mitigation measures of Chapter 6, *Water Quality*, a turbidity monitoring plan shall be developed and implemented. If turbidity limits exceed basin plan standards, construction-related earth-disturbing activities shall slow to a point that would alleviate the problem.

Implementation of the CRMP, SPCCP, SWPPP, construction BMPs, and turbidity monitoring plan included in MM-HAZ-1, MM-WQ-1, MM-WQ-2, and MM-WQ-3, respectively, would ensure all surface water and groundwater quality risks would be minimized and the impact would be reduced to **less than significant**.

7.3.3.2.3 Impact GRW-3: Operational Impacts to Groundwater Recharge Could Cause a Lowering of the Local Groundwater Level that Would Impact Pre-existing or Planned Land Uses in the Area Surrounding the Yolo Bypass

Under Alternative 1, two cutoff walls would be constructed along the eastern side of the bypass: one from Fremont Weir to the central part of Tule Pond and another just south of Tule Pond. These cutoff walls would be included because the channel construction in these areas would cut through an existing clay blanket layer that currently prevents levee underseepage. Both cutoff walls would be approximately 30 feet deep and approximately 2,850 and 3,150 feet long, respectively. Construction of the cutoff walls along the eastern levee would act as a barrier to levee underseepage from the bypass to the Elkhorn area. Where there are higher water levels in the Tule Canal that would cause water to flow from the bypass to groundwater ("losing" conditions), the cutoff wall would prevent groundwater movement from the Yolo Bypass into the aquifer to the east. In areas where the bypass may be in a "gaining" condition (groundwater outside of the bypass is higher in elevation than surface water or groundwater inside the bypass), the cutoff wall could increase water in storage to the east of the Yolo Bypass as water builds behind the wall. Figure 7-6 shows that the eastern side of the Yolo Bypass is typically in a losing condition, with higher surface water levels in the bypass than in the surrounding groundwater (well locations shown on Figure 7-4). Therefore, the cutoff walls in Alternative 1 could prevent recharge to the groundwater aquifer under the Elkhorn area from the Yolo Bypass area. However, because the cutoff walls are would only be in areas that currently have a clay blanket layer which prevents levee underseepage (i.e., areas that currently have no groundwater recharge from the Yolo Bypass), the cutoff walls would not change recharge to the aquifer under the Elkhorn area.

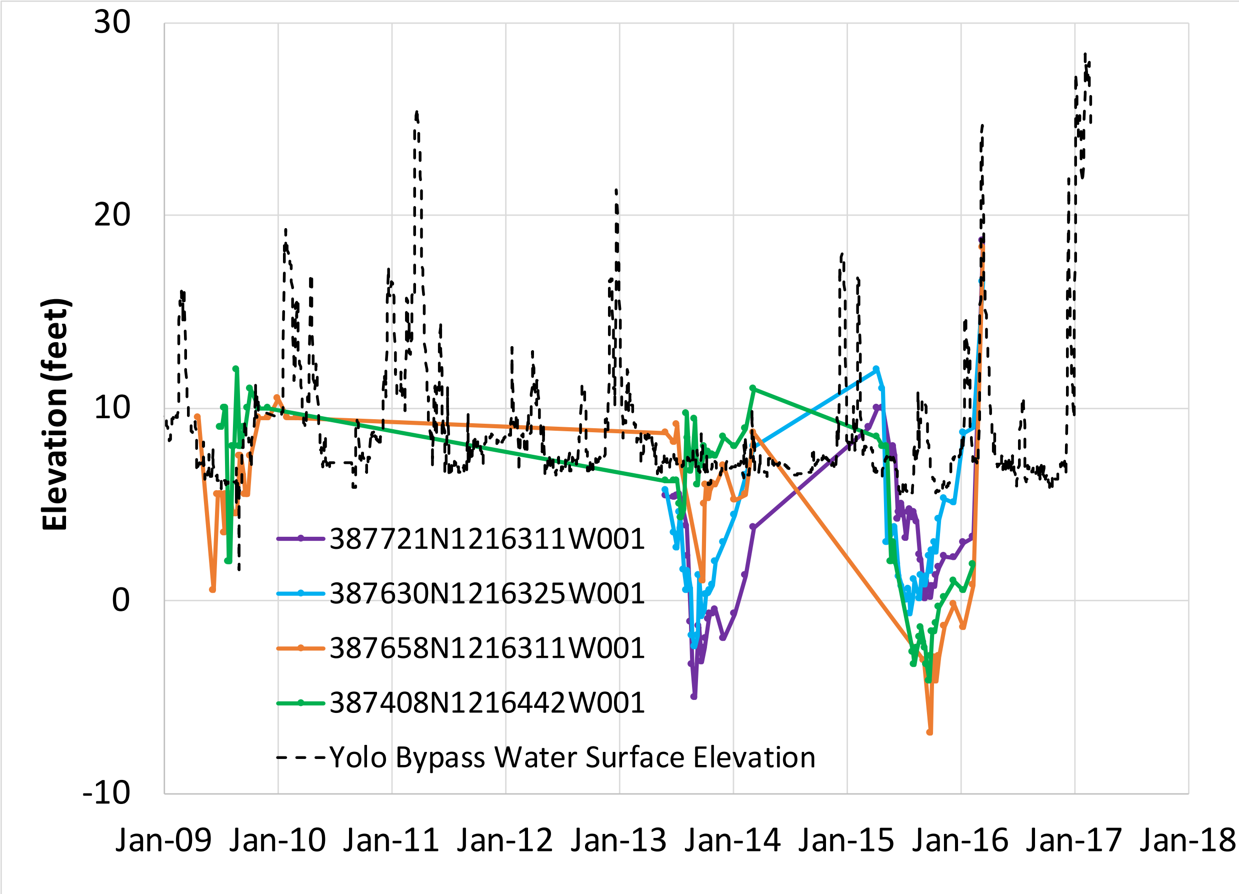


Figure 7-6. Groundwater Elevation at Wells along the East Side of the Yolo Bypass and Surface Water Elevation in the Yolo Bypass

Alternative 1 would improve an existing channel along the eastern side of the bypass running parallel to the cutoff wall discussed above. Improvements would include construction of a well-defined channel connecting the Tule Pond outlet to Tule Canal near Agricultural Road Crossing 1. This channel would go through the "wooded area" (see Figure 2-3 for details) that currently has standing water for much of the year, and shallow groundwater likely contributes to this standing water during winter and early spring. The new channel would have an invert elevation of approximately 12 feet and a typical water surface elevation of approximately 17 to 18 feet, except in the summer months when the channel most likely would be dry. The area surrounding the channel includes the wooded area to the east of the channel and the bypass to the west of the channel. Groundwater elevations in this area along the east and west of the channel range from 14.5 feet in the spring to four feet in the fall. This new channel has the potential to increase discharge out of the shallow groundwater aquifer into the channel in the spring months when the groundwater elevation is higher than the channel invert elevation. However, the channel would be wet during much of this period because of fish passage and inundation flows from Fremont Weir. During these periods, the water surface elevation would be approximately 17 to 18 feet, which is higher than groundwater elevation. When the channel is dry in the summer months, the channel elevation would be 12 feet, but the groundwater elevation in the fall and summer months would be at approximately four feet, which is lower than the channel elevation. Because the channel would be at a higher elevation than the surrounding groundwater, groundwater discharge into the channel is not expected to occur or cause a net deficit in aquifer volume.

Under Alternative 1, there is the potential for locally increased groundwater levels due to additional recharge to the shallow groundwater system from the additional flow introduced to the Yolo Bypass. Increased inundation provides for additional time when surface water in the bypass could infiltrate the ground and recharge the underlying groundwater aquifer, potentially affecting groundwater levels in and around the Yolo Bypass. Increased groundwater levels in these areas would not cause land use changes but could affect agricultural productivity. Therefore, this potential impact is discussed in Chapter 16, *Socioeconomics*.

CEQA Conclusion

Impacts to groundwater levels from changes to groundwater recharge under Alternative 1 would be **less than significant** because the cutoff walls would not fully impede groundwater recharge to the Elkhorn area and the new channel south of Tule Pond would be higher than the surrounding aquifer for most of the year.

7.3.3.2.4 Impact GRW-4: Operational Impacts to Groundwater Quality in the Area Surrounding the Yolo Bypass

Groundwater levels surrounding the Yolo Bypass may increase under Alternative 1 because of increased groundwater recharge from the additional flow in the bypass. While the Sacramento River quality upstream of Knights Landing is generally better than groundwater quality, some contaminants of concern, like methylmercury and organochlorine pesticides, do exist. Chapter 6, *Water Quality*, more thoroughly discusses water quality issues in the Project area. Similar to surface water, groundwater in the Project area is also generally good, but there are some localized groundwater quality concerns in the Yolo subbasin, including high salt content and localized nitrate and selenium issues (see also Section 7.1.1.4, *Groundwater Quality*). Increased groundwater levels due to increased recharge from surface water likely would improve groundwater quality in the Project area but could introduce some new contaminants of concern into the groundwater.

CEQA Conclusion

Impacts from increased groundwater recharge in the bypass on groundwater quality under Alternative 1 would be **less than significant** because surface water quality in the Project area is generally better than groundwater quality.

7.3.3.2.5 Impact GRW-5: Long-Term Changes to Groundwater Levels due to Decreased Allocation to North of Delta and South of Delta Contractors

Increased diversions from the Sacramento River to the Yolo Bypass under Alternative 1 could have minimal impacts on Central Valley Project (CVP) and State Water Project (SWP) deliveries to North of Delta and South of Delta Contractors. As discussed in Chapter 5, *Surface Water Supply*, the difference in deliveries under Alternative 1 compared to existing conditions and the No Action Alternative would be less than one percent. Decreased surface water deliveries could lead to increased groundwater pumping to make up for the difference in supplies. However, these reductions in deliveries would be rare and limited to a few months within limited years. Therefore, any increase in groundwater pumping in lieu of surface water deliveries would be short-term and infrequent.

CEQA Conclusion

Impacts from the potential increase in groundwater pumping caused by decreased CVP and SWP surface water supplies under Alternative 1 would be **less than significant** because the reduction in supplies would be short-term, infrequent, and less than one percent of surface water supplies.

7.3.3.2.6 Impact GRW-6: Long-Term Changes to Groundwater Quality due to Decreased Allocation to North of Delta and South of Delta Contractors

Increased groundwater pumping could substantially alter groundwater levels and/or flow patterns. Substantial reductions in groundwater levels for a long period of time could induce the movement or migration of reduced quality groundwater into previously unaffected areas. However, as discussed for Impact GRW-5, there would be minimal changes to groundwater pumping in lieu of surface water deliveries under Alternative 1. There would be no detrimental impacts from groundwater pumping causing a change in groundwater quality.

CEQA Conclusion

Because the potential increase in groundwater pumping in lieu of surface water deliveries would be short-term, infrequent, and of small magnitude, impacts to groundwater quality in the Project area would be **less than significant.**

7.3.3.2.7 Impact GRW-7: Increased Potential for Land Subsidence due to Decreased Allocation to North of Delta and South of Delta Contractors

Increased groundwater pumping could substantially alter groundwater levels and/or flow patterns. Substantial reductions in groundwater levels greater than historic low groundwater levels could increase the potential for subsidence. However, as discussed for Impact GRW-6, there would be minimal changes to groundwater pumping in lieu of surface water deliveries under Alternative 1. The potential increase in groundwater pumping in lieu of surface water deliveries would be minimal, and any increase would be distributed over a large area (within the CVP and SWP contractors' service area). Any changes to groundwater levels would not contribute to land subsidence.

CEQA Conclusion

Because the potential increase in groundwater pumping in lieu of surface water deliveries would be short-term and infrequent (less than one percent of surface water supplies), impacts to land subsidence would be **less than significant.**

7.3.3.3 Alternative 2: Central Gated Notch

Alternative 2, Central Gated Notch, would provide a new gated notch through Fremont Weir similar to the notch described for Alternative 1. The primary difference between Alternatives 1 and 2 is the location of the notch; Alternative 2 would site the notch near the center of Fremont Weir. This gate would be a similar size but would have an invert elevation that is higher (14.8 feet) because the river is higher at this upstream location, and the gate would allow up to 6,000 cfs through the notch to provide open channel flow for adult fish passage. See Section 2.5 for more details on the alternative features.

7.3.3.3.1 Impact GRW-1: Temporary and Short-Term Construction-Related Effects on Groundwater Levels

Under Alternative 2, construction activities include excavation related to the construction of the intake channel and headworks, transport channel, and downstream facilities. The headworks and intake channels under Alternative 2 would be constructed near the center of the Fremont Weir. As discussed in Appendix F, *Assessment of Groundwater Impact on Project Excavation – Technical Memorandum,* excavation activities under Alternative 2 would be below measured groundwater elevations. The headworks and inlet structure would require excavation to an elevation of eight feet. Groundwater elevation near the center of the Fremont Weir varies from nine to 17 feet between the spring and fall seasons, respectively, under existing conditions. Dewatering efforts would be required to provide relatively dry conditions for construction. The groundwater pumping required for dewatering could cause temporary groundwater level declines in the shallow aquifer at the proposed pumping sites during construction activities. Construction of the headworks structure, intake channel, and outlet channel would occur concurrently. It would take approximately 12 to 15 weeks to construct the headworks structure. Dewatering activities would end after construction is complete, allowing groundwater levels to recover.

CEQA Conclusion

Impacts from construction on groundwater levels under Alternative 2 would be **less than significant** because dewatering activities would be short-term and would end after construction is complete.

7.3.3.3.2 Impact GRW-2: Temporary and Short-Term Construction-Related Effects on Groundwater Quality

Short-term impacts to groundwater quality from construction under Alternative 2 would be identical to those discussed under Alternative 1.

CEQA Conclusion

Because construction could occur below grade and within proximity to the shallow groundwater aquifer, onsite spills or waste discharge runoff during construction under Alternative 2 would be expected to impact groundwater quality. This impact would be **significant**.

Implementation of the HMMP, SPCCP, SWPPP, construction BMPs, and turbidity monitoring plan included in MM-HAZ-1, MM-WQ-1, MM-WQ-2, and MM-WQ-3, respectively, would ensure all surface water and groundwater quality risks would be minimized and the impact would be reduced to **less than significant**.

7.3.3.3.3 Impact GRW-3: Operational Impacts to Groundwater Recharge Could Cause a Lowering of the Local Groundwater Level that Would Impact Pre-existing or Planned Land Uses in the Area Surrounding the Yolo Bypass

Under Alternative 2, a cutoff wall (3,150 feet long and 30 feet deep) would be constructed just south of Tule Pond. The cutoff wall would be included because the channel construction in this area would cut through an existing clay blanket layer that currently prevents levee underseepage. The cutoff wall along the eastern levee would act as a barrier to groundwater flow across the eastern side of the bypass. Where there are higher water levels in the Tule Canal that would cause water to flow from the bypass to groundwater ("losing" conditions), the cutoff wall would prevent groundwater movement from the Yolo Bypass into the aquifer to the east. In areas where the bypass may be in a "gaining" condition, the cutoff wall could increase water in storage to the east of Yolo Bypass as water builds behind the wall. The eastern side of the Yolo Bypass is typically in losing conditions, as shown by the higher surface water in the bypass than groundwater levels in Figure 7-6. Therefore, the cutoff wall in Alternative 2 could prevent recharge to the groundwater aquifer under the Elkhorn area from the Yolo Bypass area. However, since the cutoff wall does not extend over the entire eastern side of the bypass in areas that currently have a clay blanket preventing levee underseepage, the cutoff walls would not change recharge to the aquifer under the Elkhorn area.

Alternative 2 would improve an existing channel along the eastern side of the bypass running parallel to the cutoff wall discussed above. Improvements would include construction of a well-defined channel connecting the Tule Pond outlet to Tule Canal near Agricultural Road Crossing 1. This channel would go through the wooded area (see Figure 2-3 for details) that currently has standing water for much of the year, and shallow groundwater likely contributes to this standing water during winter and early spring. The new channel would have an invert elevation of approximately 12 feet and a typical water surface elevation of approximately 17 to 18 feet, except in the summer months when the channel most likely would be dry. Groundwater elevations in this area along the east and west of the channel range from 14.5 feet in the spring to 4 feet in the fall and summer months. This new channel has the potential to increase discharge out of the shallow groundwater aquifer into the channel in the spring months when the groundwater elevation is higher than the channel invert elevation. However, the channel would be wet during much of this period because of fish passage and inundation flows from Fremont Weir and would have a water surface elevation of approximately 17 to 18 feet, which is higher than groundwater elevation. When the channel is dry in summer months, the channel elevation would be 12 feet, but the groundwater elevation in the fall and summer months would be at approximately four feet, which is lower than the channel elevation. Because the channel would be at a higher elevation than the surrounding groundwater, groundwater discharge is not expected to occur from the aquifer into the channel or to cause a net deficit in aquifer volume.

Under Alternative 2, there is the potential for locally increased groundwater levels due to additional recharge to the shallow groundwater system from the additional flow introduced to the Yolo Bypass. Increased inundation provides for additional time when surface water in the bypass could infiltrate the ground and recharge the underlying groundwater aquifer, potentially affecting groundwater levels in and around the Yolo Bypass. Increased groundwater levels in these areas would not cause land use changes but could affect agricultural productivity. Therefore, this potential impact is discussed in Chapter 16, *Socioeconomics*.

CEQA Conclusion

Impacts to groundwater levels from changes to groundwater recharge under Alternative 2 would be **less than significant** because the cutoff wall is replacing the functionality of an existing clay blanket to reduce underseepage and improve levee stability and would not fully impede groundwater recharge to the Elkhorn area, and the new channel south of Tule Pond would be higher than the surrounding aquifer for most of the year.

7.3.3.3.4 Impact GRW-4: Operational Impacts to Groundwater Quality in the Area Surrounding the Yolo Bypass

Impacts to groundwater quality from operations of Alternative 2 would be identical to those discussed for Alternative 1.

CEQA Conclusion

Impacts from increased flows in the bypass on groundwater quality would be **less than significant** because surface water quality in the Project area is generally better than groundwater quality, barring a few constituents of concern.

7.3.3.3.5 Impact GRW-5: Long-Term Changes to Groundwater Levels due to Decreased Allocation to North of Delta and South of Delta Contractors

Impacts to groundwater levels near CVP and SWP contractors from operations of Alternative 2 would be identical to those discussed for Alternative 1.

CEQA Conclusion

Impacts from the potential increase in groundwater pumping caused by decreased CVP and SWP surface water supplies would be **less than significant** under Alternative 2 because the reduction in supplies would be short-term and infrequent.

7.3.3.3.6 Impact GRW-6: Long-Term Changes to Groundwater Quality due to Decreased Allocation to North of Delta and South of Delta Contractors

Impacts to groundwater quality near CVP and SWP contractors from operations of Alternative 2 would be identical to those discussed for Alternative 1.

CEQA Conclusion

Because the potential increase in groundwater pumping in lieu of surface water deliveries would be short-term and infrequent under Alternative 2, impacts to groundwater quality in the region would be **less than significant.**

7.3.3.3.7 Impact GRW-7: Increased Potential for Land Subsidence due to Decreased Allocation to North of Delta and South of Delta Contractors

Impacts to subsidence near CVP and SWP contractors from operations of Alternative 2 would be identical to those discussed for Alternative 1.

CEQA Conclusion

Because the potential increase in groundwater pumping in lieu of surface water deliveries would be short-term and infrequent under Alternative 1, impacts to land subsidence would be **less than significant.**

7.3.3.4 Alternative 3: West Side Gated Notch

Alternative 3, West Side Gated Notch, would provide a similar new gated notch through Fremont Weir as described for Alternative 1. The primary difference between Alternatives 1 and 3 is the location of the notch; Alternative 3 would site the notch on the western side of Fremont Weir. This gate would be a similar size but would have an invert elevation that is higher (16.1 feet) because the river is higher at this upstream location. Alternative 3 would allow up to 6,000 cfs through the gated notch to provide open channel flow for adult fish passage. See Section 2.6 for more details on the alternative features.

7.3.3.4.1 Impact GRW-1: Temporary and Short-Term Construction-Related Effects on Groundwater Levels

Under Alternative 3, construction activities include excavation related to the construction of the intake channel and headworks, transport channel, and downstream facilities. The headworks and intake channels under Alternative 3 would be constructed on the western side of Fremont Weir. As discussed in the Appendix F, *Assessment of Groundwater Impact on Project Excavation – Technical Memorandum,* excavation activities under Alternative 3 would be below measured groundwater elevations. The headworks and inlet structure would require excavation to an elevation of nine feet. Groundwater elevation on the western side of Fremont Weir varies from eight to 17 feet between the spring and fall seasons, respectively, under existing conditions. Dewatering efforts would be required to provide relatively dry conditions for construction. The groundwater pumping required for dewatering could cause temporary groundwater level declines in the shallow aquifer at the proposed pumping sites during construction activities. Construction of the headworks structure, intake channel, and outlet channel would occur concurrently. It would take approximately 12 to 15 weeks to construct the headworks structure. Any dewatering activities would end after construction is complete, allowing groundwater levels to recover.

CEQA Conclusion

Impacts from construction on groundwater levels under Alternative 3 would be **less than significant** because dewatering activities would be short-term and would end after construction is complete.

7.3.3.4.2 Impact GRW-2: Temporary and Short-Term Construction-Related Effects on Groundwater Quality

Short-term impacts to groundwater quality from construction under Alternative 3 would be identical to those discussed for Alternative 1.

CEQA Conclusion

Because construction could occur below grade and within proximity to the shallow groundwater aquifer, onsite spills or waste discharge runoff during construction would be expected to impact groundwater quality, and this impact would be **significant** under Alternative 3.

Implementation of the HMMP, SPCCP, SWPPP, construction BMPs, and turbidity monitoring plan included in MM-HAZ-1, MM-WQ-1, MM-WQ-2, and MM-WQ-3, respectively, would ensure all surface water and groundwater quality risks would be minimized and the impact would be reduced to **less than significant**.

7.3.3.4.3 Impact GRW-3: Operational Impacts to Groundwater Recharge Could Cause a Lowering of the Local Groundwater Level that Would Impact Pre-existing or Planned Land Uses in the Area Surrounding the Yolo Bypass

Operational impacts to groundwater levels under Alternative 3 would be identical to those discussed for Alternative 2.

CEQA Conclusion

Impacts to groundwater levels from changes to groundwater recharge would be **less than significant** under Alternative 3 because the cutoff walls would not fully impede groundwater recharge to the Elkhorn area and the new channel south of Tule Pond would be higher than the surrounding aquifer for most of the year.

7.3.3.4.4 Impact GRW-4: Operational Impacts to Groundwater Quality in the Area Surrounding the Yolo Bypass

Impacts to groundwater quality from operations of Alternative 3 would be identical to those discussed for Alternative 1.

CEQA Conclusion

Impacts from increased flows in the bypass on groundwater quality would be **less than significant** under Alternative 3 because surface water quality in the Project area is generally better than groundwater quality, barring a few constituents of concern.

7.3.3.4.5 Impact GRW-5: Long-Term Changes to Groundwater Levels due to Decreased Allocation to North of Delta and South of Delta Contractors

Impacts to groundwater levels near CVP and SWP contractors from operations of Alternative 3 would be identical to those discussed for Alternative 1.

CEQA Conclusion

Impacts from the potential increase in groundwater pumping caused by decreased CVP and SWP surface water supplies would be **less than significant** under Alternative 3 because the reduction in supplies would be short-term and infrequent.

7.3.3.4.6 Impact GRW-6: Long-Term Changes to Groundwater Quality due to Decreased Allocation to North of Delta and South of Delta Contractors

Impacts to groundwater quality near CVP and SWP contractors from operations of Alternative 3 would be identical to those discussed for Alternative 1.

CEQA Conclusion

Because the potential increase in groundwater pumping in lieu of surface water deliveries would be short-term and infrequent, impacts to groundwater quality in the region would be **less than significant.**

7.3.3.4.7 Impact GRW-7: Increased Potential for Land Subsidence due to Decreased Allocation to North of Delta and South of Delta Contractors

Impacts to subsidence near CVP and SWP contractors from operations of Alternative 3 would be identical to those discussed for Alternative 1.

CEQA Conclusion

Because the potential increase in groundwater pumping in lieu of surface water deliveries associated with Alternative 3 would be short-term and infrequent, impacts to land subsidence would be **less than significant.**

7.3.3.5 Alternative 4: West Side Gated Notch – Managed Flow

Alternative 4, West Side Gated Notch – Managed Flow, would have a smaller amount of flow entering the Yolo Bypass through the gated notch in Fremont Weir than some other alternatives, but it would incorporate water control structures to maintain inundation for longer periods of time within the northern portion of the Yolo Bypass. Alternative 4 would include the same gated notch and associated facilities as described for Alternative 3; however, it would be operated to limit the maximum inflow to 3,000 cfs. See Section 2.7 for more details on the alternative features.

7.3.3.5.1 Impact GRW-1: Temporary and Short-Term Construction-Related Effects on Groundwater Levels

Similar to Alternatives 1, 2, and 3, Alternative 4 includes excavation related to the construction of the intake channel and headworks, transport channel, and downstream facilities. This alternative would include additional improvements farther south in the Yolo Bypass, which consist of engineered berm improvements, fish bypass channels, and water control structures. As discussed in Appendix F, *Assessment of Groundwater Impact on Project Excavation – Technical Memorandum*, excavation activities under Alternative 4 would be below measured groundwater elevations. The headworks and inlet structure would require excavation to an elevation of nine feet. Groundwater elevation near the western side of Fremont Weir varies from eight to 17 feet between the spring and fall seasons, respectively. Construction associated with the berm improvements, fish bypass channel, and water control structures would require excavation to an elevation of 10 feet. Given that groundwater elevations in this area are a similar elevation, groundwater dewatering may be required. Dewatering efforts would be required to provide relatively dry conditions for construction. The groundwater pumping required for dewatering could cause temporary groundwater level declines in the shallow aquifer at the proposed pumping sites during construction activities. Construction of the headworks structure, intake channel, and outlet channel would occur concurrently. It would take approximately 12 to 15 weeks to construct the headworks structure. Dewatering activities would end after construction is complete, allowing groundwater levels to recover.

CEQA Conclusion

Impacts from construction on groundwater levels under Alternative 4 would be **less than significant** because dewatering activities would be short-term and would end after construction is complete.

7.3.3.5.2 Impact GRW-2: Temporary and Short-Term Construction-Related Effects on Groundwater Quality

Short-term impacts to groundwater quality from construction under Alternative 4 would be identical to those discussed for Alternative 1.

CEQA Conclusion

Because construction could occur below grade and within proximity to the shallow groundwater aquifer, onsite spills or waste discharge runoff during construction would be expected to impact groundwater quality. This impact would be **significant** under Alternative 4.

Implementation of the HMMP, SPCCP, SWPPP, construction BMPs, and turbidity monitoring plan included in MM-HAZ-1, MM-WQ-1, MW-WQ-2, and MM-WQ-3, respectively, would ensure all surface water and groundwater quality risks would be minimized and the impact would be reduced to **less than significant**.

7.3.3.5.3 Impact GRW-3: Operational Impacts to Groundwater Recharge Could Cause a Lowering of the Local Groundwater Level that Would Impact Pre-existing or Planned Land Uses in the Area Surrounding the Yolo Bypass

Operational impacts to groundwater levels under Alternative 4 would be identical to those discussed for Alternative 2.

CEQA Conclusion

Impacts to groundwater levels from changes to groundwater recharge would be **less than significant** under Alternative 4 because the cutoff walls would not fully impede groundwater recharge to the Elkhorn area and the new channel south of Tule Pond would be higher than the surrounding aquifer for most of the year.

7.3.3.5.4 Impact GRW-4: Operational Impacts to Groundwater Quality in the Area Surrounding the Yolo Bypass

Impacts to groundwater quality from operations of Alternative 4 would be identical to those discussed for Alternative 1.

CEQA Conclusion

Impacts from increased flows in the bypass on groundwater quality would be **less than significant** under Alternative 4 because surface water quality in the Project area is generally better than groundwater quality, barring a few constituents of concern.

7.3.3.5.5 Impact GRW-5: Long-Term Changes to Groundwater Levels due to Decreased Allocation to North of Delta and South of Delta Contractors

Increased diversions from the Sacramento River to the Yolo Bypass under Alternative 4 could have minimal impacts on CVP and SWP deliveries to North of Delta and South of Delta Contractors. As discussed in Chapter 5, *Surface Water Supply*, there would generally be no difference in deliveries under Alternative 4 compared to existing conditions. Under Alternative 4 compared to the No Action Alternative, reductions in deliveries up to one percent could occur under certain months in dry and critical years. Decreased surface water deliveries could lead to increased groundwater pumping to make up the difference in supplies. However, these reductions in deliveries are rare and limited to a few months within limited years. Therefore, any increase in groundwater pumping in lieu of surface water deliveries would be short-term and infrequent.

CEQA Conclusion

Impacts from the potential increase in groundwater pumping caused by decreased CVP and SWP surface water supplies under Alternative 4 would be **less than significant** because the reduction in supplies would be short-term and infrequent.

7.3.3.5.6 Impact GRW-6: Long-Term Changes to Groundwater Quality due to Decreased Allocation to North of Delta and South of Delta Contractors

Increased groundwater pumping could substantially alter groundwater levels and/or flow patterns. Substantial reductions in groundwater levels for a long period of time could induce the movement or migration of reduced quality groundwater into previously unaffected areas. However, as discussed for Impact GRW-5, there would be minimal changes to groundwater pumping in lieu of surface water deliveries under Alternative 4. There would be no detrimental impacts from groundwater pumping causing a change in groundwater quality.

CEQA Conclusion

Impacts from the potential increase in groundwater pumping due to decreased North of Delta and South of Delta surface water supplies on groundwater quality in the region would be **less than significant** under Alternative 4 because the potential increase in groundwater pumping in lieu of surface water deliveries would be short-term and infrequent.

7.3.3.5.7 Impact GRW-7: Increased Potential for Land Subsidence due to Decreased Allocation to North of Delta and South of Delta Contractors

Increased groundwater pumping could substantially alter groundwater levels and/or flow patterns. Substantial reductions in groundwater levels greater than historic low groundwater level elevations could increase the potential for subsidence. As discussed for Impact GRW-6, there would be minimal changes to groundwater pumping in lieu of surface water deliveries under Alternative 4. The expected increase in groundwater pumping in lieu of surface water deliveries would be minimal, and any increase would be distributed over a large area (within the CVP and SWP contractors' service area). Changes to groundwater levels would not cause detrimental impacts to land subsidence.

CEQA Conclusion

Because the potential increase in groundwater pumping in lieu of surface water deliveries would be short-term and infrequent under Alternative 4, impacts to land subsidence would be **less than significant.**

7.3.3.6 Alternative 5: Central Multiple Gated Notches

Alternative 5, Central Multiple Gated Notches, would improve the capture of fish through using multiple gates and intake channels so that the deeper gate could allow more flow to enter the bypass when the river is at lower elevations. Flows would move to other gates when the river is higher to control inflows. Alternative 5 incorporates multiple gated notches in the central location on the existing Fremont Weir that would allow combined flows of up to 3,400 cfs. See Section 2.8 for more details on the alternative features.

7.3.3.6.1 Impact GRW-1: Temporary and Short-Term Construction-Related Effects on Groundwater Levels

Alternative 5 includes excavation related to construction of the intake channel and headworks, transport channel, and downstream facilities. The headworks and intake channels under Alternative 5 would be constructed in the central area of Fremont Weir. The channels would extend from this point to the southeast to connect with Tule Canal at Agricultural Road Crossing 1. As discussed in Appendix F, *Assessment of Groundwater Impact on Project Excavation – Technical Memorandum,* excavation activities under Alternative 5 would be below measured groundwater elevations. This alternative includes four inlet gates that would require excavation to an elevation of seven feet. Groundwater elevation near the excavation area near Fremont Weir varies from nine to 17 feet between the spring and fall seasons, respectively, under existing conditions. Dewatering efforts would be required to provide relatively dry conditions for construction. The groundwater pumping required for dewatering could cause temporary groundwater level declines in the shallow aquifer at the proposed pumping sites during construction activities. Construction of the headworks structure, intake channel, and outlet channel would occur concurrently. It would take approximately 12 to 15 weeks to construct the headworks structure. Dewatering activities would end after construction is complete, allowing groundwater levels to recover.

CEQA Conclusion

Impacts from construction on groundwater levels under Alternative 5 would be **less than significant** because dewatering activities would be short-term and would end after construction is complete.

7.3.3.6.2 Impact GRW-2: Temporary and Short-Term Construction-Related Effects on Groundwater Quality

Short-term impacts to groundwater quality from construction under Alternative 5 would be identical to those discussed for Alternative 1.

CEQA Conclusion

Because construction could occur below grade and within proximity to the shallow groundwater aquifer under Alternative 5, onsite spills or waste discharge runoff during construction would be expected to impact groundwater quality. This impact would be **significant**.

Implementation of the HMMP, SPCCP, SWPPP, construction BMPs, and turbidity monitoring plan included in MM-HAZ-1, MM-WQ-1, MM-WQ-2, and MM-WQ-3, respectively, would ensure all surface water and groundwater quality risks would be minimized and the impact would be reduced to **less than significant**.

7.3.3.6.3 Impact GRW-3: Operational Impacts to Groundwater Recharge Could Cause a Lowering of the Local Groundwater Level that Would Impact Pre-existing or Planned Land Uses in the Area Surrounding the Yolo Bypass

Operational impacts to groundwater levels under Alternative 5 would be identical to those discussed for Alternative 2.

CEQA Conclusion

Impacts to groundwater levels from changes to groundwater recharge under Alternative 5 would be **less than significant** because the cutoff walls would not entirely impede groundwater recharge to the Elkhorn area.

7.3.3.6.4 Impact GRW-4: Operational Impacts to Groundwater Quality in the Area Surrounding the Yolo Bypass

Impacts to groundwater quality from operations of Alternative 5 would be identical to those discussed for Alternative 1.

CEQA Conclusion

Impacts from increased flows in the bypass on groundwater quality under Alternative 5 would be potentially **less than significant** because surface water quality in the Project area is generally better than groundwater quality, barring a few constituents of concern.

7.3.3.6.5 Impact GRW-5: Long-Term Changes to Groundwater Levels due to Decreased Allocation to North of Delta and South of Delta Contractors

Increased diversions from the Sacramento River to the Yolo Bypass under Alternative 5 could have a minimal impact on CVP and SWP deliveries to North of Delta and South of Delta Contractors. As discussed in Chapter 5, *Surface Water Supply*, there would generally be no difference in deliveries under Alternative 5 compared to existing conditions. Under Alternative 5 compared to the No Action Alternative, reductions in deliveries up to one percent could occur under certain months in dry and critical years. Decreased surface water deliveries could lead to increased groundwater pumping to make up the difference in supplies. However, these reductions in deliveries are rare and limited to a few months within limited years. Therefore, any increase in groundwater pumping in lieu of surface water deliveries would be short-term and infrequent.

CEQA Conclusion

Impacts from the potential increase in groundwater pumping caused by decreased CVP and SWP surface water supplies under Alternative 5 would be **less than significant** because the reduction in supplies would be short-term and infrequent.

7.3.3.6.6 Impact GRW-6: Long-Term Changes to Groundwater Quality due to Decreased Allocation to North of Delta and South of Delta Contractors

Increased groundwater pumping could substantially alter groundwater levels and/or flow patterns. Substantial reductions in groundwater levels for a long period of time could induce the movement or migration of reduced quality groundwater into previously unaffected areas. As discussed for Impact GRW-5, there would be minimal changes to groundwater pumping in lieu of surface water deliveries under Alternative 5. There would be no detrimental impacts from groundwater pumping causing a change in groundwater quality.

CEQA Conclusion

Impacts from increased groundwater pumping due to decreased North of Delta and South of Delta surface water supplies on groundwater quality under Alternative 5 in the region would be **less than significant** because the potential increase in groundwater pumping in lieu of surface water deliveries would be short-term and infrequent.

7.3.3.6.7 Impact GRW-7: Increased Potential for Land Subsidence due to Decreased Allocation to North of Delta and South of Delta Contractors

Increased groundwater pumping could substantially alter groundwater levels and/or flow patterns. Substantial reductions in groundwater levels greater than historic low groundwater level elevations could increase the potential for subsidence. As discussed for Impact GRW-6, there would be minimal changes to groundwater pumping in lieu of surface water deliveries under Alternative 5. The expected increase in groundwater pumping in lieu of surface water deliveries would be minimal, and any increase would be distributed over a large area (within the CVP and SWP contractors' service area). Changes to groundwater levels would not cause any detrimental impacts to land subsidence.

CEQA Conclusion

Because the potential increase in groundwater pumping in lieu of surface water deliveries under Alternative 5 would be short-term and infrequent, impacts to land subsidence would be **less than significant.**

7.3.3.6.8 Tule Canal Floodplain Improvements (Program Level)

As described in Section 2.8.1.7, Alternative 5 would include floodplain improvements along Tule Canal, just north of I-80. These improvements would not be constructed at the same time as the remaining facilities. They are included at a program level of detail to consider all the potential impacts and benefits of Alternative 5. Subsequent consideration of environmental impacts would be necessary before construction could begin.

The Alternative 5 program level improvements to the Tule Canal Floodplain would not affect groundwater resources because the improvements (a series of secondary channels that connect to Tule Canal north of I-80) would increase inundation of areas that are currently managed as wetland habitat for waterfowl. The secondary channels would improve functionality of the floodplain habitat but would have negligible effects on groundwater recharge, groundwater levels, or groundwater quality.

7.3.3.7 Alternative 6: West Side Large Gated Notch

Alternative 6, West Side Large Gated Notch, is a large notch in the western location that would allow flows up to 12,000 cfs. It was designed with the goal of entraining more fish with the strategy of allowing more flow into the bypass when the Sacramento River is at lower elevations. See Section 2.9 for more details on the alternative features.

7.3.3.7.1 Impact GRW-1: Temporary and Short-Term Construction-Related Effects on Groundwater Levels

Alternative 6 includes the intake channel and headworks, transport channel, and downstream facilities. As discussed in Appendix F, *Assessment of Groundwater Impact on Project Excavation – Technical Memorandum*, excavation activities under Alternative 6 would be below measured groundwater elevations. This alternative includes headworks and inlet structures that would require excavation to an elevation of nine feet. Groundwater elevation near the excavation area near Fremont Weir varies from nine to 17 feet between the spring and fall seasons, respectively, under existing conditions. Dewatering efforts would be required to provide relatively dry conditions for construction. The groundwater pumping required for dewatering could cause temporary groundwater level declines in the shallow aquifer at the proposed pumping sites during construction activities. Construction of the headworks structure, intake channel, and outlet channel would occur concurrently. It would take approximately 12 to 15 weeks to construct the headworks structure. Dewatering activities would end after construction is complete, allowing groundwater levels to recover.

CEQA Conclusion

Impacts from construction on groundwater levels under Alternative 6 would be **less than significant** because dewatering activities would be short-term and would end after construction is complete.

7.3.3.7.2 Impact GRW-2: Temporary and Short-Term Construction-Related Effects on Groundwater Quality

Short-term impacts to groundwater quality from construction under Alternative 6 would be identical to those discussed for Alternative 1.

CEQA Conclusion

Because construction could occur below grade and within proximity to the shallow groundwater aquifer under Alternative 6, onsite spills or waste discharge runoff during construction would be expected to impact groundwater quality and this impact would be **significant**.

Implementation of the HMMP, SPCCP, SWPPP, construction BMPs, and turbidity monitoring plan included in MM-HAZ-1, MM-WQ-1, MM-WQ-2 and, MM-WQ-3, respectively, would ensure all surface water and groundwater quality risks would be minimized and the impact would be reduced to **less than significant**.

7.3.3.7.3 Impact GRW-3: Operational Impacts to Groundwater Recharge Could Cause a Lowering of the Local Groundwater Level that Would Impact Pre-existing or Planned Land Uses in the Area Surrounding the Yolo Bypass

Impacts on groundwater levels from operations of Alternative 6 would be identical to those discussed for Alternative 2.

CEQA Conclusion

Impacts to groundwater levels from changes to groundwater recharge under Alternative 6 would be **less than significant** because the cutoff walls would not entirely impede groundwater recharge to the east of the bypass and the new channel south of Tule pond would be higher than the surrounding aquifer for most of the year.

7.3.3.7.4 Impact GRW-4: Operational Impacts to Groundwater Quality in the Area Surrounding the Yolo Bypass

Impacts to groundwater quality from operations of Alternative 6 would be identical to those discussed for Alternative 1.

CEQA Conclusion

Impacts from increased flows in the bypass on groundwater quality under Alternative 6 would be **less than significant** because surface water quality in the Project area is generally better than groundwater quality, barring a few constituents of concern.

7.3.3.7.5 Impact GRW-5: Long-Term Changes to Groundwater Levels due to Decreased Allocation to North of Delta and South of Delta Contractors

Increased diversions from the Sacramento River to the Yolo Bypass under Alternative 6 could have a minimal impact on CVP and SWP deliveries to North of Delta and South of Delta Contractors. As discussed in Chapter 5, *Surface Water Supply*, there would generally be no difference in deliveries under Alternative 6 compared to existing conditions. Compared to the No Action Alternative, Alternative 6 could reduce deliveries up to two percent in a few months in Dry and Critical years. Decreased surface water deliveries could lead to increased groundwater pumping to make up the difference in supplies. However, these reductions in deliveries would be rare and limited to a few months within limited years. Therefore, any increase in groundwater pumping in lieu of surface water deliveries would be short-term and infrequent.

CEQA Conclusion

Impacts from the potential increase in groundwater pumping caused by decreased CVP and SWP surface water supplies under Alternative 6 would be **less than significant** because the reduction in supplies would be short-term and infrequent.

7.3.3.7.6 Impact GRW-6: Long-Term Changes to Groundwater Quality due to Decreased Allocation to North of Delta and South of Delta Contractors

Increased groundwater pumping could substantially alter groundwater levels and/or flow patterns. Substantial reductions in groundwater levels for a long period of time could induce the movement or migration of reduced quality groundwater into previously unaffected areas. As discussed for Impact GRW-5, there would be minimal changes to groundwater pumping in lieu of surface water deliveries under Alternative 6. There would be no detrimental impacts from groundwater pumping causing a change in groundwater quality.

CEQA Conclusion

Impacts from increased groundwater pumping due to decreased North of Delta and South of Delta surface water supplies on groundwater quality under Alternative 6 in the region would be **less than significant** because the potential increase in groundwater pumping in lieu of surface water deliveries would be short-term and infrequent.

7.3.3.7.7 Impact GRW-7: Increased Potential for Land Subsidence due to Decreased Allocation to North of Delta and South of Delta Contractors

Increased groundwater pumping could substantially alter groundwater levels and/or flow patterns. Substantial reductions in groundwater levels greater than historic low groundwater level elevations could increase the potential for subsidence. As discussed for Impact GRW-6, there would be minimal changes to groundwater pumping in lieu of surface water deliveries under Alternative 6. The expected increase in groundwater pumping in lieu of surface water deliveries would be minimal, and any increase would be distributed over a large area (within the CVP and SWP contractors' service area). Any changes to groundwater levels would not cause any detrimental impacts to land subsidence.

CEQA Conclusion

Because the potential increase in groundwater pumping in lieu of surface water deliveries under Alternative 6 would be short-term and infrequent, impacts to land subsidence would be **less than significant.**

7.3.4 Summary of Impacts

Table 7-2 below provides a summary of the identified Project-related impacts to groundwater.

Table 7-2. Summary of Impacts and Mitigation Measures – Groundwater

Impact	Alternative	Level of Significance Before Mitigation	Mitigation Measures	Level of Significance After Mitigation
Impact GRW-1: Temporary and Short-Term Construction-Related Effects on Groundwater Levels	No Action	NI	----	NI
	1, 2, 3, 4, 5 (Project), 6	LTS	----	LTS
	5 (Program)	NI	----	NI
Impact GRW-2: Temporary and Short-Term Construction-Related Effects on Groundwater Quality	No Action	NI	----	NI
	1, 2, 3, 4, 5 (Project), 6	S	MM-HAZ-1 MM-WQ-1 MM-WQ-2 MM-WQ-3	LTS
	5 (Program)	NI	---	NI
Impact GRW-3: Operational Impacts to Groundwater Recharge Could Cause a Lowering of the Local Groundwater Level that Would Impact Pre-existing or Planned Land Uses in the Area Surrounding the Yolo Bypass	No Action	NI	----	NI
	1, 2, 3, 4, 5 (Project), 6	LTS	----	LTS
	5 (Program)	NI	----	NI
Impact GRW-4: Operational Impacts to Groundwater Quality in the Area Surrounding the Yolo Bypass	No Action	NI	----	NI

Impact	Alternative	Level of Significance Before Mitigation	Mitigation Measures	Level of Significance After Mitigation
	1, 2, 3, 4, 5 (Project), 6	LTS	----	LTS
	5 (Program)	NI	----	NI
Impact GRW-5: Long-Term Changes to Groundwater Levels due to Decreased Allocation to North of Delta and South of Delta Contractors	No Action	NI	----	NI
	1, 2, 3, 4, 5 (Project), 6	LTS	----	LTS
	5 (Program)	NI	----	NI
Impact GRW-6: Long-Term Changes to Groundwater Quality due to Decreased Allocation to North of Delta and South of Delta Contractors	No Action	NI	----	NI
	1, 2, 3, 4, 5 (Project), 6	LTS	----	LTS
	5 (Program)	NI	----	NI
Impact GRW-7: Increased Potential for Land Subsidence due to Decreased Allocation to North of Delta and South of Delta Contractors	No Action	NI	----	NI
	1, 2, 3, 4, 5 (Project), 6	LTS	----	LTS
	5 (Program)	NI	----	NI

Key:
LTS = less than significant; NI = no impact; S = significant

7.4 Cumulative Impacts Analysis

This section describes the cumulative effects analysis for groundwater resources. Section 3.3, *Cumulative Impacts*, presents an overview of the cumulative impacts analysis, including the methodology and the projects, plans, and programs included in the cumulative impacts analysis.

7.4.1 Methodology

This evaluation of cumulative effects considers the effects of the project and how they may combine with the effects of other past, present, and future projects or actions to create significant impacts on groundwater resources. The Project area for these cumulative effects includes both the Yolo, Colusa, and Sutter subbasins. The timeframe for this cumulative analysis includes the past, present, and probable future projects producing related or cumulative impacts that have been identified in the Project area.

This cumulative effects analysis uses the project analysis approach described in detail in Section 3.3, *Cumulative Impacts*. The cumulative projects included in this analysis are:

- Battle Creek Salmon and Steelhead Restoration Project
- California EcoRestore projects
  - Agricultural Road Crossing #4 Fish Passage Improvement Project
  - Cache Slough Area Restoration – Prospect Island
  - Fremont Weir Adult Fish Passage Modification Project
  - Lisbon Weir Modification Project
  - Lower Putah Creek Realignment Project
  - Prospect Island Tidal Habitat Restoration Project
  - Tule Red Tidal Marsh Restoration Project
  - Wallace Weir Fish Rescue Facility Project
- California WaterFix
- American River Common Features General Reevaluation Report
- Central Valley Flood Management Planning Program
- Delta Plan
- Lower Cache Creek Flood Risk Management Feasibility Study and the Woodland Flood Risk Reduction Project
- Lower Elkhorn Basin Levee Setback Project
- Lower Putah Creek 2 North American Wetlands Conservation Act (NAWCA) Project
- Lower Yolo Restoration Project
- North Bay Aqueduct Alternative Intake Project
- Sacramento River Bank Protection Project
- Sacramento River General Reevaluation Report
- Sites Reservoir Project
- SGMA
- Upstream Sacramento River Fisheries Projects
- Yolo Habitat Conservation Plan/Natural Communities Conservation Plan and the Yolo Local Conservation Plan

7.4.2 Cumulative Impacts

Several related and reasonably foreseeable projects and actions may result in impacts to groundwater resources in the Project area. Several of the projects listed above (Agricultural Road Crossing #4, Lisbon Weir, and Lower Elkhorn Basin Levee Setback Modification) may involve construction activities near the Project area. These construction activities may include excavation related to construction of physical improvements. If construction activities occur near or below the groundwater table, dewatering efforts may be required to provide relatively dry conditions for construction. The groundwater pumping required for dewatering could cause temporary groundwater level declines in the shallow aquifer in the construction area during construction activities. Any dewatering activities would end after construction is complete, allowing groundwater levels to recover.

Several of the projects listed projects may result in a change to either the area that may be wetted or the depth of ponded water (Agricultural Road Crossing #4, Lisbon Weir, and Lower Elkhorn Basin Levee Setback Modification). These changes could increase the amount of recharge to groundwater in the Project area. These projects are not expected to include water with poor water quality that could degrade groundwater conditions. The additional recharge could raise groundwater levels in the Project area.

The projects listed above also are not expected to include the development of additional groundwater pumping, which could lower the groundwater table and/or cause subsidence. No activities are expected that would alter the existing, overall groundwater flow directions and/or groundwater quality.

The SGMA legislation, passed in 2014, requires that all groundwater basins categorized as medium- and high-priority form a GSA and be managed under a GSP by January 31, 2020. A GSA is a local entity tasked with developing the GSP and associated rules and regulations. The GSP will include provisions to avoid chronic lowering of groundwater levels along with avoiding significant and unreasonable degradation of water quality and land subsidence. When the GSP is in place and the basins are managed according to that GSP, the groundwater basin will be operated sustainably for the long term and not be subject to additional degradation of conditions.

Given that any construction activities would be short-term, the projects could provide additional recharge to the groundwater aquifer, and the projects are not expected to introduce additional pumping, subsidence, or quality issues, **the combined impact of the Project alternatives with other cumulative projects would not have a cumulatively considerable impact to groundwater levels and groundwater quality.**

7.5 References

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8 Aquatic Resources and Fisheries

The following sections describe the existing fisheries and aquatic resources in the Yolo Bypass and adjacent areas of the Sacramento River as well as the areas of the Sutter Bypass and Sacramento-San Joaquin Delta (Delta) that could be affected by implementation of the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Project).

8.1 Environmental Setting/Affected Environment

8.1.1 Study Area

The study area for aquatic resources and fisheries consists of the Sacramento River from the vicinity of Fremont Weir (near river mile [RM] 83) to about Rio Vista near RM 12, the Sutter Bypass, the Yolo Bypass, and the Delta (Figures 8-1a and 8-1b). Although the Yolo Bypass is the primary region expected to be affected by the Project, changes in the frequency, duration, and volume of water spilling into the Yolo Bypass from the Sacramento River could affect aquatic resources and fisheries in the Sacramento River, the Sutter Bypass, and the Delta. Each of these regions is described in detail below.

8.1.1.1 Sacramento River

The Sacramento River is California's largest river, with an average annual runoff of 22,000,000 acre-feet. The headwaters of the Sacramento River, along with the Pit and McCloud rivers, drain into Shasta Lake about 12 miles north of the City of Redding. Flows released from Shasta Lake flow downstream for about 10 miles to Keswick Reservoir, which functions as a reregulating reservoir. Keswick Dam (RM 302) represents the upstream extent of anadromous fish.

The segment of the Sacramento River located within the study area extends from Fremont Weir (about RM 83) downstream to just above Rio Vista near RM 12. The Sacramento River within the study area is heavily channelized and leveed. It is bordered by agricultural land and the City of Sacramento and surrounding areas. This segment of the Sacramento River is characterized primarily by slow-water glides and pools, is depositional in nature, and has lower water clarity and habitat diversity relative to the upper portion of the river.

Over 30 fish species are known to occur within the Sacramento River. Many of these are anadromous, including both native and non-native species. Anadromous species include Chinook salmon (winter-run, spring-run, fall-run, and late fall-run), steelhead, green sturgeon, white sturgeon, Pacific lamprey, river lamprey, American shad, and striped bass.

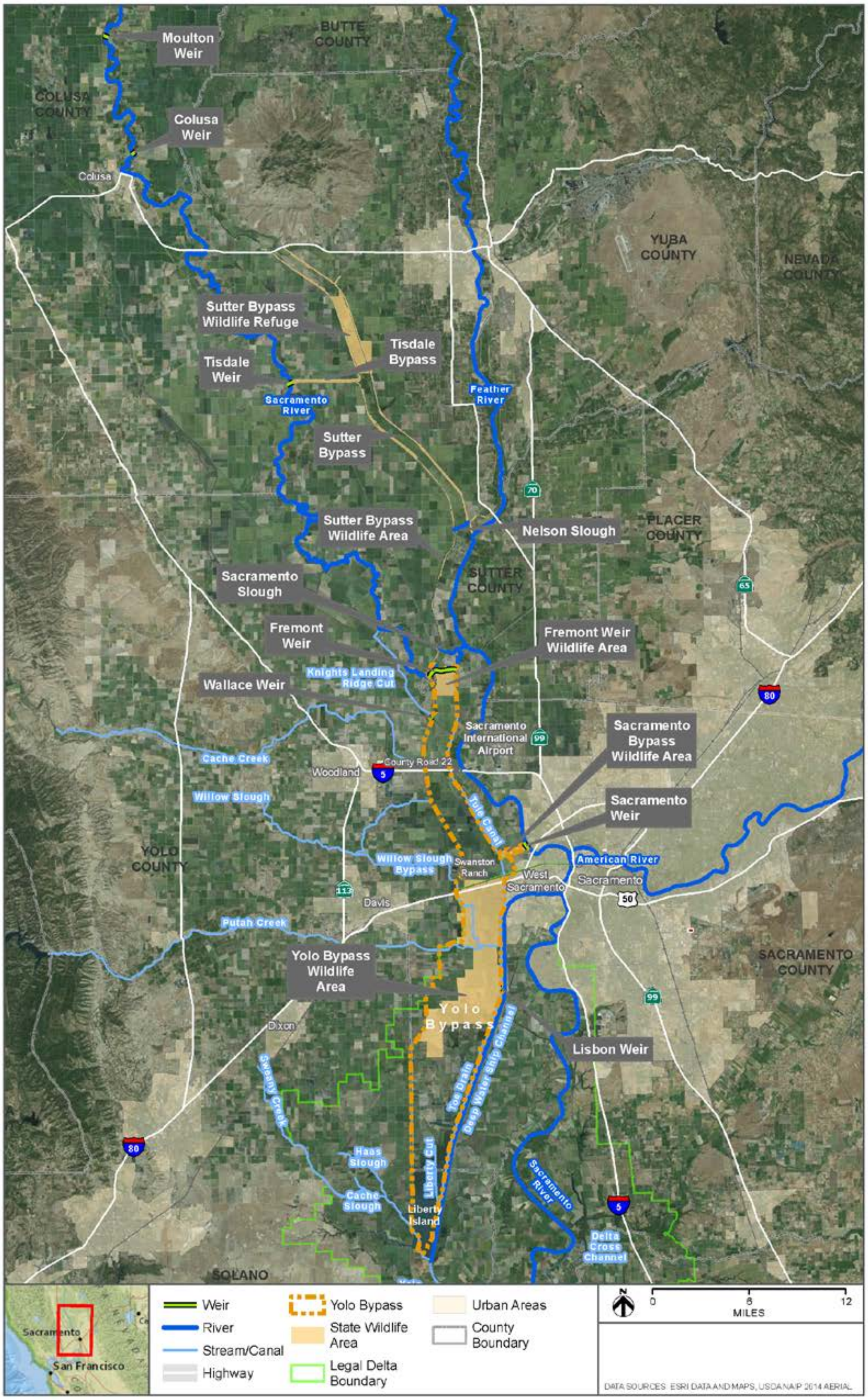


Figure 8-1a. Overview of the Northern Portion of the Aquatic Resources and Fisheries Study Area

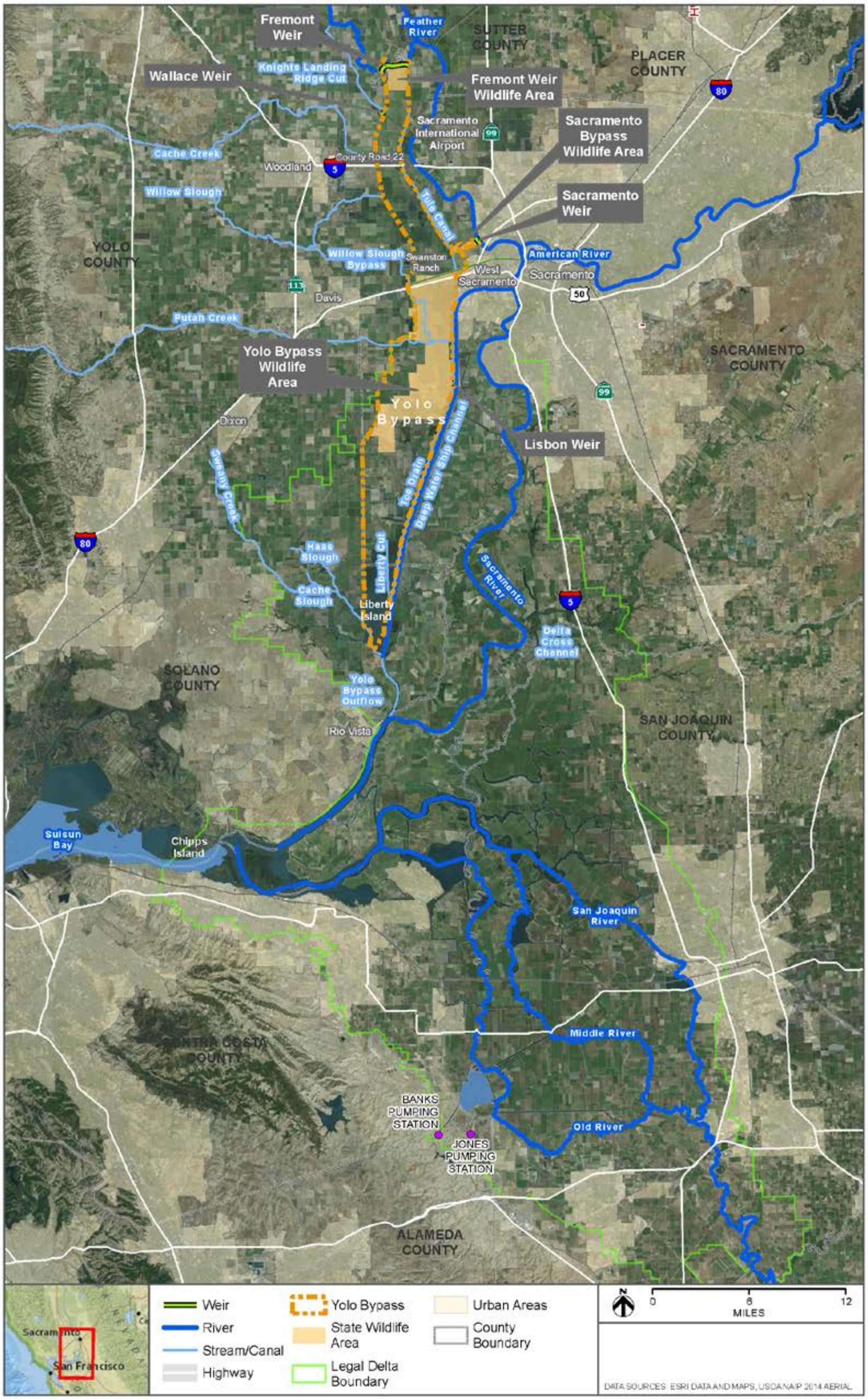


Figure 8-1b. Overview of the Southern Portion of the Aquatic Resources and Fisheries Study Area

Most anadromous salmonid spawning in the Sacramento River occurs upstream of the study area (National Oceanic and Atmospheric Administration National Marine Fisheries Services [NMFS] 2009; United States Bureau of Reclamation [Reclamation] 2015). Most Chinook salmon spawning occurs upstream of Red Bluff Diversion Dam (RBDD) (NMFS 2009; California Department of Fish and Game [CDFG] 1998; California Department of Fish and Wildlife [CDFW] 2017a). However, some Chinook salmon, particularly fall-run Chinook salmon, have been observed to also spawn in the reaches downstream of RBDD to Princeton (CDFW 2017a). Steelhead spawning in the mainstem Sacramento River likely is limited to the area upstream of RBDD although specific information regarding steelhead spawning within the mainstem Sacramento River is limited (NMFS 2009).

Green sturgeon spawning habitat has been confirmed within a 58-mile reach of the Sacramento River, extending from upstream of RBDD to downstream of RBDD, ranging from approximately RM 207 to 265 (Poytress et al. 2011; 2013). Although exact spawning locations are unknown, white sturgeon are reported to likely spawn between Knights Landing (RM 90) and upstream of Colusa (RM 143) (Kohlhorst 1976; Moyle 2002).

Downstream from the City of Red Bluff, the Sacramento River provides a migration corridor and rearing habitat for salmonids as well as spawning and rearing habitat for a variety of other native fish species such as Sacramento splittail and Sacramento pikeminnow.

During high flow events, water from the Sacramento River spills out at several locations into the Sutter Bypass or basins draining into the Sutter Bypass to minimize the potential for unintentional flooding along the Sacramento River.

8.1.1.2 Sutter Bypass

The Sutter Bypass is a wide, engineered flood control channel that carries excess Sacramento River flood waters to the Feather River and back to the Sacramento River near its confluence with the Feather River. The Sutter Bypass is approximately 30 miles long and 3,600 to 4,000 feet (ft) wide upstream of Nelson Slough and about 6,000 ft wide downstream of Nelson Slough[1]. During high flow events, water from the Sacramento River spills at several locations, which eventually drain into the Sutter Bypass, including at the Colusa and Moulton weirs into the Butte Basin and at the Tisdale Weir through the Tisdale Bypass.

The Moulton and Colusa weirs are overtopped when Sacramento River flows exceed 60,000 and 30,000 cubic feet per second (cfs), respectively (California Department of Water Resources [DWR] 2010). The Tisdale Weir is overtopped when Sacramento River flows exceed 23,000 cfs (DWR 2010). Each of these weirs is a concrete structure that passes floodwaters by gravity once the Sacramento River reaches the elevation at which flow overtops the weir. The Sacramento River also overtops the east bank at several locations when flows are above 90,000 cfs at Ord Ferry (southwest of Chico) (DWR 2010).

The Sutter Bypass has been reported to be an important nursery area for anadromous salmonids of Butte Creek and the upper Sacramento River and its tributaries, particularly during wetter water years (United States Fish and Wildlife Services [USFWS] 2000). Flooded lands of the Sutter Bypass are also reported to be an important spawning and nursery area for Sacramento

[1] Distances are based on estimated measurements taken in ArcGIS.

splittail (USFWS 2000) and have also been found to support Chinook salmon, lamprey, Sacramento pikeminnow and other (non-native) cyprinids, American shad, threadfin shad, inland silverside, channel catfish, largemouth bass, and bluegill and other sunfish species (Feyrer et al. 2006a). Other anadromous fish species also may potentially utilize the bypass for rearing (i.e., steelhead and sturgeon).

Water flowing through the Sutter Bypass reaches the northern side of the Sacramento River to the north of Fremont Weir. During flood events, water from the Sutter Bypass flows into the Sacramento River and the Yolo Bypass (Figure 8-2).

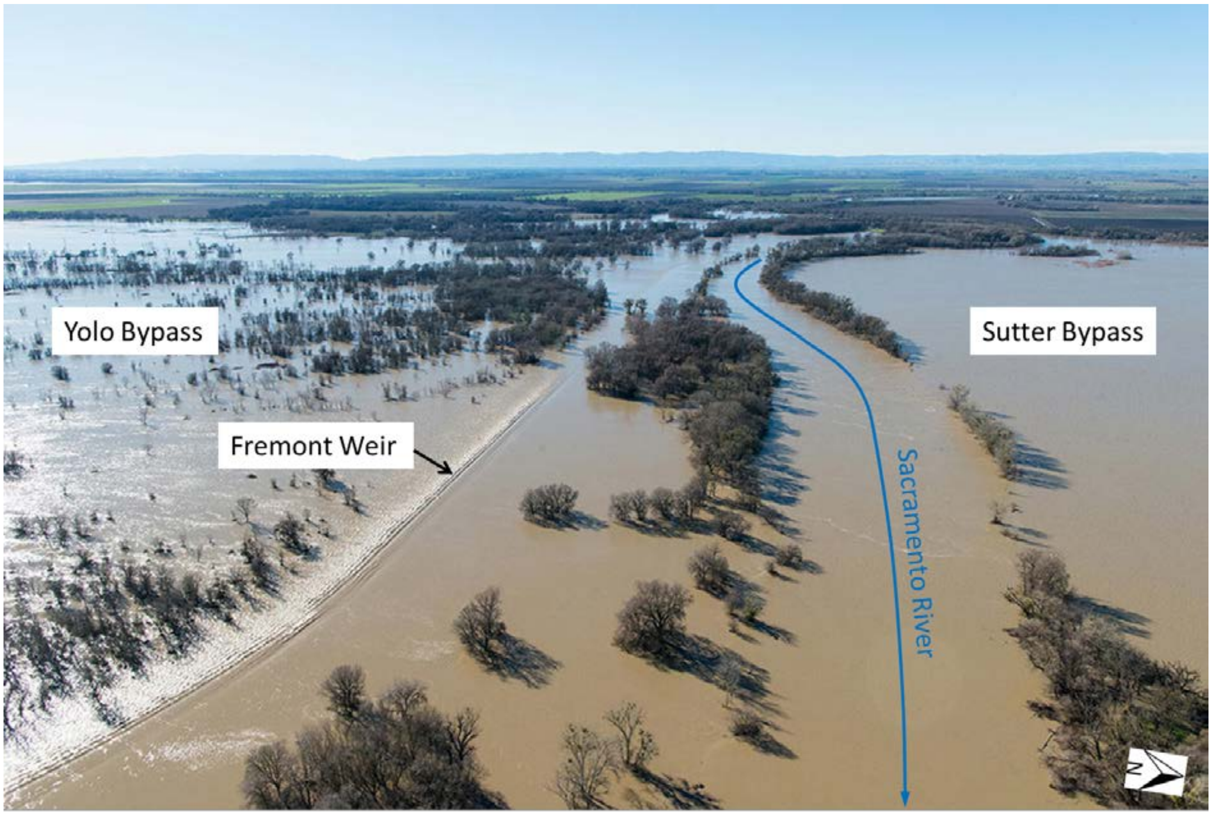


Figure 8-2. The Sutter and Yolo Bypasses and the Sacramento River

8.1.1.3 Yolo Bypass

The Yolo Bypass is an engineered floodplain located about five miles west of Sacramento. Floodwater from the Sacramento River passing over Fremont Weir initially flows through the Toe Drain before overflowing onto the floodplain when flows in the Toe Drain are greater than 3,500 cfs (Sommer et al. 2001b). The Toe Drain is a perennial, tidally influenced riparian channel running along the eastern edge of the Yolo Bypass and is the primary source of perennial water in the bypass during drier periods. Floodwaters from the Yolo Bypass re-enter the Sacramento River through Cache Slough.

Flow over the Fremont Weir is the primary flow input to the Yolo Bypass in the north, conveying floodwaters from the Sacramento River, Feather River, and the Sutter Bypass. The Fremont Weir is a concrete overflow levee extending parallel to the Sacramento River for about

9,120 ft (DWR 2010). During major storms (i.e., greater than 177,000 cfs), additional water enters the Yolo Bypass from the east via Sacramento Weir, including water from the Sacramento and American rivers (DWR 2010). In contrast to the Moulton, Colusa, Tisdale and Fremont weirs, the Sacramento Weir requires manual operation to allow flow past the weir (DWR 2010).

Flow also enters the Yolo Bypass from several west-side streams, including Cache Creek, the Willow Slough Bypass, and Putah Creek. During high-flow conditions, flow also enters the Yolo Bypass through the Knights Landing Ridge Cut, which is a manmade canal that drains agricultural water and ephemeral streams in the Colusa Basin (CDFW 2016a). These tributaries can add substantial flow to floodwaters in the Yolo Bypass and provide localized floodplain inundation prior to Fremont Weir spilling. During periods when no flow enters the Yolo Bypass from the Fremont Weir, substantial short-term (e.g., one to three weeks) flooding can occur from these tributaries (Sommer et al. 2014).

The Yolo Bypass supports multiple aquatic habitats, including stream and slough channels, as well as flooded shallow water. These diverse habitats provide opportunities for fish migration, spawning, and rearing (CALFED Bay-Delta Program [CALFED] 2000). The Yolo Bypass is inundated to some extent about 70 percent of all years when total flow in the Sacramento River exceeds about 56,270 cfs (Yolo Bypass Working Group et al. 2001). The Yolo Bypass has inundated as early as October and as late as June (Yolo Bypass Working Group et al. 2001), but the typical period of inundation has been between January and March (Sommer et al. 2001a). Even at a flow rate of 6,000 cfs, hydraulic modeling indicates that approximately 21,500 acres of the floodplain would be inundated, the majority of which would consist of low-velocity (average of 1.26 feet per second [ft/s]) and shallow (average of 2.6 feet deep) habitat (Reclamation and DWR 2012). Williams et al. (2009) identified a flow of 8,000 cfs to fully activate the floodway width of the Yolo Bypass.

The Yolo Bypass ranges from about 1.2 to 6 miles wide over its approximately 40-mile length. When flooded, the entire Yolo Bypass is considered to be floodplain habitat, providing up to about 59,300 acres of shallow floodplain habitat, at a typical mean depth of 6.5 feet or less (Sommer et al. 2008a).

Liberty Island, an inundated island encompassing 5,209 acres, is the southern outlet of the Yolo Bypass (CALFED 2005). In 1998, Liberty Island’s levees were breached for the last time during high flows through the Yolo Bypass, flooding the island. It has remained flooded since that time, and provides nearly 20 acres of riparian habitat, 55 acres of herbaceous wetlands, and over 800 acres of freshwater tidal and emergent marsh (CALFED 2005).

The Yolo Bypass is an important migratory pathway for downstream migrating Chinook salmon, steelhead, and other native, anadromous fish during wet years. Although many species are presumed to spawn in the Yolo Bypass (Harrell and Sommer 2003; Sommer et al. 2004), most of these are thought to spawn in deeper channels, such as the Toe Drain or in upstream tributaries to the Yolo Bypass. However, within the Sacramento River Basin, the Yolo Bypass is one of the most important known spawning areas for Sacramento splittail, along with the Sutter Bypass (Moyle et al. 2004). The Cosumnes River floodplain may be their most important spawning habitat in the eastern Delta (Moyle et al. 2004). Sommer et al. (1997) estimated an average juvenile Sacramento splittail abundance index of 5 during years when the Yolo Bypass was flooded for less than three weeks, compared to an average abundance index of 39 during years when the Yolo Bypass was flooded for more than three weeks. This large difference in the average abundance index based on the duration of flooding in the Yolo Bypass, leads to the belief that Sacramento splittail are spawning successfully within the flooded bypasses.

Sommer et al. (2001c) found that seasonal floodplain habitat within the Yolo Bypass also provided better rearing conditions for outmigrating anadromous salmonids than nearby Sacramento River sites because of the increased area, the complexity of suitable habitat, and increased food resources. This study concluded that these conditions allowed juvenile Chinook salmon to grow substantially faster in the Yolo Bypass, primarily because of a greater abundance of invertebrate prey in the inundated floodplain (Sommer et al. 2001c).

Analysis of beach seine fish catch data in the Yolo Bypass during a wet year (2011) and a dry year (2012) indicates that although non-native fish species dominate the fish assemblage in the Yolo Bypass, native fishes were more widely distributed during the wet year (Frantzich et al. 2013). Based on the increase in the proportion of bluegill catches during 2012, low flows may provide more suitable conditions for the spawning and recruitment of centrarchids upstream of Lisbon Weir (Frantzich et al. 2013). Table 8-1 lists fish species found in the Yolo Bypass.

Table 8-1. Fish Species Commonly Found in the Yolo Bypass

Common Name	Scientific Name	Common Name	Scientific Name
American shad	*Alosa sapidissima*	Redear sunfish	*Lepomis microlophus*
Bigscale logperch	*Percina macrolepida*	River lamprey*	*Lampetra ayresii*
Black bullhead	*Ameriurus melas*	California roach*	*Hesperoleucus symmetricus*
Black crappie	*Pomoxis negromaculatus*	Sacramento blackfish*	*Orthodon microlepidotus*
Bluegill	*Lepomis macrochirus*	Sacramento pikeminnow*	*Ptychocheilus grandis*
Brown bullhead	*Ameriurus nebulosus*	Sacramento sucker*	*Catostomus occidentalis*
Channel catfish	*Ictalurus punctatus*	Shimofuri goby	*Tridentiger bifasciatus*
Chinook salmon*	*Oncorhynchus tshawytscha*	Smallmouth bass	*Micropterus dolomieusalmoides*
Common carp	*Cyprinus carpio*	Sacramento splittail*	*Pogonichthys macrolepidotus*
Delta smelt*	*Hypomesus transpacificus*	Spotted bass	*Micropterus punctulatus*
Fathead minnow	*Pimephales promelas*	Steelhead*	*Oncorhynchus mykiss*
Golden shiner	*Notemigonus crysoleucas*	Striped bass	*Morone saxatilis*
Goldfish	*Carassius auratus*	Threadfin shad	*Dorosoma petenense*
Green sunfish	*Lepomois cyanellus*	Threespine stickleback*	*Gasterosteus aculeatus*
Green sturgeon*	*Acipenser medirostris*	Tule perch*	*Hysterocarpus traski*
Hardhead*	*Mylopharodon conocephalus*	Wakasagi	*Hypomesus nipponensis*
Sacramento hitch*	*Lavinia exilicauda*	Warmouth	*Chaenobryttus gulosus*
Inland silverside	*Menidia beryllina*	Western mosquitofish	*Gambusia afinis*
Largemouth bass	*Micropterus salmoides*	White catfish	*Ameiurus catus*
Pacific lamprey*	*Entosphenus tridentatus*	White crappie	*Pomoxis annularis*
Pacific staghorn sculpin*	*Leptocottus armatus*	White sturgeon*	*Acipenser transmontanus*
Prickly sculpin*	*Cottus asper*	Yellowfin goby	*Acanthogobius flavimanus*
Red shiner	*Cyprinella lutrensis*		

* Native Species
Source: Modified from Sommer et al. 2001a

8.1.1.4 Delta

The San Francisco Bay/Sacramento-San Joaquin River Delta Estuary (Estuary) is the largest intact estuary on the west coast of the United States (United States Environmental Protection Agency [USEPA] 2003). The upstream portion of this Estuary, the Delta, is a triangular area comprising 700 miles of sloughs, waterways, and islands located near the confluence of the Sacramento and San Joaquin rivers (Water Education Foundation 2016). The Delta covers a surface area of about 75 square miles. Relatively high-salinity waters of the San Joaquin River dominate the southern Delta, whereas the lower-salinity waters of the Sacramento River dominate the northern Delta. Delta hydrology is driven primarily by tides, river inflows, in-Delta agricultural diversions, and water export operations of the Central Valley Project (CVP) and the State Water Project (SWP) (Delta Stewardship Council 2013).

The portion of the Delta in the study area consists primarily of the Sacramento River and associated waters located downstream of the Yolo Bypass outlet near Rio Vista (see Figure 8-1). Characteristics of this area include leveed river channels, subsided and flooded leveed islands, and sloughs. Salinities are typically higher than in upstream areas because of the tidal influence of the Estuary. Estuarine fishes occurring in this area include delta smelt and longfin smelt, which use these areas depending on seasonal and diel (i.e., daily) salinity gradients. Additionally, many non-native warm water fish species spawn and rear in this area, whereas Chinook salmon, steelhead, sturgeon, and lamprey use this area primarily for migration and rearing.

8.1.2 Species Evaluated in the EIS/EIR

8.1.2.1 Methodology

Fish species considered in this Environmental Impact Statement (EIS)/Environmental Impact Report (EIR) include those that are Federally or State of California (State)-listed as threatened or endangered, species that are proposed for Federal or State listing as threatened or endangered, species classified as candidates for future Federal or State listing, Federal species of concern, or State species of special concern. Special-status fish species (i.e., fish species designated under one or more of the aforementioned categories) potentially occurring in the study area were identified by using the online NMFS species list (NMFS 2017) and the CDFW special animals list (CDFW 2017b). Additional fish species considered in this EIS/EIR include non-listed native species that are known to inhabit the study area and that could affect special-status species (e.g., native predators of listed anadromous salmonids), non-native species that could affect special-status species through competition for food resources or through ecosystem alteration, and non-native fish species of commercial or recreational importance. Table 8-2 lists fish species of focused evaluation in this EIS/EIR.

Table 8-2. Fish Species of Focused Evaluation in the Project Area

Common Name	Status
Sacramento River winter-run Chinook salmon ESU	Federal and State endangered
Central Valley spring-run Chinook salmon ESU	Federal and State threatened
Central Valley fall-/late fall-run Chinook salmon ESU	Federal species of concern State species of special concern
Central Valley steelhead DPS	Federal threatened
Southern DPS of North American green sturgeon	Federal threatened; State species of special concern
Delta smelt	Federal threatened; State endangered
Longfin smelt	Federal candidate[a]; State threatened
White sturgeon	State species of special concern
River lamprey	State species of special concern
Pacific lamprey	State species of special concern
Sacramento splittail	State species of special concern
Hardhead	State species of special concern
Sacramento hitch	State species of special concern
Sacramento pikeminnow	Native predatory species
American shad	Recreational importance
Striped bass	Recreational importance; non-native predatory species
White catfish	Recreational importance; non-native predatory species
Warm water game fishes	Recreational importance; non-native predatory species
Non-native cyprinids	Non-native competitor species

[a] Federal candidate status applies to the San Francisco Bay-Delta DPS of longfin smelt.

Key: DPS = distinct population segment; ESU = evolutionarily significant unit

8.1.2.2 Special-Status Fish Species

8.1.2.2.1 Chinook Salmon

Chinook salmon are the most important commercial anadromous fish in California.

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 (Healey 1991):

- "Stream-type" adult Chinook salmon enter freshwater months before spawning, and juveniles of this type can reside in freshwater for a year or more prior to emigrating.
- "Ocean-type" adult Chinook salmon spawn soon after entering freshwater and juveniles typically migrate to the ocean as young-of-the-year.

Both winter-run and spring-run Chinook salmon tend to enter freshwater in a sexually immature state and delay spawning for months while holding in freshwater (Moyle 2002). Fall-run Chinook salmon enter freshwater at an advanced stage of maturity and generally spawn within a few days or weeks of freshwater entry (Healey 1991).

Spawning occurs in gravel substrate in relatively fast-moving, moderately shallow riffles or along banks with relatively high-water velocities. Embryos and alevins (newly hatched fish with the yolk sac still attached) require adequate water movement through the substrate; however, this movement can be inhibited by the accumulation of fines and sand.

Eggs develop in the gravel in about 40 to 60 days where they remain for another four to six weeks until the yolk sac is completely absorbed. Emergence occurs from 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).

During the Chinook salmon juvenile rearing and downstream movement life stage, salmonids prefer stream margin habitats with sufficient depths and velocities to provide suitable cover and foraging opportunities. Juvenile Chinook salmon reportedly use river channel depths ranging from 0.9 to two feet and most frequently use water velocities ranging from zero to 1.3 ft/s (Raleigh et al. 1986). Ephemeral habitats, such as floodplains and the lower reaches of small streams are also very important to rearing Chinook salmon (Maslin et al. 1997; Sommer et al. 2001c). These areas can be more productive than the main channel and provide refuge from predatory fishes. However, side channels and low-gradient floodplains also can strand and isolate juveniles when high flows subside quickly (NMFS 1997).

During the Chinook salmon adult upstream migration period, adults enter the Yolo Bypass from the south, often straying from the adjoining Sacramento River in response to tidal exchange or substantial flow pulses coming from the Yolo Bypass. While adults have been documented in the Yolo Bypass each month that sampling has occurred, the majority have been caught between October and December (DWR and Reclamation 2017). Although juvenile Chinook salmon are in the Sacramento River throughout the year, they can only access the Yolo Bypass floodplain following a Fremont Weir overtopping event. Juveniles have been observed between December and July, with peak presence occurring between February and April (DWR 2016, as cited in DWR and Reclamation 2017). Juvenile Chinook salmon that use the Yolo Bypass are reported to be primarily fall-run; the extent to which other runs use the Yolo Bypass is not well understood (Opperman et al. 2017). In Suisun Marsh, Chinook salmon fry tend to remain close to the banks and vegetation, near protective cover, and in dead-end tidal channels (Moyle et al. 1986).

Major factors that limit the range and abundance of Chinook salmon are flow, water temperature, barriers to upstream migration, habitat quality and quantity, entrainment in water diversions, and ocean conditions (NMFS 2014). Additional factors affecting Chinook salmon include other water quality parameters (e.g., dissolved oxygen), food quality and quantity, and biotic interactions (e.g., predation and competition). 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).

Four principal life history variants are recognized in the Central Valley and named for the timing of their adult spawning runs (i.e., time of freshwater entry): winter-run, spring-run, fall-run, and late fall-run. Discussions of each of these runs are provided below.

Sacramento River Winter-run Chinook Salmon ESU

The Sacramento River winter-run Chinook salmon evolutionarily significant unit (ESU) is listed as endangered under both the Federal Endangered Species Act (ESA) and the California Endangered Species Act (CESA).

Since the construction of Shasta Dam, winter-run Chinook salmon spawning has been confined to the mainstem Sacramento River below Keswick Dam. In 1993, critical habitat for winter-run Chinook salmon was designated to include:

1. The Sacramento River from Keswick Dam (RM 302) to Chipps Island (RM 0) at the westward margin of the Delta
2. All waters from Chipps Island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait
3. All waters of San Pablo Bay westward of the Carquinez Bridge
4. All waters of San Francisco Bay north of the San Francisco-Oakland Bay Bridge (58 Federal Register [FR] 33212)

NMFS' 2016 five-year status review of winter-run Chinook salmon concluded that the overall viability of the ESU had worsened since the 2010 assessment. Specifically, a reduction in the population growth rate over the past 10 years (2005 through 2014) and an increase in the proportion of hatchery fish comprising the spawning population have increased the risk of extinction of the ESU (NMFS 2016a). Winter-run Chinook salmon escapement data for the Sacramento River Basin (CDFW 2018) indicate that the winter-run Chinook salmon population abundance has steadily declined between 2014 and 2017, following a relative peak in abundance in 2013. Reduced escapement of Sacramento River winter-run Chinook salmon has, in part, resulted in ocean salmon fishery restrictions and closures (see *Central Valley Fall-/Late Fall-run Chinook Salmon ESU*, below).

Primary spawning and rearing habitats for winter-run Chinook salmon are confined to the coldwater areas between Keswick Dam and RBDD (NMFS 2014). However, juvenile winter-run Chinook salmon have also been found to rear in non-natal areas, including the lower American River, lower Feather River, Battle Creek, Mill Creek, Deer Creek, and the Delta (Phillis et al. 2018). The lower reaches of the Sacramento River, the Delta, and San Francisco Bay serve as migration corridors for the upstream migration of adult and downstream migration of juvenile winter-run Chinook salmon.

According to NMFS (2009; 2014), adult winter-run Chinook salmon migration (upstream spawning migration) in the Sacramento River occurs from November through July. Most of the run passes the RBDD from January through May, with the peak passage occurring in mid-March (Hallock and Fisher 1985 as cited in NMFS 2009). 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 during June (Vogel and Marine 1991). Winter-run Chinook salmon embryo incubation in the Sacramento River can extend into September during wet water years (Vogel and Marine 1991).

Winter-run Chinook salmon fry in the upper Sacramento River exhibit the greatest abundance during September. Fry and juvenile emigration past the RBDD occurs as early as mid-July and extends as late as the end of March (NMFS 1997 and Vogel and Marine 1991, both as cited in NMFS 2014). Juvenile emigration past Knights Landing occurs primarily between September and March and peaks in the months of December and January, with some emigration continuing through May during some years (Snider and Titus 2000). Winter-run Chinook salmon juveniles have been observed emigrating from the Sacramento River in large numbers during the first increase in flows from storm events in late fall or early winter (Vogel and Marine 1991; Poytress et al. 2014). Based on analysis of rotary screw trap (RST) data at Knights Landing and Delta fish survey data, 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 fall storm event where flows reach approximately 14,000 cfs at Wilkins Slough (del Rosario et al. 2013).

Although juvenile Chinook salmon are in the Sacramento River throughout the year, they can only access the Yolo Bypass floodplain following a Fremont Weir overtopping event. Juveniles have been observed in the Yolo Bypass between December and July, with presence peaking between February and April (DWR 2016, as cited in DWR and Reclamation 2017).

According to NMFS (2014), juvenile winter-run Chinook salmon can occur in the Delta primarily from November through early May, based on size-at-date criteria from trawl data in the Sacramento River at West Sacramento (RM 57) (USFWS 2001, as cited in NMFS 2014). Juveniles reportedly remain in the Delta until they reach a fork length (FL) of about 118 millimeters (mm) and are from five to 10 months old. Emigration to the ocean begins as early as November and continues through May (Fisher 1994 and Myers et al. 1998, both as cited in NMFS 2014). In the Suisun Marsh, Chinook salmon fry tend to remain close to the banks and vegetation, near protective cover, and in dead-end tidal channels (Moyle et al. 1986). In the intertidal zone, mudflats and tule marshes become important habitat for juveniles during high tides.

Central Valley Spring-run Chinook Salmon ESU

The Central Valley spring-run Chinook salmon ESU was listed as a threatened species under both the ESA and the CESA because of the reduced range and small size of remaining spring-run Chinook salmon populations (64 FR 50393). Critical habitat 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, portions of the northern Delta, and the Yolo Bypass (70 FR 52488).

Based on a review of the available information, NMFS (2016b) recommended 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 significant risks, and those risks are likely to increase over at least the next few years as the full effects of the recent drought occur (Williams et al. 2016). In addition to the low adult returns observed during 2015, juveniles hatched during the drought years of 2013 through 2015 are expected to produce low adult returns in 2016 through 2018 (Williams et al. 2016). Spring-run Chinook salmon escapement data for the Sacramento River Basin (CDFW 2018) show a similar trend to the winter-run Chinook salmon population, with a steady decline in population abundance between 2014 and 2017, following a relative peak in abundance in 2013. The reported preliminary escapement in 2017 of less than 1,800 is the lowest reported escapement in the record (1975-2017) (CDFW 2018).

Spring-run Chinook salmon are known to use the Sacramento River as a migratory corridor to spawning areas in upstream tributaries. Historically, spring-run Chinook salmon did not use the mainstem Sacramento River downstream of Shasta Dam except as a migratory corridor to and from headwater streams (CDFG 1998). However, construction of Shasta and Keswick dams blocked passage to upstream areas, limiting potential spawning habitat to areas downstream of the dams.

Spring-run Chinook salmon enter the Sacramento River between mid-February and July. The peak of the migration reportedly occurs in May (CDFG 1998). Adults hold in deep cold pools in proximity to spawning areas until they are sexually mature and ready to spawn in late summer and early fall (CDFG 1998). Spring-run Chinook salmon spawning occurs during September and October, depending on water temperatures (NMFS 2009). Embryo incubation has been reported to occur primarily during September through mid-February (DWR 2004b; Moyle 2002; Vogel and Marine 1991).

Spring-run Chinook salmon 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). 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). As described by NMFS (2009), juvenile spring-run Chinook salmon emigration at the RBDD occurs primarily from November through January. 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).

Central Valley Fall-/Late Fall-run Chinook Salmon ESU

Central Valley fall-run and late fall-run Chinook salmon are considered by NMFS to be the same ESU (64 FR 50394). NMFS determined that listing this ESU as threatened was not warranted (64 FR 50394) but subsequently classified it as a species of concern because of specific risk factors, including population size and fish hatchery influence (69 FR 19975). The Central Valley fall-run and late fall-run Chinook salmon ESU is listed as a State species of special concern (CDFW 2016b). The ESU includes all naturally spawned populations of fall-run Chinook salmon in the Sacramento and San Joaquin river basins and their tributaries east of Carquinez Strait. Because the Central Valley fall-run and late fall-run Chinook salmon ESU is not listed as threatened or endangered, no critical habitat has been designated.

Fall-run Chinook salmon are an important commercial and recreational fish species that have shown recent population declines resulting in harvest management restrictions. A complete closure of commercial and recreational ocean Chinook salmon fisheries was implemented for 2007 and 2008 following low returns of fall-run Chinook salmon to the Central Valley in those years (Lindley et al. 2009). A relatively low number of spawners (66,000) are estimated to have returned to natural areas and hatcheries in 2008 (Lindley et al. 2009). In April 2009, the Pacific Fishery Management Council (PFMC) and NMFS adopted a closure of all commercial ocean salmon fishing through April 30, 2010, and placed restrictions on inland salmon fisheries (CDFG 2010a). Fishing in 2010 was also constrained for the same reasons as in the previous two years (CDFG 2011a). In 2011, both CDFW and PFMC approved reopening the commercial and recreational fishing season based on scientific information suggesting that the Sacramento River fall-run Chinook salmon ocean population size was more than 700,000 fish (CDFG 2011a).

California has experienced less-than-average precipitation during four consecutive water years (2012, 2013, 2014, and 2015); record high surface air temperatures during 2014 and 2015; and record low snowpack in 2015 (Williams et al. 2016). As stated by NMFS, “four consecutive years of drought (2012–2015) and the past two years (2014–2015) of exceptionally high air, stream, and upper ocean temperatures have together likely had negative impacts for many populations of Chinook salmon” (Williams et al. 2016).

Central Valley fall-run Chinook salmon exhibit broad fluctuations in abundance. However, following a relative peak in abundance in 2013, fall-run Chinook salmon escapement (CDFW 2018) has shown a steady decline in Central Valley populations from 2014 through 2017 since peaking in 2013. Preliminary escapement reported for 2017 was approximately 100,000 (CDFW 2018), which is the lowest abundance reported since 2007-2009. Due in part to the low escapement numbers of 2017, the PFMC enacted recreational and commercial salmon fishery closures and seasonal restrictions during 2017 to protect Klamath River fall-run Chinook salmon and Sacramento River winter-run Chinook salmon.

Although Central Valley fall-run and late fall-run Chinook salmon are part of the same ESU, because they differ in life stage-specific timing, they are discussed and considered separately below.

Fall-run Chinook Salmon

In the Central Valley, fall-run Chinook salmon are the most numerous of the four salmon runs and continue to support important commercial and recreational fisheries.

Adult fall-run Chinook salmon enter the Sacramento and San Joaquin rivers from July through December (Reclamation 2008). Migration of adult fall-run Chinook salmon into the Sacramento River basin reportedly begins in July, peaks in October, and ends in December (Vogel 2011). Unlike spring-run Chinook salmon, adult fall-run Chinook salmon do not exhibit an extended over-summer holding period. Rather, they stage for a relatively short period before spawning. Fall-run Chinook salmon generally spawn from October through December (Reclamation 2008; Vogel 2011).

In general, the fall-run Chinook salmon spawning and embryo incubation period extends from October through March (Vogel and Marine 1991). In the Sacramento River basin, fall-run Chinook salmon juvenile emigration occurs from January through June (Moyle 2002; Vogel 2011; Vogel and Marine 1991). Juvenile fall-run Chinook salmon emigration past RBDD begins as early as December, peaks in January and February during winter flow events, decreases through the spring, and extends to as late as June or July (Gaines and Martin 2001 as cited in USFWS and CDFG 2012).

Juvenile fall-run Chinook salmon habitat requirements are similar to those described for winter-run Chinook salmon.

Late Fall-run Chinook Salmon

Central Valley late fall-run Chinook salmon escapement is dominated by spawners in the Sacramento River above the RBDD and fish hatchery production from Coleman National Fish Hatchery on Battle Creek, with varying numbers of spawners in the Sacramento River downstream of the RBDD and relatively few spawners in Battle Creek (CDFW 2017a).

Adult migration of late fall-run Chinook salmon in the Sacramento River generally begins in late October and extends through March (USFWS and CDFG 2012). Spawning has been suggested to occur in tributaries to the upper Sacramento River (e.g., Battle, Cottonwood, Clear, Big Chico, Butte, and Mill creeks) and the Feather and Yuba rivers, although these fish do not make up a large proportion of the late fall-run Chinook salmon population (USFWS 1995). Late fall-run Chinook salmon spawning generally occurs from January through April in the mainstem Sacramento River, primarily from Keswick Dam to RBDD (Moyle 2002; Vogel and Marine 1991).

Late fall-run Chinook salmon embryo incubation can extend from January through June (USFWS and CDFG 2012; Vogel and Marine 1991). Post-emergent fry and juveniles rear and disperse from their spawning and rearing grounds in the upper Sacramento River and its tributaries during April through December, with low rates of emigration occurring from July into the fall although fall and winter freshets (i.e., pulses of flow during storm events) can increase emigration rates (Vogel 2011; Vogel and Marine 1991). According to USFWS and CDFG (2012), juvenile late fall-run Chinook salmon rear in the upper Sacramento River from late April through the following winter before emigrating to the Estuary. Late fall-run Chinook salmon yearlings can use flow events as migration cues during the late fall and winter, and some individuals could continue to spend another seven to 13 months in the Sacramento River before entering the Delta and ocean (Moyle 2002).

8.1.2.2.2 Central Valley Steelhead DPS

Steelhead are the anadromous form of rainbow trout (McEwan 2001). NMFS originally listed the Central Valley steelhead DPS as threatened under the ESA on March 19, 1998 (64 FR 14517), and listing was reaffirmed on January 5, 2006 (71 FR 834). Designated critical habitat for the Central Valley steelhead DPS 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). This includes major tributaries to the Sacramento River, such as the American and Feather rivers, as well as smaller and intermittent streams (McEwan 2001). NMFS’ 2016 status review found that the Central Valley steelhead DPS continues to be at a high risk of extinction (NMFS 2016c). Steelhead in the Feather and American rivers are supported by the Feather and Nimbus fish hatcheries, respectively.

Adult steelhead migration 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). Adult steelhead migration can occur during all months of the year, with upstream migration occurring primarily during September and October (NMFS 2009). However, in Mill and Deer creeks, adult steelhead migration has been reported to occur from October through June, with peak migration occurring from October through mid-March (NMFS 2009).

Steelhead reportedly spawn in small streams and tributaries from December through April, with peaks from January through March (NMFS 2009). 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 ft/s (USFWS 1995).

Eggs usually hatch within four weeks, depending on stream temperature (CDFG 1996). The yolk sac fry remain in the gravel after hatching for another four to six weeks (CDFG 1996). Steelhead fry and fingerlings rear and move downstream in the Sacramento River year-round although most steelhead smolts reportedly emigrate from January through June (McEwan 2001). Based on CDFW sampling at Knights Landing, juvenile steelhead emigration occurs primarily from January through May, with peaks during March and April (Snider and Titus 2000).

After fry emerge, they inhabit shallow areas along the stream margin and seem to prefer areas with cobble substrates (CDFG 1996). As they grow and develop, juveniles use a greater variety of habitats (CDFG 1996). Juvenile Central Valley steelhead typically migrate to the ocean after spending from one to three years in freshwater (CDFG 1996).

Generally, juvenile steelhead migrate downstream during most months of the year, but the peak period of emigration occurs in spring, with a much smaller peak in fall (Hallock et al. 1961). The emigration period for naturally spawned steelhead juveniles migrating past Knights Landing on the lower Sacramento River in 1998 ranged from late December through early May and peaked in mid-March (McEwan 2001).

Adult and juvenile steelhead can be present in the Yolo Bypass year-round although their presence often coincides with high flow events during the fall through spring. Adult steelhead have been observed in the Yolo Bypass between October and April, with peaks in January and February, and juveniles have been observed between January and June, peaking in March (DWR 2016, as cited in DWR and Reclamation 2017). Steelhead are not commonly caught in the Yolo Bypass. When steelhead are observed, they are primarily juveniles (DWR and Reclamation 2017). CDFW stranding surveys in northern Yolo Bypass scour pools and swales found that juvenile steelhead was the most abundant fish species encountered in 2017 (CDFW 2017c). Based on data from fyke trap operations in the Toe Drain of the Yolo Bypass between 2001 and 2009, ten adult steelhead were captured (DWR, unpublished data). Based on collection of over 10,000 fish during 28 fish rescue efforts by CDFW at the Fremont Weir in the Yolo Bypass (1955 through summer 2016), no adult steelhead were captured (CDFW 2016). During variable operation of the Wallace Weir fish trap between the fall of 2014 through early 2016, only one adult steelhead was captured (CDFW 2016). During fish rescue efforts in the Yolo Bypass between December of 2016 and May of 2017, two adult steelhead were captured after a Fremont Weir overtopping event during May (CDFW 2017c). In addition to relatively low steelhead catch data in the Yolo Bypass, Opperman et al. (2017) reported that the Yolo Bypass does not appear to be important habitat for steelhead.

8.1.2.2.3 Southern DPS of North American Green Sturgeon

NMFS listed the southern DPS of North American green sturgeon as threatened in 2006 (71 FR 17757). 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 Delta, and the San Francisco Estuary (74 FR 52300). In 2015, NMFS issued an updated status review in which the threatened status was confirmed (NMFS 2015). NMFS (2018) issued a draft recovery plan for the southern DPS of North American green sturgeon in 2018.

Based on surveys of sites where adult green sturgeon aggregated in the upper Sacramento River, the total number of adults in the Southern DPS population was estimated to be 2,106 ± 860 (Mora 2016 as cited in NMFS 2018). The principal factor in the decline of the Southern DPS of green sturgeon is the reduction in historical spawning habitat (NMFS 2015). The population is also threatened by insufficient flows in spawning areas, elevated water temperatures, entrainment and stranding in water and flood diversions, indirect effects of invasive species, potential poaching, and exposure to contaminants (NMFS 2015).

Green sturgeon adults in the Sacramento River are reported to begin their upstream spawning migrations into freshwater during late February, prior to spawning between March and July, with peak spawning believed to occur between April and June (Adams et al. 2002). Many studies have focused on spawning location and timing of green sturgeon in the Sacramento and Feather River watersheds. Recent data gathered from acoustically-tagged adult green sturgeon indicate that they migrate upstream as far north as the mouth of Cow Creek on the Sacramento River (NMFS 2009). Poytress et al. (2011) reported that green sturgeon spawning habitat has been confirmed within a 58-mile reach of the Sacramento River, extending from about RM 207 to RM 265. Heublein et al. (2009) observed that green sturgeon enter San Francisco Bay in March and April and migrate rapidly up the Sacramento River to the region between the Glenn Colusa Irrigation District (GCID) Hamilton City Pumping Plant and Cow Creek. Brown (2007) suggested that spawning in the Sacramento River can occur from April to June but may extend from late April through July, as indicated by RST data at the RBDD from 1994 to 2000. Green sturgeon spawning also has been documented in the Feather River (Seesholtz et al. 2015).

After spawning, some green sturgeon adults hold over in the upper Sacramento River between the RBDD and the GCID Hamilton City Pumping Plant until November (Klimley et al. 2007), whereas some adult green sturgeon rapidly leave the system following their suspected spawning activity and re-enter the ocean in early summer (Heublein 2006).

Little is known about the occurrence of green sturgeon in the Yolo Bypass; however, their presence is known to coincide with that of white sturgeon (DWR 2016, as cited in DWR and Reclamation 2017). During flood flows in the Sacramento River system, upstream migrating adult green sturgeon are attracted by high flows in the Yolo and Sutter bypasses. Adults may become stranded behind the Fremont, Sacramento and Tisdale weirs, in splash basins, and in various scour pools downstream of the weirs as flows subside (Beccio 2016; Thomas et al. 2013). Although agency biologists conduct rescues when fish become stranded behind the weirs (CDFG 2011b; CDFW 2016c), monitoring of green sturgeon has shown that some of the rescued individuals appear to abort their spawning migrations (Thomas et al. 2013; CDFG 2011b; CDFW 2016c). Recurring stranding events might have substantial population-level impacts on green sturgeon (Thomas et al. 2013). Green sturgeon have never been caught in the 18-year history of the DWR fyke trap operation in the Toe Drain of the Yolo Bypass downstream of Lisbon Weir (DWR 2016, as cited in DWR and Reclamation 2017).

Juvenile green sturgeon have been caught in traps at the RBDD and the GCID diversion in Hamilton City primarily during May through August, with peak counts reported during June and July (68 FR 4433). Juvenile emigration can reportedly extend through September (Environmental Protection Information Center et al. 2001). Juveniles appear to spend one to four years rearing in fresh and estuarine waters (Beamesderfer and Webb 2002; Moyle et al. 1995). The Yolo Bypass does not appear to be important habitat for juvenile green sturgeon (Opperman et al. 2017).

8.1.2.2.4 White Sturgeon

White sturgeon are a recreationally important species in the Central Valley. White sturgeon are regulated by CDFW through sport fishing regulations and designated as a California Species of Special Concern (CDFW 2016b). The number of adults within annual age classes is highly variable and appears to be the result of successful recruitment to the juvenile life stage; the adult population is dominated by a few strong year classes associated with high spring outflows (Moyle 2002).

White sturgeon reside in the brackish portions of estuaries of large rivers for much of their lives (Kohlhorst et al. 1991). Apparently triggered by photoperiod (Israel et al. 2011) and increases in river flow (Schaffter 1997), adult white sturgeon initiate their upstream migration into the lower Sacramento River from the Delta during late fall and winter (Kohlhorst and Cech 2001). Some mature adult white sturgeon move up the Sacramento River until they are concentrated near Colusa from March through May (Kohlhorst et al. 1991 as cited in Kohlhorst and Cech 2001).

Spawning typically occurs between February and June when water temperatures are 46 to 66 degrees Fahrenheit (°F) (Moyle 2002). White sturgeon typically spawn every three to four years; only a small percentage of the adult population spawns each season. It is believed that adults broadcast spawn in the water column in areas with swift current. Fertilized eggs sink and attach to the gravel, cobble, or bedrock substrates. Eggs reportedly hatch after four days at 61°F (Beer 1981) but can take up to two weeks at lower water temperatures (Pacific States Marine Fisheries Commission 1992).

Although exact spawning locations are unknown, white sturgeon are reported to likely spawn between Knights Landing (RM 90) and Colusa (RM 143) (CDFG 2002b and Shafter 1997, both as cited in Beamesderfer et al. 2004; Kohlhorst 1976; Moyle 2002), or several kilometers upstream of Colusa (Miller 1972, Kohlhorst 1976, and Schaffter 1997, all as cited in Israel et al. 2011). Vogel (2008) sampled adult sturgeon near the GCID Hamilton City Pumping Plant between 2003 and 2006 and sampled white sturgeon as far upstream as RM 165.

Recently hatched sturgeon larvae begin swimming in a vertical position, making them more susceptible to being carried downstream to the estuary (Wang 2010). Juvenile rearing and downstream movement can occur year-round. Juvenile presence in the Yolo Bypass has been observed in low abundances from December through February, with some presence coinciding with Fremont Weir overtopping (DWR 2016, as cited in DWR and Reclamation 2017).

Migrating adult white sturgeon have been observed in the Yolo Bypass when there was no flow overtopping Fremont Weir, resulting in migratory delay and likely preventing them from reaching their upstream spawning grounds (Harrell and Sommer 2003). White sturgeon have been rescued from both the Tisdale and Fremont weirs and from the Tule Pond by CDFW personnel (CFDW 2016b). CDFW documented dead sturgeon in the Oxbow Pond in October 2016; these fish likely were stranded during the March 2016 Fremont Weir overtopping event. Some white sturgeon rescued also have been found to abort spawning migrations based on telemetry data (CDFW, unpublished data).

DWR fyke trap efforts in the Toe Drain of the Yolo Bypass have observed adult white sturgeon presence from January through August, with peak presence between March and April (DWR 2016, as cited in DWR and Reclamation 2017).

8.1.2.2.5 Delta Smelt

The USFWS listed delta smelt as a threatened species under the ESA in March 1993 (58 Code of Federal Regulations 12854), and critical habitat for delta smelt has been designated within the Delta, including the southern portion of the Yolo Bypass south of I-80, Suisun Bay and several sloughs connected to the west Delta and Suisun Bay. A petition was submitted to elevate the status of delta smelt from threatened to endangered under the ESA on March 9, 2006 (Center for Biological Diversity et al. 2006). USFWS ruled in April 2010 that the change in status from threatened to endangered was warranted but was precluded by other higher-priority listing actions (75 FR 17667). Delta smelt were listed as threatened under the CESA in 1993. In 2009, their status was elevated to endangered under CESA.

Delta smelt are endemic to the Estuary. Delta smelt are small, slender-bodied fish with a typical adult size of two to three inches (Moyle 2002). Delta smelt are euryhaline fish (can tolerate wide-ranging salinities) but rarely occur in waters with salinities greater than 7 parts per thousand (ppt) (Baxter et al. 1999); however, delta smelt have been documented in water with a salinity of up to 19 ppt and even seawater for short durations (Moyle et al. 2016). Similarly, delta smelt tolerate a wide range of water temperatures (observed at water temperatures from 42.8 to 82.4°F) (Moyle 2002). Delta smelt are typically found in Suisun Bay and the lower reaches of the Sacramento and San Joaquin rivers although they are occasionally collected within the Carquinez Strait and San Pablo Bay.

During the late winter and spring, delta smelt migrate upstream to spawn. Delta smelt spawning reportedly occurs from February through May, with embryo incubation extending through June (Wang 1986). They are thought to spawn in shallow fresh or slightly brackish waters in tidally influenced backwater sloughs and channel edgewaters (Wang 1986). Although most delta smelt spawning seems to take place at 44.6 to 59°F, gravid delta smelt and recently hatched larvae have been collected at 59 to 71.6°F (Moyle 2002). Females generally produce between 1,000 and 2,600 eggs (Bennett 2005), which adhere to vegetation and other hard substrates. Larvae hatch in 10 to 14 days (Wang 1986) and are planktonic (float with water currents) as they are transported and dispersed downstream into the low-salinity areas in the western Delta and Suisun Bay (Moyle 2002).

Delta smelt grow rapidly, with most smelt living only one year. Most adult smelt die after spawning in the early spring although they are capable of spawning multiple times during a season (Bennett 2005; Brown and Kimmerer 2001; Moyle 2002) and will continue to spawn if water temperatures remain favorable (Damon et al. 2016). Delta smelt initially feed entirely on zooplankton and may consume mysids and amphipods when they are larger (Slater and Baxter 2014; Feyrer et al. 2003). For the majority of their one-year lifespan, delta smelt inhabit areas in the western Delta and Suisun Bay characterized by salinities of about two ppt. Delta smelt occur in open surface waters and shoal areas (Moyle et al. 1992). Because delta smelt typically have a one-year lifespan, their abundance and distribution have been observed to fluctuate substantially within and among water year types. Delta smelt abundance appears to be reduced during either unusually dry years with exceptionally low outflows (e.g., 1987 through 1991), or unusually wet years, with exceptionally high outflows (e.g., 1982 and 1986).

Delta smelt populations have shown a long-term decline in the upper Estuary (the Delta and Suisun Bay), beginning with an abrupt decline in 1982 (Kimmerer 2002a) and extremely low abundance in recent years as part of the pelagic organism decline (Baxter et al. 2010; Sommer et al. 2007). The low abundance of delta smelt since the early 1980s is attributed to many interacting factors. These include larvae being swept downstream during high flows in the winter and spring of 1982 and 1983 (Kimmerer 2002a), the prolonged drought from 1987 to 1992 (Baxter et al. 2010), the extreme drought from 2013 through 2015 (USFWS 2017), entrainment in water diversions (Kimmerer 2008), declines in salinity and increases in water clarity for juveniles (Nobriga et al. 2008) and maturing individuals (Feyrer et al. 2007; Thomson et al. 2010), predation and competition from non-native species (Bennett 2005), and a decline in food resources (Miller et al. 2012).

Fisheries surveys indicate that delta smelt abundance has declined substantially in the Estuary since the 1970s and has been relatively low during most years since 2004 (CDFW 2016d). The 2016 delta smelt abundance index was the second-lowest in the history of the annual survey, which began in 1967 (CDFW 2016d).

Delta smelt have been captured during DWR’s Yolo Bypass sampling efforts primarily from January through June, with peaks in catch during February, March, May, and June (DWR unpublished data). Most delta smelt captures occurred during RST surveys in the Toe Drain. Individuals captured averaged about 65 to 70 mm FL during January through March and about 40 to 55 mm during April through June (DWR unpublished data).

8.1.2.2.6 Longfin Smelt

Longfin smelt were listed as threatened under the CESA in 2009, and the San Francisco Bay-Delta DPS of longfin smelt was designated as a Federal candidate species by USFWS in 2012.

Longfin smelt are found in areas ranging from almost pure seawater upstream to areas of pure freshwater. In the Bay-Delta, they are most abundant in San Pablo and Suisun bays (Moyle 2002) and rarely observed upstream of Rio Vista in the Delta (Moyle et al. 1995).

Longfin smelt tend to inhabit the middle to lower portions of the water column and spend the early summer in San Pablo and San Francisco bays, generally moving into Suisun Bay in August. Most spawning occurs from February to April at water temperatures ranging from 44.6 to 58.1°F (Moyle 2002). Most longfin smelt live for up to two years although some age-three longfin smelt have been observed (CDFG 2009). Most adults die following spawning (CDFG 2009). Each female lays 5,000 to 24,000 adhesive eggs, a number that is considerably variable. Embryos hatch in about 40 days at 44.6°F (Moyle 2002). The buoyant newly hatched larvae (five to eight mm long) are swept downstream into the more brackish parts of the Estuary. High Delta outflow rates are thought to be positively correlated with longfin smelt survival as higher flows transport longfin smelt young to more suitable rearing habitat in Suisun and San Pablo bays (Moyle 2002).

Fisheries surveys indicate that longfin smelt abundance has declined in the Bay-Delta since the 1990s and has been relatively low during most years since 2001 (CDFW 2016d). The 2016 longfin smelt abundance index was the second-lowest in the history of the annual survey, which began in 1967 (CDFW 2016d).

Relatively few longfin smelt have been captured in DWR’s Yolo Bypass sampling efforts, but they have been captured during January, and April through June (DWR unpublished data).

8.1.2.2.7 River Lamprey

River lamprey are not listed under the ESA or the CESA although they are identified by CDFW as a California species of special concern (CDFW 2016b).

River lampreys generally have not been studied in California (Moyle 2002). Most of the available information on their life history is based on studies in British Columbia (UC Davis 2012).

Adult river lampreys migrate into freshwater during the fall and spawn during the winter or spring in small tributary streams. However, the timing and extent of their migration in California is poorly known (UC Davis 2012). Wang (1986) reported that adult river lampreys spawn from April to June in small tributary streams, whereas Moyle (2002) reported that river lampreys spawn during February through May. Adults create saucer-shaped depressions (redds) in gravel riffles in which to spawn (UC Davis 2012). River lampreys are semelparous (i.e., adults die after spawning).

River lamprey ammocoetes (i.e., larval lampreys) burrow into sandy or muddy substrates near river banks (Hart 1973 and Scott and Crossman 1973, both as cited in Wang 1986) and remain in silt-sand backwaters and eddies (UC Davis 2012). River lamprey ammocoetes also have been found in the Delta during dredging operations in the Stockton Deep Water Ship Channel and the Sacramento Deep Water Ship Channel (USACE 2012a). The ammocoete life stage is believed be about three to five years (Moyle 2002). During the final stages of metamorphosis, ammocoetes congregate immediately upriver from saltwater and enter the ocean during late spring (Moyle et al. 1995), which indicates that downstream migration of juveniles in the Sacramento River can occur during the winter through spring.

Based on studies of other lamprey species (see USFWS 2010), adult river lampreys presumably need clean gravel substrate in riffles in perennial streams for spawning. Lamprey ammocoetes require sandy backwaters or stream edges in which to bury themselves where water quality is continuously good and water temperatures do not exceed 77°F (Moyle 2002).

The majority of river lamprey documented in the Yolo Bypass are juveniles caught in the RST during periods of high flow in the winter and spring. River lamprey have been observed in the Yolo Bypass between December and May, with peak presence in January (DWR 2016, as cited in DWR and Reclamation 2017).

8.1.2.2.8 Pacific Lamprey

Pacific lamprey are not listed under the ESA or the CESA although they are identified as a California species of special concern (CDFW 2016b). Pacific lamprey were petitioned for protection under the ESA in 2003, but USFWS determined that insufficient population information existed to warrant listing.

Adult Pacific lampreys typically migrate into freshwater streams between March and June (Moyle 2002), but upstream migrations have been observed during January and February (Entrix 1996 and Trihey and Associates 1996a, both as cited in Moyle 2002). Most upstream movement is reported to occur at night (Chase 2001 as cited in USFWS 2010; Moyle 2002).

Pacific lamprey spawning occurs between March and July (USFWS 2010). The spawning habitat requirements of Pacific lampreys have not been well studied, but it is believed that adults need clean gravel riffles to spawn successfully and have similar habitat requirements to those of salmonids (Moyle 2002; USFWS 2010). Moyle (2002) reported that, although historical spawning locations of Pacific lampreys are not known, they have been observed spawning in Deer Creek and likely could have migrated over 300 miles to spawn. Typically, low-to-moderate-gradient stream reaches with a mix of silt and cobble substrate are reported to be optimal spawning and rearing habitat (USFWS 2010).

Ammocoete habitat is typically located near suitable spawning habitat (USFWS 2010). Moyle (2002) reported that Pacific lamprey embryos hatch in about 19 days at 59°F. Eggs hatch into ammocoetes, spend a short time in the redd, and then drift downstream to suitable areas in sand, silt, or mud substrates (Moyle 2002; USFWS 2010). Typical ammocoete habitat includes areas of low velocity with muddy or sandy substrates into which they burrow where they can remain for about three to seven years. Although mostly sedentary during their freshwater residence, ammocoetes are reported to be able to move downstream when disturbed or during high-flow events (USFWS 2010).

Ammocoetes begin metamorphosis into macropthalmia (juveniles) when they reach 14 to 16 centimeters (cm) total length. Juveniles reportedly drift and swim downstream between late fall and spring (USFWS 2010). Others reported that downstream migration is associated with increased stream flows during the winter and spring (USFWS 2010 and the references therein). Based on RST survey data from water years 2004 through 2012 at the RBDD on the Sacramento River, the primary emigration period of Pacific lamprey macropthalmia ranged from November to May (Goodman et al. 2015). The median emigration date over the period of record was December 29 but ranged annually between December 4 and March 14 (Goodman et al. 2015). Juvenile life stages of lamprey (ammocoetes and macropthalmia) and adult lampreys are reported to stay close to the stream bottom during their migration periods. Juveniles also are reported to prefer low light conditions and migrate mostly during the night (Moursund et al. 2003 as cited in Chelan County Public Utility District 2006; Goodman et al. 2015).

Pacific lamprey have been observed in the Toe Drain of the Yolo Bypass between December and April, with peak presence occurring in February (DWR 2016, as cited in DWR and Reclamation 2017). Adults are occasionally found in the Yolo Bypass, although the majority of lamprey caught in the Yolo Bypass have been composed of ammocoetes and macropthalmia during periods of increased flows in the winter and spring months (DWR 2016, as cited in DWR and Reclamation 2017).

8.1.2.2.9 Sacramento Splittail

USFWS removed Sacramento splittail from the list of threatened species on September 22, 2003 and did not subsequently identify it as a candidate for listing under the ESA. However, Sacramento splittail is identified as a California species of special concern (CDFW 2016b).

Sacramento splittail are native cyprinids (minnows) that occur in the Sacramento River and its major tributaries and are endemic to the Central Valley, with a range that centers on the San Francisco Bay Estuary. Sacramento splittail are adapted for living in estuarine waters with fluctuating conditions as well as in severe conditions that once occurred in alkaline lakes and sloughs on the floor of the Central Valley during droughts (Moyle 2002). Adults are normally found in relatively shallow water (less than 12 feet deep) in brackish tidal sloughs, such as Suisun Marsh, but can also occur in freshwater areas with either tidal or riverine flows (Moyle et al. 2004). Historically, Sacramento splittail were found as far up the Sacramento River as Redding, but today are largely absent from the upper parts of their historical range (Moyle 2002). During wet years, it has been suggested that Sacramento splittail migrate up the Sacramento River as far as the RBDD (Moyle 2002).

The average lifespan of Sacramento splittail ranges from five to seven years (Caywood 1974; Meng and Moyle 1995). Adults can attain a length of over 300 mm (USFWS 1995).

Sacramento splittail spawning can occur anytime between late February and early July, but peak spawning occurs in March (Feyrer et al. 2006b). DWR (2004a) reported that Sacramento splittail spawning, egg incubation, and initial rearing in the Feather River occurs primarily during February through May. Sacramento splittail exhibit protracted gradual upstream migration in the winter to forage and spawn although some spawning activity has been observed in Suisun Marsh (Moyle 2002). Attraction flows are necessary to initiate migration onto floodplains where spawning occurs (Moyle et al. 2004). Spawning generally occurs in water with depths of three to six feet, over submerged vegetation, where eggs adhere to vegetation or debris until hatching (Moyle 2002; Wang 1986). Caywood (1974) reported that older fish are generally the first to spawn. Based on field observations and a review of Sacramento splittail thermal tolerance literature, DWR (2004a) concluded that water temperatures from 45 to 75°F are suitable for spawning.

Eggs normally incubate for three to seven days, depending on water temperature (Moyle 2002). After hatching, Sacramento splittail larvae remain in shallow weedy areas until water recedes, then they migrate downstream (Meng and Moyle 1995). The largest catches of Sacramento splittail larvae occurred in 1995, a wet year when outflow from inundated areas peaked during March and April (Meng and Matern 2001).

Juvenile Sacramento splittail prefer shallow-water habitat with emergent vegetation (Meng and Moyle 1995). Snorkel surveys conducted in a managed wetland in the Yolo Bypass found that young Sacramento splittail juveniles (mean 21 mm FL) were strongly associated with habitats located relatively close to the edge of wetland, emergent terrestrial vegetation, and submerged aquatic vegetation during the day (Sommer et al. 2008b). At night, young juveniles moved to deeper areas with submerged terrestrial vegetation and tule stands. Most larger juveniles (mean 41 mm FL) were observed in deeper offshore areas and exhibited benthic behavior at night (Sommer et al. 2008b). Sommer et al. (2002) reported that during wetter years juvenile Sacramento splittail are abundant in the Yolo Bypass floodplain in the shallowest areas of the wetland with emergent vegetation. Downstream movement of juvenile Sacramento splittail appears to coincide with drainage from the floodplains between May and July (Caywood 1974; Meng and Moyle 1995; Sommer et al. 1997).

Floodplain inundation in the Yolo Bypass during March and April appears to be the primary factor contributing to Sacramento splittail abundance. Moyle et al. (2004) reported that moderate-to-strong year classes of Sacramento splittail developed in the Estuary when floodplains were inundated for six to 10 weeks between late February and late April. Reportedly, when the Yolo Bypass was inundated for less than a month, strong year classes were not produced (Sommer et al. 1997). Sommer et al. (1997) discussed the resiliency of Sacramento splittail populations and suggested that, because of their relatively long lifespan, high reproductive capacity, and broad environmental tolerances, their populations can recover rapidly even after several years of drought conditions. Despite downward trends in total population size during periods of drought, Moyle et al. (2004) reported that the ability of at least a few Sacramento splittail to reproduce in the Estuary under the least suitable hydrologic conditions ensures the population will persist.

Juvenile abundance in the Yolo Bypass peaks between May and June (DWR 2016, as cited in DWR and Reclamation 2017; Meng and Moyle 1995; Sommer et al. 1997).

8.1.2.2.10 Hardhead

Hardhead, a California species of special concern (CDFW 2016b), is a large, native cyprinid that is widely distributed throughout the Sacramento-San Joaquin river system although it is absent from the valley reaches of the San Joaquin River (Moyle 2002).

Hardhead generally occur in large, undisturbed low-to-mid-elevation rivers and streams of the region (Moyle 2002). Hardhead mature during their third year and often make spawning migrations into smaller tributary streams during the spring (Moyle 2002). Most hardhead spawning is reportedly restricted to foothill streams (Wang and Reyes 2007) primarily during April and May (Grant and Maslin 1999; Moyle 2002). However, spawning might occur into July in Sacramento River tributaries and into August in San Joaquin River tributaries (Wang and Reyes 2007). Estimates based on juvenile recruitment suggest that hardhead spawn by May and June in Central Valley streams (Wang 1986). Spawning behavior has not been documented, but hardhead are believed to mass spawn in gravel riffles (Moyle 2002). Hardhead forage at the bottoms of deep pools for aquatic insects, occasionally taking drifting insects on the surface (Moyle 2002).

Although hardhead occupy the Yolo Bypass, they have not been consistently observed in substantial numbers in any of DWR’s Yolo Bypass sampling efforts dating back to 1998 (DWR 2016, as cited in DWR and Reclamation 2017). They have only been observed in six of the years between 1998 and 2016, with eight individuals being the maximum number observed in a single year (2011). Hardhead are likely year-long residents in the Yolo Bypass as they have been documented in the Yolo Bypass every month that sampling occurs (DWR 2016, as cited in DWR and Reclamation 2017).

8.1.2.2.11 Sacramento Hitch

Sacramento hitch, a California species of special concern (CDFW 2016b), were historically found throughout the Sacramento and San Joaquin valleys in low elevation streams and rivers as well as in the Delta (Brown 2000). Although Sacramento hitch appear to be spread across much of their native range, populations are scattered relative to historical conditions and are only found in a few localities and in relatively low numbers (Moyle 2002; May and Brown 2002).

Sacramento hitch have high temperature tolerances; fish acclimated to 30 degrees Celsius (°C) can survive water temperatures up to 38°C for short periods of time although they are usually most abundant in waters cooler than 25°C during the summer (Moyle 2002). They most commonly inhabit warm, lowland waters, including clear streams, turbid sloughs, lakes, and reservoirs (Moyle et al. 2015). In streams, they are generally found in pools or runs among aquatic vegetation, and in lakes, adults occupy open waters (Moyle et al. 2015).

Spawning takes place over gravel riffles at temperatures ranging from 14 to 26°C, but spawning can also occur on aquatic vegetation (Moyle 2002). Spawning may begin in February, generally in response to an increase in flow associated with spring runoff, and may end as late as July (Moyle et al. 2015). Fertilized eggs sink into gravel interstices before absorbing water and then swell to become lodged in the gravel. Hatching takes place in three to seven days, and larvae become free-swimming in another three to four days (Moyle et al. 2015).

Relatively few Sacramento hitch have been caught in DWR’s Yolo Bypass sampling efforts. The largest number of Sacramento hitch caught (52) in one year occurred in 2011 (DWR unpublished data). Most individuals captured appear to have been juveniles. Therefore, it is not expected that the Yolo Bypass is an important spawning area for Sacramento hitch.

8.1.2.2.12 Sacramento Pikeminnow

Although the native Sacramento pikeminnow is not considered a special-status or commercially important species, this species can prey on listed juvenile salmonids in the study area. Therefore, Sacramento pikeminnow is discussed below and included as a fish species of focused evaluation in this EIS/EIR.

Sacramento pikeminnow are large native predatory cyprinids found throughout the Sacramento-San Joaquin river system. They are most prevalent in low- to mid-elevation streams with deep pools, slow runs, undercut banks, and overhanging vegetation (Moyle 2002). Sacramento pikeminnow begin spawning as early as April and continue through July (Moyle 2002). Fish from large rivers or reservoirs usually move into small tributaries to spawn, whereas fish resident in small- to medium-sized streams typically move into the nearest riffle (Moyle 2002).

Sacramento pikeminnows are opportunistic predators, and their predation on juvenile salmonids appears to be correlated with human-made changes to a natural free flowing riverine channel. Obstructions that cause Sacramento pikeminnows to congregate in the presence of outmigrating juvenile salmonids appear to increase the incidence of predation. A study on the predation of juvenile salmonids at the RBDD found that juvenile salmonids were not a significant food source of Sacramento pikeminnows when the gates were configured to create a free-flowing riverine environment (Tucker et al. 1998). However, when the gates were in place at the RBDD, juvenile salmonids accounted for 66 percent of the total weight of stomach contents for Sacramento pikeminnows, more than twice the weight of other fish species (Tucker et al. 1998).

DWR’s Yolo Bypass sampling efforts have captured Sacramento pikeminnow primarily during January through June; with peaks in catch during February through April (DWR unpublished data).

8.1.2.3 Non-native Species

8.1.2.3.1 Overview of Non-native Fish Species in the Yolo Bypass

Discussed below are non-native fish species of focused evaluation that have been documented in the Yolo Bypass study area. These species include recreationally important non-native species and non-native species that are known to interact with juvenile salmonids and other native fish species through predation and/or competition.

8.1.2.3.2 American Shad

American shad occur in the Sacramento River, its major tributaries, the San Joaquin River, and the Delta. Because of its importance as a sport fish, American shad has been the subject of investigations by CDFW. American shad are native to the Atlantic coast and were planted in the Sacramento River in 1871 and 1881 (Moyle 2002).

Adult American shad typically enter Central Valley rivers from April through early July (CDFG 1986), with most migration and spawning occurring from mid-May through June (CDFG 1987). Spawning takes place mostly in the main channels of rivers, and generally about 70 percent of the spawning run is made up of first-time spawners (Moyle 2002). When suitable spawning conditions are found, American shad school and broadcast their eggs throughout the water column. Based on the capture of juveniles, Harrell and Sommer (2003) suggested that American shad might spawn in the Toe Drain although a tidal slough is not believed to be preferred American shad spawning habitat (Harrell and Sommer 2003). Peak abundance of shad in the Yolo Bypass has been correlated with higher water temperature, which is generally linked to their upstream migration (Sommer et al. 2014), and might not necessarily indicate presence in the Yolo Bypass during high-flow events when juvenile salmonids might be present.

Water temperature is an important factor influencing the timing of spawning. American shad are reported to spawn at water temperatures ranging from 46 to 79°F (USFWS 1967) although optimal spawning temperatures are reported to range from 60 to 70°F (Leggett and Whitney 1972; Painter et al. 1979; Rich 1987). Eggs hatch in six to eight days at 62°F; at temperatures near 75°F, eggs reportedly hatch in three days (MacKenzie et al. 1985). Egg development and hatching, therefore, are coincident with the spawning period.

Some young shad move downstream into brackish water soon after hatching, but large numbers reportedly remain in freshwater through November when they are five to six months old (CDFG 2010b). Some juvenile American shad rear in estuaries for one to two years before migrating to the ocean, but most American shad migrate directly to the ocean after transforming from larvae to juveniles, which occurs about four weeks after hatching (UC Davis 2015). Juvenile American shad can occur in the Sacramento River year-round (Moyle 2002).

Concern has been expressed regarding the potential impacts of American shad on juvenile salmonid populations. Dietary overlaps between American shad and juvenile salmonids are the primary factor of concern and are cited as evidence of interspecific competition. However, American shad numbers have declined considerably from peak levels in the early 1990s (Stouder et al. 1997; CDFW 2016d).

8.1.2.3.3 Striped Bass

Striped bass occur in the Sacramento River, its major tributaries, and the Delta but spend most of their lives in the San Francisco Estuary. Because of its importance as a sport fish, striped bass has been the subject of investigations by CDFW. Substantial striped bass spawning and rearing occurs in the Sacramento River and Delta; however, striped bass can typically be found upstream as far as barrier dams (Moyle 2002). Striped bass are native to the Atlantic coast and were first introduced to the Pacific coast in 1879 when they were planted in the San Francisco Estuary (Moyle 2002).

Adult striped bass are present in Central Valley rivers throughout the year, with peak abundance occurring during spring (CDFG 1971; DeHaven 1979). The presence of striped bass in the Yolo Bypass has been documented from November through June (Harrell and Sommer 2003). Adult striped bass are reported to prefer water temperatures from 68 to 75.2°F (Emmett et al. 1991).

Striped bass spawn in water temperatures ranging from 59 to 68°F (Moyle 2002). Therefore, spawning can begin in April but peaks in May and early June (Moyle 2002). In the Sacramento River, most striped bass spawning is believed to occur between Colusa and the mouth of the Feather River. In years of higher flow, spawning typically occurs farther upstream than usual because striped bass continue migrating upstream while waiting for temperatures to rise (Moyle 2002). Adult and juvenile striped bass have been caught in the Yolo Bypass between November and June (Harrel and Sommer 2003; Sommer et al. 2014). Because of the high numbers of juveniles caught, it is suggested that adults might use the Toe Drain to spawn (Harrell and Sommer 2003).

Egg survival requires a sufficiently strong current to keep the eggs suspended in the water column. After fertilization, eggs hatch within two to three days, followed by a net movement of the larval fish to downstream, tidal portions of the river (Moyle 2002). Striped bass larvae are generally distributed in the Delta or Suisun Bay, depending on flow through the Estuary. During lower-flow years, striped bass eggs and larvae are generally found in the Delta, whereas during higher-flow years, eggs and larvae are transported downstream into Suisun Bay (Hassler 1988).

The number of striped bass entering Central Valley streams during the summer is believed to vary with flow levels and food production (CDFG 1986). Sacramento River tributaries can be nursery areas for young striped bass (CDFG 1971, 1986). Juvenile and sub-adult fish historically have been reported to be abundant in the lower American River and lower Yuba River during the fall (DeHaven 1977, as cited in DeHaven 1979). Optimal water temperatures for juvenile striped bass rearing have been reported to range from 61 to 71°F (Fay et al. 1983).

The predation impact of striped bass on juvenile salmonids has been well documented, as summarized below by CDFG (2011c):

> By virtue of their abundance, habits, and size, predation by striped bass has been implicated as a substantial contributor to the poor survival of young salmon used in experiments to estimate reach- and site-specific survival rates through the Delta and in the Sacramento River (see CDFG 2011c for references). By plausible extension, listed salmon (and steelhead) also suffer poor survival rates due to predation, including predation by striped bass.

Fisheries surveys in the Bay-Delta indicate that the abundance of juvenile (age 0) striped bass has declined since the 1970s and 1980s and has remained relatively low since 2002 (CDFW 2016d).

8.1.2.3.4 White Catfish

White catfish are native to the rivers of the Atlantic coastal states from Florida to New York. The species is found in sluggish, mud-bottomed pools, open channels, backwaters of small to large rivers and in lakes and impoundments. In rivers, white catfish prefer depths of greater than two meters during the day and move to shallow vegetated areas at night (UC Davis 2017). White catfish can be found in salinities of up to 14.5 ppt and prefer water temperatures above 20°C (68°F) (UC Davis 2017). White catfish spawn between June and September near vegetated or rocky areas when water temperatures are greater than 21°C (69.8F°) (UC Davis 2017).

White catfish have been collected year-round by the Yolo Bypass Fish Monitoring Program (Sommer et al. 2014) and are consistently the most abundant predatory fish collected during fyke trap operations in the Yolo Bypass (Mahardja et al. 2016). White catfish have been reported to predate on native fish species, including Chinook salmon, delta smelt, and Sacramento splittail (Grossman 2016).

8.1.2.3.5 Warm Water Game Fish

Largemouth Bass

Largemouth bass are not listed as threatened or endangered under the ESA or the CESA and are not a Federal species of concern or a State species of special concern. However, largemouth bass are a recreationally important species throughout California and are regulated by CDFW. Largemouth bass are a piscivorous species known to prey on juvenile salmonids in the Delta and portions of the Yolo Bypass.

Warm, shallow waters (less than six meters (m), or about 20 feet, deep) of moderate clarity and beds of aquatic plants are preferred habitat of largemouth bass (Moyle 2002). They are common in river backwaters and streams with large pools or ponds with dense aquatic vegetation. Stream populations are often maintained by continuous colonization from upstream sources, usually farm ponds or reservoirs (Moyle 2002). Optimal water temperatures for largemouth bass are 25 to 30°C (77 to 86°F) though largemouth bass can survive in a much wider range of temperatures.

Largemouth bass begin to spawn when water temperatures reach 15 to 16°C (59 to 61°F), which usually occurs from April through June (Moyle 2002). Nests are generally shallow depressions up to one m (3.28 feet) in diameter created by males in sand, gravel, or debris-littered bottoms at depths of 0.5 to two m (1.6 to 6.6 feet) (Moyle 2002).

Largemouth bass are solitary predators and exhibit both ambush and pursuit methods of capturing prey. Prey items are generally determined by size, with smaller juvenile bass feeding primarily on aquatic and terrestrial insects and small crustaceans and larger adult bass feeding on fish, frogs, and crayfish.

Smallmouth Bass

Smallmouth bass are not considered a special-status species. However, smallmouth bass are a recreationally important species throughout California and are regulated by CDFW. Smallmouth bass are a piscivorous species known to prey on juvenile salmonids.

Smallmouth bass are not native to California but have been introduced into suitable waters throughout the State. Smallmouth bass prefer streams with abundant cover, such as rocky bottoms and overhanging trees with water temperatures ranging from 20 to 27°C (68 to 81°F) (Moyle 2002). In streams, spawning takes place from May to July once water temperatures reach 13 to 16°C (55 to 61°F) (Moyle 2002). Males build nests or "beds" on rubble, gravel, or sandy bottoms at a depth of around one meter (Moyle 2002). Females deposit eggs within the nest, and fry emerge around one to two weeks later.

Smallmouth bass fry feed mainly on crustaceans and aquatic insects until they reach three to five centimeters (1.2 to two inches) total length when larger prey, especially crayfish and fish, start becoming more important. Larger prey rarely dominates the diet until the bass measure 10 to 15 cm (four to six inches) total length (Moyle 2002).

Spotted Bass

Spotted bass are not considered a special-status species. However, spotted bass are a recreationally important species throughout California and are regulated by CDFW. Spotted bass are a piscivorous species that is known to prey on juvenile salmonids.

Spotted bass in streams are pool dwellers and avoid riffles and backwaters with heavy growth of aquatic plants (Moyle 2002). Spotted bass prefer slower and more turbid water than do smallmouth bass and favor faster water than do largemouth bass (Moyle 2002). Spawning and feeding characteristics are similar to those of smallmouth and largemouth bass, as discussed above.

8.1.2.3.6 Cyprinids

Non-native cyprinids found in the Yolo Bypass include common carp and goldfish. Common carp and goldfish are not considered special-status species, but have the potential to affect the food web and food availability for special-status fish species through competition for prey and ecosystem alteration.

Common carp is a widely distributed invasive species which has been found to disturb aquatic ecosystems. Common carp and goldfish disturb sediment when they feed, which often results in increased turbidity and associated effects. Various studies have found that invasive common carp in shallow lakes increase nutrient availability, turbidity and phytoplankton abundance, reduce benthic macroinvertebrates and aquatic macrophytes, and modify zooplankton communities (Weber and Brown 2009 as cited in Weber and Brown 2011; Florian et al. 2016).

Common carp and goldfish have been categorized as opportunistic floodplain spawners (Moyle et al. 2004; 2007). Although they do not require floodplain habitat for spawning, their reproductive success (as indicated by YOY abundance) has been observed to improve when vegetation becomes flooded (Crain et al. 2004; Brown 2000).

8.1.3 The Toe Drain provides year-round habitat for common carp (Harrell and Sommer 2003; Sommer et al. 2014), which has been identified as one of the most abundant fish species in permanent wetlands in the Yolo Bypass Wildlife Area (Feyrer et al. 2004) and in the Toe Drain (Sommer et al. 2014). In the Cosumnes River, spawning common carp and goldfish have been observed moving into flooded areas during late February and March through April (Moyle et al. 2007). By contrast to adult Sacramento splittail, adult common carp and goldfish frequently became stranded when water levels recede (Moyle et al. 2007).Floodplain Processes and Ecology

8.1.3.1 River-Floodplain Ecological Frameworks

Generally, floodplains are low-gradient features adjacent to river channels that are subject to lateral inundation by high flows. Floodplains can provide conditions that support relatively higher biodiversity and productivity relative to conditions in river channels (e.g., Tockner and Stanford 2002; Junk et al. 1989; Opperman et al. 2009; Opperman et al. 2010; Jeffres et al. 2008; Killgore and Miller 1995).

Opperman et al. (2017) reviewed previously developed frameworks applicable to river-floodplain ecology, including the River Continuum Concept (Vannote et al. 1980), the Flood Pulse Concept (Junk et al. 1989), the Shifting Habitat Mosaic (Stanford et al. 2005), the Riverine Productivity Model, and the River Wave Concept. The River Continuum Concept suggests that productivity of large rivers is derived from upstream sources; confined rivers with minimal floodplains have been shown to conform relatively well to this concept, whereas rivers with extensive floodplains do not conform as well (Opperman et al. 2017).

Junk et al. (1989) developed the Flood Pulse Concept, which recognizes the absence of floodplains in the River Continuum Concept (Opperman et al. 2017) and proposes that periodic inundation and drought (flood pulse) is the driving force in the river-floodplain system. Junk et al. (1989) hypothesized that "*in unaltered large river systems with floodplains in the temperate, subtropical, or tropical belt, the overwhelming bulk of the riverine animal biomass derives directly or indirectly from production within the floodplains*." Opperman et al. (2017) described three ways in which river-floodplain connectivity increases production for organisms in the system under this concept: 1) during floodplain inundation, the expanding edge of the water allows for increased access to food resources in a larger area – referred to by Junk et al. (1989) as the “aquatic-terrestrial transition zone;” 2) when the floodplain is inundated for a sufficient period of time, the floodplain becomes a highly productive area due to autochthonous production[2] and from decomposition of terrestrial vegetation; and 3) the transportation of carbon, nutrients, materials and organisms from the floodplain back into the river as the floodplain drains. The Flood Pulse Concept has been verified in relatively natural large tropical river-floodplain systems (Junk 1982; Junk et al. 1989; Koponen et al. 2010). For example, the most productive fishery in the world, in the Mekong River Basin (Baran 2010), is dependent on

[2] Photosynthesis by plants such as phytoplankton (microscopic plants that inhabit upper layers of water bodies), periphyton (mixture of algae and other organisms attached to submerged surfaces), and aquatic macrophytes (aquatic plants that grow in or near water)

processes associated with the seasonal flood pulse and inundation of a large floodplain lake (Koponen et al. 2010).

Some authors have noted that the Flood Pulse Concept proposed by Junk et al. (1989) has not been as thoroughly evaluated for highly altered temperate river systems (Schramm and Eggleton 2006; Alford and Walker 2013). For example, studies conducted in some altered temperate floodplain systems found that floodplain inundation increased productivity and abundance of some fish species but not others or that floodplain inundation increased population abundance of some fish species only under particular conditions (Schramm and Eggleton 2006; Alford and Walker 2013). However, although the application of some aspects of the Flood Pulse Concept outside of tropical systems has been questioned, the general theory that the flood pulse provides an advantage to fish species has been confirmed in many temperate settings (e.g., Sommer et al. 2001c) (Opperman et al. 2017).

In an update to the concepts proposed by Junk et al. (1989), Junk and Wantzen (2004) noted that although the flood pulse is the driving force in river-wetland systems in humid tropical areas, there are additional driving forces that affect organisms and floodplain processes in the lower latitudes (Junk and Wantzen 2004). In temperate regions, the timing of the flood pulse and associated light and/or temperature regime may determine the associated biological effects (Junk et al. 1989; Junk and Wantzen 2004).

Similar to the Flood Pulse Concept, the Shifting Habitat Mosaic concept also focuses on floodplains but instead describes river ecosystems based on how hydrologic processes create, maintain and change diverse patches of habitat across longitudinal (upstream to downstream), lateral (channel and floodplain interactions), and vertical (groundwater and surface water exchange) dimensions on a floodplain (Stanford et al. 2005; Opperman et al. 2017). A conceptual model developed for Central Valley floodplains (Opperman 2012) includes aspects of both the Flood Pulse Concept (i.e., processes that occur during inundation events) and the Shifting Habitat Mosaic concept (i.e., processes that develop and maintain the floodplain) (Opperman et al. 2017).

The Riverine Productivity Model (Thorp and Delong 1994) states that even though the total ecosystem carbon is dominated by detritus from upstream sources, the riverine food webs are driven by local autochthonous production and direct inputs from the riparian zone, including periods outside of the inundation period (Opperman et al. 2017). Thorp and Delong (2002 as cited in Opperman et al. 2017) emphasized the role of autochthonous production by algae and de-emphasized the importance of riparian inputs.

The River Wave Concept (Humphries et al. 2014) proposed that previously developed frameworks, including the River Continuum Concept, the Flood Pulse Concept, and the Riverine Productivity Model, together can explain the source of organic matter and the characteristics of storage, conversion, and movement of material and energy in the river. The River Wave Concept also hypothesizes that each of the three frameworks is relatively more applicable during different hydrologic “waves” or phases—at the wave troughs (i.e., baseflow or low flows), local autochthonous and allochthonous[3] inputs are the primary sources of production (Riverine Productivity Model); on the ascending or descending limbs of waves (i.e., rising or falling hydrographs), the primary sources of production are upstream allochthonous inputs (River

[3] Sources of production from outside of the floodplain

Continuum Concept); and as waves rise to crests (i.e., flood flows), increases in production are sourced from the floodplain (Flood Pulse Concept) (Humphries et al. 2014).

As summarized by Opperman et al. (2017), these river-floodplain conceptual frameworks all emphasize the importance of the hydrology and connectivity for maintaining flood processes and the ecosystem benefits provided by these processes.

8.1.3.2 Floodplain Productivity

8.1.3.2.1 Primary Production

Food webs[4] on the floodplain are supported by carbon produced by plants on the floodplain (autochthonous inputs) and from external (allochthonous) sources. Internal sources of carbon include phytoplankton, aquatic macrophytes, and emergent plants that grow on the floodplain following inundation (Opperman et al. 2017). External sources include material from the upstream river, floodplain forests, and other terrestrial vegetation that grows on or adjacent to the floodplain when it is not inundated (Opperman et al. 2017). For example, floodplains have been shown to contribute nutrients to the system by releasing nutrients deposited during previous flood events (Junk et al. 1989; Schonbrunner et al. 2012). The relative importance of algae (i.e., phytoplankton and periphyton) and plant matter to the floodplain food web may shift, depending on flow and turbidity conditions, with detrital carbon becoming more important during periods of high flow and high turbidity (Opperman et al. 2017). However, in most floodplain systems, algae are the primary contributor to the food web, despite the dominant presence of living and detrital plant matter (reviewed by Opperman et al. 2017).

The productivity of algae is regulated by four primary factors—light, nutrients, grazing by zooplankton, and hydrology (Opperman et al. 2017). Algae production is generally greater during spring or summer due to higher light levels (and increased temperatures) and is stimulated by higher levels of dissolved nutrients in the water. Zooplankton grazing pressure can reduce the amount of phytoplankton on the floodplain under conditions that allow zooplankton to persist (when water velocities are low and residence time[5] is high) (Grosholz and Gallow 2006).

Flow is the most important variable that affects the algal community during an inundation event (Opperman et al. 2017). For example, fast growing and smaller species of phytoplankton that are adapted to higher velocity and turbid environments were found during the initial period of inundation of the Yolo Bypass; as flows decreased and residence time of the water increased, the species composition shifted to larger species (Sommer et al. 2004). In the Yolo Bypass and Cosumnes River floodplains, concentration of chlorophyll *a* (an indicator of phytoplankton productivity) was positively correlated with residence time of water on the floodplain (Schemel et al. 2004; Ahearn et al. 2006). In addition, phytoplankton biomass has been shown to be highest during the draining phase of the floodplain (i.e., after there is no longer inflow to the floodplain) as water velocity decreases and residence time, water temperature, and water clarity all increase (Ahearn et al. 2006; Grosholz and Gallo 2006; Sommer et al. 2004; Opperman et al. 2017). In the Yolo Bypass, residence time can range from five days to four weeks (Opperman et

[4] A system of interconnected food chains (linear networks of organisms dependent on one another as a source of food)

[5] The rate at which water moves through the floodplain

al 2017). Recent research indicates that aquatic macrophytes are relatively minor contributors to carbon in floodplain food webs, but they can provide shelter and structure for periphyton, invertebrates, and fish (Opperman et al. 2017).

Production of phytoplankton has been found to increase substantially in the Yolo Bypass when it is inundated compared to adjacent Sacramento River locations (Lehman et al. 2007). During the summer and fall, agricultural discharge into the Yolo Bypass can result in increased productivity in the Toe Drain and downstream in the estuary, potentially improving food production for delta smelt (Frantzich and Sommer 2015).

8.1.3.2.2 Secondary Production

Zooplankton and other invertebrates are the primary linkages between primary productivity and fish (Kreckeis et al. 2003 as cited in Opperman et al. 2017). Zooplankton productivity has been shown to be determined by the availability of carbon from algae, even where carbon from detritus dominates the available carbon (Muller-Solger et al. 2002; Jassby et al. 2003). Grosholz and Gallo (2006) observed peaks in zooplankton biomass on the Cosumnes River floodplain two to three weeks after the floodplain disconnected from the river (i.e., during the draining phase). Zooplankton can be displaced from the floodplain during flood events but can apparently quickly recolonize afterward (see Opperman et al. 2017). Abundance of zooplankton on natural floodplains can be substantially higher relative to the adjacent river, as found in the Cosumnes River (Grosholz and Gallo 2006). However, in the Yolo Bypass, zooplankton abundance was not significantly different from that observed in the Sacramento River (Sommer et al. 2004).

The distribution of aquatic invertebrates is influenced by the floodplain’s hydrologic characteristics, and their productivity has been found to be higher on floodplains than in adjacent rivers (see Opperman et al. 2017). Floodplains also provide various habitat features, such as floating and emergent plants, floating algal mats, and large wood, that can promote the abundance of invertebrates (Opperman et al. 2017).

Although zooplankton (mainly small crustaceans, including cladocerans and copepods) are an important food source for juvenile Chinook salmon in the Yolo Bypass (Sommer et al. 2001c), it is currently understood that juvenile Chinook salmon in the Yolo Bypass mainly consume insects belonging to the order Diptera (true flies), primarily within the family Chironomidae (non-biting midges) (Sommer et al. 2001c). However, juvenile Chinook salmon in an artificial flooded rice field in the Yolo Bypass primarily fed on zooplankton (Katz et al. 2017). Chironomid larvae are reported to be a particularly important food source for juvenile salmonids during the winter due to the scarcity of other food sources during this time (Sommer et al. 2001c) and have been found to be more abundant in the Yolo Bypass relative to the Sacramento River (Sommer et al. 2004). Chironomid larvae (as well as cladocerans) also are an important food source for larval and small juvenile Sacramento splittail (Moyle et al. 2004). Little currently is known about the feeding behavior of steelhead in the Yolo Bypass (Reclamation and DWR 2012), but chironomids and zooplankton have been found in the diets of post-yearling steelhead in other systems such as the Mokelumne River (Merz 2002).

Benigno and Sommer (2008) found that floodplain sediment is an important source of the initial peak of chironomid abundance in in the Yolo Bypass and that it took at least 14 days of inundation for dominant chironomid species in the Yolo Bypass to mature into the life stages that could be used as a food source for fish. However, Benigno and Sommer’s (2008) observation was made under laboratory conditions and may not reflect the timing under actual conditions in the Yolo Bypass (Reclamation and DWR 2012). Also, Benigno and Sommer's (2008) field observations during the winter may not reflect actual temporal patterns because the dominant macroinvertebrate taxa may change over time after floodplain inundation (Benigno and Sommer 2008; Grosholz and Gallo 2006) and may differ based on hydrologic conditions (Reclamation and DWR 2012). For example, Sommer et al. (2004) reported that chironomids were less abundant in a drier year than in wetter years.

In an experimental flooded rice field in the Yolo Bypass, productivity was found to increase dramatically, producing up to 100 times more zooplankton and invertebrates than adjacent river channels (Katz et al. 2013). In another study, experimental agricultural fields in the Yolo Bypass had 150 times or greater zooplankton and cladoceran densities during the study period compared to the Sacramento River (Corline et al. 2017). However, flooded rice fields in the Yolo Bypass are unique compared to natural flooding events as they receive inundation water from highly productive agricultural canals and are inundated in the summer and winter (Corline et al. 2017).

8.1.3.2.3 Downstream Productivity

Flood pulses can result in increased productivity in the floodplain, which can be "exported" to downstream waterbodies (reviewed by Opperman et al. 2017). Despite this potential source of productivity, current conditions during major flood pulses in the Yolo Bypass may not be conducive to providing the maximum beneficial impact to downstream reaches of the Delta (Opperman et al. 2017).

In the Yolo Bypass floodplain, inundation results in increased wetted area and improved conditions for phytoplankton production (Schemel et al. 2004). However, substantial increases in phytoplankton production appear to be limited by inflows from tributary streams and on a larger scale by the hydrologic conditions of the draining period of the flood pulse cycle (Lehman et al. 2007; Schemel et al. 2002; Schemel et al. 2004). The importance of the draining period on productivity has been supported by several studies, which observed that chlorophyll *a* concentrations remained relatively low until Fremont Weir was no longer overtopping and the draining phase had begun (Lehman et al. 2007; Schemel et al. 2002; Schemel et al. 2004). These studies also concluded that chlorophyll *a* concentrations in the Yolo Bypass were higher than in comparable sampling locations in the Sacramento River. From January to June 2003, Lehman et al. (2007) concluded that 14 percent of the chlorophyll *a* in the lower Sacramento River originated from the Yolo Bypass, despite only accounting for three percent of the total flow re-entering the river at this point. Additionally, this increase in chlorophyll *a* was attributed to the accumulation of diatoms and green algae, the former of which serves as a high-quality food source for primary consumers in the aquatic food web (Lehman et al. 2007).

One limitation of these aforementioned studies is that contributions of chlorophyll *a* concentrations were inferred based on direction and percentage of flow from upstream sampling locations in the Yolo Bypass and Sacramento River. More recent studies provide evidence of the exportation of primary production in the Yolo Bypass to sampling locations in the lower Sacramento River. Specifically, Fall Low Salinity Habitat studies conducted in 2011 and 2012 included data from sampling locations in the Cache Slough Complex (CSC) and Sacramento River at Rio Vista where Yolo Bypass flood water is discharged (Frantzich and Sommer 2015). The Fall Low Salinity Habitat study measured a large phytoplankton bloom in the lower

Sacramento River, following two agricultural flow pulses in the Yolo Bypass. The CSC and Yolo Bypass were determined to be the major source of the bloom, based on increased levels of chlorophyll *a* in both the CSC and Yolo Bypass and no observed increase in the Sacramento River upstream of Rio Vista (Frantzich and Sommer 2015). These flow pulses allowed for a real-time comparison of the movement of water through the Yolo Bypass and increased levels of chlorophyll *a* and productivity observed downstream at Rio Vista.

Water exiting the Yolo Bypass has been hypothesized to be an important source of nutrients for the estuary to increase food resources for estuarine fishes and other organisms. Jassby and Cloern (2000) estimated that, based on the relative amount of water discharging from the Yolo Bypass, effects of inundating the Yolo Bypass on Bay-Delta productivity are likely minor during the winter and negligible in other seasons, except potentially during wet years. However, even during wet winters, the effect of transporting organic matter downstream would be lessened due to shorter residence times through the Bay-Delta (Jassby and Cloern 2000). Under the existing infrastructure and hydrology of the Yolo Bypass, major inundation periods typically occur during the wet winter period when high flows in the Sacramento River result in overtopping at Fremont Weir and, in some extreme years, the Sacramento Weir (Sommer et al. 2001b). Consequently, high-flow conditions and low residence times in the lower Sacramento River lessen the beneficial impacts of primary and secondary productivity that is transported downstream from the Yolo Bypass (Jassby and Cloern 2000). Schemel et al. (2004) noted that although phytoplankton-rich water from the Yolo Bypass may be limited to brief periods of time during late winter and spring, these discharges may deliver food resources to nutrient-poor areas of the Delta. Moreover, multiple flooding and draining sequences within the Yolo Bypass may produce more phytoplankton for export to the Delta relative to a single flooding event (Schemel et al. 2004).

Based on a review of the available information relating to the exportation of phytoplankton and zooplankton from the Yolo Bypass to the Bay-Delta, Gray et al. (2014, p. 337) stated that “Our analysis shows no evidence that the open waters of the estuary receive a detectable subsidy of phytoplankton or zooplankton.” However, Opperman et al. (2017, p.189) stated that “…active management of Bypass flooding – controlling timing, duration, and frequency of inundation – could greatly increase its contribution to downstream productivity. For example, managed flooding of the Bypass could promote a series of relatively short pulses with long draining times that would produce pulses of productivity to the Delta.”

8.1.3.3 Fisheries Habitat and Productivity

8.1.3.3.1 Floodplain Habitat Utilization

Moyle et al. (2007) classified fishes found on the seasonal floodplain in the Cosumnes River and connected sloughs into six user groups: floodplain spawners, river spawners, floodplain foragers, floodplain pond fishes, inadvertent floodplain users, or floodplain nonusers. Descriptions of each group are summarized from Moyle et al. (2007) below.

Floodplain Spawners – Fish that use the floodplain for spawning and initial juvenile rearing; adults migrate onto the floodplain as water levels are rising or stable and spawn on flooded substrate, and juveniles leave the floodplain as it is draining. Floodplain spawners include obligate spawners[6] and opportunistic spawners[7]. Sacramento splittail is an obligate floodplain spawner; opportunistic floodplain spawners include common carp, goldfish, largemouth bass, and sunfishes. For floodplain spawners, the minimum duration of inundation must be sufficiently long to encompass spawning and juvenile rearing to a stage that allows them to leave the floodplain as it drains (Opperman et al. 2017).

River Spawners – Fish that spawn in rivers upstream of floodplains and can rear as juveniles on floodplains. The growth and survival advantage provided by floodplains to the juvenile life stage may vary, depending on the species, but the most abundant and persistent species likely benefit from juvenile rearing on floodplains. River spawners include Sacramento hitch, Sacramento pikeminnow, Sacramento sucker, Chinook salmon, prickly sculpin, and bigscale logperch.

Floodplain Foragers – Fish that move onto the floodplain to take advantage of food resources, typically later in the inundation period as water temperatures become warmer. These fish include the juvenile life stages of species that are residents in perennial waterbodies adjacent to floodplains and can include adults during prolonged flood events. Floodplain foragers include golden shiner, largemouth bass, black crappie, bluegill, and redear sunfish. These fish typically exhibit increased growth and survival on floodplains relative to mainstem rivers and appear to be able to avoid stranding as floodwaters recede (likely because their native habitat includes inundated floodplains).

Floodplain Pond/Lake Fishes – Fish that can reproduce in shallow floodplain ponds during most years and can dominate ponded areas due to high growth and survival rates. These fishes attract piscivorous birds and are often stranded in ponds that dry up. Species in California include inland silversides and western mosquitofish.

Inadvertent Users – Most of these fish species enter floodplains from adjacent perennial waterbodies but do not exhibit adaptations allowing them to necessarily benefit from using floodplain habitat. Larvae and juvenile life stages often drift into the floodplain and either pass through or become stranded. Large adults of these species also may become stranded on the floodplain, or move short distances onto the floodplain from perennial habitat to avoid being stranded. Inadvertent users include Pacific lamprey, rainbow trout/steelhead, American shad, threadfin shad, and catfishes.

Because fish species found on the floodplain have varying relationships with and dependence on floodplain habitat, physical habitat conditions can be important determinants of the timing, duration, and ecology of fish on a floodplain.

8.1.3.3.2 Fisheries Floodplain Habitat

Depending on the hydrology, characteristics of the river-floodplain connectivity, floodplain geomorphology, and anthropogenic discharges, fisheries habitat on the floodplain may include expansive seasonally inundated habitat, perennial waterways, and disconnected ephemeral ponds.

[6] Typically require floodplain-type habitat to successfully spawn

[7] Do not require floodplain habitats to spawn but often exhibit improved reproductive success and increased juvenile growth and survival on floodplains

Typically, as high flows overtop the main channel and flow onto adjacent floodplains, velocities decrease and water temperatures increase on the floodplain (Ahearn et al. 2006). For example, Sommer et al. (2001c) found that water temperatures during March of 1998 and 1999 were up to 5°C (9°F) higher in the Yolo Bypass than in the adjacent Sacramento River. Expansive areas of reduced velocities on the floodplain can provide substantially larger areas of suitable hydraulic habitat for small juvenile Chinook salmon and other fishes relative to the littoral area of the adjacent river. Lower velocities found in floodplain habitats also may potentially encourage increased growth in juvenile fishes because of a decrease in energy expended during foraging activities relative to the adjacent river (Sommer et al. 2001c).

The composition of the floodplain fish community appears to vary as the inundation season progresses in both the Cosumnes River and Yolo Bypass floodplains. Generally, native species, including juvenile Chinook salmon, adult Sacramento splittail, juvenile lamprey, juvenile white sturgeon, and juvenile Sacramento pikeminnow, are in greatest abundance during the earlier portion of the inundation period (January through April), and non-native species are heavily dominant during April through June (Sommer et al. 2004; Sommer et al. 2014; Moyle et al. 2007; DWR 2016, as cited in DWR and Reclamation 2017). However, juvenile Sacramento splittail can peak in abundance in the Yolo Bypass during May and June (DWR 2016, as cited in DWR and Reclamation 2017), and juvenile Chinook salmon can occur later in the season during wetter years (Moyle et al. 2007). In the Yolo Bypass, adult Sacramento splittail, white sturgeon, and Sacramento pikeminnow appeared to be associated with flood pulses early in the inundation season (Moyle et al. 2014). In the Cosumnes River floodplain, western mosquitofish, inland silverside, and other non-natives dominated catches in June and July; yearling and adult Sacramento sucker, juvenile pikeminnow, and in some years, adult Sacramento blackfish and Sacramento hitch, moved onto the floodplain in April and May (Moyle et al. 2007). Centrarchids also moved onto the Cosumnes River floodplain from ponds and sloughs during April and May if water temperatures exceeded 20°C (68°F) for an extended period (Moyle et al. 2007).

Physical habitat can be as important as flood pulse dynamics in structuring river–floodplain fish communities (Feyrer et al. 2006a). In the Cosumnes River floodplain, late season juvenile inhabitants (i.e., western mosquitofish, golden shiner, inland silverside, black crappie, and Sacramento blackfish) were found in shallow water associated with ponds, and common carp and Sacramento splittail were found in cooler, deeper water with submerged annual vegetation; young Sacramento sucker were found in clear and cold water early in the inundation season (Moyle et al. 2007). Yearling and adult non-native fish (i.e., black crappie, western mosquitofish, bluegill, and inland silverside) were associated with shallow ponds late in the inundation season. Because yearling Sacramento pikeminnows and golden shiners were present during early season flooding, they were associated with lower conductivity and lower water clarity (Moyle et al. 2007).

Crain et al. (2004) found that prickly sculpin and bigscale logperch larvae were associated with flooded terrestrial vegetation, Sacramento sucker and common carp larvae were associated with higher flows, and Sacramento splittail larvae were associated with higher flows and emergent vegetation. Larvae of non-native species, including inland silverside, crappie, and sunfish, showed an association with warmer temperatures and clay substrates in permanent floodplain ponds (Crain et al. 2004). Based on their observations, Crain et al. (2004) suggest that fields of annual vegetation on the floodplain may be very important habitat for larval rearing because of the abundance of food and cover, particularly for native species, including Sacramento splittail.

Moreover, Jeffres et al. (2008) found that juvenile Chinook salmon experienced higher growth rates in seasonally inundated floodplain habitat with annual terrestrial vegetation relative to perennial ponded floodplain habitat.

Feyrer et al. (2006a) suggested that the fish communities in Yolo and Sutter bypasses appeared to be structured primarily by the habitat characteristics of each floodplain, most notably the water source of the perennial channels, and secondarily by the flood pulse dynamics. The upstream freshwater source of water in the Sutter Bypass led to a community of primarily freshwater species, and the downstream source of water for the Yolo Bypass led to a higher proportion of estuarine or anadromous fishes (Feyrer et al. 2006a). Physical habitat and land use in each floodplain was similar; however, the Sutter Bypass had a much higher proportion of its area covered with native terrestrial and riparian vegetation (over 50 percent of the area of Sutter Bypass, relative to about 12 percent of the Yolo Bypass) (Feyrer et al. 2006a). Differences in the littoral habitats of the perennial channels of the two floodplain systems also probably contributed to differences in the fish communities. The Toe Drain in the Yolo Bypass is a relatively simplified channel with little riparian complexity, whereas the perennial channels of the Sutter Bypass exhibit more channel and riparian habitat complexity, including riparian forests that are inundated under relatively low flows (Feyrer et al. 2006a). The Sutter Bypass also has substantial amounts of aquatic vegetation, which is generally not present in the Yolo Bypass and likely contributes to the relatively high abundance of non-native cyprinids and centrarchids in the Sutter Bypass (Feyrer et al. 2006a).

Rearing in shallow and well-vegetated areas on a seasonal floodplain is believed to reduce predation of juvenile fishes from predators (Sommer et al. 2001c; Swenson et al. 2001). For example, higher juvenile Chinook salmon survival rates in the Yolo Bypass during a higher flow year (1998) may have been, in part, a result of the greater amount and prolonged duration of floodplain rearing associated with higher and longer duration flows (Sommer et al. 2001c). Moyle et al. (2007) found very few adult predatory fish during flood events on the Cosumnes River floodplain; non-native predatory fish species were more frequently observed as yearlings, with occasional spawning by adults in temporary floodplain ponds late in the season. Similar results were found in the Willamette River in Oregon where non-native fishes were not found in floodplain habitats until water temperatures exceeded 20°C (68°F) (Colvin et al. 2009 as cited in Opperman et al. 2017).

Although floodplains can provide substantial benefits to fish, there are factors that may lower the ecological value of floodplains for fish, such as less suitable water quality (e.g., elevated water temperature, reduced dissolved oxygen); shallow water depths; and unfavorable timing, duration, and magnitude of inundation (CDFG 2010c). For example, increased water temperatures can be beneficial to fish by increasing growth rates when temperatures are near optimal levels, or temperatures can reduce growth rates or increase susceptibility of fish to predation if temperatures are well above optimum levels (CDFG 2010c). Elevated water temperatures reaching lethal levels on the floodplain also may lower dissolved oxygen concentrations and increase stress levels, which can increase the susceptibility of fishes to disease (CDFG 2010c). Ahearn et al. (2006) found that after the floodplain became disconnected after a previous inundation event, a subsequent flood event redistributed elevated amounts of algae on the floodplain. The elevated amounts of algae on the floodplain created hypoxic zones (areas of low dissolved oxygen), resulting in mortality of juvenile Chinook salmon that were confined to enclosures (Jeffres, unpublished data, as cited in Ahearn et al. 2006). Shallow floodplains also may experience greater variation in water temperatures. Water depth (and instream cover) also influences the susceptibility of fishes such as young juvenile Chinook salmon to avian predators; piscivorous birds can consume large quantities of fish on a floodplain, particularly if they become stranded (Opperman et al. 2017), as observed in a flooded rice field in the Yolo Bypass (Katz et al. 2013). Therefore, the presence of submerged vegetation or other cover elements on the floodplain are important components to reduce avian predation on juvenile fish. Inundation depths greater than approximately one foot also may reduce the risk of mortality due to avian predation (CDFG 2010c).

The presence of non-native fish species that predate on or compete with native fish species also is an important consideration in assessing the benefits of floodplain inundation. For example, Stoffels et al. (2014) found that reconnecting a river to its floodplain in southeast Australia increased abundances of native fish species but also substantially increased the abundance of an undesirable non-native fish species. Crain et al. (2004) found that the Cosumnes River floodplains are particularly important habitat for native fishes during February through April because warmer temperatures and lower flows later in the season provide more suitable habitat for non-native fish species after April. However, some non-native species, such as common carp, also benefit from early season flooding (Crain et al. 2004).

An additional phenomenon that may reduce the ecological value of floodplains is the occurrence of fish stranding as a floodplain is draining. However, fishes native to an area where stranding may occur have often been found to exhibit life history and/or behavioral adaptations to local hydrologic regimes that reduce the potential for stranding (Opperman et al. 2017). For example, some fish will leave the floodplain before becoming stranded based on a variety of cues, such as decreasing flow and/or water depth, increasing water temperature and/or clarity (Opperman et al. 2017), or decreasing dissolved oxygen levels (Henning et al. 2006). In wetland habitats on the Chehalis River floodplain in Washington, dissolved oxygen levels appeared to serve as cues to juvenile coho salmon to emigrate from the wetland to the main river channel (Henning et al. 2006). However, if the outlet channel connecting the wetland to the main river desiccated before dissolved oxygen concentrations fell below about 1.5 milligrams per liter (mg/L), the number of juveniles stranded was substantially higher (Henning et al. 2006).

Moyle et al. (2007) found that most fish stranded in isolated ponds after the Cosumnes River floodplain drained were non-native pond species. However, a rapid and/or unusually early disconnection between the river and its floodplain can lead to high levels of stranding of other species (Opperman et al. 2017). Fish concentrated in pools also can become more susceptible to predation (Moyle et al. 2007). Anthropogenic structures that interrupt natural drainage patterns, such as gravel pits, berms, and water control structures, create the greatest risk for stranding (Sommer et al. 2005).

As summarized by CDFG (2010b), the benefit of flood events to an aquatic system is highly variable, transient, and dynamic and is influenced by hydrologic, geomorphic, and biological conditions on the floodplain. Flood events can temporarily provide optimal fish habitat conditions, but these conditions may only occur for a particular species at specific times of the year and under particular hydrologic conditions or over particular types of terrain (CDFG 2010c).

In addition to periods of flooding, the Yolo Bypass may provide important habitat for juvenile salmonids and delta smelt during dry periods and during drought. Mahardja et al. (2015) found relatively high numbers of delta smelt during the recent drought years (2013 and 2014) when the Yolo Bypass had minimal floodplain inundation. During 2014, Goertler et al. (2015) found that despite the lack of flooding during an extreme drought, a relatively high number of juvenile Chinook salmon were found occupying the Yolo Bypass (after moving upstream through Cache Slough). Based on drift invertebrates and zooplankton sampling in the Toe Drain, the Yolo Bypass may have been the most productive habitat available to juvenile Chinook salmon outmigrating from the Sacramento River during the drought (Goertler et al. 2015). Although water temperatures were elevated in the Yolo Bypass, higher prey levels may have allowed juvenile Chinook salmon to continue to rear there. In addition, the Yolo Bypass has more natural banks and riparian vegetation than the Sacramento River and is better connected to tidal wetlands than the Sacramento River (Goertler et al. 2015).

8.1.3.3.3 Fisheries Productivity

Increased spawning success, growth, or abundance of various fish species, such as black bass, sunfishes, blue catfish, common carp, Sacramento splittail, and Chinook salmon, on inundated floodplains relative to mainstem rivers has been documented in many temperate river-floodplain systems (Dutterer et al. 2013; Alford and Walker 2013; Baker and Killgore 1994; Schramm and Eggleton 2006; Crain et al. 2004; Grosholz and Gallo 2006; Jeffres et al. 2008; Feyrer et al. 2006b; Sommer et al. 1997). Opperman et al. (2017, p. 57) stated that "…there is likely to be a direct, positive relationship between total floodplain area connected to rivers and levels of productivity, biodiversity, and ecosystem services supported by floodplains." For example, production of Sacramento splittail in the Yolo Bypass exhibited a significant positive relationship with the amount of available floodplain habitat during the peak spawning and juvenile rearing period (Feyrer et al. 2006b). Authors also have reported that fisheries of temperate river floodplains have been lost or substantially reduced due in large part from the disconnection of rivers from productive floodplain habitats (Galat et al. 1998 as cited in Opperman et al. 2010).

Jeffres et al. (2008) reported that juvenile Chinook salmon grew faster in enclosures within floodplain habitats relative to enclosures in adjacent river habitats in the Cosumnes River; highest growth rates occurred in floodplain areas where the water had the highest residence time, presumably due to sufficient time to allow for primary and secondary production to increase food resources. Juvenile Chinook salmon collected from the Yolo Bypass also were significantly larger than individuals collected from the Sacramento River (Sommer et al. 2001c). Bioenergetics modeling suggested that feeding success was greater in the floodplain, despite increased metabolic costs of rearing in warmer floodplain water (Sommer et al. 2001c).

Similarly, during a recent study on an experimental flooded rice field in the Yolo Bypass, growth rates of juvenile Chinook salmon were found to be among the highest recorded in freshwater habitats in California (Katz et al. 2013; Katz et al. 2017).

The potential for increased juvenile fish growth rates resulting from highly productive floodplain habitat could be a critical component of improving the adult return rates of Chinook salmon populations. Larger sizes of juvenile salmonids emigrating to the ocean have been correlated with a higher probability of surviving a laboratory seawater challenge (Beakes et al. 2010) and a higher probability of returning to spawn as an adult (Bond et al. 2008). In addition to the increased juvenile growth, the use of floodplain habitat by Central Valley salmonids promotes life history diversity, which could increase the resiliency of Central Valley salmonids in response to varying ecological conditions (Carlson and Satterthwaite 2011).

Use of the floodplain by juvenile salmonids also can alter their ocean entry timing. Historically, Central Valley Chinook salmon juveniles reared for up to three months on inundated floodplains, growing rapidly prior to ocean entry (Sommer et al. 2001b). Following this period of rapid growth, juveniles would enter the ocean during the spring as the production of nutrients, zooplankton, and forage fish increase in the coastal ocean (Lindley et al. 2009). Based on ocean recovery rates of adult (age three) fall-run Chinook salmon released as smolts into the San Francisco Bay, Satterthwaite et al. (2014) found that marine survival was correlated with the timing of juveniles entering the ocean. However, separating out the relative influence of ocean entry timing and size of fish is difficult because these traits are often correlated (Satterthwaite et al. 2014). Although variable, the optimal juvenile release timing appeared to occur near the end of May and about 70 to 115 days after the spring transition date (Satterthwatie et al 2014). The spring transition date indicates when ocean upwelling begins, which is when ocean conditions begin to promote the production of zooplankton and small fish, increasing food availability for juvenile salmonids in the ocean.

8.1.4 Stressors in the Study Area

8.1.4.1 Habitat Availability

Prior to the construction of levees to prevent flooding of agricultural land and local cities, the Sacramento River floodplain occupied most of the valley floor, and seasonal flooding often filled much of the alluvial valley during the winter and spring (Sommer et al. 2001c). This seasonal flooding carried millions of juvenile Chinook salmon from upstream riverine habitats onto the wetted floodplains throughout the valley where they reared and grew rapidly before entering the ocean (Williams 2012).

Since 1900, approximately 95 percent of historical freshwater wetland habitat in the Central Valley floodplain habitat has been lost, typically through the construction of levees and draining for agriculture or residential uses (Hanak et al. 2011). The Yolo Basin historically contained an area of perennial wetland habitat that would have been larger than the existing area of the Yolo Bypass. The Yolo Basin currently contains about eight percent of the historical perennial wetland habitat and relatively higher amounts of seasonal wetland habitat (Whipple et al. 2012).

The remaining floodplain habitats in the valley are highly altered by upstream reservoirs and flow regulation (The Bay Institute 1998). Due to upstream flow regulation and the filling of reservoirs during the spring, the Sutter and Yolo bypasses receive muted flood pulses and are inundated less frequently and for shorter durations than prior to dam construction (Williams et al. 2009). The bypasses also are managed to minimize hydraulic roughness to promote drainage, further reducing residence time relative to historical conditions (Sommer et al. 2001a; Opperman et al. 2017). Reduced hydraulic connectivity between the floodplains and the Sacramento River, physical modifications of the floodplains, and reduced residence time of water moving through the floodplains has reduced primary and secondary productivity and associated ecological benefits to fish and aquatic resources.

The Central Valley now consists primarily of a mosaic of communities and agricultural lands that are protected by high, steep levees. This condition has disrupted the natural process of sediment and nutrient transport and fish connectivity between riverine and adjacent floodplain habitats and limited the ability of these processes to occur between upstream riverine and downstream estuarine habitats (Eisenstein and Mozingo 2013). The majority of the existing Central Valley floodplain habitat is inundated only during large floods.

In addition to floodplains adjacent to rivers along the valley floor, the Delta historically consisted of a mosaic of riverine, floodplain, and tidal marsh habitats. This mosaic of habitats enabled the Delta to support an exceptionally high level of biological productivity and influence food webs throughout the entire estuary (Jassby and Cloern 2000; Kimmerer 2004). Like many floodplain-riverine systems throughout the world, the Delta plays a critical role in supporting and shaping food webs for entire aquatic ecosystems. As with many of these systems, the Delta's ecological functioning has been severely altered and degraded by anthropogenic changes to the landscape (Strayer and Findlay 2010).

8.1.4.2 Hydrology

8.1.4.2.1 Yolo Bypass Attraction Flows

During overtopping events at Fremont Weir, flows are typically much greater in the Cache Slough area relative to Sacramento River flows, which can increase the attraction of migrating anadromous fish species. It is well documented that these flows can result in adult Chinook salmon and sturgeon using the Yolo Bypass as an alternative upstream migration route (CDFW 2016c). Flows during flooding events in the Yolo Bypass can typically convey up to 80 percent of the Sacramento River flows. Due to a lack of hydraulic connectivity between the Sacramento River and Yolo Bypass, adults migrating up the Yolo Bypass can experience migratory delays and increased mortality relative to the Sacramento River migration corridor, as further described below (Section 8.1.4.4, *Upstream Migration Barriers and Stranding*).

Based on monitored flows which include Yolo Bypass outflow into the Sacramento River (as measured at Cache Slough at Ryer Island; CDEC Station RYI) from May 2006 through 2016, average daily flows are highly variable, ranging from approximately -5,000 cfs or lower to 15,000 cfs or higher in most years during the November through March period. Day-to-day flow variability is also very high. For example, due in part to tidal influence, examination of the average daily flow time-series shows that flow rates can increase by 200 to 300 percent or more within one to two days (CDEC 2018).

Studies documenting the differential attraction of anadromous salmonids into the Yolo Bypass at various flow and inundation levels relative to the Sacramento River have not been conducted. However, because higher numbers of anadromous fish are rescued on the Fremont Weir apron (Figure 8-3) during higher-flow events, it is likely that increased flow through the Yolo Bypass at relatively high flows results in increased attraction and subsequently increased stranding.

Photo Credit: U.S. Fish and Wildlife Service

Figure 8-3. Fremont Weir and Apron

8.1.4.2.2 Sacramento River

The Sacramento River from Colusa to Sacramento is constrained by levees. The altered channel morphology in this region has resulted in altered hydrology and reduced rearing opportunities for migrating anadromous salmonids and other fishes. The altered hydrology has transformed these lower river reaches from productive rearing habitats to primarily simplified migration corridors. Detailed discussion of Sacramento River hydrology is provided in Chapter 5, *Surface Water Supply*.

Reduced flow in the Sacramento River due to inundation of the Yolo Bypass is not likely to be limiting upstream or downstream fish migration in the Sacramento River because inundation of the bypass occurs during relatively high-flow events.

8.1.4.2.3 Delta

Diversions

There are about 2,200 water diversions in the Delta (Herren and Kawasaki 2001; Reclamation 2008). Although entrainment by agricultural diversions is not frequently identified as a factor in the decline of Delta fish species, most of these small diversions are not screened (Herren and Kawasaki 2001; Moyle and Israel 2005). Many of the diversions divert water to agricultural fields between April and August. The early part of this irrigation season coincides with the timing of spawning and larval development of Delta fish species. Because spawning and larval development are likely to occur in shallow shoreline locations with limited movement, entrainment of these life stages by agricultural diversions could be more substantial (Reclamation 2008).

Reverse Flows

The CVP and the SWP both divert water from Old River, a tidal slough that intersects the lower San Joaquin River (Figure 8-1). CVP and SWP diversions can cause the tidally averaged flow in the Old River, Middle River, and other adjacent channels in the southern Delta to reverse flow toward the diversions. These reverse flows contribute to the entrainment of numerous fish species, including migrating and spawning delta smelt and their offspring and migrating anadromous salmonids. Patterns of entrainment vary with life history and season as well as with food availability and water quality (Grimaldo et al. 2009). Pilot studies conducted to investigate the effect of Delta Cross Channel operations on the movement of juvenile Chinook salmon in the Delta indicate that yearling salmonids will move into the Delta Cross Channel during flood tides, and can be drawn into the channel after initially migrating past the channel gates (CALFED 2000).

CVP and SWP exports can influence the magnitude of flows into the Delta and the outflow from the Delta into Suisun Bay. Along with Delta inflow, Delta outflow is an important regulator of habitat quality and availability and of fish distribution, survival, and abundance (Baxter et al. 2010). Delta inflow and outflow are important for species residing primarily in the Delta (e.g., delta smelt and longfin smelt) (USFWS 2008) and for juveniles of anadromous species that rear in the Delta prior to ocean entry. CVP and SWP operations can increase fish entrainment, redirect fish into areas with higher risks of mortality, affect salinity, and degrade habitat conditions. The susceptibility of entrainment of fish into the Central Delta via the Delta Cross Channel is likely variable based at least in part on Sacramento River flow.

8.1.4.3 Water Quality

8.1.4.3.1 Yolo Bypass

Water quality in the Yolo Bypass is influenced by several sources, including the Sacramento, Feather, and American rivers via the Fremont and Sacramento weirs, along with the Knights Landing Ridge Cut, Cache Creek, Willow Slough, and Putah Creek. In addition, agricultural activities in the Yolo Bypass during non-inundated periods, discharge from the City of Woodland wastewater treatment plant, and urban runoff from nearby cities (i.e., Davis, Winters, and Woodland), and major streets and highways (Interstate (I) 5 and I-80) can affect local water quality.

Although juvenile salmonids can survive a wide range of temperatures, their growth and overall fitness are maximized at levels well below upper survivable or tolerable water temperatures. The optimal growth rate might also vary based on the acclimation temperature of an individual fish. It is not uncommon for water temperatures in the Yolo Bypass to rise above 20°C (68°F) as the inundation season progresses (Frantzich and Sommer 2015), potentially making conditions less suitable for Chinook salmon growth, as suggested by Katz et al. (2013) in a flooded rice field, and more suitable for effective foraging by predators. Even in the deeper, cooler waters of the Toe Drain, water temperatures typically approach the incipient upper lethal temperature for salmonids (i.e., 70.7 to 77.2°F, depending on acclimation temperature) by late April to early May (Reclamation and DWR 2012). As water temperatures increase, conditions might become more favorable to predators, such as centrarchids, which can compete with or predate on juvenile salmonids.

Dissolved oxygen might also be a stressor to fish species of focused evaluation in the Yolo Bypass. Reported optimal dissolved-oxygen levels for juvenile Chinook salmon are greater than nine mg/L at water temperatures below 50°F (10°C) and greater than 13 mg/L at water temperatures above 50°F (10°C). Allen and Hassler (1986) reported that juvenile Chinook avoided dissolved oxygen levels below 4.5 mg/L at temperatures of 61 to 77°F (16 to 25°C) and avoided dissolved oxygen levels below three mg/L at temperatures of 46 to 64°F (8 to 18°C). In cooler waters, steelhead can survive dissolved oxygen concentrations as low as 1.5 to two mg/L, but they require concentrations close to saturation for optimal growth (Moyle 2002).

Prolonged low dissolved oxygen concentrations also reduce the overall fitness of juvenile salmonids. For example, Colt et al. (1979, as cited in Reclamation and DWR 2012) found that juvenile coho salmon showed a marked decrease in food consumption and ultimately a loss of body mass as dissolved oxygen concentrations fell to two mg/L. It is likely that Chinook salmon and other salmonids exhibit a similar response. Overall, although it is unclear whether reduced dissolved oxygen concentrations are a major stressor to fish in the Yolo Bypass, dissolved oxygen might influence the movements and potential stranding of fish and affect growth rates on the floodplain (Reclamation and DWR 2012).

During much of the winter, suspended sediment levels are elevated in the Yolo Bypass, resulting in high levels of turbidity (Sommer et al. 2001b). Hydraulic residence times are generally greater in the Yolo Bypass than in the mainstem Sacramento River (Sommer et al. 2004) because floodwaters recede from the northern and western portions of the Yolo Bypass along low gradients (Sommer et al. 2007).

California's historical gold-mining practices have resulted in high concentrations of methylmercury in much of the Central Valley, including the Yolo Bypass. 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. Domagalski (2001) found that mercury concentrations in the Yolo Bypass can exceed State standards. In 2011, the Central Valley Regional Water Quality Control Board (RWQCB) amended the *Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Methylmercury and Total Mercury in the Sacramento-San Joaquin River Delta Estuary* to identify allowable maximum concentrations of methylmercury in Delta and the Yolo Bypass waterways and established a control program to reduce current methylmercury levels to meet new standards by 2030 (Central Valley RWQCB 2016).

Methylmercury is a neurotoxin that bioaccumulates and biomagnifies in the aquatic food web (Davis et al. 2003). For example, Berntssen et al. (2003, as cited in Henery et al. 2010) showed that methylmercury can cause pathological damage and altered behavior in Atlantic salmon (*Salmo salar*). Henery et al. (2010) found that juvenile Chinook salmon reared on the Yolo Bypass floodplain displayed a more rapid accumulation of methylmercury and showed higher methylmercury levels by weight at outmigration than those reared in the Sacramento River. However, the observed levels of methylmercury in fish that spent one to 12 weeks rearing on the floodplain were reported to represent insignificant concentrations of methylmercury in the tissues of the eventual adult fish (Henery et al. 2010).

The primary source of water in the Yolo Bypass may affect the accumulation of mercury in fish. Henery et al. (2010) found that during the two years when Cache Creek was the primary source of floodwater, methylmercury accumulation in floodplain-reared fish exhibited a linear trend, increasing with duration of residence. In contrast, for two years when water in the Yolo Bypass was dominated by flood events from the Sacramento River, fish on the floodplain exhibited a quadratic pattern of methylmercury accumulation (methylmercury accumulation initially increased with residence time but stopped increasing for fish that remained on the floodplain) (Henery et al. 2010). Henery et al. (2010) indicated that methylmercury accumulation may have been greater in fish when Cache Creek was the dominant source of water in the Yolo Bypass due to lower flows and warmer water temperatures (relative to the higher flows and lower water temperatures that occur when Fremont Weir overtops), which could have increased the rates of mercury methylation.

Although bioaccumulation is more rapid on the floodplain, it is not known whether this is a function of the amount of methylmercury on the floodplain or of higher feeding rates of prey that have accumulated methylmercury, relative to the Sacramento River (Reclamation and DWR 2012).

8.1.4.3.2 Sacramento River

Water quality stressors in the Sacramento River include, but are not limited to, water temperature, urban and agricultural runoff, and methylmercury. A detailed discussion of water quality constituents in the lower reaches of the Sacramento River is provided in Section 6.1.3.2 of Chapter 6, *Water Quality*.

8.1.4.3.3 Delta

Anthropogenic and environmental toxins might adversely affect fish populations in the Delta (DWR and CDFG 2007). Although initial data on striped bass and delta smelt indicated high frequencies of liver lesions and other signs of disease indicative of toxic poisoning (Armor et al. 2005), subsequent studies have shown that acute contaminant toxicity is not likely the cause for population declines but could be a contributing factor (Baxter et al. 2010). Two liver-damaging toxins that have received notable attention are pyrethroid pesticides and *Microcystis* hepatotoxins.

Pyrethroid pesticides have been identified as a factor contributing to pelagic organism decline because of their increased use in recent years and their high toxicity to aquatic organisms. Although pyrethroids are readily absorbed into sediment, they can be mobilized during high-flow events and are highly toxic to zooplankton and fish (Werner and Moran 2008).

Microcystis is a colonial cyanobacteria that produces hepatotoxins that can affect both fish and humans. Blooms of *Microcystis* have become larger and more widespread during the summer than in the past. Reduced stream flow in the Delta seems to promote the growth of *Microcystis*, which is more abundant during drier water years (Baxter et al. 2010).

In addition to pyrethroid pesticides and *Microcystis*, contaminants, such as mercury, selenium, and herbicides, associated with agricultural production have been identified as potential stressors to fish and aquatic species in the Delta (Davis et al. 2003; Linville et al. 2002). Yolo Bypass outflow may introduce mercury and methylmercury to the Delta during high-flow events.

Delta salinity conditions are important determinants of habitat quality for Delta resident and some anadromous fish and aquatic species. Several fish species use a variety of behaviors to maintain themselves in open-water areas where water quality and food resources are favorable (Bennett et al. 2002). Delta smelt, longfin smelt, striped bass, and threadfin shad distribute themselves at different concentrations of salinity within the estuarine salinity gradient (Feyrer et al. 2007; Kimmerer 2002a), indicating that, at any point in time, salinity is a major factor affecting their geographic distributions. Because of the importance that salinity has on fish distribution in the estuary, the term low-salinity zone (LSZ) was created to define the area within the San Francisco Estuary where salinity is about 0.5 to six ppt. Located at roughly the center of the LSZ, X2 is defined as the location upstream from the Golden Gate Bridge where salinity near the bottom of the water column is about two ppt (Kimmerer 2002b).

Salinity between two and approximately 30 ppt is roughly linearly distributed between X2 location and the mouth of the Estuary (Monismith et al. 1996 as cited in Kimmerer 2002b). X2 location reflects the physical response of the Estuary to changes in flow and provides a geographic frame of reference for estuarine conditions (Kimmerer 2002b). Because the position of X2 depends on a variety of physical parameters, including river flows, water diversions, and tides, its position shifts over many kilometers on a daily and seasonal cycle. Over the course of a year, the location of X2 can range from San Pablo Bay (during high-river flow periods) to the Delta (during the summer).

The relationships between X2 location and the abundance of fish and aquatic species have been developed for many estuarine-dependent copepods, mysids, bay shrimp, and several fishes, including longfin smelt, Pacific herring, starry flounder, Sacramento splittail, American shad, and striped bass (Kimmerer 2002a). For example, Feyrer et al. (2007) reported that higher outflow that expands and moves delta smelt habitat downstream of the Delta is expected to improve conditions for delta smelt. Additionally, Kimmerer (2002a) found that distributions of fish species, including striped bass, Sacramento splittail, longfin smelt, delta smelt, and starry flounder, substantially overlapped with the LSZ.

According to CDFG (2010b), the available data and information indicate: 1) many fish and aquatic species' abundances are related to water flow timing and quantity (or the location of X2); 2) for many fish and aquatic species, more water flow translates into greater species production or abundance; 3) fish and aquatic species are adapted to use the water resources of the Delta during all seasons of the year, but, for many species, important life history stages or processes consistently coincide with increased winter and spring flows; and 4) the source, quality, and timing of water flows through the estuary influence the production of Chinook salmon in both the San Joaquin River and Sacramento River basins.

8.1.4.4 Upstream Migration Barriers and Stranding

The Yolo Bypass and Fremont Weir are a source of migratory delay and loss of adult Chinook salmon, steelhead, and sturgeon (NMFS 2009). The existing fish passage structure at Fremont Weir is inadequate to allow normal fish passage at most flows (NMFS 2009). As a result, adult salmonids and sturgeon migrating upstream through the Yolo Bypass are unable to reach upstream spawning habitat in the Sacramento River and its tributaries when there is insufficient flow through Fremont Weir (Harrell and Sommer 2003). Other structures in the Yolo Bypass, such as the Toe Drain, Lisbon Weir, and irrigation dams in the northern end of Tule Canal, can also impede migration of adult anadromous fish (NMFS 2009).

The existing agricultural road crossings and Lisbon Weir restrict the flow of water down Tule Canal, creating partial-to-complete barriers to adult fish passage, depending on flow. In addition, adult fish can become stranded in depressions within the Yolo Bypass, such as the Tule Pond or on the Fremont Weir apron, as flood flows recede. Upstream migrating adults also can become stranded at Sacramento Weir.

To hold back drainage water, the earthen Wallace Weir has been manually constructed annually at the terminus of Knights Landing Ridge Cut in the Yolo Bypass. However, winter storms often break the weir, allowing adult salmonids to stray into the Colusa Basin where they cannot re-enter the Sacramento River. Beginning in January 2014, CDFW installed a temporary fyke trap to rescue salmonids and sturgeon straying toward Wallace Weir; however, flow conditions compromised the fish rescue efforts (DWR and Reclamation 2017). Annually, beginning in 2014, a fyke trap has been installed and operated downstream of Wallace Weir beginning in fall and ending in spring or early summer. In 2016, construction began to replace Wallace Weir with a permanent structure that includes a fish collection facility that can remain operational under low and high flows (DWR and Reclamation 2017).

8.1.4.4.1 Agricultural Road Crossings

Road crossings for agricultural use during the dry season are found along Tule Canal and the Toe Drain. These road crossings create barriers that might not have any substantial effect during high-flow events but could cause migration delays and increased mortality rates during low-flow periods. Many of these crossings were constructed to allow agricultural traffic (e.g., harvesting equipment) to cross the Tule Canal and Toe Drain and enter agricultural fields west of the Tule Canal and Toe Drain in the Yolo Bypass. During the spring, these agricultural road crossings are repaired due to damage from high winter and spring flow events. Four distinct road crossings have been identified for evaluation and removal and/or improvements, two of which are in the process of being modified to improve fish passage before this EIS/EIR is submitted and are not discussed further.

The first road crossing south of Fremont Weir, referred to as Agricultural Road Crossing 1, is being evaluated for improved fish migration. This crossing serves as a vehicle crossing and a water delivery feature. An earthen berm just upstream of the road crossing creates a cross canal that conveys water across the Yolo Bypass from Wallace Weir to two 36-inch culverts that pass through the east levee of the bypass. The culverts deliver water via gravity flow into the Elkhorn area for agricultural use.

The cross-canal berm is a flow barrier in the Tule Canal. The top of the berm has an elevation of about 21 feet (North American Vertical Datum of 1988), which backs up water into the forested area and Tule Pond when water flows over Fremont Weir during an overtopping event. Additionally, the cross-canal leaks in some years, which provides water inflow to the wooded area and Tule Pond (see Figure 2-1).

Agricultural Road Crossing 4 is an earthen road crossing that spans Tule Canal, just south of where the Sacramento Bypass connects with the Yolo Bypass. The crossing provides the ability to impound water for agricultural and waterfowl purposes.

8.1.4.4.2 Fremont Weir

The Fremont Weir is the primary migration barrier to adult Chinook salmon, steelhead, and green sturgeon migrating upstream through the Yolo Bypass. In 1966, a fish ladder was constructed toward the east end of the weir to provide adult fish passage for salmonids. This ladder is operated by CDFW after flows recede and Fremont Weir is no longer overtopping.

As flows decrease at the weir, a single fish ladder is inadequate because of varying elevations of the apron. When flows decrease, the east and west sides of Fremont Weir become disconnected, and fish isolated on the west side do not have access to the fish ladder and cannot return to the Sacramento River on their own. Fish stranded on the apron either may be unable to detect flows through the Fremont Weir fish passage structure or are unwilling to traverse long shallow sections of the weir basin to reach the fish passage structure, thus, remaining in deeper water at either end of the apron. Scouring that occurs beyond the downstream edge of the Fremont Weir apron creates various scour pools, scour channels, and swales, which create additional potential for stranding. Fish unable to re-enter via the fish ladder into the Sacramento River frequently become stranded in these scour pools.

Stranding of adult salmonids and sturgeon in the Yolo Bypass has been well-documented in recent years. Since 1955, CDFW has conducted 28 fish rescues at Fremont Weir and inundated features within the Fremont Weir Wildlife Area (CDFW 2016c). Over 10,000 fish, comprising 19 species, including four listed species (Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and southern DPS green sturgeon), have been captured and relocated during these rescue efforts (CDFW 2016c). Without these efforts, many of these fish would die from poor water quality, predation, or poaching.

In 2012, velocity baffles were removed from the fish ladder to help allow for sturgeon passage, but it is unlikely that this provided substantially improved passage for sturgeon. Because the fish ladder is currently considered somewhat ineffective for adult fish passage, a project to replace the ladder is being implemented. Reclamation and DWR are planning for completion of the fish ladder improvements before construction of a gated notch associated with this Project.

8.1.4.4.3 Sacramento Weir

Fish can be stranded in the Sacramento Weir's stilling basin and various scour pools, scour channels, and swales when flows recede. Fish can also experience migration delays because of following attraction flows leaking through the flashboards at the weir. It is unknown whether adult sturgeon are able to pass the Sacramento Weir under any flow condition.

8.1.4.4.4 Lisbon Weir

Lisbon Weir is the southernmost agricultural impoundment that crosses the Toe Drain. The weir is a partial barrier to flow located about halfway down the Yolo Bypass. It helps maintain water levels upstream of the rock weir for both agricultural use and to support Yolo Bypass Wildlife Area during varying tidal cycles (Reclamation and DWR 2012). However, high tides flow over the top of the weir and through three flapgates. The flapgates allow incoming tidal flows to pass but are closed when water is higher upstream than downstream.

Lisbon Weir provides some adult fish passage at higher tides or higher net outflows. The weir is considered less of a barrier to migration than other features in the Yolo Bypass. Also, based on acoustic tagging of adult Chinook salmon and white sturgeon in the Toe Drain, the individuals that successfully passed upstream of Lisbon Weir were found to continue their upstream migration and did not attempt to migrate back downstream to Lisbon Weir (UC Davis 2013).

8.1.4.4.5 Sutter Bypass

The Sutter Bypass has not been studied as extensively as the Yolo Bypass but also contains impediments and barriers to adult fish upstream migration. Although the Sacramento River overflows Tisdale Weir during most years, it is unlikely that upstream passage at the weir occurs during flood events due to the dimensions of the weir and prohibitive hydraulic conditions below and above the weir (Reclamation and USFWS 2016). Adult and juvenile Chinook salmon, steelhead, green sturgeon, white sturgeon, and Sacramento splittail have been found in Tisdale Weir’s stilling basin after flood recessions. CDFW conducts rescue efforts at Tisdale Weir to relocate stranded individuals. Rescued fish that have been tagged have been observed migrating to spawning grounds and have been found in carcass surveys in the Sacramento River and Butte Creek. Isolated pools in the Tisdale Bypass also can strand fish (Reclamation and USFWS 2016). Efforts to improve fish passage at Fremont Weir will be used to inform potential future efforts to provide for fish passage at Tisdale Weir (Reclamation and USFWS 2016).

Moulton and Colusa weirs also can prevent fish from re-entering the Sacramento River, and juvenile Chinook salmon have been observed stranded at Moulton Weir (USRMPWT 2017). However, because Moulton Weir is relatively small and spills infrequently, fish stranding does not appear to be as significant as at the other weirs (USRMPWT 2017).

Weir No. 1, located on the west side of Sutter Bypass just north of Tisdale Bypass, has a degraded fish ladder and non-operable weir structure that impedes fish passage during critically dry water years (Reclamation and USFWS 2016).

Two weirs that were recently fish passage impediments in the Sutter Bypass include Weir No. 2 and Willow Slough Weir, which impound water in the East Borrow Canal to maintain surface water elevations for irrigation diversions. Although both weirs have fish ladders, the weirs and fish ladders deteriorated and were no longer providing reliable fish passage. The culverts and fish ladder at Willow Slough Weir were replaced in 2010, and Weir No. 2 and its fish ladder were replaced in 2013, such that both facilities could provide more reliable fish passage at a much larger range of flows.

8.1.4.5 Downstream Migration and Stranding

Juvenile salmonids have been documented in the Yolo Bypass after weir overtopping events and have been found to benefit from inhabiting floodplains during rearing stages (Sommer et al. 2001b). However, stranding on floodplains also is known to occur for various reasons (Henning et al. 2006). Although the Yolo Bypass is generally well-graded and well-drained, there are many scour ponds and channels in the northern portion of the bypass, which could potentially strand juveniles as flood waters recede. Sommer et al. (2005) found that a relatively low proportion of juvenile Chinook salmon would likely be stranded in the Yolo Bypass. However, due to the hydrologic variability on floodplains, stranding losses might cause excessive mortality in some years; however, the risks may be offset by increased rearing habitat and food resources in other years (Sommer et al. 2001c). Sommer et al. (2005) also found that, when stranding occurred in the Yolo Bypass, there were significantly higher stranding rates in the concrete weir splash basins than in the downstream scour ponds, pools, and swales, suggesting that artificial water control structures can create unnatural hydraulics that promote stranding. Documentation of precise rates of stranding under varying conditions in the Yolo Bypass are unknown and difficult to estimate for a number of reasons, including: (1)predominance of private land in the Yolo Bypass;(2) occurrence of avian predation on juvenile salmonids in isolated ponds; and (3) difficulty in estimating of juvenile salmonid abundance in the Yolo Bypass (CDFG 2008).

8.1.4.6 Predation

Predation on special-status fish species in the Sacramento River and the Yolo and Sutter bypasses is influenced by anthropogenic factors, the presence of non-native fish species, altered physical habitat, and hydrology. Marine mammals, such as sea lions, are also known to predate on adult salmonids in the lower Sacramento River and the Yolo Bypass, and river otters have been observed preying on salmonids at Wallace Weir. As described above in Section 8.1.3.3.2, piscivorous birds can consume large quantities of fish on a floodplain or in other shallow-water habitat, particularly if they become stranded (Opperman et al. 2017).

High rates of predation have been known to occur at diversions and locations where rock revetment has replaced natural river bank vegetation (NMFS 2009 as cited in Reclamation 2015). Chinook salmon fry, juveniles, and smolts are more susceptible to predation at these locations because Sacramento pikeminnow and striped bass congregate in areas that provide predator refuge (Tucker et al. 2003; Williams 2006). Non-native centrarchids, such as largemouth bass and spotted bass, will opportunistically feed on juvenile salmonids, particularly in the presence of human-made structures and altered habitat.

8.1.4.7 Structural Habitat

Many of the levees in the lower Sacramento River between Fremont Weir and Rio Vista use rock revetment to armor the bank from erosive forces. The effects of channelization and revetment include the alteration of river hydraulics, cover along the bank, and changes in bank configuration and structural features (Stillwater Sciences 2006 as cited in NMFS 2009). These changes affect the quantity and quality of near-shore habitat for juvenile fishes (Garland et al. 2002, Schmetterling et al. 2001, and USFWS 2000, all as cited in NMFS 2009).

Simple slopes protected with rock revetment generally create near-shore hydraulic conditions characterized by greater depths and faster, more homogeneous water velocities than those that occur along natural banks. These changes in hydraulic conditions result in reduced habitat complexity. Additionally, higher water velocities typically inhibit deposition and retention of sediment and woody debris. These changes generally reduce the range of habitat conditions typically found along natural shorelines, particularly by eliminating the shallow, slow-velocity river margins used by juvenile fish as refuge and escape from fast currents, deep water, and predators (Stillwater Sciences 2006 as cited in NMFS 2009). In addition, the armoring and revetment of stream banks tends to narrow rivers, reducing the amount of habitat per unit of channel length (Sweeney et al. 2004).

In addition to direct effects of levees on aquatic habitat and fishes, riparian vegetation is substantially reduced on rock revetment leveed banks, reducing overhanging vegetation and future woody debris sources (Reclamation 2008). Large woody debris provides valuable habitat to fish such as salmonids (Reclamation 2008).

8.1.4.8 Food Web

Historically, the Delta food web was supported primarily by wetlands. Currently, the Delta relies on smaller amounts of carbon inputs, primarily from tributaries (Jassby and Cloern 2000; Jassby et al. 2003). Secondary sources of carbon in the Delta include phytoplankton production and agricultural drainage (Jassby and Cloern 2000). Only carbon resulting from tributary inputs and phytoplankton production are consistently important sources in most seasons and water year types (Jassby and Cloern 2000).

Other sources include wastewater treatment plant discharges and exports from tidal marsh areas. Much of the land in the Yolo Bypass has been converted to agricultural production or is managed for waterfowl habitat, which has led to a reduction of carbon and nutrients being exchanged through tidal action and exported to the Estuary.

8.2 Regulatory Setting

This section provides the regulatory setting for aquatic resources, including potentially relevant Federal, State, and local requirements applicable to the Project.

8.2.1 Federal Plans, Policies, and Regulations

Federal laws, policies, and regulations pertaining to aquatic resources and fisheries are discussed below.

8.2.1.1 Federal Endangered Species Act

The ESA requires that both USFWS and NMFS maintain lists of threatened and endangered species. An endangered species is defined as "… any species which is in danger of extinction throughout all or a significant portion of its range." A threatened species is defined as "… any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range" (Title 16 United States Code [USC] Section 1532). Section 9 of the ESA makes it illegal to "take" (i.e., harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in such conduct) any endangered species of fish or wildlife, and regulations contain similar provisions for most threatened species of fish and wildlife (16 USC 1538).

The ESA also requires the designation of critical habitat for listed species. Critical habitat is defined as: 1) specific areas within the geographical area occupied by the species at the time of listing if they contain physical or biological features essential to a species' conservation and those features may require special management considerations or protection and 2) specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation (USFWS and NMFS 1998).

Section 7 of the ESA requires all Federal agencies to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitat. To ensure against jeopardy, each Federal agency must consult with USFWS or NMFS, or both, if the Federal agency determines that its action might affect listed species. NMFS jurisdiction under the ESA is limited to the protection of marine mammals, marine fish, and anadromous fish. All other species are within USFWS' jurisdiction.

If an activity would result in the take of a Federally listed species, one of the following is required: 1) an Incidental Take Permit issued as part of an approved Habitat Conservation Plan under Section 10(a) of the ESA or 2) an Incidental Take Statement issued pursuant to Federal interagency consultation under Section 7 of the ESA. The Incidental Take Statement typically requires various measures to avoid and minimize species take.

Where a Federal agency is not authorizing, funding, or carrying out a project, take that is incidental to the lawful operation of a project may be permitted pursuant to Section 10(a) of the ESA through approval of a Habitat Conservation Plan.

8.2.1.2 Long-term Central Valley Project and State Water Project Operations Biological Opinions

8.2.1.2.1 USFWS Biological Opinion

The 2008 USFWS biological opinion (BO) concurred with Reclamation's determination that the coordinated operations of the SWP and CVP are not likely to adversely affect listed species, except for delta smelt (USFWS 2008). USFWS concluded that the coordinated operations of the SWP and CVP, as proposed, were likely to jeopardize the continued existence of delta smelt and destroy or adversely modify delta smelt critical habitat. Consequently, USFWS developed a reasonable and prudent alternative, consisting of several components and actions to avoid the likelihood of jeopardizing the continued existence or the destruction or adverse modification of critical habitat for delta smelt.

8.2.1.2.2 NMFS Biological Opinion

The NMFS BO (NMFS 2009) concluded that the SWP and CVP operations are likely to jeopardize the continued existence of the following species:

- Sacramento River winter-run Chinook salmon
- Central Valley spring-run Chinook salmon

- Central Valley steelhead
- Southern DPS of North American green sturgeon
- Southern resident killer whale

NMFS (2009) also concluded that CVP and SWP operations are likely to adversely modify the designated critical habitats of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and green sturgeon. Consequently, NMFS developed a reasonable and prudent alternative, consisting of several components and actions to avoid the likelihood of jeopardizing the continued existence or the destruction or adverse modification of critical habitat for these species, including restoration actions to increase juvenile salmonid access to the Yolo Bypass and improve adult migration through the Yolo Bypass.

8.2.1.3 Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act (Public Law 104 to 297), requires that all Federal agencies consult with NMFS on activities or proposed activities authorized, funded, or undertaken by that agency that could adversely affect Essential Fish Habitat (EFH) of commercially managed marine and anadromous fish species. EFH includes specifically identified waters and substrate necessary for fish spawning, breeding, feeding, or growing to maturity (16 USC 1802[10]). EFH also includes all habitats necessary to allow the production of commercially valuable aquatic species, support a long-term sustainable fishery, and contribute to a healthy ecosystem.

The Pacific Fishery Management Council (2004) has designated the Delta, the Sacramento River, and tributaries as EFH to protect and enhance habitat for Chinook salmon. Because EFH applies only to commercial fisheries, all Chinook salmon habitats are included but not steelhead habitat.

8.2.1.4 Recovery Plan for Sacramento-San Joaquin Delta Native Fish Species

Since the *Recovery Plan for Sacramento-San Joaquin Delta Native Fishes* was released in 1996 (USFWS 1996), new information regarding the status, biology, and threats to Delta native species has emerged (CDFG 2008). Ongoing revision of the plan will review the new information and develop a strategy for conserving and restoring Delta native fish by identifying recovery actions that specifically address the threats to their existence. Species covered by this plan include delta smelt, longfin smelt, Sacramento splittail, and Sacramento perch.

The basic goal of the plan is to establish self-sustaining populations of the species of concern that will persist indefinitely (USFWS 1996). The plan stated that a variety of actions could be needed to achieve this goal, but the actions are not mandated by statute or policy.

8.2.1.5 Recovery Planning for Salmon and Steelhead in California

The public draft *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 Central Valley Steelhead* was released in October 2009. The final plan was released in July 2014 (NMFS 2014). As defined in the draft recovery plan, the California Central Valley Recovery Domain extends from the upper Sacramento River Valley to the northern portion of the San Joaquin River Valley (NMFS 2014). For the Central Valley Chinook salmon ESUs and the steelhead DPS to achieve recovery, each diversity group must be represented, and population redundancy within the groups must be met to achieve diversity group recovery. The following priority recovery actions to address specific limiting factors were identified by NMFS (2014) to help meet recovery objectives:

- Protect and restore watershed and estuarine habitat complexity and connectivity.
- Improve understanding of life stage survival through focused research and monitoring.
- Establish at least two additional populations of winter-run Chinook salmon that are spatially diverse and secure from natural and human-made threats.
- Develop more-effective and efficient Federal and State mechanisms to correct already documented threats to listed salmonids.
- Collaboratively balance water supply and allocation with fisheries' needs through improving criteria for water drafting, storage and dam operations, water rights programs, development of passive diversion devices and/or offstream storage, elimination of illegal diversions in priority watersheds and streams, and other such opportunities.
- Screen appropriate water diversions and provide adequate downstream flows.
- Provide outreach to Federal action agencies regarding ESA Section 7(a)(1) and carry out programs to conserve and recover Federally listed salmonids.
- Identify and treat point and non-point source pollution to streams from wastewater, agricultural practices, and urban environments.

8.2.1.6 Recovery Planning for Southern DPS of North American Green Sturgeon

In 2018, NMFS released a public draft recovery plan for the Southern DPS of North American green sturgeon. NMFS (2018) identified 20 recovery actions intended to restore passage and habitat, reduce mortality from fisheries, entrainment, and poaching, and address threats related to water quality contaminants, climate change, predation, sediment loading and oil and chemical spills. Most of the recovery efforts focus on the Sacramento River Basin and the Estuary. Priority recovery actions aim to incrementally restore habitat below Keswick, Oroville, and Englebright dams, provide volitional passage at barriers in the lower Feather and Yuba rivers, support adequate water flow and water temperature on the Sacramento, Feather, and Yuba rivers, reduce stranding at Yolo and Sutter bypasses and other sources of take (e.g., fisheries bycatch), improve rearing habitats in the Estuary, and ameliorate the risk posed by entrainment in water diversions and contaminants (NMFS 2018). Additional recovery actions address predation and non-point source sediment loading (NMFS 2018).

8.2.1.7 Fish and Wildlife Coordination Act (16 USC Section 651 et seq.)

The Fish and Wildlife Coordination Act gives the United States Secretary of the Interior the authority to assist Federal, State, public, or private agencies in developing, protecting, rearing, or stocking all wildlife, wildlife resources, and their habitats (16 USC 661). Under this act, whenever waters of any stream or other water body are proposed to be impounded, diverted, or otherwise modified by any public or private agency under a Federal permit, that agency must consult with USFWS and, in California, CDFW (16 USC 661–662(a), March 10, 1934, as amended 1946, 1958, 1978, and 1995).

8.2.1.8 Clean Water Act

The Clean Water Act (CWA) is a comprehensive set of statutes aimed at restoring and maintaining the chemical, physical, and biological integrity of the nation's waters. The CWA is the foundation of surface water quality protection in the United States (USEPA 2017). Initial authority for implementing and enforcing the CWA rests with USEPA. However, this authority can be exercised by states with approved regulatory programs. In California, this authority is exercised by the State Water Resources Control Board (SWRCB) and the RWQCBs.

The CWA contains a variety of regulatory and non-regulatory tools to significantly reduce direct pollutant discharges into waters of the United States, finance municipal wastewater treatment facilities, and manage polluted runoff. These tools (e.g., Section 303[d] List of Impaired Waters and Section 404 permitting process) are used to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters so that they can support "the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water."

8.2.1.8.1 Constituents of Concern Listed under Clean Water Act Section 303(d)

Section 303(d) of the Federal CWA requires states to identify water bodies that do not meet water quality standards and are not supporting their designated beneficial uses. These waters are placed on the Section 303(d) List of Impaired Waters. This list defines low-, medium-, and high-priority pollutants that require immediate attention by Federal and state agencies. Placement on this list triggers development of a Total Maximum Daily Load (TMDL) Program for each water body and associated pollutant and/or stressor on the list. The Central Valley RWQCB is responsible for implementing the TMDL Program in California. Completed or ongoing TMDLs in the Delta region include chlorpyrifos and diazinon, dissolved oxygen, mercury and methylmercury, pathogens, pesticides, organochlorine pesticides, salt and boron, and selenium (Central Valley RWQCB 2010). For further information about TMDLs in the Delta region, refer to Chapter 6, *Water Quality*.

8.2.1.8.2 Clean Water Act Section 404

Section 404 of the CWA authorizes USACE and USEPA to issue permits to regulate the discharge of "dredged or fill materials into waters of the United States" (33 USC 1344). Should activities such as dredging or filling of wetlands or surface waters be required for project implementation, then permits obtained in compliance with CWA Section 404 would be required for the project applicant(s).

8.2.1.8.3 Clean Water Act Section 401

Section 401 of the CWA specifies that states must certify that any activity subject to a permit issued by a Federal agency (e.g., USACE) meets all state water quality standards. In California, the SWRCB and the RWQCBs are responsible for certifying activities subject to any permit issued by USACE pursuant to Section 404 of the CWA or pursuant to Section 10 of the Rivers and Harbors Act of 1899.

8.2.1.9 River and Harbors Act of 1899

The Rivers and Harbors Act of 1899 makes it unlawful to excavate, fill, or alter the course, condition, or capacity of any port, harbor, channel, or other areas within the reach of the act without a permit. Under Section 10 of the Rivers and Harbor Act, USACE regulates all structures and work in navigable waters.

8.2.1.10 Executive Order 11990, Protection of Wetlands

Executive Order 11990 calls for each Federal agency, in carrying out its ordinary responsibilities, to take actions to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands. Federal agencies must avoid undertaking new construction located in wetlands unless no practicable alternative is available and the action includes all practicable measures to minimize harm to wetlands.

8.2.1.11 Central Valley Project Improvement Act

The Reclamation Projects Authorization and Adjustment Act of 1992 (Public Law 102-575) includes Title 34, the Central Valley Project Improvement Act (CVPIA). The CVPIA amends the authorization of the CVP to include fish and wildlife protection, restoration, and mitigation as project purposes of the CVP having equal priority with irrigation and domestic uses of CVP water and elevates fish and wildlife enhancement to a level having equal purpose with power generation. Among the changes mandated by the CVPIA was dedication of 800,000 acre-feet annually to fish, wildlife, and habitat restoration. The United States Department of the Interior’s October 5, 1999, Decision on Implementation of Section 3406(b)(2) of the CVPIA provides the basis for implementing upstream and Delta actions for fish management purposes. Implementation of Section 3406(b)(2) includes curtailing exports at Jones Pumping Plant for fishery management protection based on USFWS’ recommendations.

8.2.1.12 Central Valley Project Improvement Act 3406(b)(2) Account

According to the 1992 CVPIA, the CVP must:

> … dedicate and manage annually 800,000 acre-feet of Central Valley Project yield for the primary purpose of implementing the fish, wildlife, and habitat restoration purposes and measures authorized by this title; to assist the State of California in its efforts to protect the waters of the San Francisco Bay/Sacramento–San Joaquin Delta Estuary; and to help meet such obligations as may be legally imposed upon the CVP under federal or state law following the date of enactment of this title, including but not limited to additional obligations under the federal ESA.

Dedication of CVPIA 3406(b)(2) water occurs when Reclamation takes a fish and wildlife habitat restoration action based on recommendations of USFWS (and in consultation with NMFS and CDFW), pursuant to Section 3406(b)(2). This dedicated and managed water (i.e., (b)(2) water) is water USFWS, in consultation with Reclamation and other agencies, has at its disposal to use to meet *Water Quality Control Plan* fishery objectives and helps meet the needs of fish listed under the ESA as threatened or endangered since the enactment of the CVPIA (Reclamation 2008). To supplement the *Water Quality Control Plan* requirements, (b)(2) water may be used to augment river flows and curtail pumping in the Delta.

8.2.1.13 Anadromous Fish Restoration Program

An important goal identified to meet the fish and wildlife purposes of the CVPIA is the broad goal of restoring natural populations of anadromous fish (e.g., Chinook salmon, steelhead, green sturgeon, white sturgeon, American shad, and striped bass) in Central Valley rivers and streams to double their recent average abundance levels. The Anadromous Fish Restoration Program (AFRP) strives to achieve this goal by directing the United States Secretary of the Interior to develop and implement a program to ensure the sustainability of anadromous fish in Central Valley rivers and streams.

8.2.2 State Plans, Policies, and Regulations

State laws, policies, and regulations pertaining to aquatic resources and fisheries are discussed below.

8.2.2.1 California Endangered Species Act

CESA (Fish and Game Code Sections 2050 to 2089) establishes various requirements and protections regarding species listed as threatened or endangered under State law. California's Fish and Game Commission is responsible for maintaining lists of threatened and endangered species under CESA. CESA prohibits the "take" of listed and candidate (petitioned to be listed) species (Fish and Game Code Section 2080). "Take" under California law means to "… hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch capture, or kill …" an individual of a listed or candidate species (Fish and Game Code Section 86). The State definition does not include "harm" or "harass," as the Federal definition does. As a result, the threshold for take under CESA is typically higher than that under ESA. In accordance with Section 2081 of the California Fish and Game Code, a permit from CDFW is required for projects that could result in the incidental take of a wildlife species that is State-listed as threatened or endangered.

8.2.2.2 California Common Law Public Trust Doctrine

The Common Law doctrine of the California Public Trust protects the public's right to use California waterways for navigation, fishing, boating, natural habitat protection and other water-related activities. The Public Trust provides that tide and submerged lands and the beds of lakes, streams, and other navigable waterways are to be held in the trust by California for the benefit of the people of California.

8.2.2.3 California Fish and Game Code Section 1602, Lake and Streambed Alteration Program

Diversions, obstructions, or changes to the natural flow or bed, channel, or bank of any river, stream, or lake in California that supports wildlife resources are subject to regulation by CDFW, pursuant to Section 1602 of the California Fish and Game Code. The regulatory definition of a stream is a body of water that flows at least periodically or intermittently through a bed or channel having banks and supports wildlife, fish, or other aquatic life. This includes watercourses having a surface or subsurface flow that supports or has supported riparian vegetation. CDFW's jurisdiction within altered or artificial waterways is based on the value of those waterways to fish and wildlife.

8.2.2.4 California Fish and Game Code Sections 5901,5931 and 5937

Section 5901 of the California Fish and Game Code states that it is unlawful to construct or maintain any device in a stream which prevents, impedes, or tends to impede the passing of fish upstream and downstream. Section 5931 allows CDFW to require a fishway to be constructed to provide passage over or around a dam. Section 5937 requires that an owner of a dam allow sufficient water to pass through a fishway, or in the absence of a fishway, allow sufficient water to pass over, around or through the dam, to keep in good condition any fish that may be planted or exist downstream of the dam.

8.2.2.5 Salmon, Steelhead Trout, and Anadromous Fisheries Program Act

Enacted in 1988, the Salmon, Steelhead Trout, and Anadromous Fisheries Program Act was implemented in response to reports that the natural production of salmon and steelhead in California had declined dramatically since the 1940s, primarily because of lost stream habitat in many streams in the State. This act declares that it is the policy of the State of California to increase the State's salmon and steelhead resources, and it directs CDFW to develop a plan and program that strives to double the salmon and steelhead resources (Fish and Game Code Section 6902[a]). It is also the policy of the State that existing natural salmon and steelhead habitat shall not be diminished further without offsetting the impacts of lost habitat (Fish and Game Code Section 6902[c]).

8.2.2.6 Senate Joint Resolution 19, Chapter 141, of the Statutes of 1983

Senate Joint Resolution 19, Chapter 141, of the Statutes of 1983 re-established the California Advisory Committee on Salmon and Steelhead Trout (CAC), which was originally established in 1970. The CAC is a public committee which advises CDFW and the California Legislature (through the Joint Committee on Fisheries and Aquaculture) on salmon and steelhead issues in California. The CAC was re-established in response to declining anadromous fish populations and the associated economic value of California salmon fisheries.

8.2.2.7 Water Quality Control Plan for the San Francisco Bay / Sacramento-San Joaquin Delta Estuary

Consistent with the CVPIA and AFRP, the Water Quality Control Plan for the San Francisco Bay / Sacramento-San Joaquin Delta Estuary (SWRCB 2006) includes an objective to maintain water quality and other watershed conditions sufficient to achieve a doubling goal of natural production of Chinook salmon from the average production of 1967-1991.

8.2.2.8 Senate Joint Resolution 7, Chapter 188, of the Statutes of 2017

In recognition of declining salmon populations in California, as well as recent droughts and fishery closures and restrictions, Senate Joint Resolution 7, Chapter 188, of the Statutes of 2017 urges California state agencies to making statewide salmon fishery restoration an urgent and high priority.

8.2.2.9 Sacramento Valley Salmon Resiliency Strategy

The California Natural Resources Agency released a plan in June 2017 to address near-term and long-term needs of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon and California Central Valley steelhead. The plan relies on the NMFS (2014) Central Valley recovery plan, and incorporates conceptual models of factors affecting Chinook salmon population dynamics. Goals and objectives of the plan relate to the CVPIA salmonid doubling goals and NMFS ESU/DPS recovery criteria. Recommended actions to improve the viability and resiliency of listed salmonid species in the Central Valley include the following.

- Restoration actions in Battle Creek
- Implementation of the McCloud River reintroduction pilot plan in the upper Sacramento River Watershed
- Increasing flows in Mill, Deer, Antelope and Butte creeks
- Restoring fish passage and habitat in Mill and Deer creeks
- Restoration of instream habitats in the upper Sacramento River
- Improving fish passage at Sunset Pumps Rock Dam on the Feather River
- Restoration of rearing and migratory habitats in the Sacramento River
- Completion of fish screen construction on major diversions along the Sacramento River
- Improvement of Sutter Bypass and associated infrastructure to facilitate adult fish passage and improvement of stream flow monitoring
- Improvement of Yolo Bypass adult fish passage
- Increasing juvenile salmonid access to Yolo Bypass and increasing duration and frequency of Yolo Bypass floodplain inundation
- Construction of a permanent Georgiana Slough non-physical barrier
- Restoration of tidal habitat in the Delta

8.2.3 Regional and Local Plans, Policies, and Regulations

8.2.3.1 Yolo County 2030 Countywide General Plan

The *Yolo County 2030 Countywide General Plan* (County of Yolo 2009) includes a conservation and open space element containing goals and policies designed to protect natural resources in perpetuity for the benefit of current and future residents. These resources include water, woodlands, soils, lakes, rivers, fisheries, wildlife, and minerals. The conservation and open space goals and policies provide management guidance for biological resources that may occur in unincorporated lands within the project area.

8.2.3.2 Yolo County Habitat Conservation Plan/Natural Communities Conservation Plan

The Yolo Habitat Conservancy (YHC), a Joint Powers Agency consisting of the County of Yolo and the cities of Davis, West Sacramento, Winters, and Woodland, formed in 2002 to begin drafting a habitat conservation plan/natural community conservation plan (HCP/NCCP) (Yolo Habitat Conservancy 2017). The Yolo County HCP/NCCP will provide the YHC with long-term permits under the federal ESA and the California Natural Community Conservation Planning Act to cover a wide range of public and private activities in Yolo County. Although the Yolo County HCP/NCCP does not directly address fish species, it does include goals and policies related to protecting and improving habitat conditions in the Yolo Bypass, which could indirectly benefit fish resources (Yolo Habitat Conservancy 2017).

8.3 Environmental Consequences

This section describes the impacts of the Alternatives on fisheries and aquatic resources, including the methodology applied to evaluate impacts of the Project Alternatives. Potential impacts of the Alternatives are described relative to the regulatory baseline conditions (California Environmental Quality Act [CEQA] Existing Conditions and National Environmental Policy Act [NEPA] No Action Alternative).

Both quantitative and qualitative assessments were conducted to evaluate potential impacts to fisheries and aquatic resources that could occur as a result of the alternatives. Primarily qualitative assessments were carried out to evaluate potential impacts associated with construction- and maintenance-related activities. Assessment of operations-related impacts included both qualitative and quantitative methodologies.

Hydrologic, hydraulic, and fish population modeling was performed to provide a quantitative basis from which to assess potential operations-related impacts of the alternatives on fish species of focused evaluation and aquatic habitats. Specifically, the modeling analyses were utilized to simulate data intended to represent operational conditions that would occur due to implementation of the alternatives (e.g., Alternative 1 scenario), which were compared to modeled data intended to represent operational conditions that occur under Existing Conditions (i.e., Existing Conditions scenario) and under future conditions (i.e., the No Action Alternative scenario). The methodologies used to simulate comparative operational scenarios under the alternatives relative to the basis of comparison are described in the model-specific technical memoranda.

The impact assessment for fisheries and aquatic resources considered five primary types of potential impacts, including: 1) permanent impacts associated with the construction and operation of infrastructure, 2) temporary and localized impacts associated with construction of infrastructure, 3) ongoing impacts associated with maintenance of infrastructure, 4) short-term hydrologic changes associated with the construction of infrastructure, and 5) long-term hydrologic and aquatic habitat changes associated with the operations of the alternative. The analytical framework used to assess the potential impacts of each component of the alternatives evaluated in this EIS/EIR is described below. Detailed descriptions of the alternatives evaluated in this section are provided in Chapter 2, *Description of Alternatives*.

8.3.1 Methods for Analysis

This section describes the methodologies that the Lead Agencies implemented to evaluate the potential effects of the alternatives on fish species of focused evaluation and their aquatic habitats. In addition to generally qualitative methods for assessing potential construction- and maintenance-related impacts, impact assessment methodologies relied on simulated changes in hydrology, water temperature, water quality, and fisheries habitat parameters under the alternatives relative to the basis of comparison.

8.3.1.1 Construction- and Maintenance-related Impacts

Assessment of construction-related impacts in the project area addressed all of the alternative-specific components, which are described in more detail in Chapter 2. For each infrastructure component evaluated, the assessment was based on several considerations, including the duration and extent of construction-related activities and the proximity of construction-related activities to the Sacramento River and the Tule Canal or other waterways in the Yolo Bypass. Potential construction-related impacts could include: 1) changes in erosion, sedimentation, and turbidity in waterways; 2) potential for hazardous materials or chemicals to enter waterways; 3) changes in aquatic habitat quantity and quality, including riparian vegetation; 4) increases in hydrostatic pressure waves, noise, and vibration; 5) impediments to fish passage; 6) stranding and entrainment; 7) increases in predation risk of fish species of focused evaluation; and 8) direct harm or mortality of fish species of focused evaluation.

The potential for construction-related impacts to affect fisheries and aquatic resources is dependent on the location and type of infrastructure component to be constructed and the potential for construction-related activities to directly harm individuals and/or remove, damage, or alter onsite habitat conditions within and adjacent to the construction footprints for a given alternative.

The impact assessment took into consideration the potential for general effects to occur and the potential for construction activities to affect a particular fish species that may be present in or adjacent to the construction footprint. Depending on the specific activity evaluated, the impact assessment considered either all, or a combination of, the elements listed below, as feasible and appropriate:

- Visual inspection of conditions within the immediate construction footprint and surrounding areas to determine habitat conditions and the potential for disturbance-related effects on aquatic habitat
- Review of available maps and aerial photography to determine the proximity of the construction footprint to adjacent receiving waters
- Evaluation of the sequencing, timing, extent (e.g., long-term or short-term duration), intensity, and severity of disturbance activities resulting from construction-related activities and the use of construction equipment

- Determination if there is a potential for construction activities to adversely modify habitat or appreciably diminish the value of designated or proposed critical habitat
- Identification of avoidance measures and/or mitigation measures to minimize or mitigate for potential construction-related impacts on sensitive life stages of fish species that may be present during construction activities

Maintenance-related impacts were evaluated in the Yolo Bypass and Sacramento River associated with sediment removal within and near the intake facilities; vegetation removal in the intake channel; inspection and maintenance of the headworks facilities; and maintenance of the transport, intake, outlet, and bypass channels.

Conducting fully quantitative analyses of potential impacts on fisheries and aquatic resources associated with construction and maintenance activities requires information specific to each construction activity that often is not available at the time of environmental documentation. Much of the information required to conduct quantitative analyses becomes available as design documents progress to final design stages and as contractors are selected to construct the facilities. Design and specific equipment information can then be used to conduct subsequent analyses for use in permitting processes, including ESA and CWA permitting processes.

The requirements for conducting analyses under CEQA and NEPA include utilizing the best available information to conduct impact assessments. In the absence of final design and equipment specifications, environmental documents often rely on the use of qualitative analyses, which rely on an understanding of potential impact mechanisms, general construction activities and timing, and a detailed understanding of species habitat utilization and life history characteristics. These qualitative analyses focus on the types of impacts that could occur on a species that could be present at a general location during a general time of year.

Although most potential construction- and maintenance-related impacts were evaluated qualitatively, aquatic habitat modification was assessed quantitatively, as discussed below.

The evaluation of altered habitat conditions along the Sacramento River considers the principles of the Standard Assessment Methodology, which has been used to evaluate the value of aquatic habitat as it pertains to life stage responses of focus fish species in the Sacramento River (USACE 2004; USACE 2012b). Although the specific models were not used for assessment in this document, the principles and concepts of habitat alteration associated with the alternatives were used in the evaluation of potential impacts to fish species of focused evaluation.

To the extent feasible, habitat variables considered include structural features (bank slope, substrate size, instream woody material [IWM], riparian vegetation, and instream object cover), hydraulics, riparian habitat/overhanging shade/cover, and associated predation potential. USACE (2012b) examined the extent to which life stages of Chinook salmon, steelhead, green sturgeon, and delta smelt are sensitive to changes in key Sacramento River shoreline parameters, including bank slope, floodplain inundation, bank substrate size, instream structure (IWM), aquatic vegetation, and overhanging shade. Generally, only the juvenile life stages are expected to exhibit sensitivities to changes in physical habitat (USACE 2012b). Specifically, juvenile salmonids are expected to be the most sensitive to habitat variable changes along the Sacramento River (USACE 2012b). Therefore, this impact assessment focused on potential impacts to structural habitat conditions for juvenile anadromous salmonids.

To determine the magnitude of potential disturbance and/or removal of aquatic and riparian habitat (e.g., shaded riverine aquatic[8] [SRA]) habitat associated with construction of the alternative-specific facilities and channels along the Sacramento River and in the Yolo Bypass waterways, the total amount of available aquatic, riparian, and grassland habitat within the construction footprint was calculated for each alternative. According to the USFWS, the amount of available SRA habitat can be quantified through length and width measurements (i.e., L x W). For this impact assessment, habitat areas temporarily and permanently impacted by the alternatives were quantified using ArcGIS.

8.3.1.2 Operations-related Impacts

Potential operations-related impacts to fish species of focused evaluation and aquatic habitat associated with the alternatives would primarily occur in the Yolo Bypass and Sacramento River downstream of Fremont Weir due to changes in the magnitude, duration, and frequency of flow entering the Yolo Bypass over or through Fremont Weir. Operations of structures in the Yolo Bypass also have the potential to affect passage and predation of fish species of focused evaluation. In addition, changes in flow in the Sacramento River and the Yolo Bypass have the potential to affect habitat conditions in the Delta and downstream estuarine waterbodies. Although not expected to substantially affect fisheries habitat conditions, there also would be potential for the alternatives to result in re-operations of the SWP/CVP system and affect fisheries habitat conditions in Shasta, Oroville, Folsom, and San Luis reservoirs and in the upper Sacramento, lower Feather, and lower American rivers.

8.3.1.2.1 Analytical Tools

The fisheries and aquatic habitat impact assessment relied on hydrologic, hydraulic, water temperature, and fisheries modeling to provide a quantitative basis from which to assess the effects of the alternatives on fish species of focused evaluation and aquatic habitats in the project area relative to the basis of comparison. Models and other tools applied in the evaluation of alternatives are summarized below.

- Mean monthly hydrologic (CalSim II) and water temperature modeling (Reclamation Water Temperature Model) to address potential changes in reservoir operations and instream conditions in the Sacramento River and other areas of the SWP/CVP system, including the Delta
- Hydrologic Engineering Center River Analysis System (HEC-RAS) hydraulic modeling within facilities and in transport, intake, and outlet channels in the Yolo Bypass and Sacramento River to estimate hydraulic conditions for use in evaluating adult fish passage
- Yolo Bypass Passage for Adult Salmonids and Sturgeon (YBPASS) tool (a compilation of files generated in Microsoft Excel for water years 1997 through 2012) to evaluate modeled water depths and velocities to assess adult fish passage performance through planned facilities at the Fremont Weir

[8] The nearshore aquatic area occurring at the interface between a river (or stream) and adjacent woody riparian habitat

- Sedimentation and River Hydraulics – Two Dimensional modeling (SRH-2D) along the Fremont Weir section of the Sacramento River to predict the hydrodynamics under the influence of various Fremont Weir notch configurations
- Eulerian-Lagrangian Agent Method (ELAM) modeling at the Fremont Weir and proposed notches in the weir based on hydraulic modeling and acoustically tagged fish movement to evaluate the proportion of juvenile Chinook salmon predicted to be entrained into the Yolo Bypass at particular flows
- Critical streakline analysis to evaluate entrainment potential of various notch locations based on modeling of hydraulic conditions and acoustically tagged fish tracks
- Yolo Bypass Juvenile Entrainment Evaluation Tool (a spreadsheet tool generated in Microsoft Excel for water years 1997 through 2012) to evaluate estimated entrainment into the Yolo Bypass at the Fremont Weir that utilizes empirical juvenile Chinook salmon catch data and assumes that entrainment of fish is proportional to the volume of flow diverted
- Daily hydrodynamic Two-Dimensional Unsteady Flow modeling (TUFLOW) in the Yolo Bypass and Sacramento River downstream of Fremont Weir to evaluate hydraulic conditions in the Yolo Bypass and Sacramento River associated with changes in Sacramento River flows entering the Yolo Bypass at Fremont Weir
- Salmon Benefits Model (SBM) to simulate changes in annual size, size variation, ocean entry timing variation, and survival of juvenile Chinook salmon emigrating through the Yolo Bypass and lower Sacramento River and Delta and resulting changes in adult returns by run

CalSim II

CalSim II is the application of the Water Resources Integrated Modeling System software to the SWP and CVP. This application was jointly developed by Reclamation and DWR for planning studies relating to SWP/CVP operations.

CalSim II is used to simulate system operations for an 82-year (water years 1921 through2002) period using a monthly timestep. The model assumed that facilities, land use, water supply contracts, and regulatory requirements were constant over this period, representing a fixed level of development (LOD) (e.g., 2005, 2030). Major Central Valley rivers, reservoirs, and SWP/CVP facilities are represented by a network of arcs and nodes. Flows were simulated as monthly averages, and reservoir storages are simulated as end-of-month storages. Descriptions of the assumed regulatory standards and operations criteria used in CalSim II for the alternative and baseline scenarios are provided in Appendix E.

The hydrologic analysis conducted for this EIS/EIR used CalSim II models with 2030 and 2070 hydrology from the California Water Commission Climate Change Water Supply Improvement Project modeling to approximate system-wide changes in storage, flow, salinity, and reservoir system re-operation associated with the alternatives. Reclamation's CalSim II modeling of the Existing Conditions scenario and the alternatives under existing LOD assumed a 2030 hydrology. Future conditions in the CalSim II modeling for the No Action Alternative and the alternatives under future LOD assumed a 2070 hydrology, including estimates of climate change and sea level rise.

Hydrologic simulation results from CalSim II provided a quantitative basis to assess the effects of the alternatives and coordinated SWP/CVP operations on flows spilling over Fremont Weir into the Yolo Bypass, flows in the Sacramento River downstream of the Fremont Weir, and hydrologic and salinity conditions in the Delta. Simulated reservoir storages provided a quantitative basis to assess potential changes in fisheries habitat in Shasta, Oroville, Folsom, and San Luis reservoirs and as indicators of potential changes in hydrologic conditions in the upper Sacramento, lower Feather, and lower American rivers under the alternatives relative to the basis of comparison (i.e., Existing Conditions and No Action Alternative scenarios).

Although water temperatures would not be expected to substantially change in the project area under the alternatives, the Lead Agencies used CalSim II simulated flows as inputs to Reclamation’s water temperature model for the lower Sacramento River to simulate mean monthly water temperatures over the water years 1922 to 2003 simulation period.

YBPASS Tool and HEC-RAS Modeling

Using hydraulic criteria developed by Yolo Bypass Fisheries and Engineering Technical Team (FETT), DWR developed the YBPASS tool to compare HEC-RAS modeled water depths and velocities in the alternative-specific intake structures and transport channels to compare against adult Chinook salmon and sturgeon fish passage criteria.

SRH-2D

SRH-2D is a 2D depth-averaged hydrodynamic model for river systems developed by Reclamation (Lai 2008; 2010). Flow hydrodynamics were modeled using SRH-2D near Fremont Weir to support the ELAM modeling of fish movement within the Sacramento River and through the Fremont Weir to evaluate the effectiveness of different notch configurations (Lai 2017).

The SRH-2D model domain encompasses the approximately 18-kilometer (km) (10.8-mile) reach along the Fremont Weir section of the Sacramento River extending from Knights Landing downstream to the Verona gage station. Inflows from the Feather River, Sacramento Slough, and Natomas Cross-Cut (located between the Feather River confluence and Verona gage station) also were included in the model domain. For notch configuration prediction, 2015 bathymetric data were used in conjunction with local terrain modifications associated with the placement and configurations of each notch. Hydrology from December 2014 to January 2015 was used to generate the flow hydrodynamics, which included both low and high flows. Model input parameters were the same for all notch configurations except for the terrain and geometry modifications associated with the notch to allow for relative comparisons to be made among the notch configurations. Refer to Lai (2016; 2017) for a detailed description of the SRH-2D modeling conducted.

ELAM

The ELAM model is a mechanistic representation of individual fish movement that accounts for local hydraulic patterns represented in computational fluid dynamic models. As described in Appendix G1, Smith et al. (2017) used simulated hydraulics from the SRH-2D model and observed fish movement along the Fremont Weir to estimate entrainment of juvenile Chinook salmon into the Yolo Bypass using an ELAM model. Hydrodynamic information generated at discrete points was interpolated to locations anywhere within the physical domain where fish may be, which allowed the generation of directional sensory inputs and movements in a reference framework similar to that perceived by real fish.

The SRH-2D model was integrated with landscape topography (LiDAR [light detection and ranging]), bathymetry, and basic notch designs. The model approach was informed by 2D observations of hatchery late fall-run and winter-run Chinook salmon collected during a telemetry study on the Sacramento River at Fremont Weir (Steel et al. 2016). Individual fish telemetry tracks were not modeled directly, but rather statistical properties of the measured tracks were used to develop model coefficients. Because actual entrainment estimates into the evaluated notch configurations are unknown, the entrainment estimates using ELAM should not be viewed as absolute numbers and should be used as relative entrainment rates to highlight differences across scenarios (Smith et al. 2017).

One key limitation of the ELAM modeling is that it is based on movement of relatively large hatchery-produced juvenile Chinook salmon (mean FL of 145 mm for late fall-run and 103 mm for winter-run). Because the behavior of fry-sized juveniles may be different than that of smolt-sized juveniles, the probability of fry being entrained into a notch may differ from the probability of smolts being entrained into a notch. The probability of hatchery-produced smolts being entrained into a notch also may be different than the probability of naturally produced smolts being entrained into a notch. The ELAM modeling also could produce different entrainment results under flow conditions in the Sacramento River near Fremont Weir, which differ from the flows observed during the telemetry study used in the ELAM model. Refer to Smith et al. (2017) for a detailed description of the methods, data inputs, and limitations of the ELAM modeling.

Critical Streakline Analysis

The critical streakline analysis used hydraulic modeling and acoustically tagged juvenile Chinook salmon tracks to identify the number of juvenile Chinook salmon that would be entrained into the various notch locations based on the location of the critical streakline (Blake et al. 2017; Appendix G2). The critical streakline is the cross-stream dividing line upstream of the proposed notch that separates water that will go into the notch from water that will continue to go down the Sacramento River. Past studies have found that evaluating the movement of fish based on the cross-stream location of the critical streakline relative to the cross-stream location of a fish immediately upstream of a junction has been found to be a good predictor of a fish's movement within the junction and a good predictor of aggregate entrainment rates when predictions were summed over a group of fish (DWR 2012, 2015, 2016, all as cited in Blake et al. 2017; Appendix G2).

The cross-stream location of the critical streakline upstream of the notch was estimated from the cross-stream distribution of bathymetry and discharge immediately upstream of the notch, which was overlaid with the fish spatial distributions to estimate entrainment rates for each notch. Abundance and temporal distributions of juvenile Chinook salmon were developed from the Knights Landing RST catch data from water years 1997 through 2011. Fish tracks were developed based on acoustically tagged juvenile late fall-run Chinook salmon from Coleman National Fish Hatchery during 2016.

The largest source of uncertainty in the critical streakline analysis is that the simulation is based on a limited sample of fish tracks from hatchery-origin late fall-run Chinook salmon. Therefore, the simulation does not account for the potential differences in physiology and behavior between hatchery-produced and naturally produced juveniles (Blake et al. 2017; Appendix G2). The simulation also does not account for behavioral differences between the large (smolt-sized) juveniles used in the simulation and smaller juveniles. Additional limitations include the use of a limited range of Sacramento River backwater conditions represented in the 2016 fish track data set and the possibility that modifications to Fremont Weir could alter the hydrodynamics in the study area (Blake et al. 2017; Appendix G2). Refer to Appendix G2 for a detailed description of the methods, data inputs, and limitations of the critical streakline analysis.

Yolo Bypass Juvenile Entrainment Evaluation Tool

The FETT requested that a tool be developed that could evaluate the entrainment potential of various project alternatives using empirical juvenile salmon catch data and the corresponding Sacramento River stage and flow data. This tool needed to be capable of easily incorporating changes to alternatives as they became more refined and needed to produce a result quickly without undergoing lengthy model runs.

DWR designed the Juvenile Entrainment Evaluation Tool (DWR 2017a; Appendix G3) to incorporate juvenile salmon catch data from water years 1997 through 2011 from CDFW RSTs located approximately 5.5 miles upstream of the Fremont Weir near Knights Landing. The daily proportion of Sacramento River flow that would be diverted through alternative-specific notches and onto the Yolo Bypass was generated using TUFLOW. These flow splits were used to determine the proportion of juvenile Chinook salmon (by run) present near the Fremont Weir that would be entrained onto the Yolo Bypass. The Juvenile Entrainment Evaluation Tool was used to estimate the total annual average proportion of juvenile Chinook salmon (by run) that would be entrained into the Yolo Bypass for each Alternative and the total annual average proportion of smaller (i.e., <80 mm) juvenile Chinook salmon by run that would be entrained into the Yolo Bypass for each Alternative. Smaller fry-sized fish presumably would experience the greatest benefit because of being entrained onto the Yolo Bypass to rear (DWR 2017a; Appendix G3).

One limitation of this tool is that entrainment onto the Yolo Bypass is assumed to equal the proportion of flow diverted onto the floodplain from the Sacramento River. Entrainment through alternative-specific structures was compared to estimated entrainment for the period of record under current conditions (i.e., fish brought onto the floodplain during periods where the Sacramento River stage exceeded the crest of the Fremont Weir and spilled onto the Yolo Bypass). The product of this tool is the relative increase in entrainment from Existing Conditions for each alternative, rather than an absolute number of fish entrained.

TUFLOW

To better characterize spills into the Yolo Bypass and hydraulic conditions and inundation of the Yolo Bypass on a daily timestep, the Lead Agencies developed a 2D hydrodynamic model (TUFLOW) to compare alternatives. The 2D capabilities of the TUFLOW model allow for the comparison of the spatial distribution of flow, velocity, and depth with or without assumed future hydraulic features. The TUFLOW model extends along the Sacramento River from RM 118 to RM 12 (near Rio Vista) and includes the entire Yolo Bypass. Historical flows from the year 1997 to 2012 were simulated for several channel and weir configurations on a five- to 10-second timestep as a part of the initial alternatives evaluation (see Appendix D for detailed information on the TUFLOW modeling).

Salmon Benefits Model

The Lead Agencies used simulated daily flows overtopping Fremont Weir and flows through the proposed notches as well as modeled depths and velocities in the Yolo Bypass and Sacramento River from TUFLOW as inputs to the SBM. The SBM tracks key Chinook salmon life history stages from freshwater emigration in the lower Sacramento River (just upstream of the Yolo Bypass) to numbers of returning adults. Specifically, the SBM quantifies effects of changes in flows entering the Yolo Bypass on the size distribution of juvenile Chinook salmon emigrating to the ocean and on abundance of returning adults for each year of the simulation period (Hinkelman et al. 2017). The SBM accounts for the timing and duration of inundation of the Yolo Bypass as well as modeled depths and velocities with respect to juvenile Chinook salmon habitat suitability criteria. The SBM uses data and assumptions to determine the proportion and abundance of juveniles entrained into the bypass, the timing and duration of juvenile rearing, the timing and duration of emigration through the bypass, amount of accessible suitable habitat, and growth and survival of juveniles daily from October through May for each year of the 15-year (water years 1997 through 2011) simulation period. The SBM uses the “proportion of flow” approach such that the number of juveniles assumed to be entrained into the Yolo Bypass is proportional to the amount of Sacramento River flow diverted into the Yolo Bypass. Specifically, the SBM uses the proportion of each Chinook salmon run estimated to be entrained using the proportion of flow approach based on all size classes of each run (i.e., it is not limited to the entrainment of smaller juveniles).

It should be noted that the SBM was developed as a comparative model between scenarios, and is not a predictive model. Therefore, the specific values from the SBM are not exact, but are useful to compare between alternatives or operational scenarios. In addition, the modeled values for a given year are not cumulative (i.e., changes in SBM outputs are not compounded or affected by previous year’s results).

Hinkelman et al. (2017) reported that although all the effects examined in the SBM have the potential to influence the fish benefit results of the alternatives, there is a particularly strong interactive effect of the rearing rule and rearing survival value. Hinkelman et al. (2017) recommended that the rearing rule and rearing survival assumptions be targets for additional investigations. Detailed information on the methodology, limitations, and results of the SBM is provided in Appendix G4, *Salmon Benefits Model* (Hinkelman et al. 2017).

8.3.1.2.2 Application of Model Output

The Lead Agencies used computer simulation models and post-processing tools to assess changes in hydrology and water quality and associated changes in habitat conditions and fish populations that could occur under the alternatives, relative to the basis of comparison. The Lead Agencies used model assumptions and results for comparative purposes, rather than for absolute predictions, and focused the analysis on differences in the results among comparative scenarios. The assumptions are generally the same for both the with-project and without-project model runs, except for assumptions associated with the different alternatives themselves, and the focus of the analysis is the differences in the results.

The models used in the analyses, although mathematically precise, should be viewed as having inherent uncertainty because of limitations in the theoretical basis of the models and the scope of the formulation and function for which each model is designed. Nonetheless, models developed for planning and impact-assessment purposes represented the best available information with which to conduct evaluations of the alternatives on fisheries and aquatic resources in the project area.

Figure 8-4 displays the linkages between the models applied, the model outputs used, and the species that were evaluated.

Riverine Flows

The Lead Agencies assessed effects on fish species of focused evaluation by evaluating hydrologic model outputs to identify changes in aquatic habitat that could affect fish species of focused evaluation. Specific types of model output used to assess changes in fisheries habitat conditions are summarized below.

Post-processing tools use monthly output to calculate the average monthly flows that would occur over the respective simulation periods under the alternatives and the basis of comparison. The Lead Agencies used monthly average simulated flows by water year type to compare differences between the basis of comparison and the alternatives. Presented in tabular format, the data tables for the average flows by month over the entire simulation period, and the monthly average flows by water year type, demonstrate the changes that could occur with the alternatives, relative to the basis of comparison.

The Lead Agencies developed monthly flow probability of exceedance distributions (or curves) from monthly outputs for the entire simulation periods. These curves illustrate the distribution of simulated flows with the alternatives and the basis of comparison. Exceedance distributions generally represent the monthly flow output for a given month sorted by magnitude for the entire period of record. In general, flow exceedance distributions represent the probability, as a percentage of time, that modeled flow values would be met or exceeded at a specific location during a certain period. Therefore, exceedance distributions demonstrate the cumulative probabilistic distribution of flows for each month at a given river location under a given simulation. Exceedance distributions also allow a comparison of flow output among model scenarios without attributing unwarranted specificity to changes between model years.

Because changes in river flows associated with the alternatives are expected to occur primarily in the Sacramento River downstream of Fremont Weir, life stages of fish species of focused evaluation that could potentially be affected would generally be restricted to adult and juvenile migration and juvenile rearing. For the purposes of this impact assessment, changes in flow of 10 percent or greater are used to indicate potential substantial changes in simulated mean monthly flows. Although there is no direct biologic rationale to indicate that flow changes of 10 percent or more would substantially affect fish species or aquatic habitat, a change in monthly flow of 10 percent or greater has been previously identified by various environmental documents as an appropriate criterion to evaluate flow changes, including the *Trinity River Mainstem Fishery Restoration Draft EIS/EIR* (USFWS et al. 1999), the *San Joaquin River Agreement EIS/EIR* (San Joaquin River Group Authority 1999), the *Freeport Regional Water Project Draft EIR/EIS* (Reclamation and Freeport Regional Water Authority 2003), the *Yuba Accord EIR/EIS*

(YCWA et al. 2007), the *Sites Reservoir Project Draft EIR/EIS* (Sites Project Authority and Bureau of Reclamation 2017), and the *Substitute Environmental Document in Support of Potential Changes to the Water Quality Control Plan for the San Francisco Bay-Sacramento/San Joaquin Delta Estuary* (SWRCB 2016).

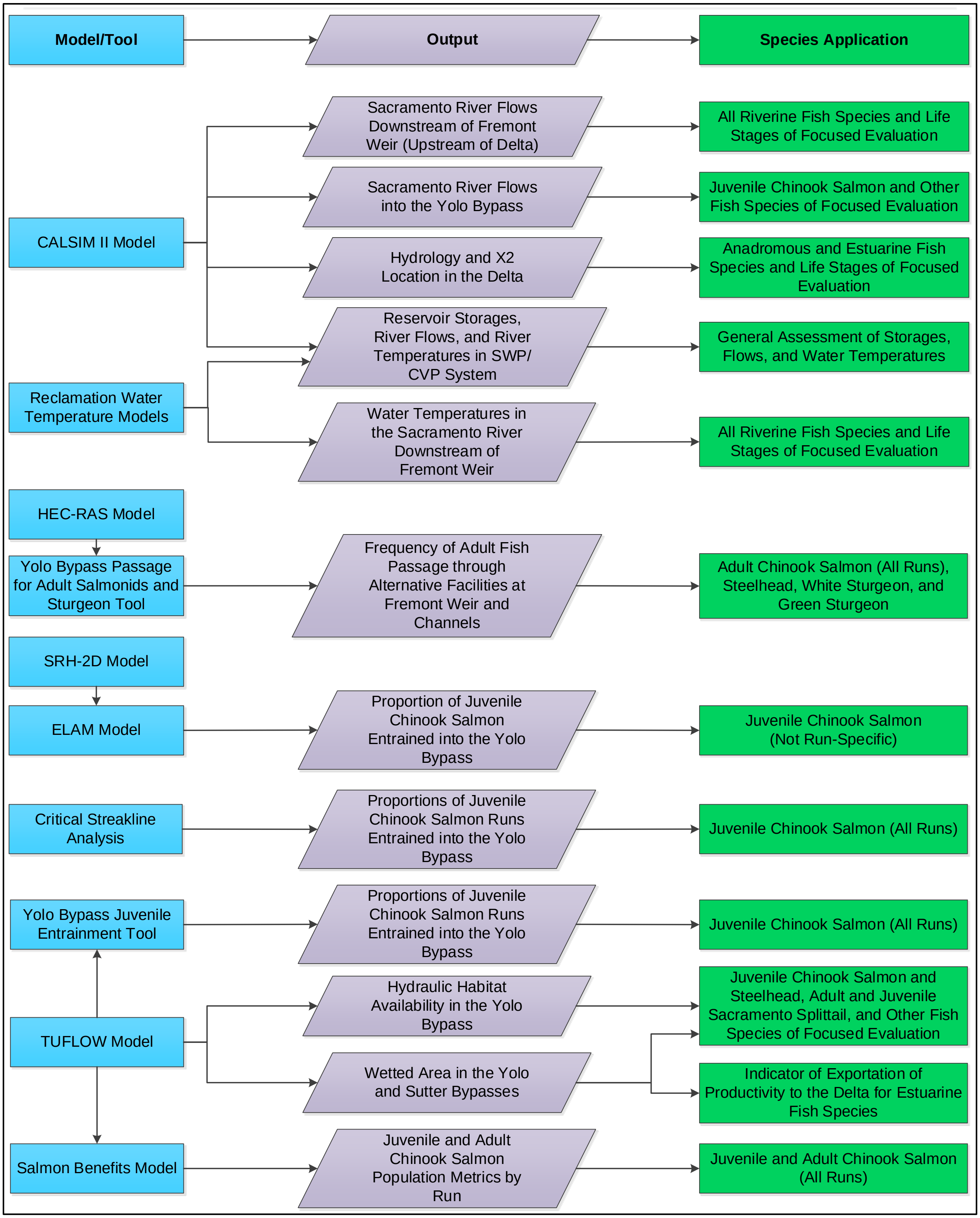


Figure 8-4. Linkages between Models/Tools, Outputs, and Species Evaluations

As suggested by previous environmental documents, a change of 10 percent or more was selected because it is assumed to be high enough to reveal a potentially significant change to a condition while a lesser amount of change could be due to errors or uncertainties in the various analytical and modeling techniques. Therefore, a change of 10 percent provides a conservative qualitative basis to evaluate whether adverse effects to sensitive species at the population level could occur (SWRCB 2016).

Because it is not expected that changes in flows under relatively high-flow conditions would adversely affect fish species of focused evaluation in the lower Sacramento River, this impact assessment specifically evaluated changes during low-flow conditions (e.g., flows for critical and dry water year types). This is consistent with previous environmental documents, such as SWRCB (2016), which determined that flow reductions of 10 percent or more over the highest 50 percent distribution of flows would not adversely affect anadromous salmonids or other fish species of focused evaluation. Recent and current hydrologic modeling of the SWP/CVP included an 82-year period of record for evaluation (water years 1922 to 2003) of which 30 years (37 percent) are classified as dry or critical according to the Sacramento Valley (40-30-30)[9] Index. Recent regulatory and environmental documents evaluating fisheries in the Central Valley, including the Reclamation (2008) biological assessment on the continued long-term operations of the SWP and CVP and the NMFS BO (NMFS 2009) on the long-term operations of the SWP and CVP evaluated flows and/or fisheries indicators of potential impact by water year type. In accordance with the selected flow criteria described above, a change in flow generally encompassing dry and critical conditions (i.e., the lowest 40 percent of monthly flows over the flow exceedance probability distributions) of 10 percent or greater under an alternative, relative to the basis of comparison, was used as an indicator of potential impact. Specifically, net changes in flow of 10 percent or more were calculated to determine if flow increases by 10 percent or more with higher frequency or if flow decreases by 10 percent or more with higher frequency (i.e., the percentage of the time that flow increases by 10 percent or more minus the percentage of time that flow decreases by 10 percent or more). The net change in flow of 10 percent or more was evaluated monthly for the lowest 40 percent of the distribution of monthly flows.

Riverine Water Temperatures

The Lead Agencies developed monthly water temperature exceedance distributions (or curves) from Reclamation's monthly water temperature model output for the entire simulation period for the Sacramento River at Freeport to identify whether simulated water temperatures would exhibit substantial differences under the alternatives relative to the basis of comparison. In general, water temperature exceedance distributions represent the probability, as a percentage of time, that modeled water temperature values would be met or exceeded at a specific location during a certain period. Monthly water temperature exceedance distributions were compared under the alternatives relative to the basis of comparison in the lower Sacramento River to determine whether potential impacts to fish species of focused evaluation may occur. An initial evaluation was conducted by comparing the differences in the probability of exceeding water temperature index values for fish species of focused evaluation, including Chinook salmon, steelhead, green sturgeon, white sturgeon, and Pacific and river lamprey, under the alternatives relative to the

[9] 40-30-30 refers to the coefficients used in the calculation of the index (i.e., 0.4*Current April-July runoff + 0.3*Current October-March runoff + 0.3*Previous Year's Index)

basis of comparison. Water temperature index values evaluated and supporting information are provided by Sites Project Authority and Bureau of Reclamation (2017). More detailed evaluations would be conducted for this impact assessment if substantial differences in water temperatures would be expected to occur at other locations in the SWP/CVP system under an alternative relative to the basis of comparison.

Potentially substantial changes in water temperature suitability were identified based on changes in the frequency of exceeding species and life stage-specific water temperature index values of 10 percent or more under an alternative relative to a basis of comparison. A change in frequency of exceedance of 10 percent was assumed to be high enough to reveal the potential for a substantial change yet minimizes the potential for identifying a change due to error or uncertainty in the analytical methodologies and modeling (SWRCB 2016).

Delta Hydrologic and Water Quality Conditions

CALSIM II was used to simulate mean monthly hydrologic and water quality conditions in the Delta to assess species and life stage-specific impacts under the alternatives relative to the basis of comparison. Parameters modeled included flows at Rio Vista, Delta outflow, X2 location, water temperature at Freeport, and Old and Middle River (OMR) flows. Modeled variables were evaluated using probability of exceedance distributions to compare the frequency with which modeled conditions were within ranges of life stage-specific suitabilities or exceeded thresholds of life stage-specific suitability previously identified by regulatory agencies or in scientific studies (e.g., SWRCB 2010), as applied by Sites Project Authority and Bureau of Reclamation (2017). The following modeled parameters were evaluated for particular life stages of fish species of focused evaluation expected to occur in the Delta:

- Delta smelt (adult, egg, larval, and juvenile life stages)
  - Water temperature, X2 location, OMR flows, and Delta outflow
- Longfin smelt (adult and larval/juvenile life stages)
  - OMR flows, X2 location
- Chinook salmon (juvenile life stage; all Central Valley runs)
  - OMR flows, Delta outflow, Rio Vista flows
- Chinook salmon (San Joaquin River Basin adults)
  - OMR flows
- Steelhead (juvenile life stage)
  - OMR flows, Delta outflow, Rio Vista flows
- Striped bass and American shad (egg and larval life stages)
  - X2 location

Potentially substantial changes in Delta flows were identified based on changes in flow of 10 percent or more occurring 10 percent or more of the time during a month (based on the monthly flow exceedance distributions). Changes in average monthly flow of 10 percent or more over the entire simulation period and by water year type also were considered potentially substantial changes under an alternative relative to the basis of comparison.

In addition to evaluating the Delta parameters above, an assessment was conducted to determine whether the alternatives could cause substantial changes in fish salvage and entrainment at the Skinner Fish Protection Facility (part of the SWP) and the Tracy Fish Collection Facility (part of the CVP) by comparing mean monthly total water export volumes from the SWP and CVP export facilities relative to the basis of comparison. More detailed evaluation of fish salvage and entrainment loss for fish species of focused evaluation would be conducted if substantial (i.e., greater than 10 percent) changes in average monthly exports over the entire simulation period and by water year type would occur under an alternative, relative to the basis of comparison.

Juvenile Entrainment into the Yolo Bypass

A key objective of the Project is to increase the entrainment of juvenile Chinook salmon into the Yolo Bypass. Multiple methods were applied by the Lead Agencies to assess and evaluate the proportion of emigrating juvenile Chinook salmon that could be entrained into the Yolo Bypass associated with different Fremont Weir notch configurations and different notch flow capacities, as described below. The proportion of flow approach was the only methodology used to estimate juvenile Chinook salmon entrainment into the Yolo Bypass in the SBM.

Proportion of Flow Approach

One method to estimate entrainment of juvenile fish into the Yolo Bypass was to assume that juveniles are equally distributed across the wetted channel and throughout the water column in the Sacramento River at Fremont Weir; therefore, juveniles would enter the Yolo Bypass at Fremont Weir in proportion to the total volume of flow passing through and over Fremont Weir (DWR 2017a; Appendix G3). Similar dispersion assumptions have been used to evaluate juvenile salmon entrainment into the central Delta using particle tracking (Kimmerer and Nobriga 2008). However, it should be noted that tagged juvenile hatchery late fall-run and winter-run Chinook salmon exhibited a non-uniform distribution within the channel near Fremont Weir, with a tendency to use area along the outer bend more frequently than the inner bend (Steel et al. 2016).

DWR (2017a) used the proportion of flow approach to estimate the daily and seasonal average annual proportion of juvenile Chinook salmon by run entrained onto the Yolo Bypass for each alternative. Under the proportion of flow approach, Alternatives 1, 2, and 3 were assumed to entrain the same proportion or number of juvenile Chinook salmon because they have the same flow capacity (6,000 cfs) and are designed to function and entrain the same volume of water at a given Sacramento River stage (DWR 2017a; Appendix G3). Although this method does not account for behavior of juvenile salmonids (or potentially variable behaviors of different size classes at different flows), it provides a consistent methodology for comparing potential differences in entrainment of juvenile salmonids, including smaller juveniles (i.e., <80 mm FL), into the Yolo Bypass. The SBM and the Juvenile Entrainment Evaluation Tool both utilized this methodology to estimate the proportion and number of juvenile Chinook salmon entrained into the Yolo Bypass.

ELAM

The Lead Agencies used simulated 2D hydraulics as inputs to the ELAM to estimate entrainment of juvenile Chinook salmon into the Yolo Bypass under each of the six alternatives (see Appendix 1 of Smith et al. 2017). Estimates of entrainment percentages for each alternative were made over a range of Sacramento River stages at Fremont Weir (20.23 to 28.83 feet), which correspond to Sacramento River flows ranging from 14,952 to 24,640 cfs at Fremont Weir (Appendix G1). For the purposes of this impact assessment, ELAM simulation results were used to inform the relative difference in proportion of juvenile Chinook salmon expected to be entrained through the alternative-specific notch configurations at specific modeled flows. ELAM was not used as an input to the SBM to simulate population metrics.

Critical Streakline Analysis

The critical streakline analysis was performed for six scenarios corresponding to different alternative notches and variations of the alternatives (Blake et al. 2017; Appendix G2). Scenarios modeled were intended to represent Alternative 3 (Scenario 1), Alternative 4 (Scenario 2), and Alternative 6 (Scenario 3). No scenarios were modeled near the central or eastern portions of Fremont Weir corresponding to the proposed locations of Alternatives 1, 2, and 5. Therefore, relative differences in estimated entrainment rates were compared among the notch configurations of Alternatives 3, 4, and 6. The Critical Streakline Analysis was not used as an input to the SBM to simulate population metrics.

Flow-Dependent Habitat Availability

Flow-dependent habitat availability refers to the quantity and quality of habitat available to individual species and life stages for a particular flow. The project objectives include improving access to and area of seasonal floodplain fisheries habitat for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead. Improving access to and area of floodplain habitat also could improve conditions for Sacramento splittail and Central Valley fall-run/late fall-run Chinook salmon. Therefore, this impact assessment evaluates changes in hydraulic (i.e., water depth and velocity) habitat availability for these species. It should be recognized that the suitability of floodplain habitat for a given species and life stage may be affected by factors other than water depth and velocity, including substrate type, the presence and type of instream cover, food resources, water temperature, dissolved oxygen levels, and predation from and competition with other aquatic species. Therefore, the modeled areas of hydraulic habitat availability may overestimate actual habitat availability.

Because there is relatively more information and modeling available for Chinook salmon, and because improving habitat conditions for juvenile Chinook salmon is a key objective of the Project, modeled hydraulic habitat availability for juvenile Chinook salmon was used as a surrogate for hydraulic habitat availability for other fish species and life stages with similar habitat suitability criteria (described below).

Chinook Salmon

Habitat suitability criteria for Sacramento River juvenile Chinook salmon (USFWS 2005) were used to define suitable floodplain rearing habitat for fry (<70 mm FL) and smolts (≥70 mm FL) in the SBM (Hinkelman et al. 2017). Suitable habitat for fry (or pre-smolts) was characterized as 0.39 to 4.0 feet deep, with velocities less than 1.6 ft/s, and for smolts as 0.39 to 8.0 feet deep, with velocities less than 1.6 ft/s (USFWS 2005). This impact assessment compared the period of record average and average by water year type daily hydraulic habitat availability for the pre-smolt and smolt life stages in the Yolo Bypass for winter-run, spring-run, fall-run, and late fall-run Chinook salmon under the alternatives relative to the basis of comparison. Due to the potential masking effect of comparing average values, this impact assessment also compared daily hydraulic habitat availability values over the entire period of record (using probability of exceedance distributions) for each Chinook salmon run and juvenile life stage (pre-smolt and smolt) under the alternatives relative to the basis of comparison. Consistent with previous environmental documentation (e.g., SWRCB 2016), changes in area of potential habitat of 10 percent or more were identified under the alternatives relative to the basis of comparison.

Steelhead

Juvenile steelhead are not as likely to utilize floodplain habitat in the Yolo Bypass to the extent of juvenile Chinook salmon. However, CDFW stranding surveys in northern Yolo Bypass scour pools and swales found that juvenile steelhead was the most abundant fish species encountered in 2017 (CDFW 2017c). In other surveys, juvenile steelhead caught in the Yolo Bypass were smolt-sized (DWR unpublished data). Because steelhead smolts can likely utilize similar ranges of depths and velocities as Chinook salmon smolts on the Yolo Bypass, the relative difference in modeled hydraulic habitat availability for Chinook salmon smolts was used as an indicator for evaluating differences in hydraulic habitat availability for juvenile steelhead.

Sacramento Splittail

Based on information and studies on Sacramento splittail (Moyle et al. 2004; Sommer et al. 2002; Moyle et al. 2007; Young and Cech 1996; Feyrer et al. 2005; Sommer et al. 2008b), Merced Irrigation District (2013) developed consensus-based habitat suitability curves for juvenile and spawning adult Sacramento splittail in consultation with NMFS, USFWS, and CDFW. For juveniles, depths corresponding to optimal suitability (i.e., a Habitat Suitability Index of 1.0) ranged from 0.5 to 3.0 feet, and velocities corresponding to optimal suitability ranged from zero to about 1.4 ft/s. For adult spawning, depths corresponding to optimal suitability ranged from 1.0 to 6.0 feet, and velocities corresponding to optimal suitability ranged from 0.4 to 1.37.

Because the ranges of depths and velocities corresponding to optimal suitability for juvenile Sacramento splittail are similar to those used to define Chinook salmon pre-smolt hydraulic habitat availability (i.e., 0.39 to 4.0 feet; <1.6 ft/s), relative differences in modeled hydraulic habitat availability for Chinook salmon pre-smolts were used as an indicator for evaluating relative differences in hydraulic habitat availability for juvenile Sacramento splittail. Because the ranges of depths and velocities corresponding to optimal suitability for adult spawning Sacramento splittail are similar to those used to define Chinook salmon smolt hydraulic habitat availability (i.e., 0.39 to 8.0 feet; <1.6 ft/s), relative differences in modeled hydraulic habitat availability for Chinook salmon smolts were used as an indicator for evaluating differences in hydraulic habitat availability for adult spawning Sacramento splittail.

Other Fish Species of Focused Evaluation

Although the alternatives are not expected to substantially affect hydraulic habitat availability for fish species other than those described above, potential changes in hydraulic habitat availability were assessed for other fish species of focused evaluation. As an indicator of potential change in habitat availability, changes in modeled hydraulic habitat availability for Chinook salmon pre-smolts and smolts, and changes in modeled wetted area (i.e., the area with a water depth greater than zero) would encompass the range of potential changes in hydraulic habitat availability for the other fish species of focused evaluation that may occur in the Yolo Bypass. As an indicator of a potentially substantial difference in hydraulic habitat availability, changes in area of potential habitat of 10 percent or more were identified under the alternatives relative to the basis of comparison using probability of exceedance distributions over the entire simulation period and averages over the entire simulation period and by water year type.

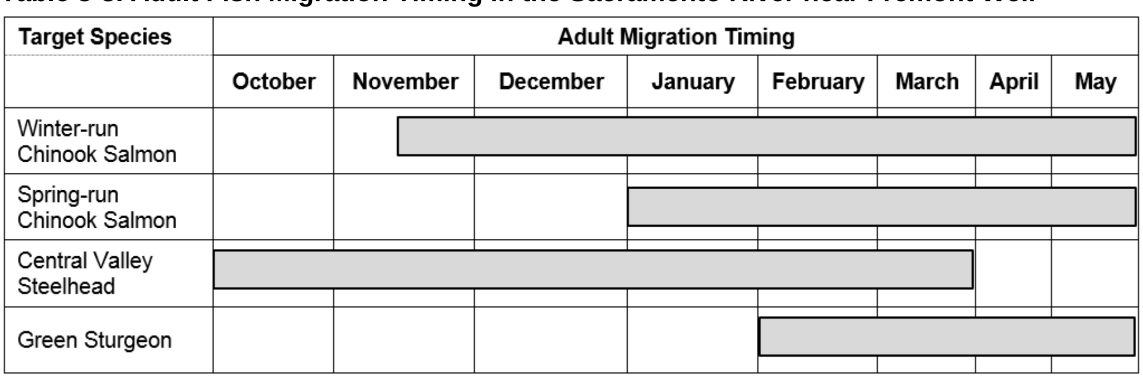
Sutter Bypass Inundation

Because the Alternatives would result in increased flows entering the Yolo Bypass from the Sacramento River at Fremont Weir at reduced Sacramento River flows, the alternatives could result in some reduction in wetted extent and duration in the area of the Sutter Bypass north of the Sacramento River at Fremont Weir. The TUFLOW model extent includes the Sutter Bypass north of the Sacramento River at Fremont Weir upstream to the area just south of where East Canal/Nelson Slough cross the Sutter Bypass. Therefore, changes in the number of days when this area of the Sutter Bypass would be wetted under the alternatives was compared relative to Existing Conditions as an indicator of changes in hydraulic habitat availability for fish species of focused evaluation.

Adult Fish Passage through the Yolo Bypass

Adult fish passage at the Fremont Weir for the target fish species (i.e., winter-run Chinook salmon, spring-run Chinook salmon, steelhead, and green sturgeon) was evaluated over the expected migration periods in the Yolo Bypass (Table 8-3) (DWR 2017b; Appendix G5).

Table 8-3. Adult Fish Migration Timing in the Sacramento River near Fremont Weir



Source: DWR 2017b; Appendix G5

Based on these migration timings, the target fish species could be present near Fremont Weir from October through May. However, the Fremont Weir notch gates are not proposed to be operational in October and May under the alternatives. In addition, because flow conditions at Fremont Weir are generally too low to allow for fish migration between the Sacramento River and the Yolo Bypass (DWR 2017b; Appendix G5) and because project operations are unlikely to affect flow conditions at Fremont Weir during May, the evaluation period selected for adult fish passage at Fremont Weir extends from November through April.

The YBPASS Tool analyzes adult fish passage potential under two different operational ranges due to differences in operations between the November 1 through March 15 period and the March 16 through April 30 period. During the November 1 through March 15 period, the gated notch would be potentially in operation to allow flow through Fremont Weir up to the alternative-specific capacity. During the March 16 through April 30 period, most alternatives would allow for flows up to the available Tule Canal capacity (about 300 cfs) to pass through the gated notch to continue to allow for fish passage through the gated notch and transport channel without increasing inundation of the Yolo Bypass (DWR 2017b; Appendix G5).

The YBPASS Tool incorporates adult fish passage criteria for depth, velocity, and width for anadromous salmonids and sturgeon, including a minimum of three feet of depth at fish passage structures (i.e., gated notch/short channel transitions) and five feet of depth in project channels greater than or equal to 60 feet long (i.e., transport channels) to facilitate sturgeon passage (DWR 2017b; Appendix G5). Although adult anadromous salmonids can migrate through shallower depths (e.g., one foot), meeting the sturgeon passage depth criteria is expected to provide a positive behavioral response for both sturgeon and salmonids, which are likely to avoid shallow channels (DWR 2017b; Appendix G5). Velocity criteria also differ among target species. To avoid passage impedance due to excessive velocities for both adult salmonids and sturgeon, the FETT (2015, as cited in DWR 2017b) recommended a maximum velocity criterion of six ft/s at fish passage structures and four ft/s in project channels greater than or equal to 60 feet long. The width criterion applied for fish passage structures and channels was based on allowing sturgeon to make a complete directional change within the structure or channel. Therefore, a minimum width of 10 feet was used to evaluate the width of the gated notch and the downstream transport channel for each alternative (DWR 2017b; Appendix G5).

To compare adult fish passage performance among alternatives, the YBPASS tool relies on modeled velocity and depth from the HEC-RAS modeling that was developed to inform the dimensions of the proposed alternatives. For each alternative, water depth and velocity were measured as a function of the invert elevation at the weir, the bottom width, and the side slopes. HEC-RAS modeling determined corresponding channel configurations necessary to achieve the proposed discharge rates, and velocities were determined by modeling upstream and downstream water surface elevations associated with the alternatives (DWR 2017b; Appendix G5).

As described by DWR (2017a), to determine the operational range for each alternative, the TUFLOW-modeled stage must meet the minimum depth criterion and not exceed the maximum velocity criterion established for adult fish passage. The minimum stage input for depth represents the lower threshold for passage, and the maximum stage input for velocity represents the upper threshold for passage. If the stage input for depth is greater than the stage input for velocity, the depth criterion for passage is not met before the velocity criterion is exceeded. This results in an inoperable range for fish passage. In addition, if the stage input for velocity is greater than the stage input for discharge, the discharge criterion supersedes the velocity criterion. Therefore, stage inputs for depth, velocity, and discharge correspond to an operational fish passage window for each alternative.

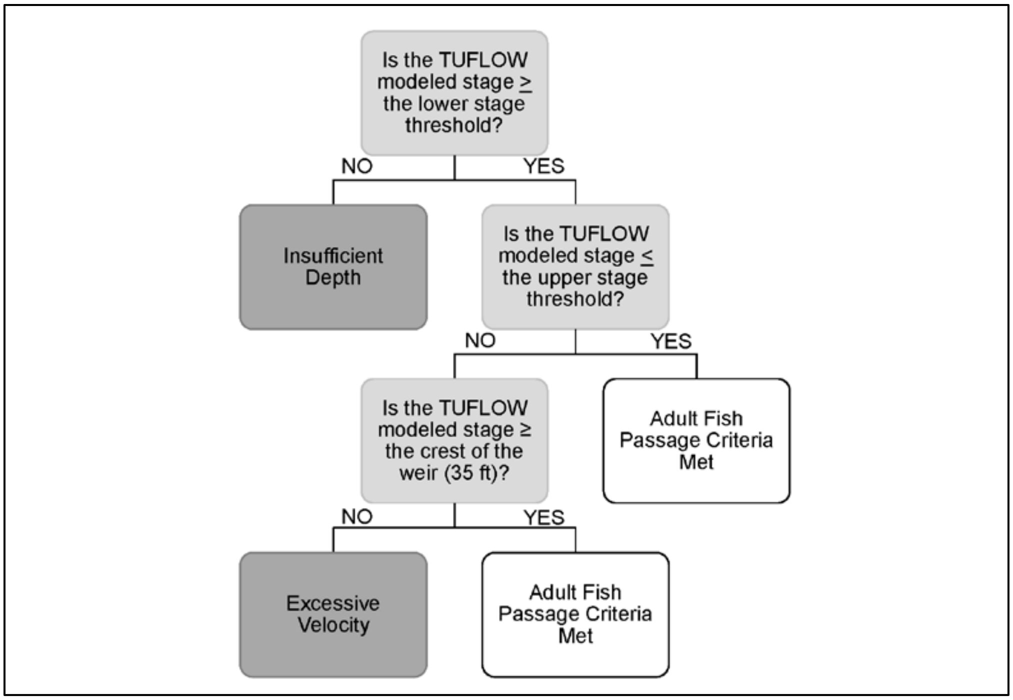
However, operational ranges exist for each component of an alternative, including the gated notch, transport channel, and benches (if included). To consolidate the ranges into one operational range for all components of an alternative, ranges must overlap. In other words, the transport channel's operational range is limited by the gated notch. Flows that exit the gated notch cannot exceed the criterion for the transport channel without causing a delay in passage. If benches are proposed, operational ranges must be within the operational range of the gated notch to meet criteria for passage. By overlapping the operational ranges, the alternative would have one operational range for the gated notch and transport channel. If benches are proposed, an additional operational range for benches can exist if it falls within the operational range of the gated notch. If a gap is present between the operational ranges for the transport channel and bench(es), passage delay is attributed to the TUFLOW-modeled stage exceeding the velocity criterion (DWR 2017b; Appendix G5).

Alternatives 1 through 4 were modeled using HEC-RAS to determine the operational range for adult fish passage through the gated notch, transport channel, and bench (DWR 2017b; Appendix G5). The operational range corresponds to passage windows for the transport channel and bench. For Alternatives 5 and 6, HEC-RAS modeling determined the operational ranges for the gated notch and transport channel. The upper stage threshold of the operational ranges (November 1 through March 15) for Alternatives 1, 2, and 6 do not include the maximum stage input for the design discharge because the stage input for the design discharge exceeded the stage input for the velocity criterion. Alternative 6 does not have an operational range after March 15 due to a velocity barrier once stage reaches the lower stage threshold for fish passage. Therefore, when the Alternative 6 TUFLOW-modeled stage is less than 21.12 feet, depth is a barrier to passage, and when the modeled stage is greater than or equal to 21.12 feet, velocity is a barrier to passage (DWR 2017b; Appendix G5).

For each water year, the effects of both depth and velocity criteria on adult fish passage were evaluated to determine their individual and combined impact on passage. Compliance with depth and velocity criteria was determined through a series of if-then statements as summarized in Appendix G5 (Figure 8-5).

For each alternative, data were summarized for each water year to include the number of days depth caused a barrier to passage, the number of days velocity caused a barrier to passage, the number of days and percent of season the alternative met the criteria, and the last date the alternative met the criteria. Each summary statistic was averaged across water years and includes standard deviation.

In addition to the evaluation of fish passage at the gated notches and transport channels for each alternative, a similar evaluation also was conducted specifically for Alternative 4, which includes two water control structures in the Tule Canal and a sturgeon bypass channel constructed around each of the water control structures. Evaluation of adult fish passage through the bypass channels and at the water control structures was conducted qualitatively.



Source: DWR 2017b; Appendix G5

Figure 8-5. Schematic Diagram Depicting YBPASS Tool's Series of If-Then Statements used to Determine Adult Fish Passage through Project Alternatives

In addition to assessment of fish passage hydraulic (depth and velocity) criteria, this impact assessment also considers guidelines identified in the California Salmonid Stream Habitat Restoration Manual (Flosi et al. 2010) and other literature regarding potential impacts of alternative-specific structures and channels on adult fish passage and other life stages in the Yolo Bypass.

Viable Salmonid Population Parameters

The viable salmonid population (VSP) concept (McElhany et al. 2000) was developed as a conceptual framework for use in assessing salmonid population viability and ESU viability to facilitate establishment of ESU-level delisting goals and assist in recovery planning. The VSP framework identifies four key parameters related to population viability, including: 1) abundance, 2) productivity, 3) diversity, and 4) spatial structure. Because the SBM simulates habitat use and population-related metrics, the VSP parameters serve as a useful framework for presenting and describing changes in the SBM metrics under the alternatives relative to Existing Conditions.

Abundance (i.e., population size of a given life stage) and trends in abundance reflect extinction risk—small populations are generally at greater risk of extinction than large populations (McElhaney et al. 2000). Productivity over the entire life cycle (i.e., population growth rate), life stage-to-life stage-specific productivity (e.g., abundance of outmigrant juveniles relative to the number of spawning adults), and factors that affect productivity provide information on how well a population is "performing" in the habitats occupied during the life cycle of the species

(McElhaney et al. 2000). Diversity reflects the various life histories, sizes, ages, fecundity, run timing, and other traits expressed by individuals within a population and the genetic variation that allows a species to use a variety of environments, respond to short-term changes in the environment, and survive long-term environmental change (McElhaney et al. 2000). Spatial structure refers to the distribution of individuals in a population of a given life stage among the potentially available habitats and associated habitat-forming processes (McElhaney et al. 2000).

The SBM provides simulated output that was used in this impact assessment to qualitatively evaluate changes in the VSP parameters for Chinook salmon species and runs under the alternatives relative to Existing Conditions, as further described below. Population parameters were compared using period of record average and average by water year type tables and probability of exceedance distributions over the entire simulation period. Potentially substantial changes in VSP parameters were identified based on changes of 10 percent or more under a Project Alternative relative to Existing Conditions. Potentially substantial changes also were identified based on changes of 10 percent or more over the exceedance distributions under a Project Alternative relative to Existing Conditions. Changes in VSP parameters based on the average values and over the exceedance distributions of 5 percent or less were considered to be similar under a Project Alternative relative to Existing Conditions.

Abundance and Productivity

Spawner abundance measured over time (e.g., abundance over multiple generations) is the most fundamental population viability metric (NMFS 2016d). Productivity is calculated as the trend in abundance over time. Therefore, productivity is an indicator of a population’s performance in response to its environment, and environmental change and variability. Because the SBM simulates changes in adult returns under the alternatives over a 15-year simulation period, potential changes in abundance and productivity of winter-run, spring-run, fall-run, and late fall-run Chinook salmon were qualitatively evaluated in this impact assessment under the alternatives relative to Existing Conditions. It is important to note that the SBM does not account for juvenile migration pathway through the Delta. Juvenile salmonids migrating from the Sacramento River into the Delta have a higher likelihood of entering the central and south Delta relative to juveniles migrating through the Yolo Bypass. Juvenile salmonids that enter the central and south Delta have higher potential for entrainment at the SWP and CVP pumping facilities (e.g., NMFS 2009). Therefore potential changes in future adult returns associated with juvenile migration pathway through the Delta also were considered in this evaluation.

Diversity

The broad array of juvenile Chinook salmon life history types observed in the Yolo Bypass relative to the Delta suggest that the Yolo Bypass supports a greater diversity of migratory phenotypes and could play a role augmenting the juvenile life history portfolio for the larger Central Valley Chinook salmon population (Takata et al. 2017). For example, fry, parr, and smolt migratory stages were consistently observed emigrating from the Yolo Bypass floodplain, whereas unmarked (i.e., intact adipose fin) juvenile Chinook salmon outmigrants in the Delta are often dominated by fry and smolt-sized juveniles (Takata et al. 2017). Therefore, increasing the entrainment of juveniles onto the Yolo Bypass may support the diversity and resilience of Chinook salmon populations.

The SBM simulates annual changes in variation of size (length) of juvenile Chinook salmon and variation in estuary (Chipps Island) entry timing over a 15-year simulation period. Therefore, simulated change in size variation and estuary entry timing were used as indicators of increases in phenotypic diversity for winter-run, spring-run, fall-run, and late fall-run Chinook salmon under the alternatives relative to Existing Conditions.

Spatial Structure

Spatial structure encompasses the geographic distribution of a population as well as the processes that generate or affect that distribution (McElhaney et al. 2000). Spatial structure depends fundamentally on habitat quality, spatial configuration, dynamics, and the dispersal characteristics of individuals in the population (McElhaney et al. 2000). Because the SBM allows for evaluating the annual number of emigrating juveniles that reared on the Yolo Bypass, the annual number of juveniles rearing on the Yolo Bypass was used as an indicator of changes in spatial structure for juvenile winter-run, spring-run, fall-run, and late fall-run Chinook salmon under the alternatives relative to Existing Conditions.

SWP/CVP System

As indicators of potential changes in fisheries habitat conditions in Shasta, Oroville, Folsom, and San Luis reservoirs and in the upper Sacramento, lower Feather, and lower American rivers, simulated changes in end-of-month storages in Shasta, Oroville, Folsom, and San Luis reservoirs were evaluated under the alternatives relative to the basis of comparison. If substantial (i.e., greater than 10 percent) changes in average end-of-month reservoir storage occur or if reductions in end-of-month storage of 10 percent or more occur over 10 percent or more of the simulation period, then more detailed evaluations would be conducted to assess potential impacts on fish species of focused evaluation in the applicable reservoirs and downstream rivers. It is assumed that relatively minor changes in reservoir storage would not substantially impact coldwater or warmwater fisheries habitat conditions or substantially affect instream flows or water temperatures downstream of the reservoir, particularly outside of the period of April through November.

The focus of this impact assessment was on fish species targeted by the project objectives—winter-run Chinook salmon, spring-run Chinook salmon, steelhead, and green sturgeon. However, this impact assessment also addresses the other fish species of focused evaluation with the potential to occur in the project area, with emphasis on species and life stages most likely to occur in the Yolo Bypass and the lower Sacramento River during periods when the alternatives would generally impact them. Construction-related impacts would occur from April through October, operations-related impacts would occur primarily from November through March or April, and maintenance-related impacts could potentially occur year-round. Species-specific spatial and temporal distributions and relative use of the project area used to inform this impact assessment are summarized in Section 8.1.2.

8.3.2 Significance Threshold – CEQA

The thresholds of significance for impacts are based on the environmental checklist in Appendix G to the State CEQA Guidelines, as amended, and were modified based on thresholds used for other projects and conservation plans in the region (e.g., the Bay Delta Conservation

Plan/California WaterFix). These thresholds also encompass the factors considered under NEPA to determine the significance of an action in terms of its context and the intensity of its impacts. An impact resulting from the implementation of an alternative would be significant if it would:

- Have a substantial adverse effect, either directly or through habitat modifications, on any fish species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the CDFW, the USFWS, or NMFS. An effect would be substantial if it would result in a substantial permanent reduction in area and quality of suitable habitat for special-status fish species.
- Interfere substantially with the movement of any native resident or migratory fish species.
- Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan.

8.3.3 Effects and Mitigation Measures

This section provides an evaluation of the direct and indirect effects on fisheries and aquatic resources associated with implementing the Project alternatives. This evaluation is organized by Project alternative, with specific impact topics numbered sequentially under each alternative.

The operations-related impact determinations described below apply to each Alternative under the existing LOD relative to Existing Conditions as well as to each alternative under the future LOD relative to the No Action Alternative.

The quantitative modeling described below represents each alternative under the existing LOD relative to Existing Conditions because all modeling conducted for the Project is available for this comparison. Only mean monthly flow (using CalSim II) and mean monthly water temperature (using Reclamation water temperature models) modeling were conducted for the alternatives under the future LOD and the No Action Alternative. However, potential changes to fisheries habitat conditions under each alternative under the future LOD relative to the No Action Alternative would be similar to the changes described for each alternative under the existing LOD relative to Existing Conditions. Although the frequency and/or magnitude of spills into the Yolo Bypass from the Sacramento River would increase more often from December through March under the future LOD scenarios relative to the existing LOD scenarios, the assumptions under each Alternative with an existing LOD are the same as the assumptions used for the Existing Conditions scenario (with the exception of the Project), and the assumptions used for each Alternative with a future LOD are the same as the assumptions used in the No Action Alternative scenario (with the exception of the Project). Therefore, relative differences described for each Alternative under the existing LOD relative to Existing Conditions would be similar to the relative differences expected to occur under each Alternative under the future LOD relative to the No Action Alternative.

8.3.3.1 No Action Alternative

Both NEPA and CEQA require the evaluation of a No Action or No Project Alternative, which presents the reasonably foreseeable future conditions in the absence of the project. As previously discussed (see Chapter 2, *Description of Alternatives*), for the purposes of this EIS/EIR, the CEQA No Project Alternative and NEPA No Action Alternative are represented as the same scenario, referred to hereafter as the No Action Alternative.

Under the No Action Alternative, no construction activities would occur to increase seasonal floodplain inundation in the lower Sacramento River Basin or improve fish passage throughout the Yolo Bypass. The Yolo Bypass would continue to be inundated when Sacramento River levels overtop Fremont Weir. Juvenile fish would continue to enter the Yolo Bypass only when Sacramento River flows overtop the Fremont Weir. Continued stranding and mortality of adult green sturgeon and white sturgeon would occur in the Yolo Bypass after cessation of overtopping events of the Fremont Weir. CDFW rescue operations may continue, but rescued sturgeon would still undergo considerable stress and potential injury during capture, which may result in delays in spawning migrations and reduced spawning opportunities. Moreover, green sturgeon and white sturgeon have been shown to abort spawning migrations after rescue (CDFW, unpublished data).

The No Action Alternative assumes reasonably foreseeable actions that could occur in the project area in the future and do not rely on approval or implementation of the action alternatives, including actions with current authorization, secured funding for design and construction, and environmental permitting and compliance activities that are substantially complete. These reasonably foreseeable actions, in addition to changes in regulatory conditions and water supply demands, would result in differences in flows on the Sacramento River and in the Delta under the No Action Alternative. Possible changes include the following:

- Sea level rise and climate change
- Implementation of the California WaterFix
- Full implementation of the Grassland Bypass Project
- Implementation of the South Bay aqueduct improvement and enlargement project
- San Joaquin River Restoration Program Full Restoration Flows

8.3.3.1.1 Construction- and Maintenance-related Impacts – Evaluation of Substantial Adverse Effects on Fish Species of Focused Evaluation and their Habitat and Movement

Impacts FISH-1 through FISH-8: Potential Disturbance to Fish Species or their Habitat from Construction and Maintenance Activities due to 1) Erosion, Sedimentation, and Turbidity; 2) Hazardous Materials and Chemical Spills; 3) Aquatic Habitat Modification; 4) Hydrostatic Pressure Waves, Noise, and Vibration; 5) Stranding and Entrainment; 6) Predation Risk; 7) Fish Passage; or 8) Direct Harm

No construction- or maintenance-related impacts would occur under the No Action Alternative relative to Existing Conditions on aquatic resources and fisheries. Therefore, there would be no impacts related to: 1) erosion, sedimentation, and turbidity; 2) hazardous materials and chemical spills; 3) aquatic habitat modification; 4) hydrostatic pressure waves, noise, and vibration; 5) stranding and entrainment; 6) predation risk; 7) fish passage; or 8) direct harm associated with construction-related activities or ongoing maintenance-related activities.

CEQA Conclusion

The No Action Alternative would result in no change to fisheries and aquatic resources in the study area relative to Existing Conditions, would not substantially adversely affect any fish species of focused evaluation or their habitat, and would not interfere with the movement of any native resident or migratory fish species. Therefore, the No Action Alternative would have **no impact**.

8.3.3.1.2 Operations-related Impacts – Evaluation of Substantial Adverse Effects on Fish Species of Focused Evaluation and their Habitat and Movement

Operations-related impacts under the No Action Alternative were evaluated for the Yolo Bypass as well as for the Sacramento River downstream of Fremont Weir, the Delta and downstream habitats, and the SWP/CVP system. Modeling results indicate that mean monthly flows spilling into the Yolo Bypass from the Sacramento River at Fremont Weir under the No Action Alternative relative to Existing Conditions indicate that flows would be lower in November, substantially higher (i.e., higher by 10 percent or more) more often from December through March, and similar under both scenarios over the remainder of the year (see Appendix G6). Increases in flows entering the Yolo Bypass from the Sacramento River primarily would be due to increases in flows from the Sutter Bypass and Feather River. Overall, it is expected that juvenile salmonids and potentially other fish species would be more likely to be entrained into the Yolo Bypass during the winter months under the No Action Alternative. Overall impacts of the No Action Alternative in relation to the impact discussions below were generally evaluated by Reclamation and DWR (2015).

Impact FISH-9: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Flows in the Sacramento River

Modeling results indicate that average monthly flows in the Sacramento River downstream of Fremont Weir would be lower in April and May and from July through November; higher from January through March and June; and generally similar in December under the No Action Alternative relative to Existing Conditions (see Appendix G6). During relatively low-flow conditions (i.e., lowest 40 percent of flows over the cumulative monthly probability of exceedance distributions), net increases in flow of 10 percent or more would occur in October, June, and August, whereas net decreases in flow of 10 percent or more would occur in November, July, and September (see Appendix G6). Changes in mean monthly flows under the No Action Alternative relative to Existing Conditions primarily would be due to implementation of California WaterFix, assumptions related to future climate change and water demands under the future level of development.

CEQA Conclusion

The No Action Alternative would result in substantial hydrologic changes in the study area relative to Existing Conditions; therefore, the No Action Alternative could have a **significant impact**. However, mitigation is not applicable to the No Action Alternative.

Impact FISH-10: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Water Temperatures in the Sacramento River

Comparison of simulated mean monthly water temperatures in the Sacramento River at Freeport to species and life stage-specific water temperature index values indicates that water temperature conditions would be substantially less suitable due to increases in water temperature in October, April, May, and September for most of the applicable migration and rearing life stages of fish species of focused evaluation (see Appendix G7).

CEQA Conclusion

The No Action Alternative would result in substantial changes to water temperatures relative to Existing Conditions; therefore, the No Action Alternative could potentially have a **significant impact**. However, mitigation is not applicable to the No Action Alternative.

Impact FISH-11: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Delta Hydrologic and Water Quality Conditions

Evaluation of simulated mean monthly Delta hydrologic and water quality parameters with respect to species and life stage-specific time periods indicates that habitat conditions in the Delta would be substantially more suitable for some life stages during some months and substantially less suitable during other months.

CEQA Conclusion

The No Action Alternative would result in substantial changes to habitat conditions for fish species of focused evaluation in the Delta and potentially downstream areas relative to Existing Conditions; therefore, the No Action Alternative could potentially have a **significant impact**. However, mitigation is not applicable to the No Action Alternative.

Impact FISH-12: Impacts to Fisheries Habitat Conditions due to Changes in Flow-Dependent Habitat Availability in the Study Area (Yolo Bypass/Sutter Bypass)

Modeling results indicate that flows entering the Yolo Bypass from the Sacramento River at Fremont Weir would substantially increase more often from December through March. The simulated increase in flows in the Sacramento River at Fremont Weir is primarily from the Feather River and Sutter Bypass. Therefore, inundation extent and/or duration of the Yolo Bypass and Sutter Bypass would increase during these months, potentially providing for increased hydraulic habitat availability for fish species of focused evaluation, particularly juvenile salmonids and adult and juvenile Sacramento splittail. Overall impacts of the No Action Alternative are generally evaluated by Reclamation and DWR (2015).

CEQA Conclusion

Based on increased mean monthly flows entering the Yolo Bypass, greater extent and/or duration of inundation of the Yolo Bypass under the No Action Alternative is expected to result in more suitable habitat conditions for fish species of focused evaluation in the Yolo Bypass; therefore, the No Action Alternative could potentially have a **beneficial impact**.

Impact FISH-13: Impacts to Fisheries Habitat Conditions due to Changes in Water Quality in the Study Area

Modeling results indicate that flows entering the Yolo Bypass from the Sacramento River at Fremont Weir would substantially increase more often from December through March. Therefore, increased flows and the potential for increased wetting and drying of the Yolo Bypass could increase the amount of methylmercury and other contaminants in the Yolo Bypass and in fish prey. Increased concentrations of contaminants in the Yolo Bypass could result in an increase in the exportation of contaminated water to the Delta. However, for juvenile Chinook salmon rearing in the Yolo Bypass, increased concentrations of accumulated methylmercury were reported to be insignificant in the tissues of the eventual adult-sized fish (Henery et al. 2010). Effects of increased methylmercury accumulation could be more substantial on resident fish species such as largemouth bass. Overall impacts of the No Action Alternative on the Yolo Bypass are generally evaluated by Reclamation and DWR (2015).

CEQA Conclusion

Based on higher mean monthly flows entering the Yolo Bypass, increased concentrations of methylmercury and other contaminants may occur in the Yolo Bypass and the Delta. However, the potential for increased concentrations of contaminants is not expected to substantially affect fish species of focused evaluation; therefore, the No Action Alternative would have a **less than significant impact**.

Impact FISH-14: Impacts to Aquatic Primary and Secondary Production in the Study Area

Modeling results indicate that the No Action Alternative would result in increased flows through the Sutter and Yolo bypasses relative to Existing Conditions. An increase in frequency and duration of inundation of shallow-water habitat in the Yolo Bypass would be expected to increase primary production in the Sutter and Yolo bypasses (Lehman et al. 2007). Increased primary and associated secondary production could potentially be exported to the Delta downstream of the Yolo Bypass.

CEQA Conclusion

Based on higher mean monthly flows entering the bypasses, increased primary and secondary production may occur, which could increase prey resources for fish species of focused evaluation; therefore, the No Action Alternative would have a **beneficial impact**.

Impact FISH-15: Impacts to Fish Species of Focused Evaluation due to Changes in Adult Fish Passage Conditions through the Yolo Bypass

Modeling results indicate that flows entering the Yolo Bypass from the Sacramento River at Fremont Weir would substantially increase more often from December through March. As shown in the Appendix E discussion of the California Water Commission (CWC) scenarios used as the basis for this project’s modeling, differences in flow under the No Action Alternative relative to Existing Conditions is based on changes in future flow patterns due to climate change, sea level rise, and implementation of the reasonably foreseeable projects). Therefore, the duration of potential adult fish passage from the Yolo Bypass into the Sacramento River could potentially increase for fall/late fall-run Chinook salmon, spring-run Chinook salmon, winter-run Chinook salmon, steelhead, green and white sturgeon, and Pacific and river lamprey, which could provide for increased spawning opportunities in the Sacramento River Basin and reduced potential for mortality or migration delay in the Yolo Bypass. The potential for increased hydraulic connectivity of the west-side streams (e.g., Putah Creek) in the Yolo Bypass could improve migration conditions for anadromous fish species entering and emigrating from these creeks. In addition, under the No Action Alternative, the Fremont Weir Adult Fish Passage Modification Project would be implemented, which would improve passage of the adult life stage of fish species of focused evaluation from the Yolo Bypass into the Sacramento River at Fremont Weir.

Increased flows entering the Delta from the Yolo Bypass under the No Action Alternative relative to Existing Conditions could potentially result in increased straying of anadromous adult fish native to watersheds outside of the upper Sacramento River Basin (e.g., from the American River, Feather River and Butte Creek watersheds), which could result in hybridization and associated genetic effects to anadromous fish populations in the Sacramento River Basin upstream of Fremont Weir. However, as described in Section 8.1.4.2.1, flow rates downstream of the Yolo Bypass in Cache Slough are highly variable and include large and rapid increases in flow under Existing Conditions during the December through March period. Therefore, the increase in flows in the Yolo Bypass under the No Action Alternative is not expected to have a substantial impact on attraction of anadromous fish into Cache Slough relative to Existing Conditions. In addition, populations of most anadromous fish species of focused evaluation with known population structure are restricted to, or primarily spawn in, the Sacramento River Basin upstream of Fremont Weir, including winter-run Chinook salmon, green sturgeon and white sturgeon (see Section 8.1.2.2). Substantial increases in adult steelhead from outside of the upper Sacramento River Basin straying into the Yolo Bypass are not expected due to the infrequent observations of adult steelhead in the Yolo Bypass (see Section 8.1.2.2). Substantial increases in adult spring-run Chinook salmon from outside the upper Sacramento River Basin straying into the Yolo Bypass also are not expected because adult Chinook salmon have primarily been observed migrating upstream in the Yolo Bypass during October through December, outside of the spring-run Chinook salmon adult migration period (mid-February through July; peaking during May) (see Section 8.1.2.2). Although increased straying of adult fall-run Chinook salmon from outside of the upper Sacramento River Basin could occur, Central Valley fall-run Chinook salmon populations have been determined to be relatively homogenous with high rates of gene flow between tributaries (Garza et al. 2008).

CEQA Conclusion

Increased duration of potential adult fish passage opportunity from the Yolo Bypass into the Sacramento River under the No Action Alternative is expected to result in improved upstream spawning opportunities and less potential for mortality or migration delay for fish species of focused evaluation; therefore, the No Action Alternative could potentially have a **beneficial impact**.

Impact FISH-16: Impacts to Fish Species due to Changes in Potential for Stranding and Entrainment

The No Action Alternative would not include the construction of any facilities that would alter the potential for stranding or entrainment of fish species of focused evaluation. Overall impacts of the No Action Alternative are generally evaluated by Reclamation and DWR (2015).

CEQA Conclusion

No changes in the potential for fish stranding or entrainment are expected under the No Action Alternative relative to existing conditions; therefore, the No Action Alternative would be expected to have a **less than significant impact**.

Impact FISH-17: Impacts to Fish Species due to Changes in Potential for Predation and Competition

The No Action Alternative would not include the construction of any facilities that would alter the potential for predation of fish species of focused evaluation. Increased flows into the Yolo Bypass under the No Action Alternative during December through March could reduce the potential for predation of fish species such as juvenile salmonids by non-native fish species. For example, Sommer et al. (2014) found that increased connectivity to the Yolo Bypass would provide an overall benefit to native fish species, particularly during the winter, because it is prior to the spawning periods of non-native fish species in the spring. Frantzich et al. (2013) found that native fish species were more widely distributed during wetter years, and low flows may provide more suitable conditions for the spawning and recruitment of non-native centrarchids. Increased flows during February and March could increase habitat availability for non-native cyprinids, such as common carp and goldfish, which could result in increased competition for food resources with fish species of focused evaluation. However, because increased primary and associated secondary production in the Yolo Bypass would likely increase food resources for fish species of focused evaluation in the Yolo Bypass and downstream (see Impact FISH-14), increased habitat for non-native cyprinids is not expected to substantially affect fish species of focused evaluation in the Yolo Bypass or in the Delta. Increased water temperatures during April and May in the Sacramento River (see *Impact FISH-10*, above) indicate the potential for increased thermal suitability for predator and competitor fish species, which could result in increased predation of, and competition with, fish species of focused evaluation.

Overall, Opperman et al. (2017) argued that flooding the Yolo Bypass from January through April would benefit native fish species. Overall impacts of the No Action Alternative are generally evaluated by Reclamation and DWR (2015).

CEQA Conclusion

Substantial changes in the potential for predation of, and competition with, fish species of focused evaluation are not expected under the No Action Alternative relative to Existing Conditions; therefore, the No Action Alternative would be expected to have a **less than significant impact**.

Impact FISH-18: Impacts to Chinook Salmon Species/Runs due to Changes in Viable Salmonid Population Parameters

Because the No Action Alternative could improve habitat conditions for juvenile Chinook salmon in the Yolo Bypass, VSP parameters, including abundance, productivity, diversity, and spatial structure, may potentially be improved for Sacramento River Chinook salmon species. However, passage of adult and juvenile fish between the Yolo Bypass and the Sacramento River would still be dependent on existing hydrologic conditions (i.e., Sacramento River stage relative to Fremont Weir). In addition, highly variable changes in habitat conditions in the lower Sacramento River and Delta may result in a combination of positive and negative impacts to fish species of focused evaluation in these areas under the No Action Alternative. Overall, it is not expected that the No Action Alternative would substantially affect Chinook salmon VSP parameters. Overall impacts of the No Action Alternative are generally evaluated by Reclamation and DWR (2015).

CEQA Conclusion

Potential changes in VSP parameters for Chinook salmon spawning in the Sacramento River Watershed are not expected to be substantially affected under the No Action Alternative relative to Existing Conditions; therefore, the No Action Alternative would be expected to have a **less than significant impact**.

Impact FISH-19: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Hydrologic Conditions in the SWP/CVP System

Simulated mean monthly storages in Trinity, Shasta, Oroville, and Folsom reservoirs indicate that storage would be lower or substantially lower (i.e., lower by 10 percent or more) during most months of the year. Therefore, reservoir and instream habitat conditions in the Sacramento, Feather, and American rivers may be substantially changed under the No Action Alternative relative to Existing Conditions. Mean monthly storage in San Luis Reservoir would be lower during portions of the fall and winter and higher or substantially higher more often from late winter through summer. Both warmwater and coldwater fisheries habitat conditions in San Luis Reservoir likely would be similar or more suitable under the No Action Alternative relative to Existing Conditions. Overall impacts of the No Action Alternative are generally evaluated by Reclamation and DWR (2015).

CEQA Conclusion

Due to substantial changes in mean monthly storages in the North-of-Delta SWP/CVP reservoirs, fisheries habitat conditions in the reservoirs and instream habitat conditions below the reservoirs may be changed under the No Action Alternative relative to Existing Conditions; therefore, the No Action Alternative could potentially have a **significant impact**. However, mitigation is not applicable to the No Action Alternative.

Impact FISH-20: Conflict with Adopted Habitat Conservation Plan; Natural Community Conservation Plan; or Other Approved Local, Regional, or State Habitat Conservation Plan

Although the Yolo County HCP/NCCP does not directly address fish species, it does include goals and policies related to protecting and improving habitat conditions in the Yolo Bypass, which could indirectly benefit fish resources (Yolo Habitat Conservancy 2017). Because projects assumed to potentially occur under the No Action Alternative would be expected to mitigate for any significant impacts to fisheries and aquatic resources in the study area, it is not expected that the No Action Alternative would conflict with HCPs, NCCPs, or other relevant habitat conservation plans. This impact consideration is addressed for vegetation, wetlands and wildlife resources in Chapter 9 under Impact TERR-11 for each Alternative.

CEQA Conclusion

The No Action Alternative is expected to have a **less than significant impact** relative to Existing Conditions.

8.3.3.2 Alternative 1: East Side Gated Notch

Alternative 1, East Side Gated Notch, would allow increased flow from the Sacramento River to enter the Yolo Bypass through a gated notch on the east side of Fremont Weir. The invert of the new notch would be at an elevation of 14 feet, which is approximately 18 feet below the existing Fremont Weir crest. Alternative 1 would allow up to 6,000 cfs to flow through the notch during periods when the river levels are not high enough to go over the crest of Fremont Weir to provide open channel flow for adult fish passage. See Section 2.4 for more details on the alternative features.

Therefore, the operations-related (as well as construction- and maintenance-related) impact determinations identified below would be the same for Alternative 1 relative to the No Action Alternative.

8.3.3.2.1 Construction- and Maintenance-related Impacts – Evaluation of Substantial Adverse Effects on Fish Species of Focused Evaluation and their Habitat and Movement

Construction of Alternative 1 would likely begin in 2020 or early 2021 and is estimated to last 28 weeks. All project components are expected to be completed in one season (April 15 through November 1). Construction of the components of Alternative 1 would begin with the demolition of a portion of the existing concrete Fremont Weir.

Maintenance-related activities would include sediment removal within and near the intake facilities; vegetation removal in the intake channel; inspection and maintenance of the headworks facilities; and maintenance of the transport, intake, and outlet channels.

Impact FISH-1: Potential Disturbance to Fish Species or their Habitat due to Erosion, Sedimentation, and Turbidity

Increased erosion in the Sacramento River and the Yolo Bypass could potentially occur during construction activities associated with Alternative 1 during the construction period of mid-April through October, whereas maintenance activities would primarily occur during the dry season. Construction activities with the potential to increase erosion or sedimentation include grading and excavation activities; use of staging, storage, and disposal areas; and construction-related traffic on access routes. The estimated excess amount of spoils to be excavated during construction would be about 266,000 cubic yards (CY). The estimated additional annual amount of sediment removal required in the area between Fremont Weir and Agricultural Road Crossing 1 due to increased flows into the Yolo Bypass under Alternative 1 is 37,800 CY. This corresponds to an estimated total annual amount of sediment removal required of 334,350 CY under Alternative 1 relative to 296,550 CY under Existing Conditions. However, local deposition patterns would depend on the specific design of downstream facilities.

Increased erosion also could occur indirectly due to removal of vegetation associated with construction activities along the Sacramento River and in the Yolo Bypass. Increased erosion could increase sedimentation and siltation, resulting in increased turbidity in the Sacramento River and in the Tule Canal or other waterways in the Yolo Bypass as well as in downstream waterbodies. The magnitude of potential impacts on fish would be dependent upon the timing and extent of sediment loading, flow conditions in the Sacramento River, and inundation or saturation of the Yolo Bypass during and immediately following construction. Excavation activities conducted under "wet" conditions would be expected to increase localized turbidity in the Yolo Bypass and the Sacramento River, which would occur from late May through early July.

In addition to potential sedimentation and turbidity within the construction footprint, there is the potential for increased sedimentation and turbidity to occur in waterbodies near the sediment disposal site.

Although most fish are highly migratory and capable of moving freely throughout the study area, a sudden localized increase in turbidity may potentially affect some juvenile fish by temporarily disrupting normal behaviors that are essential to growth and survival such as feeding, sheltering, and migrating. Behavioral avoidance of turbid waters may be one of the most important effects of suspended sediments on salmonids (Birtwell et al. 1984; DeVore et al. 1980; Scannell 1988). Salmonids have been observed moving laterally and downstream to avoid turbidity plumes (Lloyd 1987; McLeay et al. 1984; Scannell 1988; Servizi and Martens 1991; Sigler et al. 1984). Juvenile salmonids tend to avoid streams that are chronically turbid, such as glacial streams or those disturbed by human activities, except when the fish need to traverse these streams along migration routes. Additional turbidity-related effects associated with behavioral alteration include disruption of feeding behaviors, which increases the likelihood that individual fish would face increased competition for food and space and experience reduced growth rates or possibly weight loss. Potential turbidity increases also may affect the sheltering abilities of some juvenile salmonids and may decrease their likelihood of survival by increasing their susceptibility to predation. Newly emerged salmonid fry could be particularly vulnerable to even moderate amounts of turbidity (Bjornn and Reiser 1991).

Although fish species of focused evaluation could be temporarily adversely affected physiologically or due to avoidance of preferred habitats, implementation of Mitigation Measure MM-WQ-2: Implement a Stormwater Pollution and Prevention Plan and MM-WQ-3: Develop turbidity monitoring program would be expected to minimize the potential for substantial adverse effects to fish species and their habitats. MM-WQ-2 would include measures related to timing of construction, stabilization of grading spoils, site stabilization, staging materials, minimizing soil and vegetation disturbance, and installation of sediment barriers (see Chapter 6 for more information). MM-WQ-3 would include the development and implementation of a turbidity sampling plan to ensure that turbidity limits are not exceeded during construction activities (see Chapter 6 for more information).

CEQA Conclusion

Erosion, sedimentation, and turbidity impacts would be **significant** because construction and maintenance activities would result in temporary increases in sedimentation and turbidity in the Sacramento River and the Yolo Bypass and could temporarily adversely affect all fish species of focused evaluation.

Development and implementation of Mitigation Measure MM-WQ-2: Implement a Stormwater Pollution and Prevention Plan and Mitigation Measure MM-WQ-3: Develop Turbidity Monitoring Program would reduce this impact to **less than significant**.

Impact FISH-2: Potential Disturbance to Fish Species or their Habitat due to Hazardous Materials and Chemical Spills

Construction- and maintenance-related activities have the potential to result in the release of hazardous materials or chemicals into adjacent aquatic habitats or waterbodies, including the Tule Canal and other waterbodies in the Yolo Bypass and the Sacramento River. The accidental release of contaminants into the environment could occur anytime during the construction period of April 15 through October and, although with lesser probability, during other times of the year when future maintenance-related activities are required. Activities with the highest likelihood of introducing contaminants into the environment would include excavation and construction activities in wet conditions from late May through early July in the Yolo Bypass and the Sacramento River.

Accidental discharge of hazardous materials and chemicals could potentially affect fish that may be present in the immediate vicinity and downstream of the construction area by increasing physiological stress, altering primary and secondary production, causing direct mortality, and reducing biodiversity.

Although contaminants could be accidentally released into aquatic habitats during construction- and maintenance-related activities and adversely affect fish species of focused evaluation, implementation of Mitigation Measure MM-WQ-1: Prepare and Implement a Spill Prevention, Control, and Countermeasure Plan is expected to minimize the potential for any chemical spills or seepage to occur. For example, the plan will specify that all maintenance materials (i.e., oils, grease, lubricants, antifreeze and similar materials) will be stored away from construction activities at offsite staging or storage areas and all construction vehicles and equipment will have regular maintenance performed to ensure they are in working order throughout the construction period.

CEQA Conclusion

Hazardous materials and chemical spills impacts would be **significant** because construction and maintenance activities could potentially result in the release of contaminants to aquatic habitats in the Sacramento River and the Yolo Bypass and could adversely affect all fish species of focused evaluation.

Development and implementation of Mitigation Measure MM-WQ-1: Prepare and Implement a Spill Prevention, Control, and Countermeasure Plan would reduce this impact to **less than significant**.

Impact FISH-3: Potential Disturbance to Fish Species or their Habitat due to Aquatic Habitat Modification

Ground-disturbing activities within the Yolo Bypass would have the potential to disturb floodplain vegetation, substrate, and the hyporheic zone (i.e., area where there is mixing of surface water and groundwater). Removal and disturbance of aquatic and riparian vegetation also would occur along the Sacramento River near the intake channel and headworks facility and in the Yolo Bypass near the outlet and transport channels. Potential effects on fish species of focused evaluation and aquatic habitat could include reduced refuge for fry and juveniles, altered macroinvertebrate production, altered biodiversity, altered exchange of nutrients between surface and subsurface waters and between aquatic and terrestrial ecosystems, and reduced potential for benthic invertebrate re-colonization of disturbed substrates.

Construction of the intake channels and other alternative elements could potentially require the removal of SRA and IWM from the Sacramento River channel and the Yolo Bypass floodplain, potentially reducing native fish refugia from predators and high flows and causing reductions in pool-forming structures and sediment and organic matter storage capacity. IWM is important to healthy riverine ecosystems and may be the most important structural component promoting stable fisheries resources. Because IWM has a key role in maintaining habitat complexity and refugia, potential loss of IWM could reduce available habitat quantity and quality.

Existing bank slope and substrate conditions in the affected areas adjacent to the Sacramento River for constructing the temporary cofferdam, headworks facility, and the intake channel would be primarily altered through grading activities and the placement of rock along the length of the intake channel from the Sacramento River to the headworks facility. The placement of rock along the lengths of the outlet and transport channels also would alter existing substrate conditions in the Yolo Bypass. The use of rock revetment in streams has been shown to affect natural river processes and functions through the following mechanisms (USFWS 2004):

- Halting new accretion of point bars and other deposition areas where riparian vegetation can colonize
- Halting meander migration which, over time, reduces habitat renewal, diversity, and complexity
- Incising the thalweg of the river adjacent to the rock revetment-lined area
- Filling in sloughs, tributary channels, and oxbow lake areas, causing loss of nearby wetland habitat and diversity
- Limiting lateral mobility of the channel, potentially reducing habitat complexity, including small backwaters and eddies
- Decreasing near shore roughness, causing stream velocity to increase at a high rate with increasing discharge, potentially causing accelerated erosion of earthen banks downstream

- Reducing the contribution of allochthonous material to the stream by inhibiting plant growth adjacent to the stream
- Reducing recruitment of IWM to the stream system, potentially resulting in a range of negative effects

Preliminary estimates based on calculations in ArcGIS indicate that a total of 28.9 acres (temporary impacts) and 47.1 acres (permanent impacts) of vegetated area would have the potential to be disturbed during Alternative 1 construction activities. Specifically, this includes 7.1 acres (temporary impacts) and 16.0 acres (permanent impacts) of riparian vegetation, which provides a potential source of IWM inputs to the Sacramento River or Yolo Bypass (Table 8-4 and Figure 8-6).

Table 8-4. Vegetation Communities Potentially Affected by Construction of Alternative 1

Vegetation Community					
	Grassland	Freshwater Aquatic Vegetation	Freshwater Emergent Marsh	Riparian Forest/Woodland	Total
Acres (Temporary)	17.9	0.9	3.0	7.1	28.9
Acres (Permanent)	19.3	3.1	8.7	16.0	47.1

CEQA Conclusion

Aquatic habitat modification adjacent to the Sacramento River and in the Yolo Bypass associated with construction and maintenance activities would be **significant** because aquatic and riparian habitat would be permanently affected. Although the temporary and permanent removal of riparian and aquatic habitat could adversely affect habitat availability and suitability for fish species of focused evaluation, particularly juvenile salmonids, temporarily affected habitats would be restored, including planting and seeding the aquatic and upland areas with plant species found in areas of suitable habitat on the Project site through implementation of Mitigation Measure MM-TERR-13: Restore Temporarily Disturbed Giant Garter Snake Aquatic and Upland Habitat. In addition, for areas of SRA habitat that are permanently removed, replacement of those habitats in adjacent areas would be conducted according to a restoration plan to be implemented after construction is completed as part of Mitigation Measure MM-FISH-1: Restore Degraded Riparian and SRA Habitat.

Mitigation Measure MM–FISH-1: Restore Degraded Riparian and SRA Habitat

As mitigation for loss of riparian and SRA habitat, degraded habitat would be restored or preserved to provide riparian and/or SRA habitat at or near the areas affected by construction of the intake facilities. If sufficient suitable area is not available near the Project Area, then offsite mitigation options will be pursued. Proposed restoration activities would include re-vegetation with native riparian species to provide SRA and/or riparian habitat that would provide instream or overhead cover for fish species of focused evaluation. As a component of SRA habitat, riparian tree species, such as alders, cottonwoods, and willows, would be planted. In addition to habitat restoration actions, due to the importance of IWM to juvenile fishes in the Sacramento River (USFWS 2000), any IWM that is moved or altered by construction or maintenance activities would stay on site or be replaced with a functional equivalent to the extent practicable. The specific restoration activities and mitigation ratios would depend on considerations that are not known at this time, including the location and environmental setting of the location where the restoration will occur or if offsite mitigation options are pursued. However, monitoring of restoration actions would be conducted for a specified number of years per the Mitigation Monitoring and Reporting Program (MMRP) to ensure that restored habitat is functioning as intended, and is able to provide the same or increased areal extent of SRA habitat of the same or higher quality than the SRA habitat which was degraded or removed.

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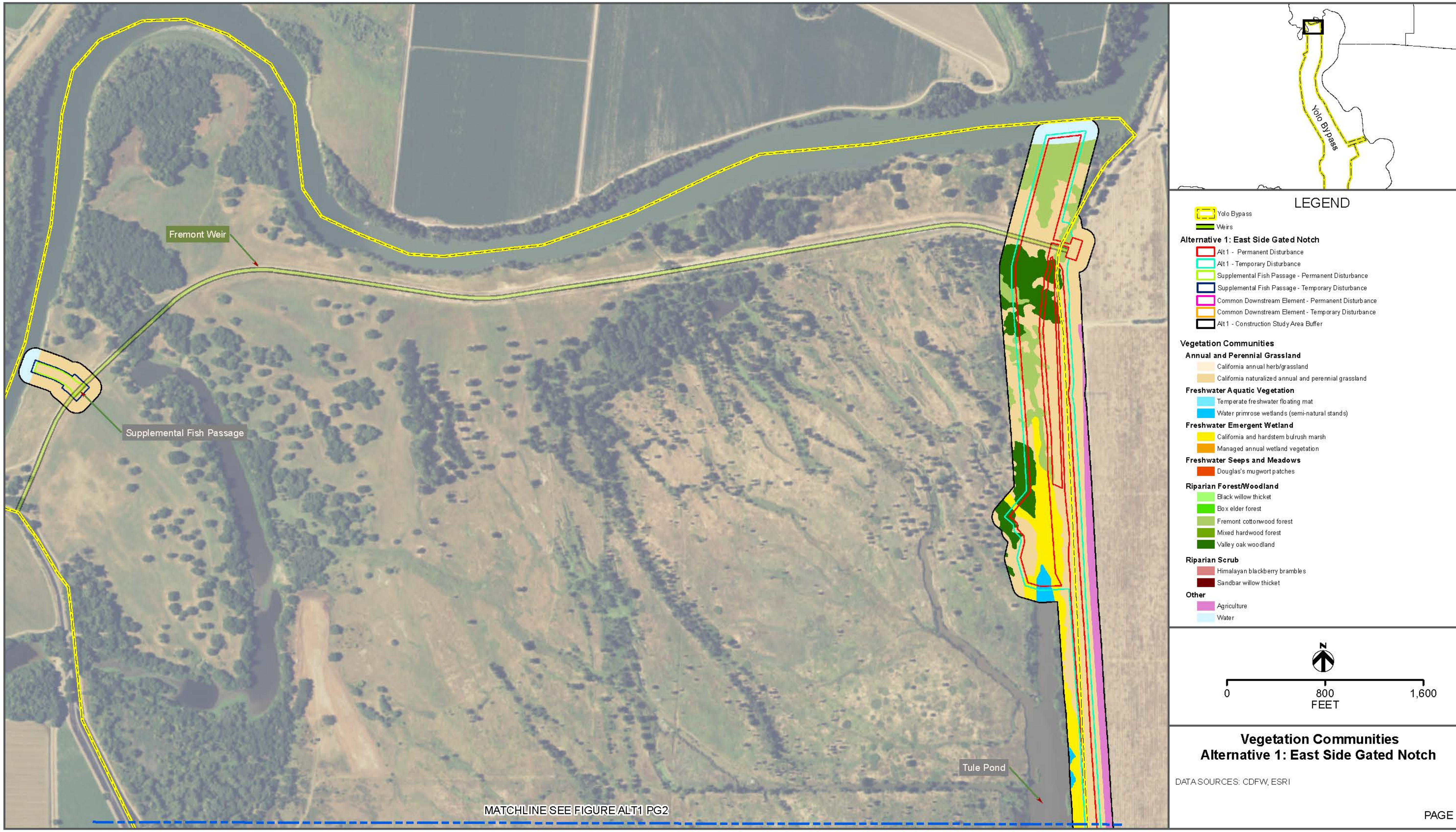

Figure 8-6a. Vegetation Communities Potentially Affected by Construction of Alternative 1.

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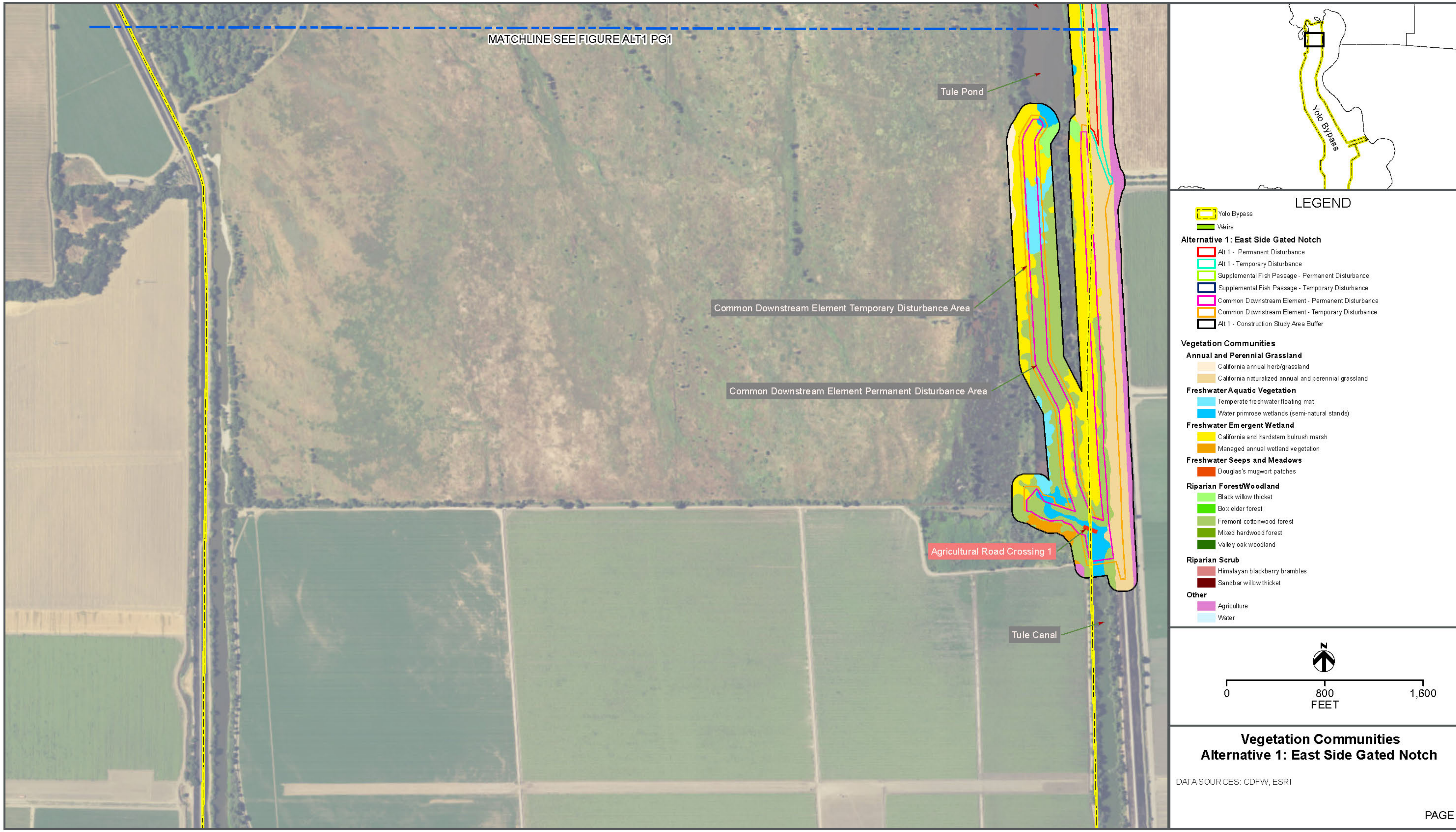

Figure 8-6b. Vegetation Communities Potentially Affected by Construction of Alternative 1.

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Implementation of Mitigation Measures MM-TERR-13, MM-TERR-11 and MM-FISH-1 would reduce this impact to **less than significant**.

Impact FISH-4: Potential Disturbance to Fish Species or their Habitat due to Hydrostatic Pressure Waves, Noise, and Vibration

Alternative 1 would include pile driving to construct the headworks structure foundation and a temporary cofferdam around the headworks structure. Pile driving for the headworks structure would occur after the completion and dewatering of the temporary cofferdam such that the construction would be completed within the "dry" confines of the cofferdam.

Hydrostatic pressure waves and vibration generated by disturbance activities reportedly adversely affect all life stages of fish (NOAA 2016). Other studies (Fitch and Young 1948; Teleki and Chamberlain 1978; Yeleverton et al. 1975) suggest that adverse effects to fish resulting from hydrostatic pressure waves and vibration primarily are a function of species morphology and species physiology. Hydrostatic pressure waves could potentially rupture the swim bladders and other internal organs of all life stages of fish in the immediate construction area (NOAA 2016). Although understanding effects from pile-driving activities on fish is evolving, it remains problematic. There is evidence that lethal effects can occur from pile driving, but accurately analyzing and addressing these impacts as well as sublethal impacts (e.g., injury, temporary hearing threshold shifts, stress, and behavioral disturbance) is complicated by several factors. Sound levels and particle motion produced from pile driving can vary, depending on pile type, pile size, substrate composition, and type of equipment used.

The California Department of Transportation (Caltrans), in coordination with the Federal Highway Administration and the Departments of Transportation in Oregon and Washington established a Fisheries Hydroacoustic Working Group (FHWG) to improve and coordinate information on fishery impacts resulting from underwater sound pressure caused by in-water pile driving (Caltrans 2015). The FHWG also includes representatives from NMFS, USFWS, CDFW, and the USACE. In 2008, the FHWG developed an agreement on interim sound pressure criteria for injury to fish associated with pile driving. The criteria identify sound pressure levels of a peak of 206 decibels (dB) for all fish sizes, an accumulated sound exposure level (SEL) of 187 dB for fish larger than 2 grams, and an accumulated SEL of 183 dB for fish less than 2 grams (FHWG 2008). Although recent research summarized in Popper et al. (2014) suggested that cumulative SEL thresholds for fish injury may be well above 200 dB, until there is broad agreement on the use of higher thresholds, the thresholds from FHWG (2008) should be used (Caltrans 2015). These interim injury criteria identified in FHWG (2008) are considered to be protective of listed fish species (Caltrans 2015). It is important to recognize that these criteria were developed for impact pile driving only; they do not apply to vibratory pile driving or any other sound-generating activities (Caltrans 2015). The injury thresholds for impact pile driving are likely to be much lower than the injury thresholds for non-impulsive, continuous sounds produced by vibratory pile drivers (Caltrans 2015). Vibratory pile driving has been utilized in place of impact pile driving to minimize adverse effects on fish and other aquatic organisms (USFWS 2017).

Cofferdams that have been dewatered down to the mud line substantially reduce underwater pile driving sound, and although underwater noise cannot be eliminated due to energy transmitted through the ground, pile driving in a dewatered cofferdam is the best method for isolating underwater noise (Caltrans 2015). Therefore, sound pressure waves generated from construction activities within the confines of the cofferdam are expected to be attenuated to levels below which fish would be adversely affected.

Pile driving to construct the temporary cofferdam would be conducted over an approximate 3-week period in May and could occur in the “wet” (i.e., when the construction area is wetted) in the Sacramento River.

The cofferdam likely would be installed by driving interlocking sheet piles into the existing Fremont Weir with a pile driver, beginning at the upstream end of the cofferdam area and proceeding downstream until the cofferdam is complete. Based on existing information, it is expected that sheet pilings would be vibrated into place during construction of the cofferdam to minimize underwater pressure waves and subsequent impacts on fish. Specifically, if sheet pilings are vibrated into place during construction of the cofferdam, it is expected that resultant sound pressure waves would remain below the levels that would result in mortality or physical injury to fish (Caltrans 2015).

Construction and maintenance equipment noise sources, such as heavy diesel equipment (e.g., backhoes, graders, pavers, cranes), other earth-moving equipment, and stationary sources (e.g., compressors and generators), are not expected to produce sound pressure waves of sufficient magnitude to adversely impact fish species near construction and maintenance activities.

CEQA Conclusion

Impacts associated with construction noise would be **less than significant** if a vibratory pile driver can be used for the entire construction of the cofferdam. However, impacts associated with noise would be **significant** if impact pile driving was conducted in the Sacramento River, resulting in direct potential impacts to fish species of focused evaluation. If an impact pile driver is necessary to construct the cofferdam in the wet, Mitigation Measure MM-FISH-2: Implement an Underwater Noise Reduction and Monitoring Plan would be implemented to reduce the underwater noise, such as placing a bubble curtain system underwater.

Mitigation Measure MM-FISH-2: Implement an Underwater Noise Reduction and Monitoring Plan with Measures to Reduce Underwater Noise to Below Thresholds

If an impact pile driver is necessary to construct the cofferdam in the wet, mitigation measures would be implemented to reduce the underwater noise, such as placing a bubble curtain system underwater. This mitigation measure would also include underwater sound monitoring during impact pile-driving activities to minimize the potential for sound levels to exceed those which may adversely affect fish. Because both juvenile and adult life stages of fish species of focused evaluation may be present during pile driving in the Sacramento River, underwater noise thresholds to be applied include a peak level of 206 dB and an accumulated SEL of 183 dB (FHWG 2008).

Implementation of Mitigation Measure MM-FISH-2: Implement an Underwater Noise Reduction and Monitoring Plan would reduce this impact to **less than significant**.

Impact FISH-5: Potential Disturbance to Fish Species or their Habitat due to Stranding and Entrainment

Construction of the headworks structures adjacent to the Sacramento River could require dewatering of a temporary cofferdam, which may reportedly cause harm, injury, and mortality to fish species of focused evaluation by confining them to areas of increased water temperature, decreased dissolved oxygen concentration, and predation (Cushman 1985). Dewatering of channels in the Yolo Bypass and the Tule Pond associated with construction of facilities in the Yolo Bypass also could result in stranding or harm to fish species. The effects of stranding could include increased stress and direct mortality of individual fish. However, it is anticipated that impacts to fish species of focused evaluation would be minimized through implementation of a Fish Rescue and Salvage Plan (MM-FISH-3).

CEQA Conclusion

Stranding and entrainment impacts would be **significant** because fish species of focused evaluation could be entrained in the temporary cofferdam and could become stranded in the Yolo Bypass.

Implementation of Mitigation Measure MM-FISH-3: Prepare a Fish Rescue and Salvage Plan would reduce this impact to **less than significant**.

Mitigation Measure MM-FISH-3: Prepare a Fish Rescue and Salvage Plan

Implementation of a Fish Rescue and Salvage Plan would limit the number of fishes that may potentially be entrained and stranded during construction. A Fish Rescue and Salvage Plan would be prepared and approved by the Lead Agencies and implemented before construction to minimize the number of fish stranded within the cofferdam during placement and removal and to minimize fish stranding associated with dewatering activities in the Tule Canal. This plan would stipulate that at least one resource agency biologist shall be on site to assist with fish rescue activities and ensure that cofferdam construction and removal procedures have been implemented according to resource agency standards and protocols. A list of approved equipment (e.g., dip nets, seines, backpack electrofishers, fyke nets) will be included in the Fish Rescue and Salvage Plan. Equipment used for the stranding event will be chosen at the discretion of the onsite biologist.

Impact FISH-6: Potential Disturbance to Fish Species or their Habitat due to Predation Risk

Construction activities have the potential to increase the risk of predation of fishes nearby and downstream of the construction footprints due to the potential for increased turbidity, hazardous spills, and vibration and pressure waves. Potential effects associated with construction activities that are not directly associated with predation risk are described above in the previous sections.

Temporary indirect effects associated with construction activities, such as increased turbidity, potential for hazardous spills, and increased underwater vibration and pressure waves, could result in fish species of focused evaluation moving from preferred habitats such that they could be more susceptible to predation. For example, it has been reported that behavioral avoidance of turbid waters reportedly may be one of the most important effects on fishes from suspended sediments (Birtwell et al. 1984; DeVore et al. 1980; Scannell 1988) although it also has been reported that increased turbidity could potentially decrease piscine predation on fish (Gregory and Levings 1998). Disorientation caused by noise associated with pile driving can temporarily disrupt normal fish behaviors, thereby increasing the risk of predation (Caltrans 2015). However, implementation of mitigation measures is expected to minimize the potential for fishes to be at increased risk of predation. Temporary instream structures, such as cofferdams, also may temporarily provide increased refugia to predatory species such as striped bass. This could potentially result in increased predation of fish species of focused evaluation such as juvenile salmonids. However, the temporary installation of these structures is not expected to substantially increase predation of fish species of focused evaluation.

CEQA Conclusion

Predation risk impacts would be **significant** because fish species of focused evaluation could be at increased risk of predation due to potential indirect effects of construction and maintenance activities.

Implementation of Mitigation Measures MM-WQ-2: Implement a Stormwater Pollution and Prevention Plan; MM-WQ-1: Prepare and Implement a Spill Prevention, Control, and Countermeasure Plan; MM-FISH-2: Implement an Underwater Noise Reduction and Monitoring Plan; and MM-FISH-3: Prepare a Fish Rescue and Salvage Plan would reduce this impact to less than significant.

Impact FISH-7: Potential Disturbance to Fish Species due to Changes in Fish Passage Conditions

Construction activities have potential to impair migration or passage of fishes nearby and downstream of the construction footprints due to the potential for increased turbidity, hazardous spills, and underwater noise. However, implementation of mitigation measures described above is anticipated to minimize potential passage impediments to fish species of focused evaluation in the Sacramento River and the Yolo Bypass associated with turbidity, potential hazardous spills, and underwater noise.

Installation of a cofferdam to facilitate construction of the intake facility could potentially physically impede migrating adults, limiting their ability to reach spawning areas, and could hinder migration of juveniles, potentially exposing them to increased predation and unsuitable aquatic habitat conditions. However, because most of the width of the cofferdam is expected to be in the dry, it is not expected to result in substantial changes to hydraulic conditions in the Sacramento River, which typically has a wetted width of 200 or more feet in the Project area. Therefore, it is not anticipated that the movement or survival of juvenile or adult fish species of focused evaluation would be substantially affected.

During construction activities associated with Agricultural Road Crossing 1, Tule Canal could be partially blocked to fish passage. However, most construction activities that could substantially affect Tule Canal would occur primarily from late June through mid-August. Because there would not be hydrologic connectivity between the Sacramento River and the Yolo Bypass at Fremont Weir, construction activities would not be expected to substantially affect large numbers of migratory fish. In addition, operation of the new fish collection facility at Wallace Weir could help to attract fish to Wallace Weir and away from construction areas near Tule Canal if flows in the Colusa Basin Drain and Knights Landing Ridge Cut are sufficient to create an attraction toward the weir. The potential for temporarily impeding passage of non-migratory fish species of focused evaluation in this area would not be expected to result in adverse impacts to those species because there would be habitat available downstream of and away from construction activities in Tule Canal.

CEQA Conclusion

Fish passage impacts would be **less than significant** because fish species of focused evaluation would either generally not be present near temporary fish passage blockages or would not be substantially affected by temporary blockages.

Impact FISH-8: Potential Disturbance to Fish Species or Their Habitat due to Direct Harm

Construction of the cofferdam, channels adjacent to the Sacramento River and Tule Canal, and Agricultural Road Crossing 1 have the potential to cause direct harm to fish species of focused evaluation if construction occurs in the wet.

Future ongoing maintenance-related impacts associated with expected maintenance activities at proposed facilities and channels in and adjacent to the Sacramento River and the Yolo Bypass could potentially occur because of direct contact between maintenance personnel or equipment and fish species of focused evaluation and potential effects associated with maintenance of project facilities and intake and transport channels, such as temporary increases in sedimentation and the potential for hazardous spills. Potential impacts associated with maintenance activities would generally be expected to be limited to the areas in the immediate vicinities of the infrastructure footprints and within and near the intake, outlet, and transport channels.

CEQA Conclusion

Direct harm impacts would be **significant** because fish species of focused evaluation could be directly harmed due to construction- and maintenance-related equipment, personnel, or debris. However, a qualified biologist would provide construction monitoring throughout all phases of the project. If possible, all fish species would be allowed to independently move away from the construction area. Fishes that become entrapped in any channel where construction work is taking place would be netted, transported to the river, and released according to the Fish Rescue and Salvage Plan (MM-FISH-3). General fish protection measures also would be implemented to minimize the potential for direct harm to fish species of focused evaluation (MM-FISH-4).

Mitigation Measure MM-FISH-4: General Fish Protection Measures

The construction contractor and operations and maintenance personnel shall implement the following general fish-protection measures during construction:

- Limit construction and maintenance activities to daylight hours.
- Construction activities will occur outside of the flood season (i.e., during April 15 through November 1).
- Confine clearing to the minimal area necessary to facilitate construction and maintenance activities.
- Clearly delineate the Project area limits by using fencing, flagging, or other means prior to construction activities.
- Keep construction equipment and materials as far away from suitable aquatic and riparian habitat as practicable.
- Retain a qualified biologist (approved by Lead Agencies) to be present or on call during construction and maintenance activities with the potential to affect sensitive biological resources. The biological monitor shall be on site during ground-disturbing activities occurring in the wet or adjacent to potential fish-bearing waterbodies. The biological monitor shall ensure that any construction barrier is maintained and construction activities allow for fish species in the vicinity to move away from the construction area on their own volition.

Implementation of Mitigation Measures MM-FISH-3 and MM-FISH-4: Implement General Fish Protection Measures would reduce this impact to **less than significant**.

8.3.3.2.2 Operations-related Impacts – Evaluation of Substantial Adverse Effects on Fish Species of Focused Evaluation and their Habitat and Movement

Implementation of the Alternatives would result in Sacramento River flows entering the Yolo Bypass more frequently. Changes in the frequency, magnitude, and duration of flow entering the Yolo Bypass from the Sacramento River could change fish passage conditions to and from the Sacramento River and the Yolo Bypass and fisheries habitat conditions in the Yolo Bypass, Sutter Bypass, and Sacramento River downstream of Fremont Weir relative to the basis of comparison. In addition, changes in the magnitude and timing of flows entering the Delta from the Yolo Bypass and the Sacramento River could change hydrology, water quality, and fisheries habitat conditions in the Delta, Suisun Bay, and other downstream estuarine habitats.

In addition to the potential for direct changes in Sacramento River and Delta hydrology and water quality associated with alternatives, changes in the frequency, magnitude, and duration of flow entering the Yolo Bypass could potentially result in re-operation of the SWP/CVP water export facilities and upstream reservoirs. Although Shasta, Folsom, and Oroville reservoirs would not be re-operated to inundate the Yolo Bypass, the increase in Sacramento River inflow to the Yolo Bypass would reduce flows in the Sacramento River between Fremont Weir and the Delta, which could affect water availability for diversion through the California WaterFix intakes under the alternatives with future LOD. A reduction in diversion through the California WaterFix intakes could affect storage in San Luis Reservoir, which could result in changes to operations of north-of-Delta reservoirs, such as Shasta, Folsom, and Oroville reservoirs.

Reoperation of north-of-Delta reservoirs has the potential to alter hydrologic and water temperature conditions in the Sacramento River below Keswick Dam, in the lower Feather River below the Fish Barrier Dam, and in the American River below Nimbus Dam because of the coordinated SWP/CVP operations between the Sacramento, Feather, and American rivers.

Operations-related impacts associated with Alternative 1 are evaluated in the Yolo Bypass, the Sacramento River at and downstream of the Fremont Weir, the Delta and downstream waterbodies, and the broader SWP/CVP system, as appropriate.

Impact FISH-9: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Flows in the Sacramento River

Simulated average monthly flows over the entire simulation period under Alternative 1 relative to Existing Conditions in the Sacramento River downstream of Fremont Weir indicate that flows generally would be the same or similar (see Appendix G6). During relatively low-flow conditions (i.e., lowest 40 percent of flows over the monthly probability of exceedance distributions), no changes in flow of 10 percent or more would occur during any month of the year (see Appendix G6). Therefore, migration and rearing conditions would be similar under Alternative 1 relative to Existing Conditions in the lower Sacramento River for fish species of focused evaluation, including winter-run, spring-run, fall-run, and late fall-run Chinook salmon, steelhead, green sturgeon, white sturgeon, river lamprey, and Pacific lamprey. In addition, there would be minimal potential for reduced flows in the Sacramento River to result in increased exposure of fish species of focused evaluation to predators or to higher concentrations of water quality contaminants and minimal potential to exacerbate the channel homogenization in the lower Sacramento River.

CEQA Conclusion

Alternative 1 would result in the same or similar flows in the Sacramento River downstream of Fremont Weir relative to Existing Conditions; therefore, Alternative 1 would have a **less than significant impact** due to changes in flows in the Sacramento River.

Impact FISH-10: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Water Temperatures in the Sacramento River

Modeling results indicate that mean monthly water temperatures in the Sacramento River at Freeport generally would not exceed species and life stage-specific water temperature index values more often under Alternative 1 relative to Existing Conditions (see Appendix G7). Therefore, migration and rearing thermal conditions would not be substantially affected for fish species of focused evaluation expected to occur in the lower Sacramento River, including winter-run, spring-run, fall-run, and late fall-run Chinook salmon, steelhead, green sturgeon, white sturgeon, river lamprey, and Pacific lamprey under Alternative 1 relative to Existing Conditions.

CEQA Conclusion

Alternative 1 would not result in substantial changes to water temperature suitability for fish species of focused evaluation relative to Existing Conditions; therefore, Alternative 1 would have a **less than significant impact** due to changes in water temperatures in the Sacramento River.

Impact FISH-11: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Delta Hydrologic and Water Quality Conditions

Evaluation of simulated mean monthly Delta hydrologic and water quality parameters with respect to species and life stage-specific time periods indicate that hydrologic and water quality metrics would not change under Alternative 1 relative to Existing Conditions. Therefore, habitat conditions in the Delta would be similar for all life stages evaluated. In addition, based on mean monthly Delta outflow, fisheries habitat conditions would be the same or similar in Suisun Bay.

CEQA Conclusion

Alternative 1 would result in the same or similar habitat conditions for fish species of focused evaluation in the Delta and in downstream areas relative to Existing Conditions; therefore, Alternative 1 would have a **less than significant impact** due to changes in Delta conditions.

Impact FISH-12: Impacts to Fisheries Habitat Conditions due to Changes in Flow-dependent Habitat Availability in the Study Area (Yolo Bypass/Sutter Bypass)

Average monthly hydraulic habitat availability over the entire simulation period for Chinook salmon pre-smolts in the Yolo Bypass would be substantially higher from December through March and similar for the remainder of the October through May evaluation period under Alternative 1 relative to Existing Conditions (Table 8-5). Average monthly hydraulic habitat availability by water year type would be substantially higher during most water year types from December through February and during dry and critical water year types in March.

Chinook salmon pre-smolt hydraulic habitat availability would increase under Alternative 1 relative to Existing Conditions over about 40 percent of the distribution (Figure 8-7). Over the exceedance distribution from November through March, daily hydraulic habitat availability would increase by 10 percent or more about 42 percent of the time and would never decrease by 10 percent or more under Alternative 1.

Table 8-5. Average Monthly Area of Pre-smolt Chinook Salmon Hydraulic Habitat in the Yolo Bypass from October through May based on TUFLOW Modeling (Water Years 1997 through 2012)

Alternative	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)
	October	November	December	January	February	March	April	May
Entire Simulation Period[1] (n=16)								
Alternative 1	20.0	21.5	38.8	55.6	56.1	52.3	37.0	27.0
Existing Conditions	19.8	21.2	31.1	47.6	43.7	46.9	36.9	27.2
Difference	0.2	0.3	7.7	8.0	12.4	5.4	0.1	-0.2
Percent Difference[2]	1.0	1.4	24.8	16.8	28.4	11.5	0.3	-0.7
Water Year Types[3]								
Wet (n=5)								
Alternative 1	20.0	22.2	55.7	58.5	69.5	72.1	58.3	31.6
Existing Conditions	19.8	21.1	37.7	48.5	56.9	68.7	58.3	31.8
Difference	0.2	1.1	18.0	10.0	12.6	3.4	0.0	-0.2
Percent Difference[2]	1.0	5.2	47.7	20.6	22.1	4.9	0.0	-0.6
Above Normal (n=3)								

Alternative	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)
	October	November	December	January	February	March	April	May
Alternative 1	20.3	22.0	39.0	79.0	65.0	51.0	36.0	37.0
Existing Conditions	20.1	21.6	36.2	66.6	41.4	48.0	36.5	37.5
Difference	0.2	0.4	2.8	12.4	23.6	3.0	-0.5	-0.5
Percent Difference[2]	1.0	1.9	7.7	18.6	57.0	6.3	-1.4	-1.3
Below Normal (n=3)								
Alternative 1	19.9	21.3	28.9	53.6	50.7	43.8	26.8	20.9
Existing Conditions	19.7	21.2	25.1	45.4	41.8	40.0	26.6	21.0
Difference	0.2	0.1	3.8	8.2	8.9	3.8	0.2	-0.1
Percent Difference[2]	1.0	0.5	15.1	18.1	21.3	9.5	0.8	-0.5
Dry (n=4)								
Alternative 1	19.9	20.9	29.2	38.3	33.3	39.6	22.1	19.9
Existing Conditions	19.8	20.9	25.9	35.7	26.6	29.0	21.8	20.1
Difference	0.1	0.0	3.3	2.6	6.7	10.6	0.3	-0.2
Percent Difference[2]	0.5	0.0	12.7	7.3	25.2	36.6	1.4	-1.0
Critical (n=1)								
Alternative 1	19.8	20.9	21.6	45.7	69.8	32.8	22.4	20.2
Existing Conditions	19.7	20.7	21.4	39.9	57.7	27.6	22.2	20.5
Difference	0.1	0.2	0.2	5.8	12.1	5.2	0.2	-0.3
Percent Difference[2]	0.5	1.0	0.9	14.5	21.0	18.8	0.9	-1.5

[1] Based on modeled average daily values over a 16-year simulation period (water years 1997 through 2012)
[2] Relative difference of the monthly average
[3] As defined by the Sacramento Valley Index (DWR 2017c)
Key: km^2 = square kilometer

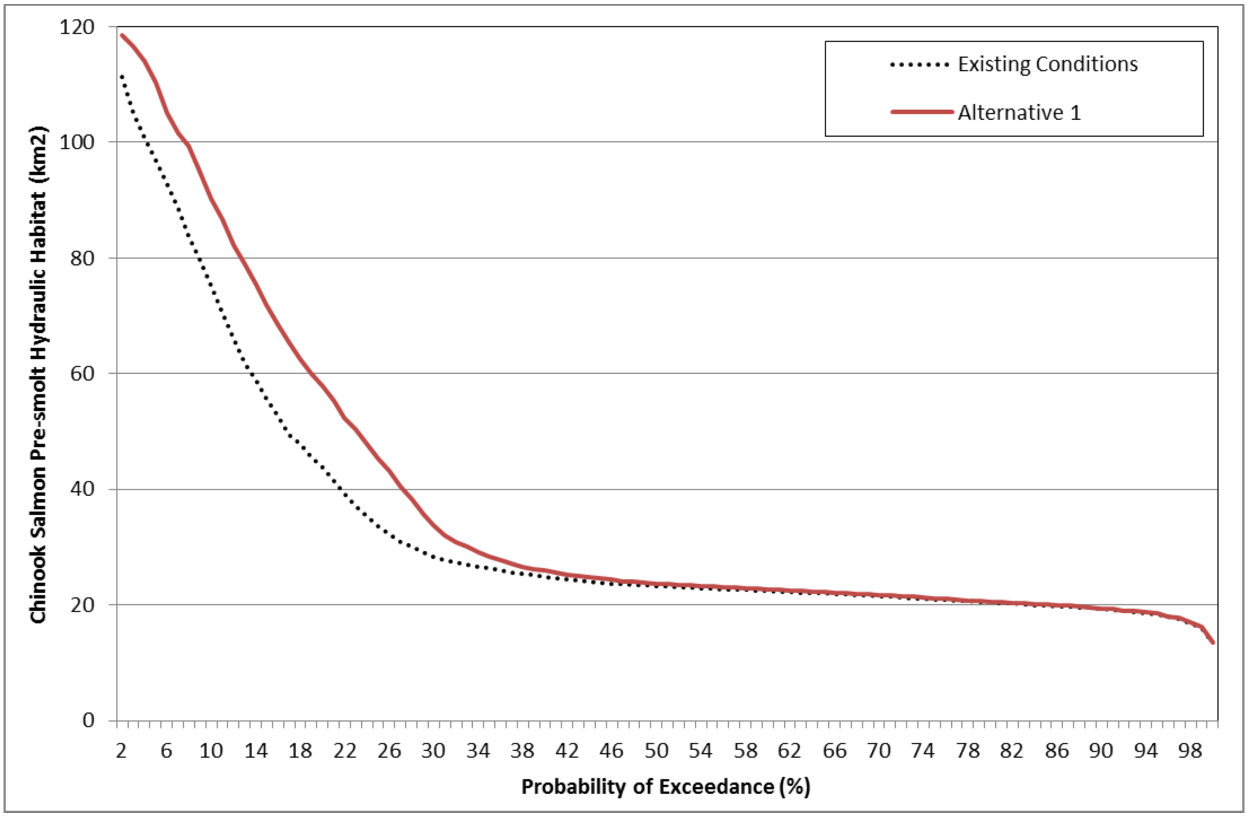

Figure 8-7. Simulated Chinook Salmon Pre-Smolt Hydraulic Habitat Availability Probability of Exceedance Distributions under Alternative 1 and Existing Conditions from October through May based on TUFLOW Modeling (Water Years 1997 through 2012)

Simulated average monthly hydraulic habitat availability over the entire simulation period for Chinook salmon smolts in the Yolo Bypass under Alternative 1 relative to Existing Conditions indicates that availability would be substantially higher (i.e., higher by 10 percent or more) from December through February, higher by less than 10 percent in March, and similar (i.e., change by less than 5 percent) for the remainder of the October through May evaluation period (Table 8-6). Average monthly hydraulic habitat availability by water year type would be substantially higher during most water year types in January and February, during wet and below normal water year types in December, and during dry and critical water year types in March.

Chinook salmon smolt hydraulic habitat availability would be higher under Alternative 1 relative to Existing Conditions over about 35 percent of the cumulative probability exceedance distribution (Figure 8-8). Over the exceedance distribution from November through March, daily hydraulic habitat availability would increase by 10 percent or more about 35 percent of the time and would never decrease by 10 percent or more under Alternative 1.

Table 8-6. Average Monthly Area of Chinook Salmon Smolt Hydraulic Habitat in the Yolo Bypass from October through May based on TUFLOW Modeling (Water Years 1997 through 2012)

Alternative	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)
	October	**November**	**December**	**January**	**February**	**March**	**April**	**May**
Entire Simulation Period[1] (n=16)								
Alternative 1	31.7	32.3	52.9	80.5	83.4	82.0	58.8	42.8
Existing Conditions	31.6	32.0	44.2	70.0	69.7	76.0	58.8	43.1
Difference	0.1	0.3	8.7	10.5	13.7	6.0	0.0	-0.3
Percent Difference[2]	0.3	0.9	19.7	15.0	19.7	7.9	0.0	-0.7
Water Year Types[3]								
Wet (n=5)								
Alternative 1	31.5	33.1	75.3	101.9	115.1	123.6	99.6	50.3
Existing Conditions	31.4	32.1	55.4	90.2	100.6	119.0	99.6	50.7
Difference	0.1	1.0	19.9	11.7	14.5	4.6	0.0	-0.4
Percent Difference[2]	0.3	3.1	35.9	13.0	14.4	3.9	0.0	-0.8
Above Normal (n=3)								
Alternative 1	32.1	33.0	53.0	100.0	93.0	80.0	50.0	54.0
Existing Conditions	32.1	32.9	48.3	82.4	68.3	76.6	50.4	54.6
Difference	0.0	0.1	4.7	17.6	24.7	3.4	-0.4	-0.6
Percent Difference[2]	0.0	0.3	9.7	21.4	36.2	4.4	-0.8	-1.1
Below Normal (n=3)								
Alternative 1	31.8	32.0	40.2	69.9	72.2	67.3	40.7	34.7
Existing Conditions	31.7	31.8	36.2	57.8	62.3	62.6	40.6	34.9
Difference	0.1	0.2	4.0	12.1	9.9	4.7	0.1	-0.2
Percent Difference[2]	0.3	0.6	11.0	20.9	15.9	7.5	0.2	-0.6
Dry (n=4)								
Alternative 1	31.7	31.5	39.9	52.7	44.7	52.2	34.1	33.1
Existing Conditions	31.6	31.5	36.6	48.9	37.9	41.0	33.9	33.4
Difference	0.1	0.0	3.3	3.8	6.8	11.2	0.2	-0.3
Percent Difference[2]	0.3	0.0	9.0	7.8	17.9	27.3	0.6	-0.9
Critical (n=1)								
Alternative 1	31.1	31.4	31.2	58.5	84.7	44.3	34.4	33.5
Existing Conditions	31.0	31.2	30.9	52.1	70.2	39.2	34.4	33.9
Difference	0.1	0.2	0.3	6.4	14.5	5.1	0.0	-0.4
Percent Difference[2]	0.3	0.6	1.0	12.3	20.7	13.0	0.0	-1.2

[1] Based on modeled average daily values over a 16-year simulation period (water years 1997 through 2012)

[2] Relative difference of the monthly average

[3] As defined by the Sacramento Valley Index (DWR 2017c)

Key: km^2 = square kilometer

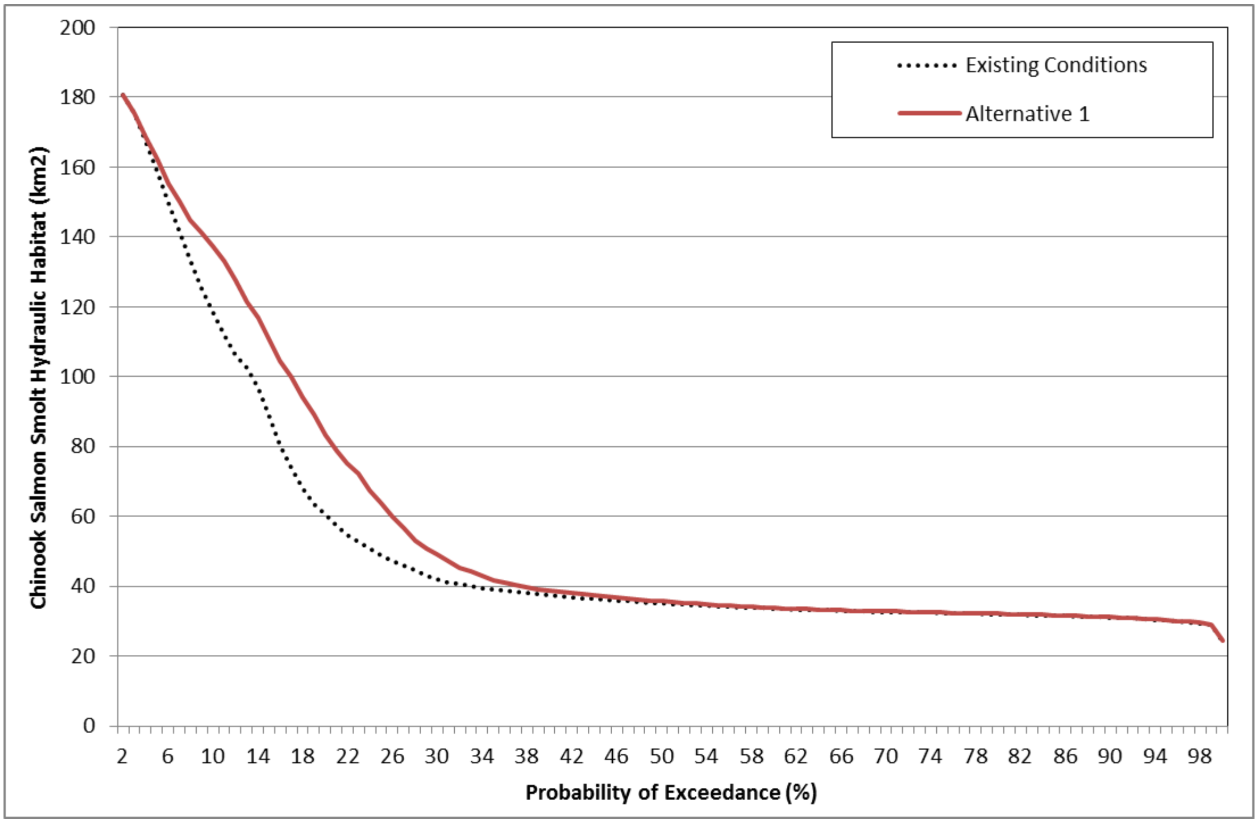

Figure 8-8. Simulated Chinook Salmon Smolt Hydraulic Habitat Availability Probability of Exceedance Distributions under Alternative 1 and Existing Conditions from October through May based on TUFLOW Modeling (Water Years 1997 through 2012)

As previously discussed, changes in estimated hydraulic habitat availability for Chinook salmon pre-smolts is expected to be generally representative of potential changes in hydraulic habitat availability for juvenile Sacramento splittail, and changes in estimated hydraulic habitat availability for Chinook salmon smolts is generally expected to be representative of potential changes in hydraulic habitat availability for adult spawning Sacramento splittail and juvenile steelhead.

To provide a more comprehensive range of potential changes in hydraulic habitat availability for other fish species of focused evaluation, simulated wetted extent (area with a water depth greater than 0.0 ft) was estimated for the Yolo Bypass under Alternative 1 relative to Existing Conditions. Average monthly wetted extent over the entire simulation period would be substantially higher from December through February, higher by less than 10 percent in March, and generally similar for the remainder of the October through May evaluation period under Alternative 1 relative to Existing Conditions. Average monthly wetted extent by water year type would be higher from December through February and substantially higher in December of wet water years, January of above normal and below normal water years, February of all water year types except for wet water years, and March in dry and critical water years (Table 8-7).

Table 8-7. Average Monthly Wetted Area in the Yolo Bypass under Alternative 1 from October through May based on TUFLOW Modeling (Water Years 1997 through 2012)

Alternative	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)
	October	**November**	**December**	**January**	**February**	**March**	**April**	**May**
Entire Simulation Period[1] (n=16)								
Alternative 1	48.0	48.9	73.3	115.6	121.2	114.7	85.9	63.8
Existing Conditions	47.8	48.4	64.1	105.0	106.4	107.5	85.9	64.1
Difference	0.2	0.5	9.2	10.6	14.8	7.2	0.0	-0.3
Percent Difference[2]	0.4	1.0	14.4	10.1	13.9	6.7	0.0	-0.5
Water Year Types[3]								
Wet (n=5)								
Alternative 1	47.8	49.9	100.1	166.6	176.8	169.0	145.3	77.1
Existing Conditions	47.6	48.6	78.9	154.3	161.7	163.4	145.3	77.5
Difference	0.2	1.3	21.2	12.3	15.1	5.6	0.0	-0.4
Percent Difference[2]	0.4	2.7	26.9	8.0	9.3	3.4	0.0	-0.5
Above Normal (n=3)								
Alternative 1	48.6	50.0	72.0	124.0	127.0	116.0	72.0	77.0
Existing Conditions	48.5	49.9	68.3	108.0	100.1	111.7	72.5	77.0
Difference	0.1	0.1	3.7	16.0	26.9	4.3	-0.5	0.0
Percent Difference[2]	0.2	0.2	5.4	14.8	26.9	3.8	-0.7	0.0
Below Normal (n=3)								
Alternative 1	48.1	48.2	58.2	91.2	102.6	94.9	59.6	52.0
Existing Conditions	47.9	47.9	53.9	79.2	91.7	89.6	59.6	52.3
Difference	0.2	0.3	4.3	12.0	10.9	5.3	0.0	-0.3
Percent Difference[2]	0.4	0.6	8.0	15.2	11.9	5.9	0.0	-0.6
Dry (n=4)								
Alternative 1	48.0	47.9	58.6	72.4	64.1	73.1	50.6	49.8
Existing Conditions	47.8	47.6	54.5	68.3	56.0	60.3	50.3	49.9
Difference	0.2	0.3	4.1	4.1	8.1	12.8	0.3	-0.1
Percent Difference[2]	0.4	0.6	7.5	6.0	14.5	21.2	0.6	-0.2
Critical (n=1)								
Alternative 1	47.2	46.9	47.0	81.8	111.0	64.8	51.1	50.6
Existing Conditions	46.9	46.7	46.6	74.4	95.7	58.1	51.1	50.9
Difference	0.3	0.2	0.4	7.4	15.3	6.7	0.0	-0.3
Percent Difference[2]	0.6	0.4	0.9	9.9	16.0	11.5	0.0	-0.6

[1] Based on modeled average daily values over a 16-year simulation period (water years 1997 through 2012)
[2] Relative difference of the monthly average
[3] As defined by the Sacramento Valley Index (DWR 2017c)
Key: km^2 = square kilometer

Wetted extent would be higher under Alternative 1 relative to Existing Conditions over about 30 percent of the middle to upper portion of the cumulative probability exceedance distribution (Figure 8-9). Over the exceedance distribution from November through March, daily wetted extent would increase by 10 percent or more about 34 percent of the time and would never decrease by 10 percent or more under Alternative 1.

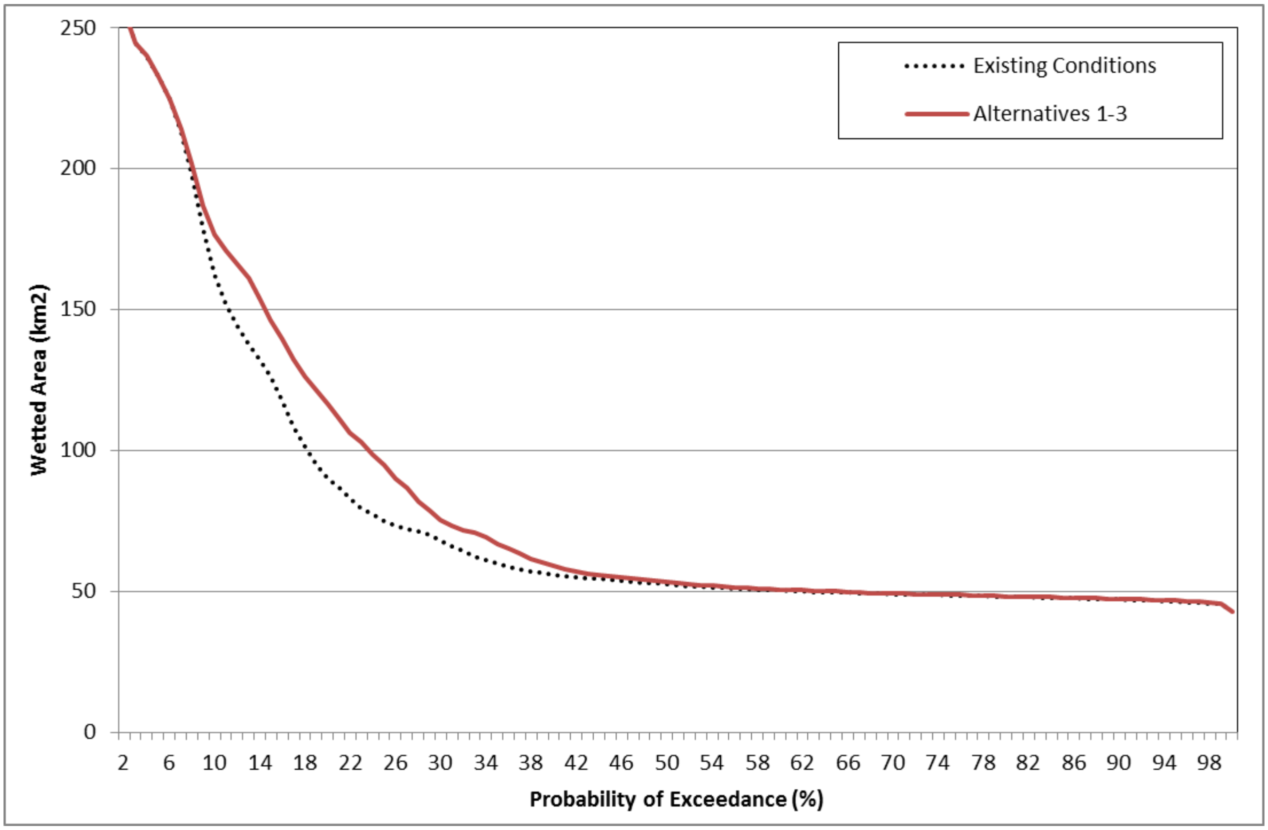

Figure 8-9. Simulated Wetted Area Probability of Exceedance Distributions under Alternative 1 and Existing Conditions from October through May based on TUFLOW Modeling (Water Years 1997 through 2012)

Average annual wetted days in the Sutter Bypass would decrease under Alternative 1 relative to Existing Conditions by approximately three to seven days in most of the area of Sutter Bypass between the Sacramento River and Sacramento Slough and by approximately one to three days over most of the Sutter Bypass between Sacramento Slough and Nelson Slough. This reduction in wetted area of the Sutter Bypass is due to less water from the Sacramento River spilling into the Sutter Bypass when Alternative 1 would be discharging water through the Fremont Weir and water is not overtopping Fremont Weir. During flood events when both the Sutter Bypass and the Yolo Bypass are inundated and water is spilling over Fremont Weir, Alternative 1 would not be expected to affect connectivity between the Sutter Bypass and the Sacramento River. Because migration impediments and barriers exist for fish moving upstream in the Sutter Bypass, minor reductions in connectivity between the Sutter Bypass and Sacramento River during non-inundation events is not expected to adversely affect fish species of focused evaluation.

CEQA Conclusion

In the Yolo Bypass under Alternative 1, increased hydraulic habitat availability for fish species of focused evaluation, particularly juvenile Chinook salmon and steelhead and adult and juvenile Sacramento splittail, is expected to result in more suitable conditions for these and other fish species of focused evaluation. Relatively minor reductions in the number of wetted days in the Sutter Bypass upstream of the Sacramento River at Fremont Weir would not be expected to substantially affect rearing or migration of fish species of focused evaluation; therefore, Alternative 1 would be expected to have a **beneficial impact** on flow-dependent hydraulic habitat availability in the Yolo Bypass and a **less than significant impact** on flow-dependent hydraulic habitat availability in the Sutter Bypass.

Impact FISH-13: Impacts to Fisheries Habitat Conditions due to Changes in Water Quality in the Study Area

Modeling results indicate that flows entering the Yolo Bypass from the Sacramento River at Fremont Weir would substantially increase more often from December through March under Alternative 1 relative to Existing Conditions (see Appendix G6). Therefore, increased flows and the potential for increased wetting and drying of the Yolo Bypass could increase the amount of methylmercury and other contaminants in the Yolo Bypass and in fish prey. Increased concentrations of contaminants in the Yolo Bypass could potentially result in an increase in the exportation of contaminated water to the Delta. However, for juvenile Chinook salmon rearing in the Yolo Bypass, increased concentrations of accumulated methylmercury were reported to be insignificant in the tissues of the eventual adult-sized fish (Henery et al. 2010). Effects of increased methylmercury accumulation could be more substantial on resident fish species such as largemouth bass. Increased flows in the Yolo Bypass also could temporarily increase turbidity levels in the Yolo Bypass.

CEQA Conclusion

Based on higher mean monthly flows entering the Yolo Bypass, increased concentrations of methylmercury and other contaminants may occur in the Yolo Bypass and the Delta. However, the potential for increased concentrations of contaminants is not expected to substantially affect fish species of focused evaluation; therefore, Alternative 1 would have a **less than significant impact**.

Impact FISH-14: Impacts to Aquatic Primary and Secondary Production in the Study Area

Modeling results indicate that Alternative 1 would result in increased frequency and duration of inundation of the Yolo Bypass relative to Existing Conditions. An increase in frequency and duration of inundation of shallow-water habitat in the Yolo Bypass would be expected to increase primary production in the Yolo Bypass (Lehman et al. 2007). Increased primary and associated secondary production in the Yolo Bypass would likely increase food resources for fish species of focused evaluation in the Yolo Bypass. More productive water in the Yolo Bypass also could potentially be exported to the Delta downstream of the Yolo Bypass, which could increase food resources for fish in the Delta.

Modeled wetted area of the Yolo Bypass under Alternative 1 relative to Existing Conditions was used as an indicator of relative changes in inundation and associated primary and secondary production. As described above, increases in average monthly wetted area would occur under

Alternative 1 relative to Existing Conditions, particularly from December through March, depending on water year type. Increased food resources in the Yolo Bypass during this period would be expected to improve growth and survival of some fish species of focused evaluation such as Chinook salmon and freshwater resident species. The potential for increased productivity downstream of the Yolo Bypass could improve prey availability conditions for fish species of focused evaluation.

Minor reductions in wetted area in the Sutter Bypass could reduce primary and secondary production in the Sutter Bypass. However, these reductions in wetted area are not expected to substantially affect primary or secondary production in the Sutter Bypass or substantially affect fish species of focused evaluation in the Sutter Bypass.

CEQA Conclusion

Based on increased wetted extent in the Yolo Bypass during the winter, increased primary and secondary production in the Yolo Bypass (and potentially in localized areas of the Delta) could increase food resources for fish species of focused evaluation. In the Sutter Bypass, slight reductions in wetted area could reduce primary and secondary production, but these reductions are not expected to be sufficient to substantially affect food resources for fish species of focused evaluation. Therefore, Alternative 1 would have a **beneficial impact** in the Yolo Bypass and a **less than significant impact** on the Sutter Bypass.

Impact FISH-15: Impacts to Fish Species of Focused Evaluation due to Changes in Adult Fish Passage Conditions through the Yolo Bypass

Modeling results indicate that flows entering the Yolo Bypass from the Sacramento River at Fremont Weir would substantially increase more often from December through March (see Appendix G6). Therefore, the duration of potential adult fish passage from the Yolo Bypass into the Sacramento River may potentially increase for fall/late fall-run Chinook salmon, spring-run Chinook salmon, winter-run Chinook salmon, steelhead, green and white sturgeon, and Pacific and river lamprey, potentially providing for increased spawning opportunities in the Sacramento River and its tributaries through reduced potential for mortality or migration delay in the Yolo Bypass. Increased flows entering the Yolo Bypass also would increase the average number of days that areas adjacent to portions of the west-side tributaries within the Yolo Bypass are inundated, including Cache Creek, Willow Slough and Putah Creek. Therefore, hydraulic connectivity and migration conditions for anadromous fishes in the west-side streams could potentially improve under Alternative 1 relative to Existing Conditions.

There is the potential that increased flows entering the Delta from the Yolo Bypass could attract more adult fish into the Yolo Bypass relative to the Sacramento River. However, adult fish passage would be provided at Fremont Weir more often relative to Existing Conditions. Based on results of the YBPASS Tool, which applied fish passage criteria to modeled hydraulic conditions in the intake facility and transport channel under Alternative 1, adult salmon and sturgeon would be expected to successfully pass upstream through the transport channel and intake structure into the Sacramento River about 23 percent of the days from November through April over the water years 1997 through 2012 simulation period. The annual average date after which Alternative 1 would no longer meet the fish passage criteria would be April 2.

Increased flows entering the Delta from the Yolo Bypass under Alternative 1 relative to Existing Conditions could potentially result in increased straying of anadromous adult fish native to watersheds outside of the upper Sacramento River Basin (e.g., from the American River, Feather River, and Butte Creek watersheds), which could result in hybridization and associated genetic effects to anadromous fish populations in the Sacramento River Basin upstream of Fremont Weir. However, as described in Section 8.1.4.2.1, flow rates downstream of the Yolo Bypass in Cache Slough are highly variable and include large and rapid increases in flow under Existing Conditions during the December through March period. Therefore, the increase in flows in the Yolo Bypass under Alternative 1 is not expected to have a substantial impact on attraction of anadromous fish into Cache Slough relative to Existing Conditions. In addition, populations of most anadromous fish species of focused evaluation with known population structure are restricted to or primarily spawn in the Sacramento River Basin upstream of Fremont Weir, including winter-run Chinook salmon, green sturgeon and white sturgeon (see Section 8.1.2.2). Substantial increases in adult steelhead from outside of the upper Sacramento River Basin straying into the Yolo Bypass are not expected due to the infrequent observations of adult steelhead in the Yolo Bypass (see Section 8.1.2.2). Substantial increases in adult spring-run Chinook salmon from outside the upper Sacramento River Basin straying into the Yolo Bypass also are not expected because adult Chinook salmon have primarily been observed migrating upstream in the Yolo Bypass during October through December, outside of the spring-run Chinook salmon adult migration period (mid-February through July; peaking during May) (see Section 8.1.2.2). Although increased straying of adult fall-run Chinook salmon from outside of the upper Sacramento River Basin could occur, Central Valley fall-run Chinook salmon populations have been determined to be relatively homogenous with high rates of gene flow between tributaries (Garza et al. 2008).

The Project Alternative would be adaptively managed to ensure that biological goals and objectives are met (see Appendix C). For example, management responses would be evaluated if more than one percent of an ESA-listed salmon ESU or green sturgeon annual escapement is found to stray to Wallace Weir during Project operations, or if more than one percent of an ESA-listed salmon ESU or green sturgeon annual escapement or juvenile production estimate are stranded in the Yolo Bypass. Potential management responses are identified in Appendix C. Future management responses would be subject to future environmental compliance documentation, as applicable.

CEQA Conclusion

Increased duration of potential adult fish passage opportunity from the Yolo Bypass into the Sacramento River under Alternative 1 is expected to result in improved upstream spawning opportunities and less potential for mortality or migration delay for fish species of focused evaluation; therefore, Alternative 1 would be expected to have a **beneficial impact** on adult fish passage conditions through the Yolo Bypass.

Impact FISH-16: Impacts to Fish Species due to Changes in Potential for Stranding and Entrainment

Project facilities constructed under Alternative 1, such as the transport and intake channels, would be graded to provide suitable passage conditions for fish, assuming sufficient water is present. Although Alternative 1 would allow for entrainment of juvenile fish at lower flows relative to Existing Conditions, the design of the transport channel to Tule Canal is expected to minimize the potential for stranding of juveniles. However, anthropogenic structures that interrupt natural drainage patterns, such as water control structures, create the greatest risk for stranding (Sommer et al. 2005). Therefore, there is some potential for increased juvenile stranding in the Yolo Bypass.

Because Alternative 1 would allow for adult migration into the Sacramento River during periods when adult migration is impeded or blocked at Fremont Weir under Existing Conditions, the potential for adult fish stranding in the Yolo Bypass would be expected to be reduced.

CEQA Conclusion

The potential for adult fish stranding would be expected to be reduced under Alternative 1 relative to Existing Conditions. Juvenile stranding may potentially increase under Alternative 1, but design of the project facilities is expected to minimize any increases in juvenile stranding. Therefore, Alternative 1 would be expected to have a **less than significant impact** on stranding and entrainment.

Impact FISH-17: Impacts to Fish Species due to Changes in Potential for Predation and Competition

Construction of the intake facility, supplemental fish passage facility, and intake and transport channels lined with rock could increase the potential for predation of fish species of focused evaluation under Alternative 1 relative to Existing Conditions by providing habitat for predatory fish species in these areas. However, the facilities on the Sacramento River are not expected to substantially increase the potential area of refugia for species such as striped bass relative to Existing Conditions. In the Yolo Bypass, increased flow pulses into the Yolo Bypass associated with Alternative 1 during the winter months (primarily December through March) could reduce the potential for predation of fish species such as juvenile salmonids by non-native fish species. For example, Sommer et al. (2014) found that increased connectivity to the Yolo Bypass would provide an overall benefit to native fish species, particularly during the winter, because it is prior to the spawning periods of non-native fish species in the spring. Frantzich et al. (2013) found that native fish species were more widely distributed during wetter years, and low flows may provide more suitable conditions for the spawning and recruitment of non-native centrarchids. Increased flows during February and March under Alternative 1 could increase habitat availability for non-native cyprinids, such as common carp and goldfish, which could result in increased competition for food resources with fish species of focused evaluation relative to Existing Conditions. However, because increased primary and associated secondary production in the Yolo Bypass would likely increase food resources for fish species of focused evaluation in the Yolo Bypass and downstream (see Impact FISH-14), increased habitat for non-native cyprinids is not expected to substantially affect fish species of focused evaluation in the Yolo Bypass or in the Delta. Overall, Opperman et al. (2017) argued that flooding the Yolo Bypass from January through April would benefit native fish species. In addition, given the perennial nature of the Tule Canal and its ability to support non-native fish species under Existing Conditions, it is not expected that the proposed facilities under Alternative 1 would increase predation of fish species of focused evaluation above baseline levels in the Yolo Bypass. In addition, results of the SBM (evaluated under *Impact FISH-18*) account for predation associated with the estimated migration path and migration duration for juvenile Chinook salmon in the Yolo Bypass associated with Alternative 1.

CEQA Conclusion

Overall potential for predation of, and competition with, fish species of focused evaluation is not expected to substantially differ relative to predation and competition conditions under Existing Conditions; therefore, Alternative 1 would be expected to have a **less than significant impact** on predation and competition.

Impact FISH-18: Impacts to Chinook Salmon Species/Runs due to Changes in Viable Salmonid Population Parameters

As previously discussed, model output from the SBM is used to evaluate the VSP parameters (abundance, productivity, diversity, and spatial structure) for fall-run, late fall-run, spring-run, and winter-run Chinook salmon.

Abundance and Productivity

Modeling results indicate that annual average adult returns under Alternative 1 relative to Existing Conditions would be higher over the entire simulation period and by water year type for fall-run and spring-run Chinook salmon (Table 8-8). Annual average adult returns would be similar for late fall-run Chinook salmon and winter-run Chinook salmon under Alternative 1 relative to Existing Conditions. The simulated adult Chinook salmon returns probability of exceedance distributions under Alternative 1 relative to Existing Conditions would be similar for late fall-run and winter-run Chinook salmon and similar or higher for fall-run and spring-run Chinook salmon (Figures 8-10 through 8-13). In addition, because more juvenile Chinook salmon would enter the Delta from the Yolo Bypass relative to from the Sacramento River, potentially reduced juvenile mortality at the south Delta pumping facilities could increase adult returns under Alternative 1 relative to Existing Conditions (relative to the SBM output).

Table 8-8. Average Annual Chinook Salmon Adult Returns under Alternative 1

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Fall-run Chinook Salmon						
Alternative 1	183,201	246,886	209,237	85,997	167,110	45,448
Existing Conditions	172,025	232,876	192,956	82,267	158,383	39,065
Difference	11,176	14,010	16,281	3,730	8,728	6,383
Percent Difference[3]	6	6	8	5	6	16
Late Fall-run Chinook Salmon						
Alternative 1	57,533	59,184	67,251	19,697	61,556	79,707
Existing Conditions	58,390	60,218	68,937	19,914	61,780	81,012
Difference	-857	-1,033	-1,686	-217	-224	-1,305
Percent Difference[3]	-1	-2	-2	-1	0	-2
Spring-run Chinook Salmon						
Alternative 1	6,391	9,652	6,049	2,345	5,094	4,385
Existing Conditions	5,960	8,803	5,821	2,174	4,884	4,031

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Difference	431	849	228	171	210	354
Percent Difference[3]	7	10	4	8	4	9
Winter-run Chinook Salmon						
Alternative 1	5,630	5,732	5,574	5,344	6,297	3,192
Existing Conditions	5,518	5,504	5,558	5,334	6,197	3,118
Difference	112	227	16	11	99	74
Percent Difference[3]	2	4	0	0	2	2

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

[3] Relative difference of the annual average

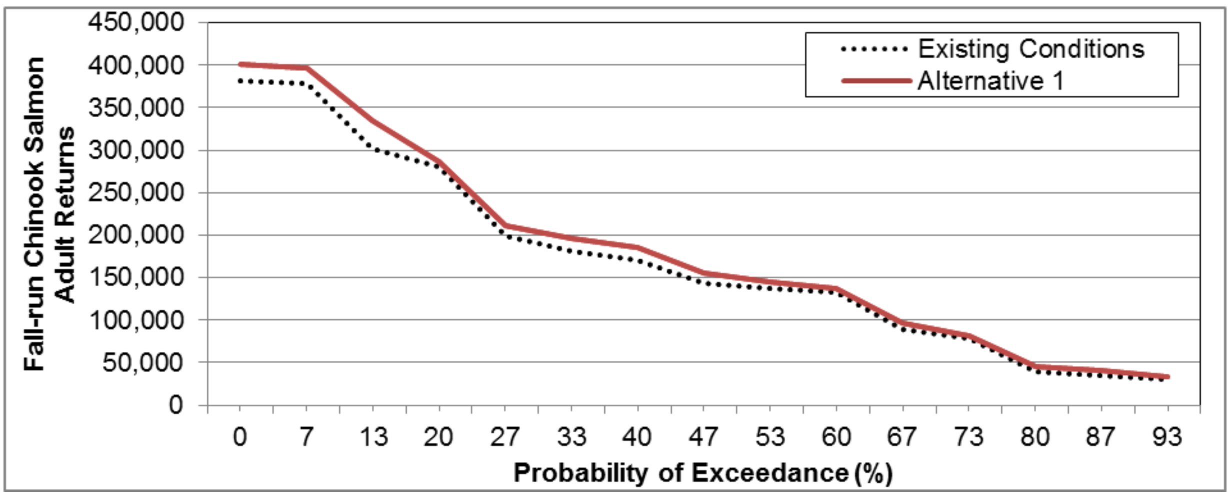

Figure 8-10. Simulated Adult Fall-Run Chinook Salmon Returns Probability of Exceedance Distributions under Alternative 1 and Existing Conditions

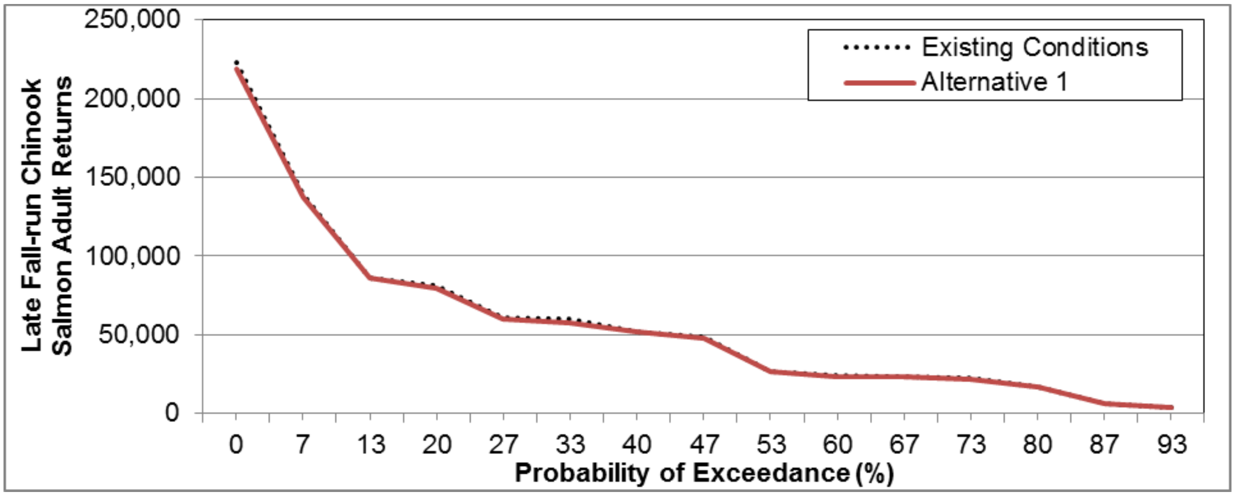

Figure 8-11. Simulated Adult Late Fall-Run Chinook Salmon Returns Probability of Exceedance Distributions under Alternative 1 and Existing Conditions

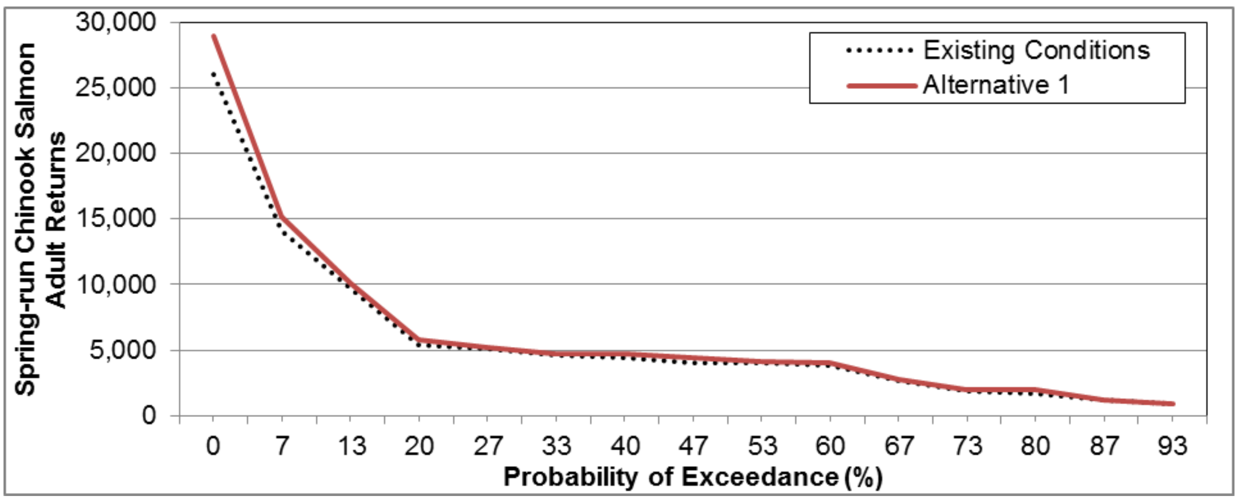

Figure 8-12. Simulated Adult Spring-run Chinook Salmon Returns Probability of Exceedance Distributions under Alternative 1 and Existing Conditions

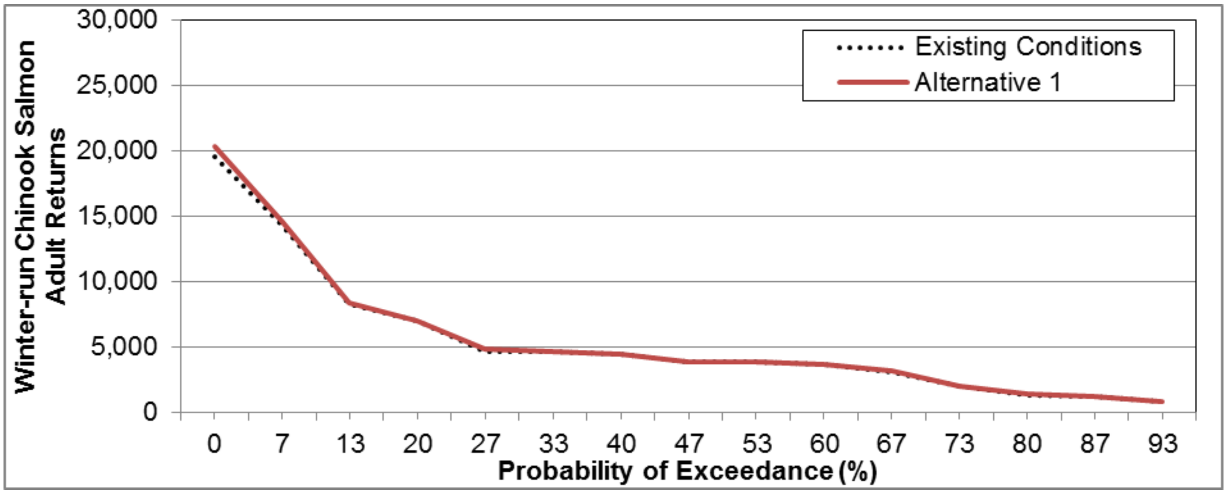

Figure 8-13. Simulated Adult Winter-run Chinook Salmon Returns Probability of Exceedance Distributions under Alternative 1 and Existing Conditions

Diversity

VARIATION IN JUVENILE CHINOOK SALMON SIZE

Modeling results indicate that annual average juvenile Chinook salmon coefficient of variation in size (FL) under Alternative 1 relative to Existing Conditions would be substantially higher (i.e., higher by 10 percent or more) over the entire simulation period and during most water year types for fall-run, spring-run, and winter-run Chinook salmon and similar for late fall-run Chinook salmon (Table 8-9). Similarly, the juvenile Chinook salmon coefficient of variation in size probability of exceedance distributions would be higher over the entire distributions under Alternative 1 relative to Existing Conditions for fall-run, spring-run, and winter-run Chinook salmon and would be similar for late fall-run Chinook salmon (Figures 8-14 through 8-17).

Table 8-9. Average Annual Juvenile Chinook Salmon Coefficient of Variation in Size under Alternative 1

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Fall-run Chinook Salmon						
Alternative 1	0.43	0.47	0.42	0.40	0.41	0.38
Existing Conditions	0.35	0.44	0.32	0.35	0.31	0.13
Difference	0.08	0.03	0.10	0.05	0.10	0.26
Percent Difference[3]	22	6	31	13	32	198
Late Fall-run Chinook Salmon						
Alternative 1	0.33	0.41	0.48	0.50	0.11	0.07
Existing Conditions	0.33	0.41	0.48	0.50	0.11	0.07
Difference	0.00	0.00	0.00	0.00	0.00	0.00
Percent Difference[3]	0	1	0	0	0	0
Spring-run Chinook Salmon						
Alternative 1	0.36	0.45	0.34	0.35	0.27	0.28
Existing Conditions	0.30	0.42	0.30	0.26	0.22	0.18
Difference	0.05	0.04	0.05	0.09	0.04	0.11
Percent Difference[3]	17	9	15	35	19	61
Winter-run Chinook Salmon						
Alternative 1	0.17	0.23	0.15	0.19	0.12	0.09
Existing Conditions	0.14	0.20	0.12	0.17	0.10	0.06
Difference	0.03	0.03	0.03	0.02	0.02	0.03
Percent Difference[3]	19	15	26	12	22	59

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

[3] Relative difference of the annual average

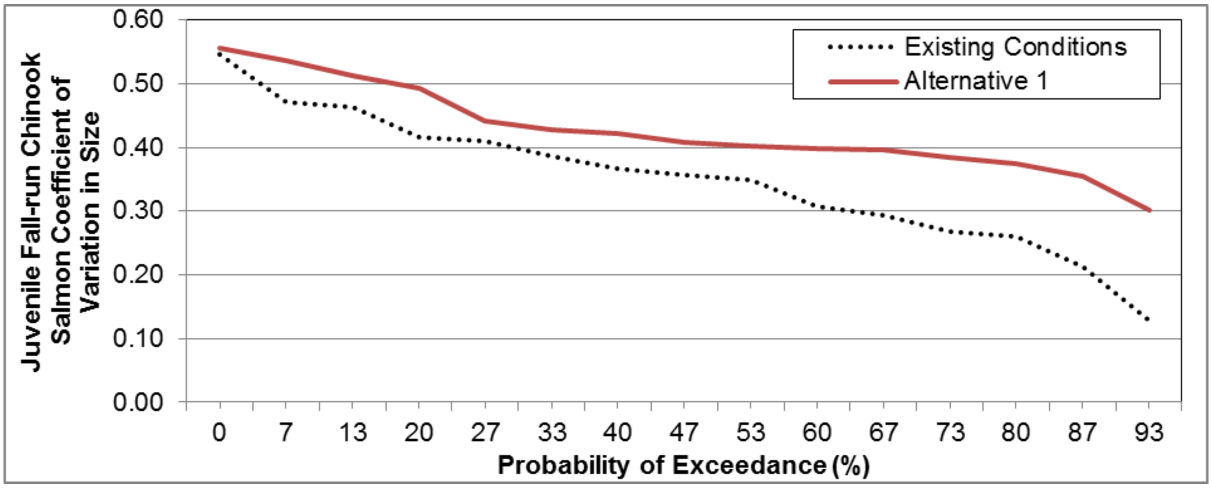

Figure 8-14. Simulated Juvenile Fall-run Chinook Salmon Coefficient of Variation in Size Probability of Exceedance Distributions under Alternative 1 and Existing Conditions

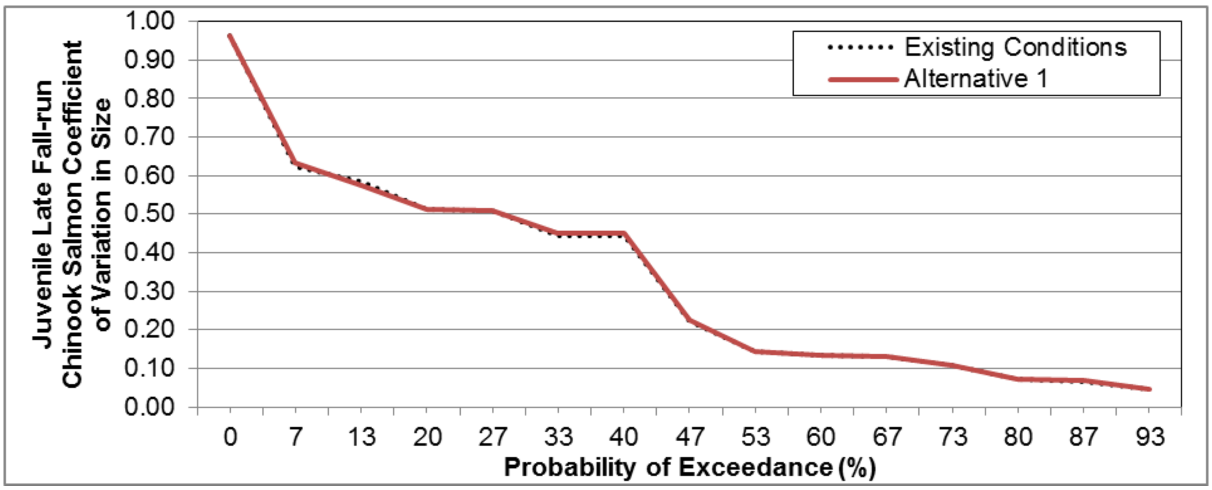

Figure 8-15. Simulated Juvenile Late Fall-run Chinook Salmon Coefficient of Variation in Size Probability of Exceedance Distributions under Alternative 1 and Existing Conditions

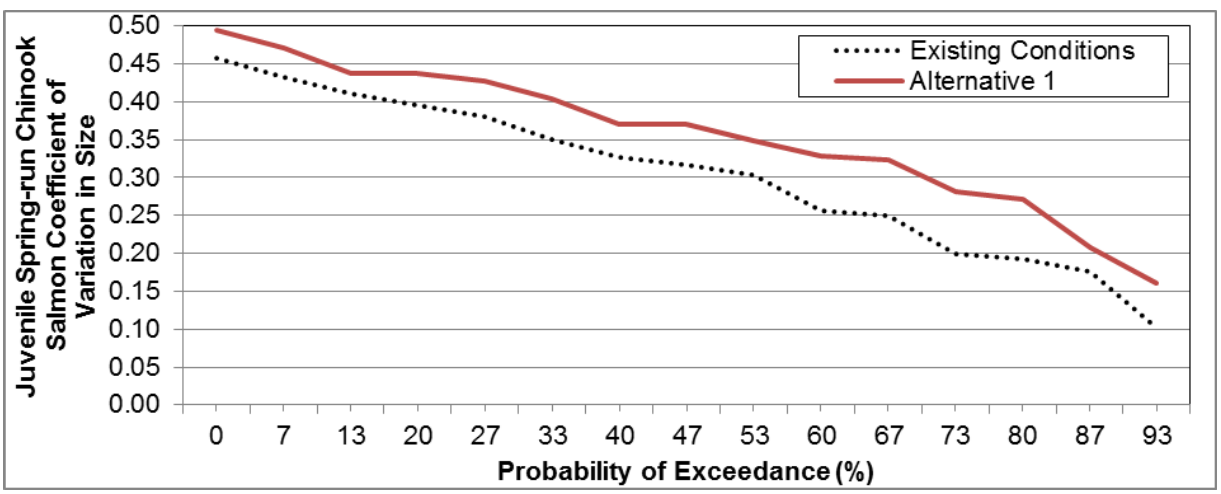

Figure 8-16. Simulated Juvenile Spring-Run Chinook Salmon Coefficient of Variation in Size Probability of Exceedance Distributions under Alternative 1 and Existing Conditions

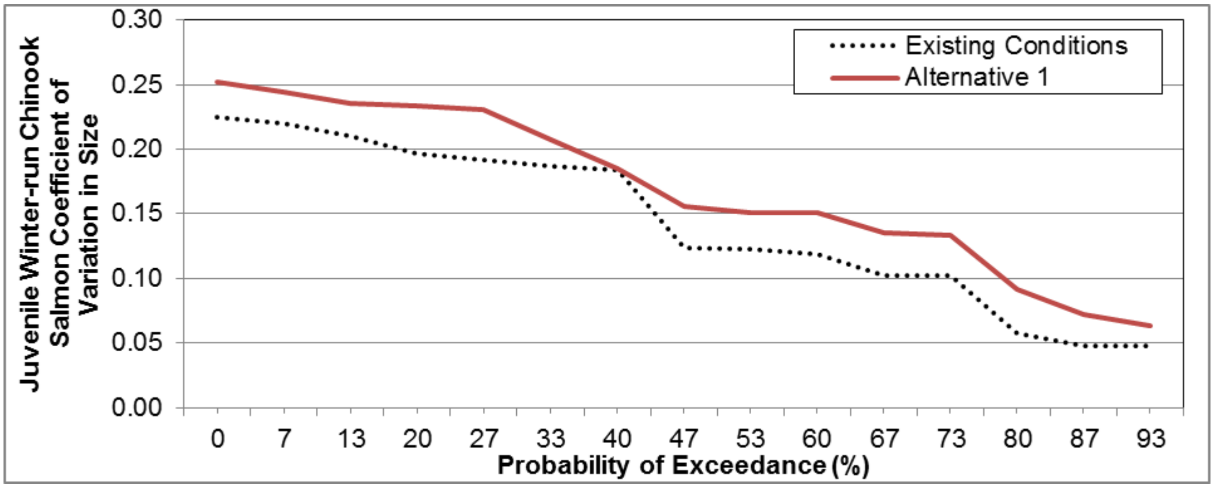

Figure 8-17. Simulated Juvenile Winter-run Chinook salmon Coefficient of Variation in Size Probability of Exceedance Distributions under Alternative 1 and Existing Conditions

Variation in Juvenile Chinook Salmon Estuary Entry Timing

Modeling results indicate that annual average juvenile Chinook salmon coefficient of variation in estuary entry timing under Alternative 1 relative to Existing Conditions would be higher over the entire simulation period; similar during wet and below normal water years; and substantially higher during above normal, dry, and critical water years for fall-run Chinook salmon (Table 8-10). Annual average juvenile Chinook salmon coefficient of variation in estuary entry timing under Alternative 1 relative to Existing Conditions would be similar over the entire simulation period and during most water year types for late fall-run, spring-run, and winter-run Chinook salmon but would be substantially higher during critical water years for spring-run Chinook salmon.

The juvenile Chinook salmon coefficient of variation in estuary entry timing probability of exceedance distributions would be higher over most of the distributions under Alternative 1 relative to Existing Conditions for fall-run, spring-run, and winter-run Chinook salmon and would be similar for late fall-run Chinook salmon (Figure 8-18 through Figure 8-21).

Table 8-10. Average Annual Juvenile Chinook Salmon Coefficient of Variation in Size under Alternative 1

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Fall-run Chinook Salmon						
Alternative 1	0.25	0.29	0.24	0.25	0.22	0.21
Existing Conditions	0.24	0.29	0.22	0.25	0.19	0.16
Difference	0.01	0.00	0.02	0.00	0.02	0.05
Percent Difference[3]	6	0	10	1	12	30

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Late Fall-run Chinook Salmon						
Alternative 1	0.33	0.44	0.32	0.21	0.29	0.15
Existing Conditions	0.33	0.44	0.33	0.21	0.29	0.15
Difference	0.00	0.00	0.00	0.00	0.00	0.00
Percent Difference[3]	-1	-1	-1	0	0	-1
Spring-run Chinook Salmon						
Alternative 1	0.30	0.39	0.28	0.28	0.24	0.21
Existing Conditions	0.29	0.38	0.28	0.26	0.23	0.18
Difference	0.01	0.00	0.01	0.02	0.01	0.03
Percent Difference[3]	3	1	3	8	3	14
Winter-run Chinook Salmon						
Alternative 1	0.28	0.39	0.23	0.31	0.22	0.13
Existing Conditions	0.28	0.38	0.22	0.30	0.21	0.12
Difference	0.01	0.01	0.01	0.01	0.01	0.01
Percent Difference[3]	3	2	4	2	3	7

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

[3] Relative difference of the annual average

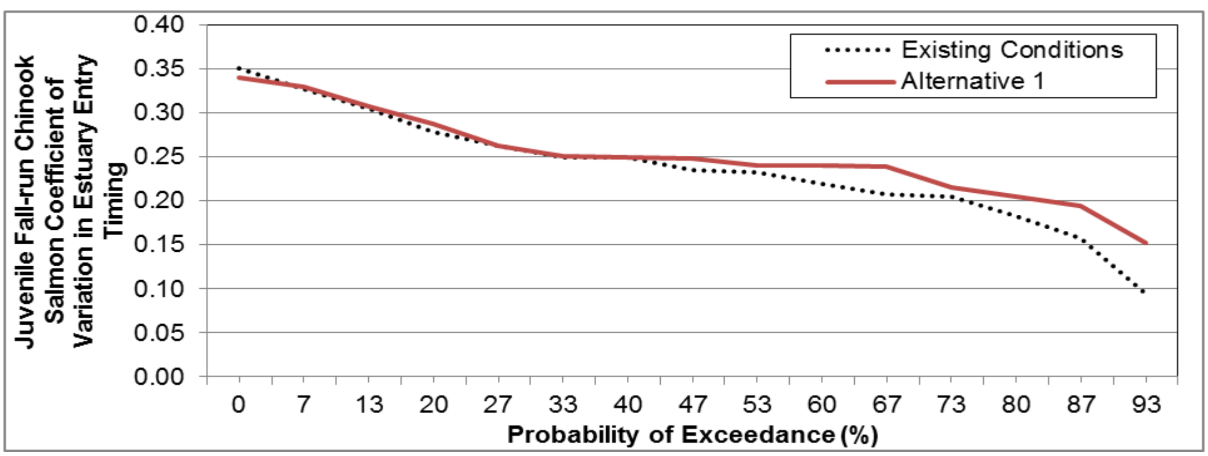

Figure 8-18. Simulated Juvenile Fall-run Chinook Salmon Coefficient of Variation in Estuary Entry Timing Probability of Exceedance Distributions under Alternative 1 and Existing Conditions

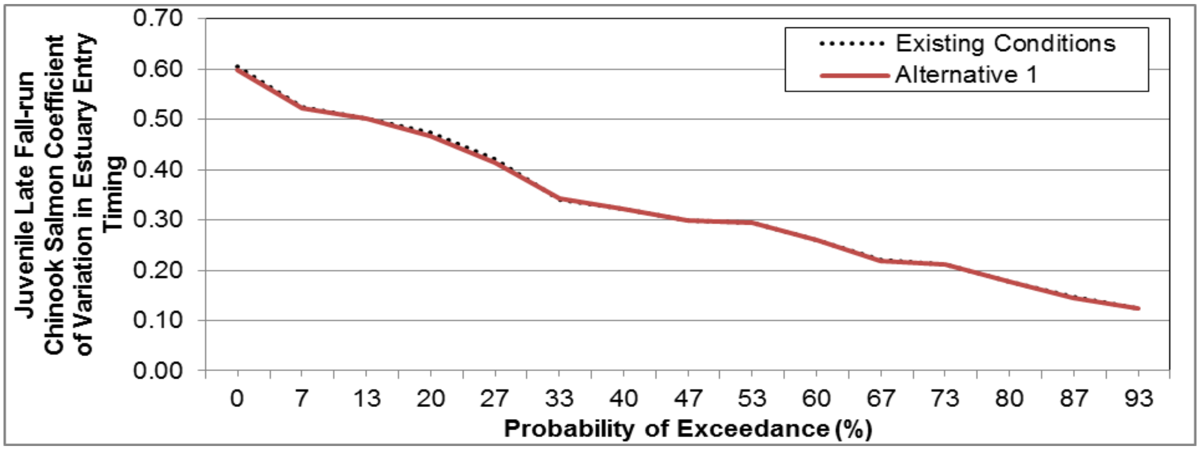

Figure 8-19. Simulated Juvenile Late Fall-run Chinook Salmon Coefficient of Variation in Estuary Entry Timing Probability of Exceedance Distributions under Alternative 1 and Existing Conditions

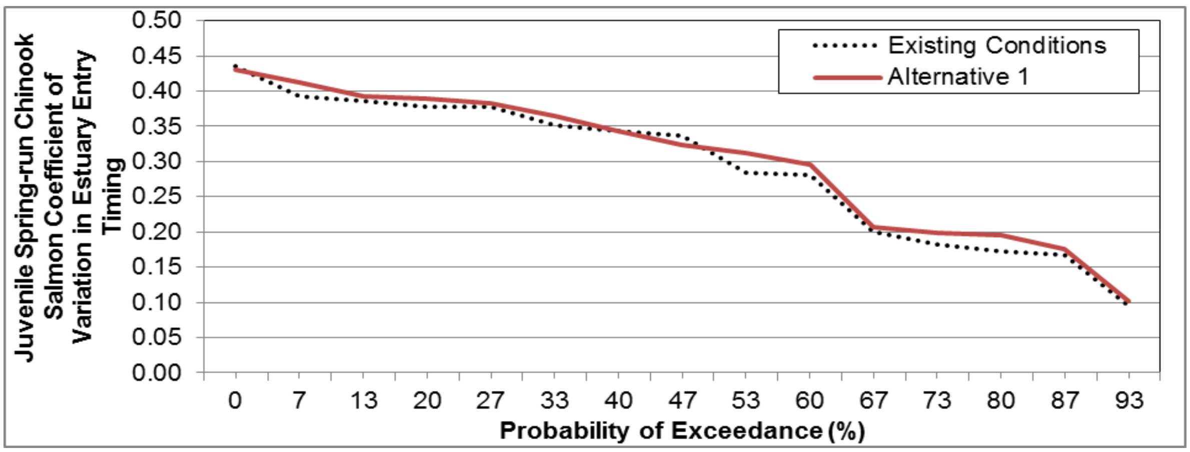

Figure 8-20. Simulated Juvenile Spring-Run Chinook Salmon Coefficient of Variation in Estuary Entry Timing Probability of Exceedance Distributions under Alternative 1 and Existing Conditions

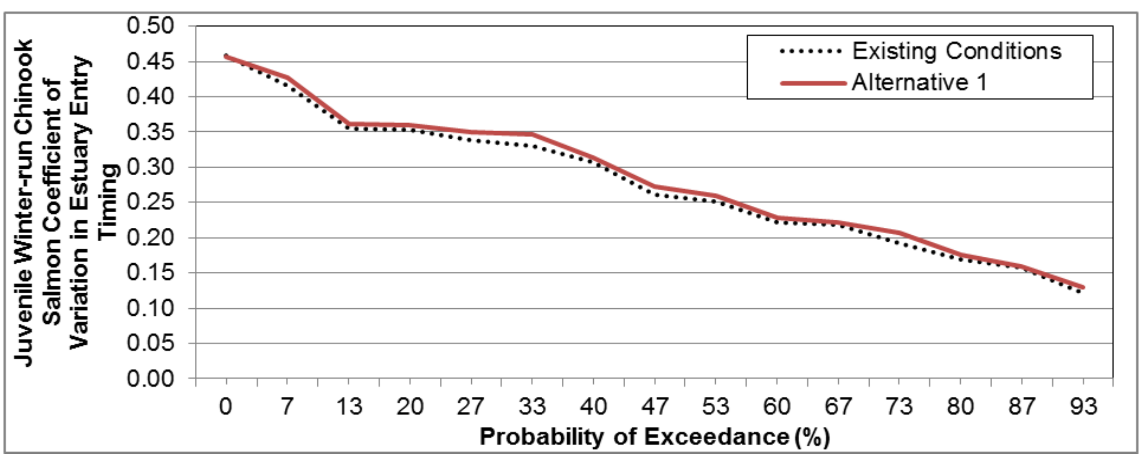

Figure 8-21. Simulated Juvenile Winter-run Chinook salmon Coefficient of Variation in Estuary Entry Timing Probability of Exceedance Distributions under Alternative 1 and Existing Conditions

Spatial Structure

Entrainment into the Yolo Bypass

Modeling results indicate that mean monthly flows spilling into the Yolo Bypass from the Sacramento River at Fremont Weir under Alternative 1 relative to Existing Conditions would be higher from November through March and similar over the remainder of the year (see Appendix G6). Mean monthly flows would be substantially higher (by 10 percent or more) during at least some water year types in November (wet water years), December (wet and above normal water years), January (above normal, below normal, and dry water years), February (above normal, below normal, dry, and critical water years), and March (above normal, below normal, and dry water years). Over the entire simulation period, net increases in flows of 10 percent or more would occur with substantially higher frequency (10 percent or more often) from December through March (see Appendix G6).

Based on increases in monthly flows from December through March, it is expected that juvenile salmonids and potentially other fish species would be more likely to be entrained into the Yolo Bypass from December through March under Alternative 1 relative to Existing Conditions.

The estimated average annual percentages of juvenile fall-run, late fall-run, winter-run, and spring-run Chinook salmon (all sizes) entrained into the Yolo Bypass using the proportion of flow approach would be 15.4, 5.9, 11.3, and 10.3 percent under Alternative 1, respectively, relative to 7.1, 2.6, 3.9, and 3.1 percent, respectively, under Existing Conditions (DWR 2017a; Appendix G3). For smaller juveniles (i.e., <80 mm), the percentages of fall-run, late fall-run, winter-run, and spring-run Chinook salmon entrained into the Yolo Bypass would be 15.3, 1.1, 7.1, and 10.6 percent, respectively.

The ELAM modeling for Alternative 1 indicates that at the highest Sacramento River stage modeled, up to about 14 percent of juveniles could be entrained into the Yolo Bypass (Smith et al. 2017; Appendix G1). The entrainment-Sacramento River stage relationship exhibits a positive trend as Sacramento River stage increases from 20.23 to 28.83 ft.

Juvenile Rearing in the Yolo Bypass for One or More Days

Modeling results indicate that annual average numbers of juvenile Chinook salmon rearing for one or more days in the Yolo Bypass under Alternative 1 relative to Existing Conditions would be substantially higher over the entire simulation period and during all water year types for fall-run, late fall-run, spring-run, and winter-run Chinook salmon (Table 8-11).

Similarly, the annual number of juvenile Chinook salmon rearing for one or more days in the Yolo Bypass under Alternative 1 relative to Existing Conditions would be higher over the entire exceedance distribution for fall-run, substantially higher over the entire distributions for spring-run and winter-run Chinook salmon, and higher about half of the time for late fall-run Chinook salmon (Figures 8-22 through 8-25). In addition, Alternative 1 would provide for juvenile rearing in the Yolo Bypass over about 20 percent of the distribution when no juvenile fall-run Chinook salmon would be rearing in the Yolo Bypass, over about 40 percent of the distribution when no juvenile late fall-run Chinook salmon would be rearing in the Yolo Bypass, and over about 30 percent of the distribution when few or no juvenile spring-run and winter-run Chinook salmon would be rearing in the Yolo Bypass under Existing Conditions.

Table 8-11. Average Annual Number of Juvenile Chinook Salmon that Reared in the Yolo Bypass for One or More Days under Alternative 1

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Fall-run Chinook Salmon						
Alternative 1	4,753,465	9,978,883	4,755,768	1,003,178	1,104,158	717,273
Existing Conditions	3,179,250	8,028,286	2,198,294	436,145	20,038	0
Difference	1,574,215	1,950,597	2,557,474	567,034	1,084,121	717,273
Percent Difference[3]	50	24	116	130	5,410	n/a
Late Fall-run Chinook Salmon						
Alternative 1	247,949	691,939	54,013	13,388	17,551	516
Existing Conditions	190,830	571,919	953	0	0	0
Difference	57,118	120,020	53,060	13,388	17,551	516
Percent Difference[3]	30	21	5,566	n/a	n/a	n/a
Spring-run Chinook Salmon						
Alternative 1	93,719	193,287	78,417	24,560	28,243	42,004
Existing Conditions	32,657	72,311	41,409	1,894	70	0
Difference	61,062	120,976	37,007	22,666	28,173	42,004
Percent Difference[3]	187	167	89	1,197	40,103	n/a
Winter-run Chinook Salmon						
Alternative 1	66,153	104,777	85,621	38,842	28,468	19,998
Existing Conditions	28,031	54,261	46,976	3,552	283	0
Difference	38,122	50,516	38,645	35,290	28,184	19,998
Percent Difference[3]	136	93	82	994	9,950	n/a

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

[3] Relative difference of the annual average

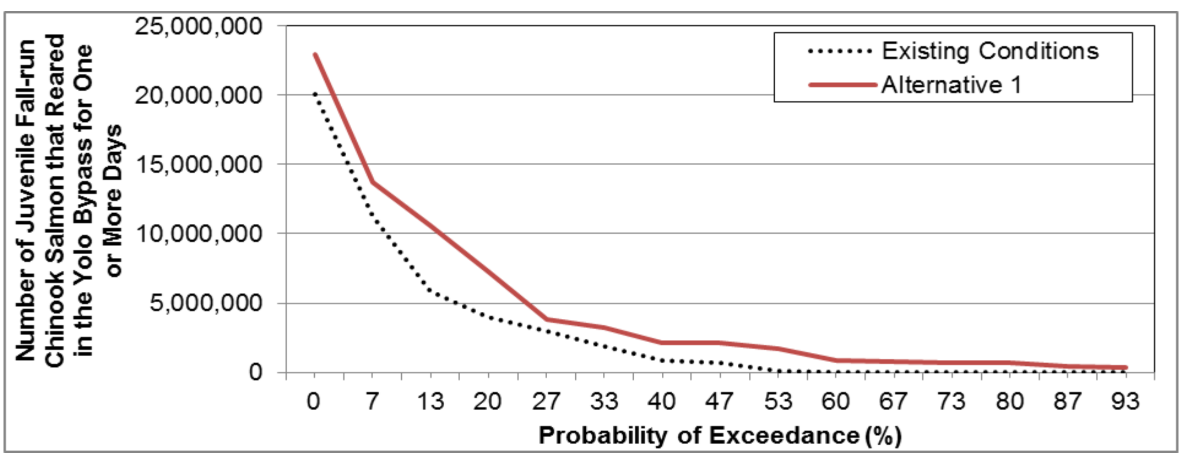

Figure 8-22. Simulated Number of Juvenile Fall-run Chinook Salmon Rearing for One or More Days in the Yolo Bypass Probability of Exceedance Distributions under Alternative 1 and Existing Conditions

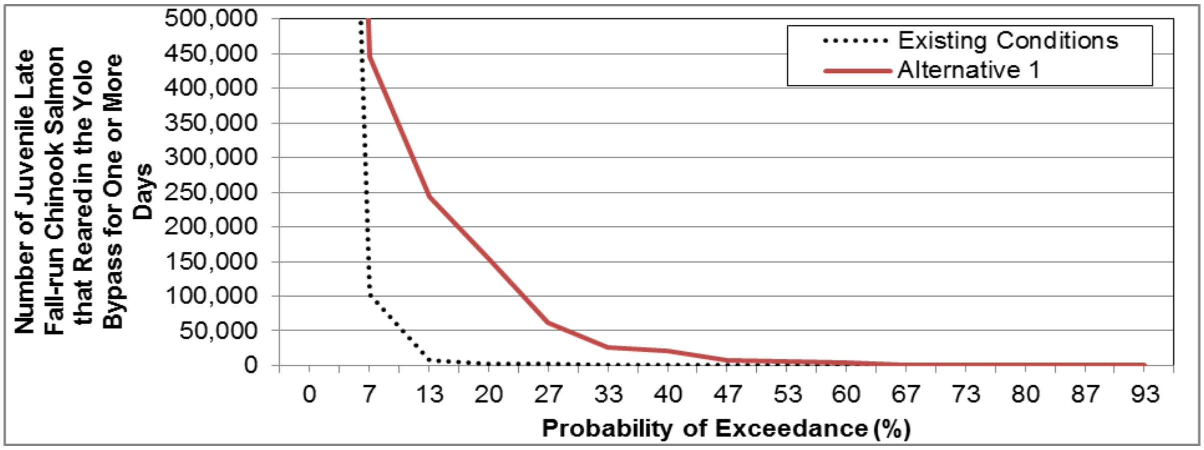

Figure 8-23. Simulated Number of Juvenile Late Fall-run Chinook Salmon Rearing for One or More Days in the Yolo Bypass Probability of Exceedance Distributions under Alternative 1 and Existing Conditions

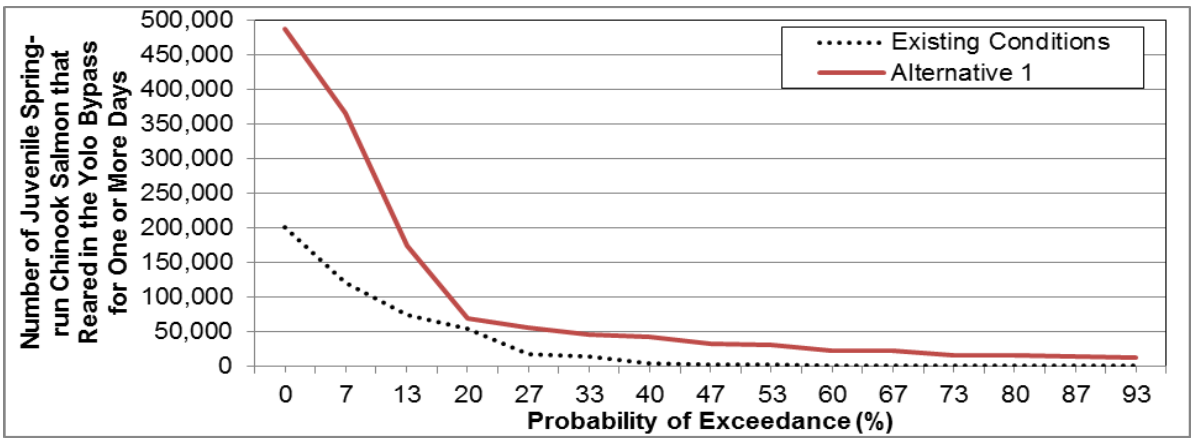

Figure 8-24. Simulated Number of Juvenile Spring-run Chinook Salmon Rearing for One or More Days in the Yolo Bypass Probability of Exceedance Distributions under Alternative 1 and Existing Conditions

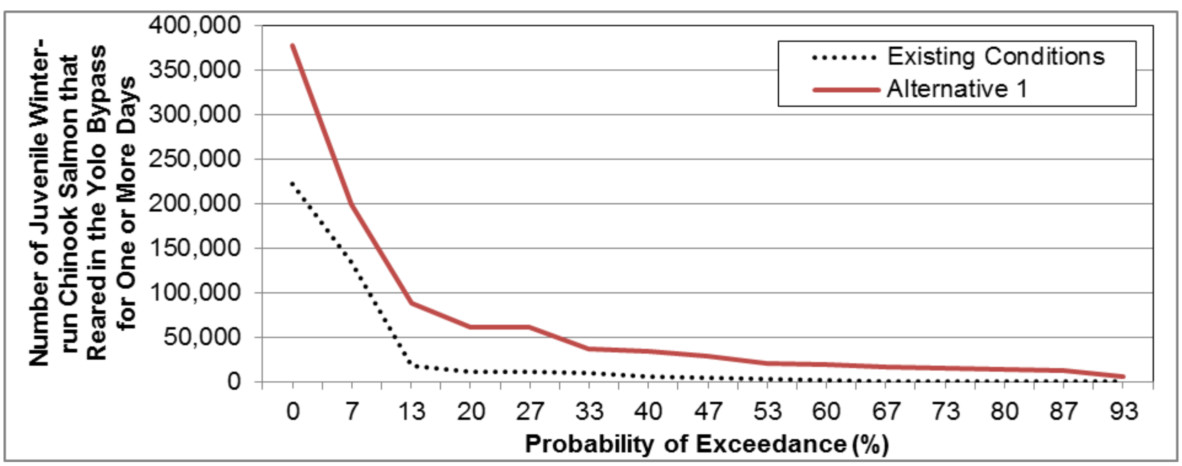

Figure 8-25. Simulated Number of Juvenile Winter-Run Chinook Salmon Rearing for One or More Days in the Yolo Bypass Probability of Exceedance Distributions under Alternative 1 and Existing Conditions

CEQA Conclusion

Simulated population metric indicators from the SBM were used to evaluate changes in the VSP parameters under Alternative 1 relative to Existing Conditions. Except for the abundance and productivity parameters for late fall-run and winter-run Chinook salmon and the diversity parameter for late fall-run Chinook salmon, which indicate generally similar conditions under Alternative 1 and Existing Conditions, the abundance, productivity, diversity, and spatial structure indicators would improve for fall-run, late fall-run, spring-run, and winter-run Chinook salmon under Alternative 1 relative to Existing Conditions.

Therefore, Alternative 1 would be expected to have a **less than significant impact** on VSP parameters.

Impact FISH-19: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Hydrologic Conditions in the SWP/CVP System

Modeling results indicated that mean monthly storage in Trinity, Shasta, Oroville, Folsom, and San Luis reservoirs would be the same or generally similar during all months of the year under Alternative 1 relative to Existing Conditions (see Appendix G6). Relative to the No Action Alternative, CalSim II modeling does indicate that there would be some changes in mean monthly storage of 10 percent or more in SWP/CVP reservoirs and changes of 10 percent or more in mean monthly flows in SWP/CVP system and Delta under Alternative 1, primarily because of assumed re-operations from other projects under the future LOD. However, the changes would be infrequent and would not occur over 10 percent or more of any monthly distribution. Therefore, changes under Alternative 1 relative to the No Action Alternative (and Existing Conditions) would not result in substantial adverse effects to fish species of focused evaluation and their habitats in the SWP/CVP system.

CEQA Conclusion

Due to similar modeled hydrology in the SWP/CVP system, Alternative 1 would be expected to have a **less than significant impact** on hydrologic conditions in the SWP/CVP system.

Impact FISH-20: Conflict with Adopted Habitat Conservation Plan; Natural Community Conservation Plan; or Other Approved Local, Regional, or State Habitat Conservation Plan

Although the Yolo County HCP/NCCP does not directly address fish species, it does include goals and policies related to protecting and improving habitat conditions in the Yolo Bypass that could indirectly benefit fish resources (Yolo Habitat Conservancy 2017). Because Alternative 1 would include mitigation for physical habitat impacts, Alternative 1 would not conflict with HCPs or NCCPs, including the Yolo County HCP/NCCP (Yolo Habitat Conservancy 2017). This impact consideration is addressed for vegetation, wetlands and wildlife resources in Chapter 9 under Impact TERR-11 for each Alternative.

CEQA Conclusion

Alternative 1 is expected to have a **less than significant impact** on habitat conservation plans.

8.3.3.3 Alternative 2: Central Gated Notch

Alternative 2, Central Gated Notch, would provide a similar new gated notch through Fremont Weir as described for Alternative 1. The primary difference between Alternatives 1 and 2 is the location of the notch; Alternative 2 would site the notch near the center of Fremont Weir. This gate would be a similar size but would have an invert elevation that is higher (14.8 feet) because the river is higher at this upstream location, and the gate would convey up to 6,000 cfs to provide open channel flow for adult fish passage. In addition, because hydraulic conditions upstream of the proposed Fremont Weir notch are not favorable to entraining juvenile Chinook salmon, Alternative 2 includes Sacramento River channel and bank improvements. These improvements include removing pilings in the Sacramento River and re-grading the Sacramento River channel and right bank. These improvements also are expected to fill in a scour hole near the pilings. See Section 2.5 for more details on the alternative features.

8.3.3.3.1 Construction-related Impacts – Evaluation of Substantial Adverse Effects on Fish Species of Focused Evaluation and their Habitat and Movement

The proposed construction schedule for Alternative 2 would be similar to the schedule described for Alternative 1. Construction- and maintenance-related activities evaluated for Alternative 2 are similar to those described for Alternative 1. However, Alternative 2 includes additional in-river activities just upstream of the proposed Fremont Weir notch. Activities include removing instream piles and re-grading the Sacramento River channel and right bank. In addition, future maintenance may be necessary to maintain the re-graded conditions in the Sacramento River channel and along the right bank to maintain hydraulic conditions that promote entrainment of juvenile Chinook salmon into the Fremont Weir notch.

Impact FISH-1: Potential Disturbance to Fish Species or their Habitat due to Erosion, Sedimentation, and Turbidity

Potential impacts due to erosion, sedimentation, and turbidity under Alternative 2 are expected to be similar to those described for Alternative 1. As an indicator of the extent of excavation that would occur under Alternative 2 in the Yolo Bypass, the estimated excess amount of spoils to be excavated during construction would be about 546,000 CY. As an indicator of maintenance-related impacts, the estimated additional annual amount of sediment removal required in the area between Fremont Weir and Agricultural Road Crossing 1 because of increased flows into the Yolo Bypass under implementation of Alternative 2 is 37,800 CY. This corresponds to an estimated total annual amount of sediment removal required of 334,350 CY under Alternative 2 relative to 296,550 CY under Existing Conditions. However, local depositional patterns will be dependent on the specific design of the downstream facilities. For example, although the total estimated increase in sediment deposition due to increased flows would be the same under Alternatives 1, 2, and 3, the additional lengths of channel connecting the intake facility to the Tule Pond under Alternatives 2 and 3 may result in the need for additional sediment removal under Alternatives 2 and 3 relative to Alternative 1.

CEQA Conclusion

Erosion, sedimentation, and turbidity impacts would be **significant** because construction and maintenance activities would result in temporary increases in sedimentation and turbidity in the Sacramento River and the Yolo Bypass and could temporarily adversely affect all fish species of focused evaluation.

Development and implementation of Mitigation Measure MM-WQ-2: Implement a Stormwater Pollution and Prevention Plan and Mitigation Measure MM-WQ-3: Develop Turbidity Monitoring Program would reduce this impact to **less than significant**.

Impact FISH-2: Potential Disturbance to Fish Species or their Habitat due to Hazardous Materials and Chemical Spills

Potential impacts associated with hazardous materials and chemical spills under Alternative 2 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Hazardous materials and chemical spills impacts would be **significant** because construction and maintenance activities could potentially result in the release of contaminants to aquatic habitats in the Sacramento River and the Yolo Bypass and could adversely affect all fish species of focused evaluation.

Development and implementation of Mitigation Measure MM-WQ-1: Prepare and Implement a Spill Prevention, Control, and Countermeasure Plan would reduce this impact to **less than significant**.

Impact FISH-3: Potential Disturbance to Fish Species or their Habitat due to Aquatic Habitat Modification

Potential impacts associated with aquatic habitat modification under Alternative 2 are expected to be similar to those described for Alternative 1, except as described below.

Preliminary estimates based on calculations in ArcGIS indicate that a total of 27.4 acres (temporary impacts) and 72.5 acres (permanent impacts) of vegetated area would have the potential to be disturbed during Alternative 2 construction activities. Specifically, 6.0 acres (temporary impacts) and 15.9 acres (permanent impacts) would be riparian vegetation and would be a potential source of IWM inputs to the Sacramento River or Yolo Bypass (Table 8-12 and Figure 8-26).

Table 8-12. Vegetation Communities Potentially Affected by Alternative 2

Vegetation Community					
	Grassland	**Freshwater Aquatic Vegetation**	**Freshwater Emergent Marsh**	**Riparian Forrest/Woodland**	**Total**
Acres (Temporary)	18.8	1.0	1.6	6.0	27.4
Acres (Permanent)	43.3	4.0	9.3	15.9	72.5

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Figure 8-26a. Vegetation Communities Potentially Affected under Alternative 2

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Figure 8-26b. Vegetation Communities Potentially Affected under Alternative 2

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CEQA Conclusion

Aquatic habitat modification adjacent to the Sacramento River and in the Yolo Bypass associated with construction and maintenance activities would be **significant** because aquatic and riparian habitat would be permanently affected.

Implementation of Mitigation Measures MM-TERR-13, MM-TERR-11, and MM-FISH-1 would reduce this impact to **less than significant**.

Impact FISH-4: Potential Disturbance to Fish Species or their Habitat due to Hydrostatic Pressure Waves, Noise, and Vibration

Potential impacts associated with hydrostatic pressure waves, noise, and vibration under Alternative 2 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Impacts associated with construction noise would be **less than significant** if a vibratory pile driver can be used for the entire construction of the cofferdam. However, impacts associated with noise would be **significant** if impact pile driving was conducted in the Sacramento River, resulting in direct potential impacts to fish species of focused evaluation.

Implementation of Mitigation Measure MM-FISH-2: Implement an Underwater Noise Reduction and Monitoring Plan would reduce this impact to **less than significant**.

Impact FISH-5: Potential Disturbance to Fish Species or their Habitat due to Stranding and Entrainment

Potential impacts associated with construction- and maintenance-related stranding and entrainment under Alternative 2 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Stranding and entrainment impacts would be **significant** because fish species of focused evaluation could be entrained in the temporary cofferdam or stranded in the Yolo Bypass associated with dewatering activities.

Implementation of Mitigation Measure MM-FISH-3: Prepare a Fish Rescue and Salvage Plan would reduce this impact to **less than significant**.

Impact FISH-6: Potential Disturbance to Fish Species or their Habitat due to Predation Risk

Potential impacts associated with predation risk under Alternative 2 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Predation risk impacts would be **significant** because fish species of focused evaluation could be at increased risk of predation due to potential indirect effects of construction and maintenance activities.

Implementation of Mitigation Measures MM-WQ-2: Implement a Stormwater Pollution and Prevention Plan; MM-WQ-1: Prepare and Implement a Spill Prevention, Control, and Countermeasure Plan; MM-FISH-2: Implement an Underwater Noise Reduction and Monitoring Plan; and MM-FISH-3: Prepare a Fish Rescue and Salvage Plan would reduce this impact to less than significant.

Impact FISH-7: Potential Disturbance to Fish Species due to Changes in Fish Passage Conditions

Potential impacts associated with fish passage under Alternative 2 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Fish passage impacts would be **less than significant** because fish species of focused evaluation would either generally not be present near temporary fish passage blockages or would not be substantially affected by temporary blockages.

Impact FISH-8: Potential Disturbance to Fish Species or their Habitat due to Direct Harm

Potential impacts associated with direct physical injury and/or mortality under Alternative 2 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

This impact would be **significant** because fish species of focused evaluation could be directly harmed due to construction- and maintenance-related equipment, personnel, or debris.

Implementation of Mitigation Measure MM-FISH-4: Implement General Fish Protection Measures would reduce this impact to **less than significant**.

8.3.3.3.2 Operations-Related Impacts – Evaluation of Substantial Adverse Effects on Fish Species of Focused Evaluation and their Habitat and Movement

Operations-related impacts associated with Alternative 2 are evaluated in the Yolo Bypass, the Sacramento River at and downstream of the Fremont Weir, the Delta and downstream waterbodies, and the broader SWP/CVP system as appropriate. Operations-related impacts under Alternative 2 are generally similar to operations-related impacts under Alternative 1.

Impact FISH-9: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Flows in the Sacramento River

Modeling results indicate that changes in average monthly flows over the entire simulation period under Alternative 2 in the Sacramento River downstream of Fremont Weir would be similar to those described for Alternative 1. Therefore, migration and rearing conditions would be similar under Alternative 2 relative to Existing Conditions in the lower Sacramento River for fish species of focused evaluation, including winter-run, spring-run, fall-run, and late fall-run Chinook salmon, steelhead, green sturgeon, white sturgeon, river lamprey, and Pacific lamprey. In addition, there would be minimal potential for reduced flows in the Sacramento River to result in increased exposure of fish species of focused evaluation to predators or to higher concentrations of water quality contaminants and minimal potential to exacerbate the channel homogenization in the lower Sacramento River.

CEQA Conclusion

Alternative 2 would result in the same or similar flows in the Sacramento River downstream of Fremont Weir relative to Existing Conditions; therefore, Alternative 2 would have a **less than significant impact** due to changes in flows in the Sacramento River.

Impact FISH-10: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Water Temperatures in the Sacramento River

Modeling results indicate that changes in mean monthly water temperatures in the Sacramento River would be similar to those described for Alternative 1. Therefore, migration and rearing thermal conditions would not be substantially affected for fish species of focused evaluation expected to occur in the lower Sacramento River, including winter-run, spring-run, fall-run, and late fall-run Chinook salmon, steelhead, green sturgeon, white sturgeon, river lamprey, and Pacific lamprey under Alternative 2 relative to Existing Conditions.

CEQA Conclusion

Alternative 2 would not result in substantial changes to water temperature suitability for fish species of focused evaluation relative to Existing Conditions; therefore, Alternative 2 would have a **less than significant impact** due to changes in water temperatures in the Sacramento River.

Impact FISH-11: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Delta Hydrologic and Water Quality Conditions

Modeling results indicate that changes in mean monthly Delta hydrologic and water quality parameters under Alternative 2 would be similar to those described for Alternative 1. Therefore, habitat conditions in the Delta would be similar for all life stages evaluated. In addition, based on mean monthly Delta outflow, fisheries habitat conditions would be the same or similar in Suisun Bay.

CEQA Conclusion

Alternative 2 would result in the same or similar habitat conditions for fish species of focused evaluation in the Delta and in downstream areas relative to Existing Conditions; therefore, Alternative 2 would have a **less than significant impact** due to Delta conditions.

Impact FISH-12: Impacts to Fisheries Habitat Conditions due to Changes in Flow-Dependent Habitat Availability in the Study Area (Yolo Bypass/Sutter Bypass)

Changes in flow-dependent hydraulic habitat availability under Alternative 2 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

In the Yolo Bypass under Alternative 2, increased hydraulic habitat availability for fish species of focused evaluation, particularly juvenile Chinook salmon and steelhead and adult and juvenile Sacramento splittail, is expected to result in more suitable conditions for these and other fish species of focused evaluation. Relatively minor reductions in the number of wetted days in the Sutter Bypass upstream of the Sacramento River at Fremont Weir are not expected to substantially affect rearing or migration of fish species of focused evaluation; therefore, Alternative 2 would be expected to have a **beneficial impact** on flow-dependent hydraulic habitat availability in the Yolo Bypass and a **less than significant impact** on flow-dependent hydraulic habitat availability in the Sutter Bypass.

Impact FISH-13: Impacts to Fisheries Habitat Conditions due to Changes in Water Quality in the Study Area

Flows entering the Yolo Bypass from the Sacramento River at Fremont Weir under Alternative 2 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Based on higher mean monthly flows entering the Yolo Bypass, increased concentrations of methylmercury and other contaminants may occur in the Yolo Bypass and the Delta. However, the potential for increased concentrations of contaminants is not expected to substantially affect fish species of focused evaluation; therefore, Alternative 2 would have a **less than significant impact**.

Impact FISH-14: Impacts to Aquatic Primary and Secondary Production in the Study Area

Wetted extent in the Yolo and Sutter bypasses under Alternative 2 is expected to be similar to that described for Alternative 1. Therefore, an increase in wetted extent during the winter in the Yolo Bypass could increase food resources for fish species of focused evaluation in the Yolo Bypass and potentially the Delta. Minor reductions in wetted area in the Sutter Bypass could result in minor reductions in food resources in the Sutter Bypass.

CEQA Conclusion

Based on increased wetted extent in the Yolo Bypass during the winter, increased primary and secondary production in the Yolo Bypass (and potentially in localized areas of the Delta) could increase food resources for fish species of focused evaluation. In the Sutter Bypass, slight reductions in wetted area could reduce primary and secondary production, but these reductions are not expected to be sufficient to substantially affect food resources for fish species of focused evaluation. Therefore, Alternative 2 would result in a **beneficial impact** in the Yolo Bypass and a **less than significant impact** in the Sutter Bypass.

Impact FISH-15: Impacts to Fish Species of Focused Evaluation due to Changes in Adult Fish Passage Conditions through the Yolo Bypass

Flows entering the Yolo Bypass from the Sacramento River at Fremont Weir under Alternative 2 are expected to be similar to those described for Alternative 1. Therefore, the duration of potential adult fish passage from the Yolo Bypass into the Sacramento River may increase for fish species of focused evaluation. Hydraulic conditions in the Yolo Bypass under Alternative 2 could also improve migration conditions for anadromous fish species entering and emigrating from the west-side streams relative to Existing Conditions. The potential for straying of anadromous fish species into the Yolo Bypass that are native to watersheds from outside of the upper Sacramento River Basin would be similar to the discussion for Alternative 1 relative to Existing Conditions.

Based on results of the YBPASS Tool, which applied fish passage criteria to modeled hydraulic conditions in the intake facility and transport channel under Alternative 2, adult salmon and sturgeon would be expected to successfully pass upstream through the transport channel and intake structure into the Sacramento River about 23 percent of the days from November through April over the water years 1997 through 2012 simulation period. The annual average date after which Alternative 2 would no longer meet the fish passage criteria is April 2.

As described for Alternative 1, the Project Alternative would be adaptively managed to ensure that biological goals and objectives are met (see Appendix C).

CEQA Conclusion

Increased duration of potential adult fish passage opportunity from the Yolo Bypass into the Sacramento River under Alternative 2 is expected to result in improved upstream spawning opportunities and less potential for mortality or migration delay for fish species of focused evaluation; therefore, Alternative 2 would be expected to have a **beneficial impact** on changes in adult fish passage conditions through the Yolo Bypass.

Impact FISH-16: Impacts to Fish Species due to Changes in Potential for Stranding and Entrainment

Project facilities constructed under Alternative 2, such as the transport and intake channels, would be graded to provide suitable passage conditions for fish, assuming sufficient water is present. Although Alternative 1 would allow for entrainment of juvenile fish at lower flows relative to Existing Conditions, the design of the transport channel to Tule Canal is expected to minimize the potential for stranding of juveniles. However, anthropogenic structures that interrupt natural drainage patterns, such as water control structures, create the greatest risk for stranding (Sommer et al. 2005). Therefore, there is some potential for increased juvenile stranding in the Yolo Bypass.

Because Alternative 2 would allow for adult migration into the Sacramento River during periods when adult migration is impeded or blocked at Fremont Weir under Existing Conditions, the potential for adult fish stranding in the Yolo Bypass would be expected to be reduced. However, because the Fremont Weir notch would be in the central region of the Fremont Weir and the supplemental fish passage facility would be located at the western region of the Fremont Weir, adults located near the eastern portion of Fremont Weir may still have the same likelihood of stranding as occurs under Existing Conditions.

CEQA Conclusion

The overall potential for adult fish stranding would be expected to be reduced under Alternative 2 relative to Existing Conditions. Juvenile stranding may potentially increase under Alternative 2, but design of the project facilities is expected to minimize any increases in juvenile stranding. Therefore, Alternative 2 would be expected to have a **less than significant impact** on stranding and entrainment.

Impact FISH-17: Impacts to Fish Species due to Changes in Potential for Predation and Competition

Construction of the intake facility, supplemental fish passage facility, and intake and transport channels lined with rock could increase the potential for predation of fish species of focused evaluation under Alternative 2 relative to Existing Conditions by providing habitat for predatory fish species in these areas. However, the facilities on the Sacramento River are not expected to substantially increase the potential area of refugia for species such as striped bass relative to Existing Conditions. In the Yolo Bypass, increased flow pulses into the Yolo Bypass associated with Alternative 2 during the winter months (primarily December through March) could reduce the potential for predation of fish species such as juvenile salmonids by non-native fish species. For example, Sommer et al. (2014) found that increased connectivity to the Yolo Bypass would provide an overall benefit to native fish species, particularly during the winter, because it is prior to the spawning periods of non-native fish species in the spring. Frantzich et al. (2013) found that native fish species were more widely distributed during wetter years, and low flows may provide more suitable conditions for the spawning and recruitment of non-native centrarchids. Increased flows during February and March under Alternative 2 could increase habitat availability for non-native cyprinids, such as common carp and goldfish, which could result in increased competition for food resources with fish species of focused evaluation relative to Existing Conditions. However, because increased primary and associated secondary production in the Yolo Bypass would likely increase food resources for fish species of focused evaluation in the Yolo Bypass and downstream (see *Impact FISH-14*), increased habitat for non-native cyprinids is not expected to substantially affect fish species of focused evaluation in the Yolo Bypass or in the Delta. Overall, Opperman et al. (2017) argued that flooding the Yolo Bypass from January through April would benefit native fish species. In addition, given the perennial nature of the Tule Canal and its ability to support non-native fish species under Existing Conditions, it is not expected that the proposed facilities under Alternative 2 would increase predation of fish species of focused evaluation above baseline levels in the Yolo Bypass. In addition, results of the SBM (evaluated under *Impact FISH-18*) account for predation associated with the estimated migration path and migration duration for juvenile Chinook salmon in the Yolo Bypass associated with Alternative 2.

CEQA Conclusion

Overall potential for predation of, and competition with, fish species of focused evaluation is not expected to substantially differ relative to predation and competition conditions under Existing Conditions; therefore, Alternative 2 would be expected to have a **less than significant impact** on predation and competition.

Impact FISH-18: Impacts to Chinook Salmon Species/Runs due to Changes in Viable Salmonid Population Parameters

As previously discussed, model output from the SBM is used to evaluate the VSP parameters (abundance, productivity, diversity, and spatial structure) for fall-run, late fall-run, spring-run, and winter-run Chinook salmon.

Modeling results indicate that changes in mean monthly flows spilling into the Yolo Bypass from the Sacramento River at Fremont Weir under Alternative 2 would be similar to those described for Alternative 1. However, entrainment estimates from the ELAM modeling are different for Alternative 2 relative to Alternative 1 and are presented for Alternative 2 below.

The ELAM modeling indicates that the entrainment-Sacramento River stage relationship under Alternative 2 exhibits a positive relationship as Sacramento River stage increases from 22.32 to 28.83 ft. Without the proposed Sacramento River channel and bank improvements, the percent of juveniles entrained peaks at 9.4 percent at the highest stage modeled (Smith et al. 2017; Appendix G1). However, based on the differences in maximum entrainment under ELAM model scenarios for Alternative 5 with the Sacramento River improvements (about 10 percent) and without the Sacramento River improvements (about 5.6 percent), entrainment of juveniles under Alternative 2 with the Sacramento River improvements is expected to increase the maximum rate of entrainment above 9.4 percent (representations of Alternative 5 were modeled with and without the Sacramento River improvements; Alternative 2 was only modeled without the improvements).

Because operations under Alternative 2 are expected to be very similar to operations under Alternative 1, simulated changes in indicators of the VSP parameters for fall-run, late fall-run, spring-run, and winter-run Chinook salmon would be similar to those described for Alternative 1. Although the SBM modeling was conducted using the proportion of flow approach to estimate juvenile entrainment into the Yolo Bypass, the ELAM modeling with and without Sacramento River improvements for a different alternative that would be at the same location (Alternative 5) suggests that the maximum entrainment rates for Alternative 2 with the Sacramento River improvements may be similar to Alternative 1. Therefore, the indicators of the VSP parameters under Alternative 2 are assumed to be similar to the results shown and described for Alternative 1.

CEQA Conclusion

Except for the abundance and productivity parameters for late fall-run and winter-run Chinook salmon and the diversity parameter for late fall-run Chinook salmon, which indicate generally similar conditions under Alternative 2 and Existing Conditions, the abundance, productivity, diversity, and spatial structure indicators all exhibit improvement for fall-run, late fall-run, spring-run, and winter-run Chinook salmon under Alternative 2 relative to Existing Conditions.

Therefore, Alternative 2 would be expected to have a **less than significant impact** on VSP parameters.

Impact FISH-19: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Hydrologic Conditions in the SWP/CVP System

Changes in simulated mean monthly storages in the SWP/CVP system under Alternative 2 relative to the bases of comparison would be similar to those described for Alternative 1. Therefore, simulated changes under Alternative 2 relative to the No Action Alternative (and Existing Conditions) would not result in substantial adverse effects to fish species of focused evaluation and their habitats in the SWP/CVP system.

CEQA Conclusion

Due to similar modeled hydrology in the SWP/CVP system, Alternative 2 would be expected to have a **less than significant impact**.

Impact FISH-20: Conflict with Adopted Habitat Conservation Plan; Natural Community Conservation Plan; or Other Approved Local, Regional, or State Habitat Conservation Plan

Although the Yolo County HCP/NCCP does not directly address fish species, it does include goals and policies related to protecting and improving habitat conditions in the Yolo Bypass, which could indirectly benefit fish resources (Yolo Habitat Conservancy 2017). Because Alternative 2 would include mitigation for physical habitat impacts, Alternative 2 would not conflict with HCPs or NCCPs, including the Yolo County HCP/NCCP (Yolo Habitat Conservancy 2017). This impact consideration is addressed for vegetation, wetlands and wildlife resources in Chapter 9 under Impact TERR-11 for each Alternative.

CEQA Conclusion

Alternative 2 is expected to have a **less than significant impact** on habitat conservation plans.

8.3.3.4 Alternative 3: West Side Gated Notch

Alternative 3, West Side Gated Notch, would provide a similar new gated notch through Fremont Weir as described for Alternative 1. The primary difference between Alternatives 1 and 3 is the location of the notch; Alternative 3 would site the notch on the western side of Fremont Weir. This gate would be a similar size but would have an invert elevation that is higher (16.1 feet) because the river is higher at this upstream location. Alternative 3 would allow up to 6,000 cfs through the gated notch to provide open channel flow for adult fish passage. See Section 2.6 for more details on the alternative features.

8.3.3.4.1 Construction-related Impacts – Evaluation of Substantial Adverse Effects on Fish Species of Focused Evaluation and their Habitat and Movement

The proposed construction schedule for Alternative 3 would be similar to the schedule described for Alternative 1. Construction- and maintenance-related activities evaluated for Alternative 3 are similar to those described for Alternative 1.

Impact FISH-1: Potential Disturbance to Fish Species or their Habitat due to Erosion, Sedimentation, and Turbidity

Potential impacts associated with erosion, sedimentation, and turbidity under Alternative 3 are expected to be similar to those described for Alternative 1. As an indicator of the extent of excavation that would occur under Alternative 3 in the Yolo Bypass, the estimated excess amount of spoils to be excavated during construction would be about 806,000 CY. As an indicator of maintenance-related impacts, the estimated additional annual amount of sediment removal required in the area between Fremont Weir and Agricultural Road Crossing 1 because of increased flows into the Yolo Bypass under implementation of Alternative 3 is 37,800 CY. This corresponds to an estimated total annual amount of sediment removal required of 334,350 CY under Alternative 2 relative to 296,550 CY under Existing Conditions. However, local depositional patterns will be dependent on the specific design of the downstream facilities. For example, although the total estimated increase in sediment deposition because of increased flows would be the same under Alternatives 1, 2, and 3, the additional lengths of channel connecting the intake facility to the Tule Pond under Alternatives 2 and 3 may result in the need for additional sediment removal under Alternatives 2 and 3 relative to Alternative 1.

CEQA Conclusion

Erosion, sedimentation, and turbidity impacts would be **significant** because construction and maintenance activities would result in temporary increases in sedimentation and turbidity in the Sacramento River and the Yolo Bypass and could temporarily adversely affect all fish species of focused evaluation.

Development and implementation of Mitigation Measure MM-WQ-2: Implement a Stormwater Pollution and Prevention Plan and Mitigation Measure MM-WQ-3: Develop Turbidity Monitoring Program would reduce this impact to **less than significant**.

Impact FISH-2: Potential Disturbance to Fish Species or their Habitat due to Hazardous Materials and Chemical Spills

Potential impacts associated with hazardous materials and chemical spills under Alternative 3 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Hazardous materials and chemical spills impacts would be **significant** because construction and maintenance activities could potentially result in the release of contaminants to aquatic habitats in the Sacramento River and the Yolo Bypass and could adversely affect all fish species of focused evaluation.

Development and implementation of Mitigation Measure MM-WQ-1: Prepare and Implement a Spill Prevention, Control, and Countermeasure Plan would reduce this impact to **less than significant**.

Impact FISH-3: Potential Disturbance to Fish Species or their Habitat due to Aquatic Habitat Modification

Potential impacts associated with aquatic habitat modification under Alternative 3 are expected to be similar to those described for Alternative 1, except as described below.

Preliminary estimates based on calculations in ArcGIS indicate that a total of 32.5 acres (temporary impacts) and 80.9 acres (permanent impacts) of vegetated area would have the potential to be disturbed during Alternative 3 construction activities. Specifically, 8.8 acres (temporary impacts) and 20.1 acres (permanent impacts) would be riparian vegetation which would be a potential source of IWM inputs to the Sacramento River or Yolo Bypass (Table 8-13 and Figure 8-27).

Table 8-13. Vegetation Communities Potentially Affected under Alternative 3

Vegetation Community						
	Grassland	Freshwater Aquatic Vegetation	Freshwater Emergent Marsh	Marsh/Seep	Riparian Forest/Woodland	Total
Acres (Temporary)	19.6	1.0	2.2	0.9	8.8	32.5
Acres (Permanent)	42.8	4.0	10.0	4.0	20.1	80.9

CEQA Conclusion

Aquatic habitat modification adjacent to the Sacramento River and in the Yolo Bypass associated with construction activities would be **significant** because aquatic and riparian habitat would be permanently affected.

Implementation of Mitigation Measures MM-TERR-13, MM-TERR-11, and MM-FISH-1 would reduce this impact to **less than significant**.

Impact FISH-4: Potential Disturbance to Fish Species or their Habitat due to Hydrostatic Pressure Waves, Noise, and Vibration

Potential impacts associated with hydrostatic pressure waves, noise, and vibration under Alternative 3 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Impacts associated with construction and maintenance noise would be **less than significant** if a vibratory pile driver can be used for the entire construction of the cofferdam. However, impacts associated with noise would be **significant** if impact pile driving was conducted in the Sacramento River, resulting in direct potential impacts to fish species of focused evaluation.

Implementation of Mitigation Measure MM-FISH-2: Implement an Underwater Noise Reduction and Monitoring Plan would reduce this impact to **less than significant**.

Impact FISH-5: Potential Disturbance to Fish Species or their Habitat due to Stranding and Entrainment

Potential impacts associated with stranding and entrainment under Alternative 3 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Stranding and entrainment impacts would be **significant** because fish species of focused evaluation could be entrained in the temporary cofferdam and stranded in the Yolo Bypass. Implementation of Mitigation Measure MM-FISH-3: Prepare a Fish Rescue and Salvage Plan would reduce this impact to **less than significant**.

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Figure 8-27a. Vegetation Communities Potentially Affected under Alternative 3

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Figure 8-27b. Vegetation Communities Potentially Affected under Alternative 3

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Impact FISH-6: Potential Disturbance to Fish Species or their Habitat due to Predation Risk

Potential impacts associated with predation risk under Alternative 3 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Predation risk impacts would be **significant** because fish species of focused evaluation could be at increased risk of predation due to potential indirect effects of construction and maintenance activities.

Implementation of Mitigation Measures MM-WQ-2: Implement a Stormwater Pollution and Prevention Plan; MM-WQ-1: Prepare and Implement a Spill Prevention, Control, and Countermeasure Plan; MM-FISH-2: Implement an Underwater Noise Reduction and Monitoring Plan; and MM-FISH-3: Prepare a Fish Rescue and Salvage Plan would reduce this impact to **less than significant**.

Impact FISH-7: Potential Disturbance to Fish Species due to Changes in Fish Passage Conditions

Potential impacts associated with fish passage under Alternative 3 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Fish passage impacts would be **less than significant** because fish species of focused evaluation would either not be present near temporary fish passage blockages or would not be substantially affected by temporary blockages.

Impact FISH-8: Potential Disturbance to Fish Species or their Habitat due to Direct Harm

Potential impacts associated with direct physical injury and/or mortality under Alternative 3 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Direct harm impacts would be **significant** because fish species of focused evaluation could be directly harmed due to construction- and maintenance-related equipment, personnel, or debris.

Implementation of Mitigation Measure MM-FISH-4: Implement General Fish Protection Measures would reduce this impact to **less than significant**.

8.3.3.4.2 Operations-Related Impacts – Evaluation of Substantial Adverse Effects on Fish Species of Focused Evaluation and their Habitat and Movement

Operations-related impacts associated with Alternative 3 are evaluated in the Yolo Bypass, the Sacramento River at and downstream of the Fremont Weir, the Delta and downstream waterbodies, and the broader SWP/CVP system as appropriate. Operations-related impacts under Alternative 3 are generally similar to operations-related impacts under Alternative 1.

Impact FISH-9: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Flows in the Sacramento River

Changes in simulated average monthly flows over the entire simulation period under Alternative 3 in the Sacramento River downstream of Fremont Weir are expected to be similar to those described for Alternative 1. Therefore, migration and rearing conditions would be similar under Alternative 3 relative to Existing Conditions in the lower Sacramento River for fish species of focused evaluation, including winter-run, spring-run, fall-run, and late fall-run Chinook salmon, steelhead, green sturgeon, white sturgeon, river lamprey, and Pacific lamprey. In addition, there would be minimal potential for reduced flows in the Sacramento River to result in increased exposure of fish species of focused evaluation to predators or to higher concentrations of water quality contaminants and minimal potential to exacerbate the channel homogenization in the lower Sacramento River.

CEQA Conclusion

Alternative 3 would result in the same or similar flows in the Sacramento River downstream of Fremont Weir relative to Existing Conditions; therefore, Alternative 3 would have a **less than significant impact** due to changes in flows in the Sacramento River.

Impact FISH-10: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Water Temperatures in the Sacramento River

Changes in simulated mean monthly water temperatures in the Sacramento River at Freeport under Alternative 3 are expected to be similar to those described for Alternative 1. Therefore, migration and rearing thermal conditions would not be substantially affected for fish species of focused evaluation expected to occur in the lower Sacramento River, including winter-run, spring-run, fall-run, and late fall-run Chinook salmon, steelhead, green sturgeon, white sturgeon, river lamprey, and Pacific lamprey under Alternative 3 relative to Existing Conditions.

CEQA Conclusion

Alternative 3 would not result in substantial changes to water temperature suitability for fish species of focused evaluation relative to Existing Conditions; therefore, Alternative 3 would have a **less than significant impact** due to changes in water temperatures in the Sacramento River.

Impact FISH-11: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Delta Hydrologic and Water Quality Conditions

Changes in simulated mean monthly Delta hydrologic and water quality parameters under Alternative 3 are expected to be similar to those described for Alternative 1. Therefore, habitat conditions in the Delta would be similar for all life stages evaluated. In addition, based on mean monthly Delta outflow, fisheries habitat conditions would be the same or similar in Suisun Bay.

CEQA Conclusion

Alternative 3 would result in the same or similar habitat conditions for fish species of focused evaluation in the Delta and in downstream areas relative to Existing Conditions; therefore, Alternative 3 would have a **less than significant impact** due to changes in Delta conditions.

Impact FISH-12: Impacts to Fisheries Habitat Conditions due to Changes in Flow-Dependent Habitat Availability in the Study Area (Yolo Bypass/Sutter Bypass)

Changes in flow-dependent hydraulic habitat availability under Alternative 3 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

In the Yolo Bypass under Alternative 3, increased hydraulic habitat availability for fish species of focused evaluation, particularly juvenile Chinook salmon and steelhead and adult and juvenile Sacramento splittail, is expected to result in more suitable conditions for these and other fish species of focused evaluation. Relatively minor reductions in the number of wetted days in the Sutter Bypass upstream of the Sacramento River at Fremont Weir are not expected to substantially affect rearing or migration of fish species of focused evaluation; therefore, Alternative 3 would be expected to have a **beneficial impact** on flow-dependent hydraulic habitat availability in the Yolo Bypass and a **less than significant impact** on flow-dependent hydraulic habitat availability in the Sutter Bypass.

Impact FISH-13: Impacts to Fisheries Habitat Conditions due to Changes in Water Quality in the Study Area

Flows entering the Yolo Bypass from the Sacramento River at Fremont Weir under Alternative 3 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Based on higher mean monthly flows entering the Yolo Bypass, increased concentrations of methylmercury and other contaminants may occur in the Yolo Bypass and the Delta. However, the potential for increased concentrations of contaminants is not expected to substantially affect fish species of focused evaluation; therefore, Alternative 3 would have a **less than significant impact**.

Impact FISH-14: Impacts to Aquatic Primary and Secondary Production in the Study Area

Wetted extent in the Yolo and Sutter bypasses under Alternative 3 is expected to be similar to that described for Alternative 1. Therefore, an increase in wetted extent during the winter in the Yolo Bypass could increase food resources for fish species of focused evaluation in the Yolo Bypass and potentially the Delta. Minor reductions in wetted area in the Sutter Bypass could result in minor reductions in food resources in the Sutter Bypass.

CEQA Conclusion

Based on increased wetted extent in the Yolo Bypass during the winter, increased primary and secondary production in the Yolo Bypass (and potentially in localized areas of the Delta) could increase food resources for fish species of focused evaluation. In the Sutter Bypass, slight reductions in wetted area could reduce primary and secondary production, but these reductions are not expected to be sufficient to substantially affect food resources for fish species of focused evaluation. Therefore, Alternative 3 would result in a **beneficial impact** in the Yolo Bypass and a **less than significant impact** in the Sutter Bypass.

Impact FISH-15: Impacts to Fish Species of Focused Evaluation due to Changes in Adult Fish Passage Conditions through the Yolo Bypass

Modeling results indicate that flows entering the Yolo Bypass from the Sacramento River at Fremont Weir under Alternative 3 would be similar to those described for Alternative 1. Therefore, the duration of potential adult fish passage from the Yolo Bypass into the Sacramento River may potentially increase for fish species of focused evaluation. Hydraulic conditions in the Yolo Bypass under Alternative 3 could also improve migration conditions for anadromous fish species entering and emigrating from the west-side streams relative to Existing Conditions. The potential for straying of anadromous fish species into the Yolo Bypass that are native to watersheds from outside of the upper Sacramento River Basin would be similar to the discussion for Alternative 1 relative to Existing Conditions.

Based on results of the YBPASS Tool, which applied fish passage criteria to modeled hydraulic conditions in the intake facility and transport channel under Alternative 3, adult salmon and sturgeon would be expected to successfully pass upstream through the transport channel and intake structure into the Sacramento River about 23 percent of the days from November through April over the water years 1997 through 2012 simulation period. The annual average date after which Alternative 3 would no longer meet the fish passage criteria is April 1.

As described for Alternative 1, the Project Alternative would be adaptively managed to ensure that biological goals and objectives are met (see Appendix C).

CEQA Conclusion

Increased duration of potential adult fish passage opportunity from the Yolo Bypass into the Sacramento River under Alternative 3 is expected to result in improved upstream spawning opportunities and less potential for mortality or migration delay for fish species of focused evaluation; therefore, Alternative 3 would be expected to have a **beneficial impact** on adult fish passage conditions through the Yolo Bypass.

Impact FISH-16: Impacts to Fish Species due to Changes in Potential for Stranding and Entrainment

Project facilities constructed under Alternative 3, such as the transport and intake channels, would be graded to provide suitable passage conditions for fish, assuming sufficient water is present. Although Alternative 3 would allow for entrainment of juvenile fish at lower flows relative to Existing Conditions, the design of the transport channel to Tule Canal is expected to minimize the potential for stranding of juveniles. However, anthropogenic structures that interrupt natural drainage patterns, such as water control structures, create the greatest risk for stranding (Sommer et al. 2005). Therefore, there is some potential for increased juvenile stranding in the Yolo Bypass.

Because Alternative 3 would allow for adult migration into the Sacramento River during periods when adult migration is impeded or blocked at Fremont Weir under Existing Conditions, the potential for adult fish stranding in the Yolo Bypass would be expected to be reduced.

CEQA Conclusion

The potential for adult fish stranding would be expected to be reduced under Alternative 3 relative to Existing Conditions. Juvenile stranding may potentially increase under Alternative 3, but design of the project facilities is expected to minimize any increases in juvenile stranding. Therefore, Alternative 3 would be expected to have a **less than significant impact** on stranding and entrainment.

Impact FISH-17: Impacts to Fish Species due to Changes in Potential for Predation and Competition

Construction of the intake facility, supplemental fish passage facility, and intake and transport channels lined with rock could increase the potential for predation of fish species of focused evaluation under Alternative 3 relative to Existing Conditions by providing habitat for predatory fish species in these areas. However, the facilities on the Sacramento River are not expected to substantially increase the potential area of refugia for species such as striped bass relative to Existing Conditions. In the Yolo Bypass, increased flow pulses into the Yolo Bypass associated with Alternative 3 during the winter months (primarily December through March) could reduce the potential for predation of fish species such as juvenile salmonids by non-native fish species. For example, Sommer et al. (2014) found that increased connectivity to the Yolo Bypass would provide an overall benefit to native fish species, particularly during the winter, because it is prior to the spawning periods of non-native fish species in the spring. Frantzich et al. (2013) found that native fish species were more widely distributed during wetter years, and low flows may provide more suitable conditions for the spawning and recruitment of non-native centrarchids. Increased flows during February and March under Alternative 3 could increase habitat availability for non-native cyprinids, such as common carp and goldfish, which could result in increased competition for food resources with fish species of focused evaluation relative to Existing Conditions. However, because increased primary and associated secondary production in the Yolo Bypass would likely increase food resources for fish species of focused evaluation in the Yolo Bypass and downstream (see Impact FISH-14), increased habitat for non-native cyprinids is not expected to substantially affect fish species of focused evaluation in the Yolo Bypass or in the Delta. Overall, Opperman et al. (2017) argued that flooding the Yolo Bypass from January through April would benefit native fish species. In addition, given the perennial nature of the Tule Canal and its ability to support non-native fish species under Existing Conditions, it is not expected that the proposed facilities under Alternative 3 would increase predation of fish species of focused evaluation above baseline levels in the Yolo Bypass. In addition, results of the SBM (evaluated under *Impact FISH-18*) account for predation associated with the estimated migration path and migration duration for juvenile Chinook salmon in the Yolo Bypass associated with Alternative 3.

CEQA Conclusion

Overall potential for predation of, and competition with, fish species of focused evaluation is not expected to substantially differ relative to predation and competition conditions under Existing Conditions; therefore, Alternative 3 would be expected to have a **less than significant impact** on predation and competition.

Impact FISH-18: Impacts to Chinook Salmon Species/Runs due to Changes in Viable Salmonid Population Parameters

As previously discussed, model output from the SBM was used to evaluate the VSP parameters (abundance, productivity, diversity, and spatial structure) for fall-run, late fall-run, spring-run, and winter-run Chinook salmon.

Changes in simulated mean monthly flows spilling into the Yolo Bypass from the Sacramento River at Fremont Weir under Alternative 3 are expected to be similar to those described for Alternative 1. However, juvenile entrainment estimates from the ELAM modeling differ under Alternative 3 relative to Alternative 1. Therefore, the entrainment estimates from the ELAM modeling, as well as the entrainment estimates from the critical streakline analysis (which was not conducted for Alternative 1), are provided below for Alternative 3.

The ELAM modeling indicates that the entrainment-Sacramento River stage relationship under Alternative 3 exhibits a positive relationship as Sacramento River stage increases from 21.16 to 28.83 ft. The percent of juveniles entrained would peak at about 11 percent at the highest stage modeled (Smith et al. 2017; Appendix G1).

The critical streakline analysis for Alternative 3 (critical streakline scenario 1), which has the same maximum flow capacity as Alternative 1 but is located on the western edge of Fremont Weir, found that the percentage of the total annual abundance of juveniles entrained by run over the entire simulation period would be about 12 percent (confidence interval [CI] 6-21%) for fall-run Chinook salmon, five percent (CI 0-12%) for late fall-run Chinook salmon, nine percent (CI 2-17%) for winter-run Chinook salmon, and nine percent (CI 4-15%) for spring-run Chinook salmon. By contrast, the average annual percentages entrained by run using the proportion of flow approach would be about 15.4, 5.9, 11.3, and 10.3 percent (for all sizes), respectively, indicating that the critical streakline analysis-predicted average annual entrainment rates would be about three percent lower for fall-run, one percent lower for late fall-run, two percent lower for winter-run, and one percent lower for spring-run Chinook salmon for Alternative 3.

Because operations under Alternative 3 are expected to be similar to operations under Alternative 1, simulated changes in indicators of the VSP parameters for fall-run, late fall-run, spring-run, and winter-run Chinook salmon are expected to be similar to those described for Alternative 1. However, because 1) the SBM modeling was conducted using the proportion of flow approach to estimate juvenile entrainment into the Yolo Bypass, 2) the ELAM modeling indicates lower maximum entrainment rates for Alternative 3 relative to Alternative 1, and 3) the critical streakline analysis predicts lower total annual average entrainment rates by run than the proportion of flow approach, the indicators of the VSP parameters under Alternative 3 may be less beneficial than shown for Alternative 1.

CEQA Conclusion

Except for the abundance and productivity parameters for late fall-run and winter-run Chinook salmon and the diversity parameter for late fall-run Chinook salmon, which indicate generally similar conditions under Alternative 3 and Existing Conditions, the abundance, productivity, diversity, and spatial structure indicators all exhibit improvement for fall-run, late fall-run, spring-run, and winter-run Chinook salmon under Alternative 3 relative to Existing Conditions.

Therefore, Alternative 3 would be expected to have a **less than significant impact** on VSP parameters.

Impact FISH-19: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Hydrologic Conditions in the SWP/CVP System

Changes in simulated mean monthly storages in the SWP/CVP system under Alternative 3 relative to the basis of comparison would be similar to those described for Alternative 1. Therefore, simulated changes under Alternative 3 relative to the No Action Alternative (and Existing Conditions) would not result in substantial adverse effects to fish species of focused evaluation and their habitats in the SWP/CVP system.

CEQA Conclusion

Due to similar modeled hydrology in the SWP/CVP system, Alternative 3 would be expected to have a **less than significant impact** due to changes in hydrologic conditions in the SWP/CVP system.

Impact FISH-20: Conflict with Adopted Habitat Conservation Plan; Natural Community Conservation Plan; or Other Approved Local, Regional, or State Habitat Conservation Plan

Although the Yolo County HCP/NCCP does not directly address fish species, it does include goals and policies related to protecting and improving habitat conditions in the Yolo Bypass, which could indirectly benefit fish resources (Yolo Habitat Conservancy 2017). Because Alternative 3 would include mitigation for physical habitat impacts, Alternative 3 would not conflict with HCPs or NCCPs, including the Yolo County HCP/NCCP (Yolo Habitat Conservancy 2017). This impact consideration is addressed for vegetation, wetlands and wildlife resources in Chapter 9 under Impact TERR-11 for each Alternative.

CEQA Conclusion

Alternative 3 is expected to have a **less than significant impact** on habitat conservation plans.

8.3.3.5 Alternative 4: West Side Gated Notch – Managed Flow

Alternative 4, West Side Gated Notch – Managed Flow, would have a smaller amount of flow entering the Yolo Bypass through the gated notch in Fremont Weir than some other alternatives, but it would incorporate water control structures to maintain inundation for longer periods of time within the northern portion of the Yolo Bypass. Alternative 4 would include the same gated notch and associated facilities as described for Alternative 3; however, it would be operated to limit the maximum inflow to 3,000 cfs. See Section 2.7 for more details on the alternative features.

8.3.3.5.1 Construction- and Maintenance-related Impacts – Evaluation of Substantial Adverse Effects on Fish Species of Focused Evaluation and their Habitat and Movement

The proposed construction schedule for Alternative 4 would be similar to the schedule described for Alternative 1. Construction- and maintenance-related activities evaluated for Alternative 4 are similar to those described for Alternative 1: however, Alternative 4 includes additional major construction activities, including construction of the two water control facilities, modifications to berms, and sturgeon bypass channels.

Impact FISH-1: Potential Disturbance to Fish Species or their Habitat due to Erosion, Sedimentation, and Turbidity

Potential impacts associated with erosion, sedimentation, and turbidity under Alternative 4 are expected to be similar to those described for Alternative 1. However, due to additional construction activity on and adjacent to Tule Canal associated with the water control structures and bypass channels, there is additional potential for increased sedimentation and turbidity in the Tule Canal under Alternative 4 relative to Alternative 1. As an indicator of the extent of excavation that would occur under Alternative 4 in the Yolo Bypass, the estimated excess amount of spoils to be excavated during construction would be about 746,000 CY. As an indicator of maintenance-related impacts, the estimated additional annual amount of sediment removal required in the area between Fremont Weir and Agricultural Road Crossing 1 because of increased flows into the Yolo Bypass from implementation of Alternative 4 is 18,900 CY. This corresponds to an estimated total annual amount of sediment removal required of 315,450 CY under Alternative 4 relative to 296,550 CY under Existing Conditions. However, local deposition patterns will be dependent on the specific design of downstream facilities.

CEQA Conclusion

Erosion, sedimentation, and turbidity impacts would be **significant** because construction and maintenance activities would result in temporary increases in sedimentation and turbidity in the Sacramento River and the Yolo Bypass and could temporarily adversely affect all fish species of focused evaluation.

Development and implementation of Mitigation Measure MM-WQ-2: Implement a Stormwater Pollution and Prevention Plan and Mitigation Measure MM-WQ-3: Develop Turbidity Monitoring Program would reduce this impact to **less than significant**.

Impact FISH-2: Potential Disturbance to Fish Species or their Habitat due to Hazardous Materials and Chemical Spills

Potential impacts associated with hazardous materials and chemical spills under Alternative 4 are expected to be similar to those described for Alternative 1. However, due to additional construction activity on and adjacent to Tule Canal associated with the water control structures and bypass channels, there is additional potential for the accidental release of contaminants into Tule Canal under Alternative 4 relative to Alternative 1.

CEQA Conclusion

Hazardous materials and chemical spills impacts would be **significant** because construction and maintenance activities could potentially result in the release of contaminants to aquatic habitats in the Sacramento River and the Yolo Bypass and could adversely affect all fish species of focused evaluation.

Development and implementation of Mitigation Measure MM-WQ-1: Prepare and Implement a Spill Prevention, Control, and Countermeasure Plan would reduce this impact to **less than significant**.

Impact FISH-3: Potential Disturbance to Fish Species or their Habitat due to Aquatic Habitat Modification

Potential types of impacts associated with aquatic habitat modification under Alternative 4 are expected to be similar to those described for Alternative 1; however, additional acreages would have the potential to be affected due to construction associated with additional facilities and berms under Alternative 4.

Preliminary estimates based on calculations in ArcGIS indicate that a total of 168.4 acres (temporary impacts) and 117.4 acres (permanent impacts) of vegetated area would have the potential to be disturbed during Alternative 4 construction activities. Specifically, 31.1 acres (temporary impacts) and 23.0 acres (permanent impacts) would be riparian vegetation, which would be a potential source of IWM inputs to the Sacramento River or Yolo Bypass (Table 8-14 and Figure 8-28).

Table 8-14. Vegetation Communities Potentially Affected by Alternative 4

Vegetation Community						
	Grassland	Freshwater Aquatic Vegetation	Freshwater Emergent Marsh	Marsh/Seep	Riparian Forest/Woodland	Total
Acres (Temporary)	102.7	2.7	27.0	4.9	31.1	168.4
Acres (Permanent)	66.1	4.1	20.2	4.0	23.0	117.4

CEQA Conclusion

Aquatic habitat modification adjacent to the Sacramento River and in the Yolo Bypass associated with construction activities would be **significant** because aquatic and riparian habitat would be permanently affected.

Implementation of Mitigation Measures MM-TERR-13, MM-TERR-11, and MM-FISH-1 would reduce this impact to **less than significant**.

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Figure 8-28a. Vegetation Communities Potentially Affected under Alternative 4

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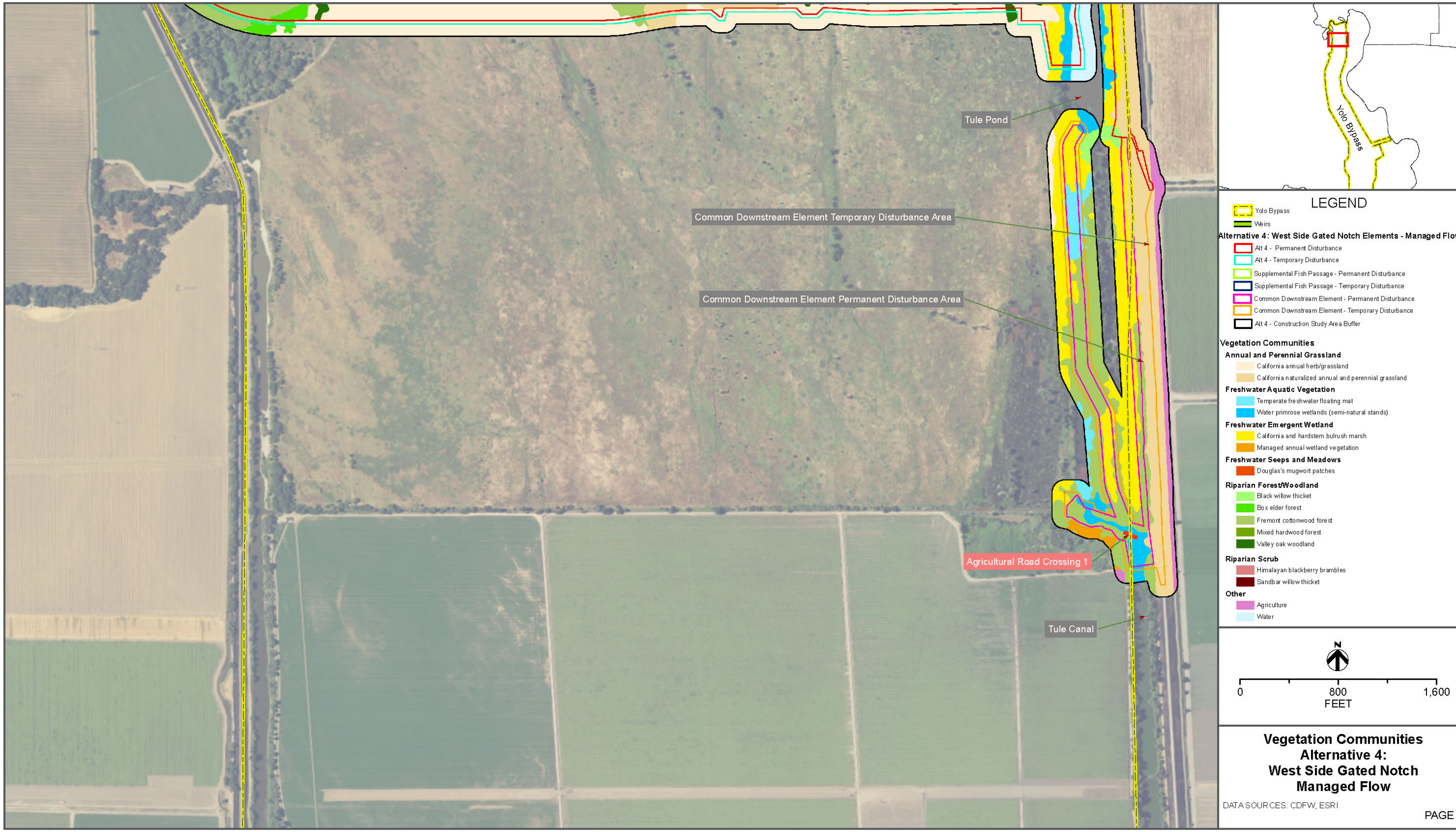

Figure 8-28b. Vegetation Communities Potentially Affected under Alternative 4

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Figure 8-28c. Vegetation Communities Potentially Affected under Alternative 4

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Figure 8-28d. Vegetation Communities Potentially Affected under Alternative 4

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Figure 8-28e. Vegetation Communities Potentially Affected under Alternative 4

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Figure 8-28f. Vegetation Communities Potentially Affected under Alternative 4

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Figure 8-28g. Vegetation Communities Potentially Affected under Alternative 4

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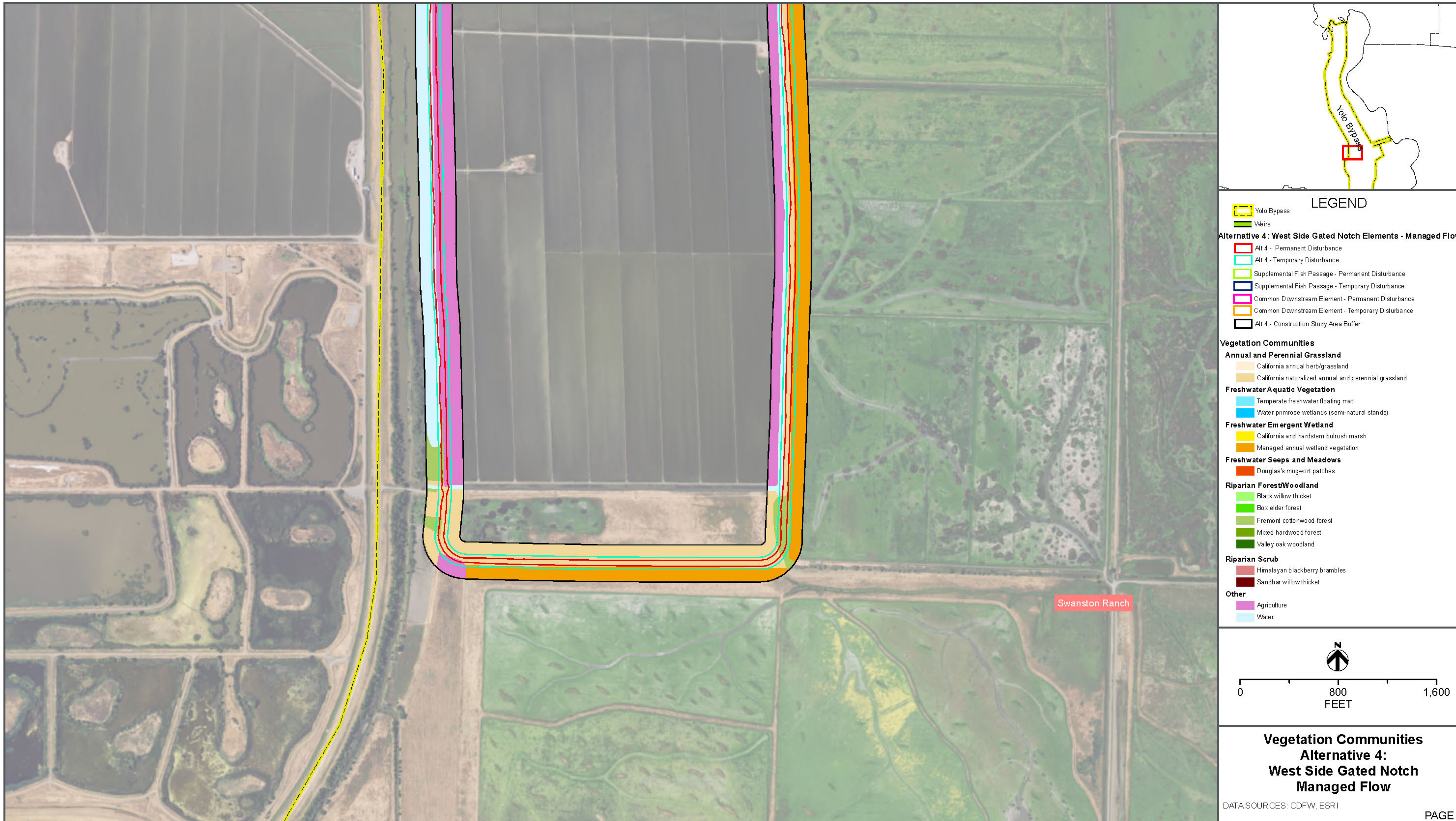

Figure 8-28h. Vegetation Communities Potentially Affected under Alternative 4

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Impact FISH-4: Potential Disturbance to Fish Species or their Habitat due to Hydrostatic Pressure Waves, Noise, and Vibration

Potential impacts associated with hydrostatic pressure waves, noise, and vibration under Alternative 4 are expected to be similar to those described for Alternative 1. However, there is increased potential for pressure waves and underwater noise to occur under Alternative 4 in and adjacent to the Tule Canal associated with constructing temporary cofferdams and pile driving associated with the water control structures.

CEQA Conclusion

Impacts associated with construction noise would be **less than significant** if a vibratory pile driver can be used for the entire construction of the cofferdam. However, impacts associated with noise would be **significant** if impact pile driving was conducted in the Sacramento River, resulting in direct potential impacts to fish species of focused evaluation.

Implementation of Mitigation Measure MM-FISH-2: Implement an Underwater Noise Reduction and Monitoring Plan would reduce this impact to **less than significant**.

Impact FISH-5: Potential Disturbance to Fish Species or their Habitat due to Stranding and Entrainment

Potential impacts associated with stranding and entrainment under Alternative 4 are expected to be similar to those described for Alternative 1. However, there would be additional potential for entrainment to fish species of focused evaluation associated with the dewatering of cofferdams for constructing the water control structures on the Tule Canal under Alternative 4.

CEQA Conclusion

Stranding and entrainment impacts would be **significant** because fish species of focused evaluation could be entrained in the temporary cofferdam.

Implementation of Mitigation Measure MM-FISH-3: Prepare a Fish Rescue and Salvage Plan would reduce this impact to **less than significant**.

Impact FISH-6: Potential Disturbance to Fish Species or their Habitat due to Predation Risk

Potential impacts associated with predation risk under Alternative 4 are expected to be similar to those described for Alternative 1. However, there could be increased potential for predation risk associated with increased construction activity, including for constructing the water control structures and bypass channels on the Tule Canal.

CEQA Conclusion

Predation risk impacts would be **significant** because fish species of focused evaluation could be at increased risk of predation due to potential indirect effects of construction and maintenance activities.

Implementation of Mitigation Measures MM-WQ-2: Implement a Stormwater Pollution and Prevention Plan; MM-WQ-1: Prepare and Implement a Spill Prevention, Control, and Countermeasure Plan; MM-FISH-2: Implement an Underwater Noise Reduction and Monitoring Plan; and MM-FISH-3: Prepare a Fish Rescue and Salvage Plan would reduce this impact to **less than significant**.

Impact FISH-7: Potential Disturbance to Fish Species due to Changes in Fish Passage Conditions

Potential impacts associated with fish passage under Alternative 4 are expected to be similar to those described for Alternative 1, but Alternative 4 has additional potential to impede fish passage associated with construction of the temporary cofferdams, water control structures, and bypass channels on the Tule Canal. However, migratory fish species of focused evaluation would not be migrating through Tule Canal during construction activities, and non-migratory species would have habitat available in the Tule Canal downstream of and away from construction activities.

CEQA Conclusion

Fish passage impacts would be **less than significant** because fish species of focused evaluation would either generally not be present near temporary fish passage blockages or would not be substantially affected by temporary blockages.

Impact FISH-8: Potential Disturbance to Fish Species or their Habitat due to Direct Harm

Potential impacts associated with direct physical injury and/or mortality under Alternative 4 are expected to be similar to those described for Alternative 1. However, additional construction activities on the Tule Canal under Alternative 4 could result in additional potential for direct harm to occur to fish species of focused evaluation in the Tule Canal.

This impact would be **significant** because fish species of focused evaluation could be directly harmed due to construction- and maintenance-related equipment, personnel, or debris.

Implementation of Mitigation Measure MM-FISH-4: Implement General Fish Protection Measures would reduce this impact to **less than significant**.

8.3.3.5.2 Operations-related Impacts – Evaluation of Substantial Adverse Effects on Fish Species of Focused Evaluation and their Habitat and Movement

Operations-related impacts associated with Alternative 4 are evaluated in the Yolo Bypass, the Sacramento River at and downstream of the Fremont Weir, the Delta and downstream waterbodies, and the broader SWP/CVP system as appropriate.

Impact FISH-9: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Flows in the Sacramento River

Modeling results indicate that average monthly flows over the entire simulation period under Alternative 4 in the Sacramento River downstream of Fremont Weir would be the same or similar relative to Existing Conditions (see Appendix G6). During relatively low-flow conditions (i.e., lowest 40 percent of flows over the cumulative monthly probability of exceedance distributions), no changes in flow of 10 percent or more would occur during any month of the year (see Appendix G6). Therefore, migration and rearing conditions would be similar under Alternative 4 relative to Existing Conditions in the lower Sacramento River for fish species of focused evaluation, including winter-run, spring-run, fall-run, and late fall-run Chinook salmon, steelhead, green sturgeon, white sturgeon, river lamprey, and Pacific lamprey. In addition, there would be minimal potential for reduced flows in the Sacramento River to result in increased exposure of fish species of focused evaluation to predators or to higher concentrations of water quality contaminants and minimal potential to exacerbate the channel homogenization in the lower Sacramento River.

CEQA Conclusion

Alternative 4 would result in the same or similar flows in the Sacramento River downstream of Fremont Weir relative to Existing Conditions; therefore, Alternative 4 would have a **less than significant impact** due to changes in flows in the Sacramento River.

Impact FISH-10: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Water Temperatures in the Sacramento River

Modeling results indicate mean monthly water temperatures in the Sacramento River at Freeport would not exceed species and life stage-specific water temperature index values more often under Alternative 4 relative to Existing Conditions (Appendix G7). Therefore, migration and rearing thermal conditions would not be substantially affected for fish species of focused evaluation expected to occur in the lower Sacramento River, including winter-run, spring-run, fall-run, and late fall-run Chinook salmon, steelhead, green sturgeon, white sturgeon, river lamprey, and Pacific lamprey under Alternative 4 relative to Existing Conditions.

CEQA Conclusion

Alternative 4 would not result in substantial changes to water temperature suitability for fish species of focused evaluation relative to Existing Conditions; therefore, Alternative 4 would have a **less than significant impact** due to changes in water temperatures in the Sacramento River.

Impact FISH-11: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Delta Hydrologic and Water Quality Conditions

Evaluation of simulated mean monthly Delta hydrologic and water quality parameters with respect to species and life stage-specific time periods indicate that hydrologic and water quality metrics would not be altered under Alternative 4 relative to Existing Conditions. Therefore, habitat conditions in the Delta would be similar for all life stages evaluated. In addition, based on mean monthly Delta outflow, fisheries habitat conditions would be the same or similar in Suisun Bay.

CEQA Conclusion

Alternative 4 would result in the same or similar habitat conditions for fish species of focused evaluation in the Delta and in downstream areas relative to Existing Conditions; therefore, Alternative 4 would have a **less than significant impact** due to changes in Delta conditions.

Impact FISH-12: Impacts to Fisheries Habitat Conditions due to Changes in Flow-Dependent Habitat Availability in the Study Area (Yolo Bypass/Sutter Bypass)

Modeling results indicate that flows entering the Yolo Bypass from the Sacramento River at Fremont Weir would substantially increase more often from December through March. Therefore, inundation extent and/or duration of the Yolo Bypass would increase during these months, providing for increased hydraulic habitat availability for fish species of focused evaluation, particularly juvenile salmonids and adult and juvenile Sacramento splittail.

Because Alternative 4 includes two potential variations in operation, allowing inundation flows through the notch through March 7 or March 15, hydraulic habitat availability was simulated for both options—Alternative 4a (March 15) and Alternative 4b (March 7).

Modeling results indicate that average monthly hydraulic habitat availability over the entire simulation period for Chinook salmon pre-smolts in the Yolo Bypass would be substantially higher from December through March and similar for the remainder of the October through May evaluation period under Alternatives 4a and 4b (Tables 8-15 and 8-16). Simulated average monthly hydraulic habitat availability by water year type is substantially higher during most water year types from December through March under Alternatives 4a and 4b.

Modeling results indicate that Chinook salmon pre-smolt hydraulic habitat availability would be higher under Alternatives 4a and 4b relative to Existing Conditions over about 50 percent of the cumulative probability exceedance distribution (Figure 8-29). Alternative 4a would provide more habitat over a relatively small portion of the exceedance distribution relative to Alternative 4b. Over the exceedance distribution from November through March, daily hydraulic habitat availability would be higher by 10 percent or more about 64 and 62 percent of the time under Alternative 4a and Alternative 4b, respectively, and would never be lower by 10 percent or more under Alternatives 4a or 4b.

Table 8-15. Average Monthly Area of Pre-smolt Chinook Salmon Hydraulic Habitat in the Yolo Bypass under Alternative 4a from October through May based on TUFLOW Modeling

Alternative	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)
	October	November	December	January	February	March	April	May
Entire Simulation Period[1] (n=16)								
Alternative 4a	20.1	22.0	42.2	59.9	63.2	57.0	37.6	27.5
Existing Conditions	19.8	21.2	31.1	47.6	43.7	46.9	36.9	27.2
Difference	0.3	0.8	11.1	12.3	19.5	10.1	0.7	0.3
Percent Difference[2]	1.5	3.8	35.7	25.8	44.6	21.5	1.9	1.1
Water Year Types[3]								
Wet (n=5)								
Alternative 4a	20.1	23.3	58.8	60.2	70.9	74.2	59.0	32.0
Existing Conditions	19.8	21.1	37.7	48.5	56.9	68.7	58.3	31.8
Difference	0.3	2.2	21.1	11.7	14.0	5.5	0.7	0.2
Percent Difference[2]	1.5	10.4	56.0	24.1	24.6	8.0	1.2	0.6
Above Normal (n=3)								
Alternative 4a	20.3	21.7	43.0	80.9	68.9	56.8	37.2	38.1
Existing Conditions	20.1	21.6	36.2	66.6	41.4	48.0	36.5	37.5
Difference	0.2	0.1	6.8	14.3	27.5	8.8	0.7	0.6
Percent Difference[2]	1.0	0.5	18.8	21.5	66.4	18.3	1.9	1.6
Below Normal (n=3)								
Alternative 4a	20.0	21.4	30.8	55.8	60.1	48.9	27.1	21.2
Existing Conditions	19.7	21.2	25.1	45.4	41.8	40.0	26.6	21.0
Difference	0.3	0.2	5.7	10.4	18.3	8.9	0.5	0.2
Percent Difference[2]	1.5	0.9	22.7	22.9	43.8	22.3	1.9	1.0
Dry (n=4)								
Alternative 4a	20.0	21.4	34.1	47.8	48.0	45.5	22.7	20.3
Existing Conditions	19.8	20.9	25.9	35.7	26.6	29.0	21.8	20.1
Difference	0.2	0.5	8.2	12.1	21.4	16.5	0.9	0.2
Percent Difference[2]	1.0	2.4	31.7	33.9	80.5	56.9	4.1	1.0
Critical (n=1)								
Alternative 4a	19.9	21.0	22.9	55.5	77.5	41.8	23.4	20.5
Existing Conditions	19.7	20.7	21.4	39.9	57.7	27.6	22.2	20.5
Difference	0.2	0.3	1.5	15.6	19.8	14.2	1.2	0.0
Percent Difference[2]	1.0	1.4	7.0	39.1	34.3	51.4	5.4	0.0

[1] Based on modeled average daily values over a 16-year simulation period (water years 1997 through 2012)
[2] Relative difference of the monthly average
[3] As defined by the Sacramento Valley Index (DWR 2017c)

Key: km[2] = square kilometer

Table 8-16. Average Monthly Area of Pre-smolt Chinook Salmon Hydraulic Habitat in the Yolo Bypass under Alternative 4b from October through May based on TUFLOW Modeling

Alternative	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)
	October	November	December	January	February	March	April	May
Entire Simulation Period[1] (n=16)								
Alternative 4b	20.0	22.0	42.1	59.9	63.2	53.3	37.4	27.4
Existing Conditions	19.8	21.2	31.1	47.6	43.7	46.9	36.9	27.2
Difference	0.2	0.8	11.0	12.3	19.5	6.4	0.5	0.2
Percent Difference[2]	1.0	3.8	35.4	25.8	44.6	13.6	1.4	0.7
Water Year Types[3]								
Wet (n=5)								
Alternative 4b	20.1	23.3	58.8	60.2	70.9	71.9	58.9	31.9
Existing Conditions	19.8	21.1	37.7	48.5	56.9	68.7	58.3	31.8
Difference	0.3	2.2	21.1	11.7	14.0	3.2	0.6	0.1
Percent Difference[2]	1.5	10.4	56.0	24.1	24.6	4.7	1.0	0.3
Above Normal (n=3)								
Alternative 4b	20.2	21.6	43.0	80.9	68.9	53.8	36.9	38.0
Existing Conditions	20.1	21.6	36.2	66.6	41.4	48.0	36.5	37.5
Difference	0.1	0.0	6.8	14.3	27.5	5.8	0.4	0.5
Percent Difference[2]	0.5	0.0	18.8	21.5	66.4	12.1	1.1	1.3
Below Normal (n=3)								
Alternative 4b	20.0	21.4	30.8	55.8	60.1	45.2	26.8	21.1
Existing Conditions	19.7	21.2	25.1	45.4	41.8	40.0	26.6	21.0
Difference	0.3	0.2	5.7	10.4	18.3	5.2	0.2	0.1
Percent Difference[2]	1.5	0.9	22.7	22.9	43.8	13.0	0.8	0.5
Dry (n=4)								
Alternative 4b	19.9	21.3	34.1	47.8	48.0	39.6	22.4	20.2
Existing Conditions	19.8	20.9	25.9	35.7	26.6	29.0	21.8	20.1
Difference	0.1	0.4	8.2	12.1	21.4	10.6	0.6	0.1
Percent Difference[2]	0.5	1.9	31.7	33.9	80.5	36.6	2.8	0.5
Critical (n=1)								
Alternative 4b	19.8	21.0	22.8	55.6	77.5	37.2	23.1	20.4
Existing Conditions	19.7	20.7	21.4	39.9	57.7	27.6	22.2	20.5

Alternative	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)
	October	November	December	January	February	March	April	May
Difference	0.1	0.3	1.4	15.7	19.8	9.6	0.9	-0.1
Percent Difference[2]	0.5	1.4	6.5	39.3	34.3	34.8	4.1	-0.5

[1] Based on modeled average daily values over a 16-year simulation period (water years 1997 through 2012)
[2] Relative difference of the monthly average
[3] As defined by the Sacramento Valley Index (DWR 2017c)
Key: km^2 = square kilometer

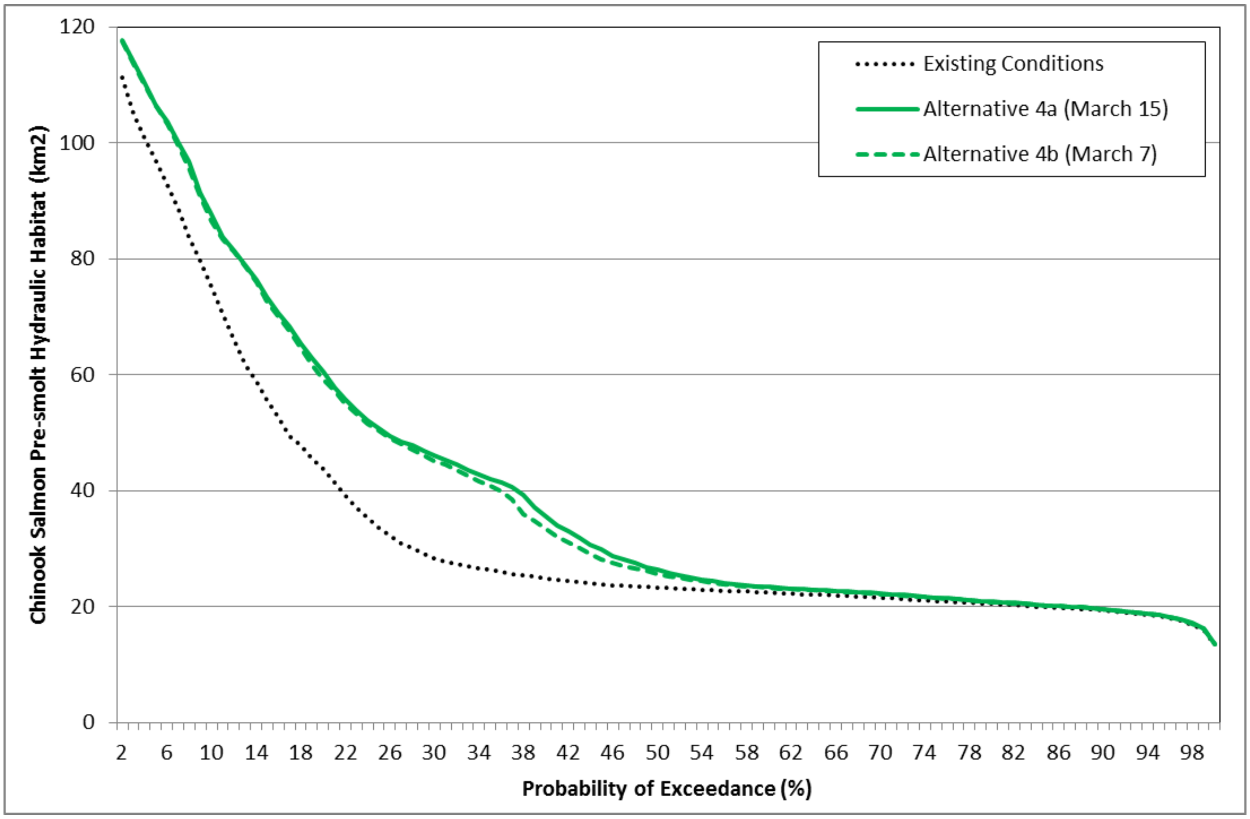

Figure 8-29. Simulated Chinook Salmon Pre-Smolt Hydraulic Habitat Availability Probability of Exceedance Distributions under Alternatives 4a and 4b and Existing Conditions from October through May based on TUFLOW Modeling

Modeling results indicate that average monthly hydraulic habitat availability over the entire simulation period for Chinook salmon smolts in the Yolo Bypass would be substantially higher (i.e., higher by 10 percent or more) from December through March, including during most water year types, and would be similar (i.e., change by less than 5 percent) for the remainder of the October through May evaluation period over the entire simulation period and during most water year types under Alternatives 4a and 4b relative to Existing Conditions (Tables 8-17 and 8-18).

Modeling results indicate that Chinook salmon smolt hydraulic habitat availability would be higher under Alternative 4a and 4b relative to Existing Conditions over about 60 percent of the cumulative probability exceedance distribution (Figure 8-30). Alternative 4a would provide more habitat over a relatively small portion of the exceedance distribution relative to Alternative 4b. Over the exceedance distribution from November through March, daily hydraulic habitat availability would be higher by 10 percent or more about 58 and 56 percent of the time under Alternatives 4a and 4b, respectively, and would never be lower by 10 percent or more under either alternative.

Table 8-17. Average Monthly Area of Chinook Salmon Smolt Hydraulic Habitat in the Yolo Bypass under Alternative 4a from October through May based on TUFLOW Modeling

Alternative	**Area (km^2)**	**Area (km^2)**	**Area (km^2)**	**Area (km^2)**	**Area (km^2)**	**Area (km^2)**	**Area (km^2)**	**Area (km^2)**
	October	**November**	**December**	**January**	**February**	**March**	**April**	**May**
Entire Simulation Period[1] (n=16)								
Alternative 4a	31.8	32.9	56.4	84.6	91.2	87.2	59.6	43.2
Existing Conditions	31.6	32.0	44.2	70.0	69.7	76.0	58.8	43.1
Difference	0.2	0.9	12.2	14.6	21.5	11.2	0.8	0.1
Percent Difference[2]	0.6	2.8	27.6	20.9	30.8	14.7	1.4	0.2
Water Year Types[3]								
Wet (n=5)								
Alternative 4a	31.6	34.4	78.2	103.5	116.4	126.0	100.6	50.9
Existing Conditions	31.4	32.1	55.4	90.2	100.6	119.0	99.6	50.7
Difference	0.2	2.3	22.8	13.3	15.8	7.0	1.0	0.2
Percent Difference[2]	0.6	7.2	41.2	14.7	15.7	5.9	1.0	0.4
Above Normal (n=3)								
Alternative 4a	32.2	33.0	56.8	100.8	97.6	86.2	50.9	55.1
Existing Conditions	32.1	32.9	48.3	82.4	68.3	76.6	50.4	54.6
Difference	0.1	0.1	8.5	18.4	29.3	9.6	0.5	0.5
Percent Difference[2]	0.3	0.3	17.6	22.3	42.9	12.5	1.0	0.9
Below Normal (n=3)								
Alternative 4a	31.9	32.0	42.3	70.9	82.8	72.4	41.1	34.9
Existing Conditions	31.7	31.8	36.2	57.8	62.3	62.6	40.6	34.9
Difference	0.2	0.2	6.1	13.1	20.5	9.8	0.5	0.0
Percent Difference[2]	0.6	0.6	16.9	22.7	32.9	15.7	1.2	0.0
Dry (n=4)								
Alternative 4a	31.7	31.9	45.3	62.8	60.5	58.6	34.7	33.4
Existing Conditions	31.6	31.5	36.6	48.9	37.9	41.0	33.9	33.4
Difference	0.1	0.4	8.7	13.9	22.6	17.6	0.8	0.0
Percent Difference[2]	0.3	1.3	23.8	28.4	59.6	42.9	2.4	0.0
Critical (n=1)								
Alternative 4a	31.1	31.4	32.7	69.6	93.7	54.4	35.4	33.8
Existing Conditions	31.0	31.2	30.9	52.1	70.2	39.2	34.4	33.9
Difference	0.1	0.2	1.8	17.5	23.5	15.2	1.0	-0.1
Percent Difference[2]	0.3	0.6	5.8	33.6	33.5	38.8	2.9	-0.3

[1] Based on modeled average daily values over a 16-year simulation period (water years 1997 through 2012)
[2] Relative difference of the monthly average
[3] As defined by the Sacramento Valley Index (DWR 2017c)
Key: km^2 = square kilometer

Table 8-18. Average Monthly Area of Chinook Salmon Smolt Hydraulic Habitat in the Yolo Bypass under Alternative 4b from October through May based on TUFLOW Modeling

Alternative	Area (km^2) October	Area (km^2) November	Area (km^2) December	Area (km^2) January	Area (km^2) February	Area (km^2) March	Area (km^2) April	Area (km^2) May
Entire Simulation Period[1] (n=16)								
Alternative 4b	31.7	32.8	56.3	84.5	91.1	82.9	59.3	43.2
Existing Conditions	31.6	32.0	44.2	70.0	69.7	76.0	58.8	43.1
Difference	0.1	0.8	12.1	14.5	21.4	6.9	0.5	0.1
Percent Difference[2]	0.3	2.5	27.4	20.7	30.7	9.1	0.9	0.2
Water Year Types[3]								
Wet (n=5)								
Alternative 4b	31.5	34.3	78.1	103.4	116.3	123.1	100.5	50.8
Existing Conditions	31.4	32.1	55.4	90.2	100.6	119.0	99.6	50.7
Difference	0.1	2.2	22.7	13.2	15.7	4.1	0.9	0.1
Percent Difference[2]	0.3	6.9	41.0	14.6	15.6	3.4	0.9	0.2
Above Normal (n=3)								
Alternative 4b	32.1	32.9	56.7	100.7	97.5	83.0	50.6	55.0
Existing Conditions	32.1	32.9	48.3	82.4	68.3	76.6	50.4	54.6
Difference	0.0	0.0	8.4	18.3	29.2	6.4	0.2	0.4
Percent Difference[2]	0.0	0.0	17.4	22.2	42.8	8.4	0.4	0.7
Below Normal (n=3)								
Alternative 4b	31.9	32.0	42.2	70.9	82.7	68.2	40.8	34.9
Existing Conditions	31.7	31.8	36.2	57.8	62.3	62.6	40.6	34.9
Difference	0.2	0.2	6.0	13.1	20.4	5.6	0.2	0.0
Percent Difference[2]	0.6	0.6	16.6	22.7	32.7	8.9	0.5	0.0
Dry (n=4)								
Alternative 4b	31.7	31.9	45.2	62.6	60.3	52.2	34.3	33.3
Existing Conditions	31.6	31.5	36.6	48.9	37.9	41.0	33.9	33.4
Difference	0.1	0.4	8.6	13.7	22.4	11.2	0.4	-0.1
Percent Difference[2]	0.3	1.3	23.5	28.0	59.1	27.3	1.2	-0.3
Critical (n=1)								
Alternative 4b	31.1	31.4	32.6	69.5	93.6	49.3	35.1	33.8
Existing Conditions	31.0	31.2	30.9	52.1	70.2	39.2	34.4	33.9
Difference	0.1	0.2	1.7	17.4	23.4	10.1	0.7	-0.1
Percent Difference[2]	0.3	0.6	5.5	33.4	33.3	25.8	2.0	-0.3

[1] Based on modeled average daily values over a 16-year simulation period (water years 1997 through 2012)
[2] Relative difference of the monthly average

[3] As defined by the Sacramento Valley Index (DWR 2017c)
Key: km^2 = square kilometer

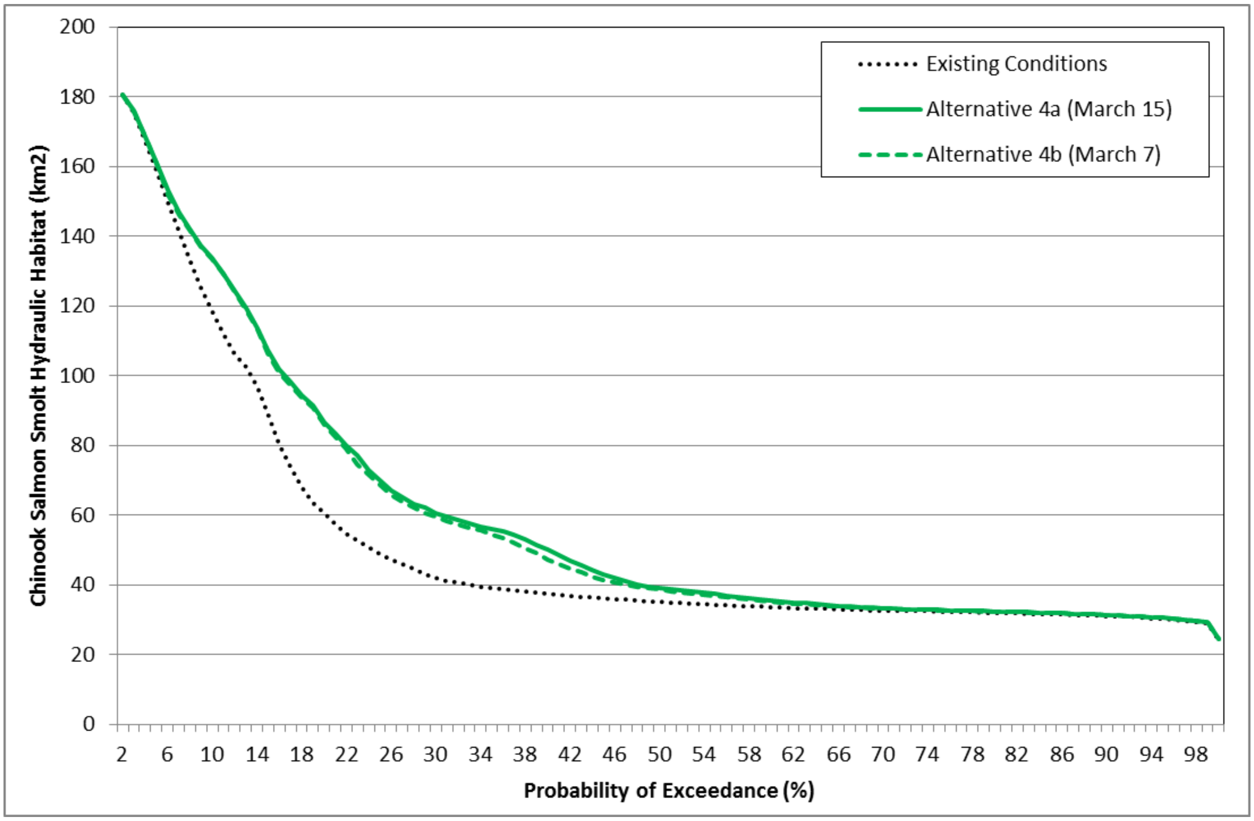

Figure 8-30. Simulated Chinook Salmon Smolt Hydraulic Habitat Availability Probability of Exceedance Distributions under Alternatives 4a and 4b and Existing Conditions from October through May based on TUFLOW Modeling

As previously discussed, changes in estimated hydraulic habitat availability for Chinook salmon pre-smolts is expected to be generally representative of potential changes in hydraulic habitat availability for juvenile Sacramento splittail, and changes in estimated hydraulic habitat availability for Chinook salmon smolts is generally expected to be representative of potential changes in hydraulic habitat availability for adult spawning Sacramento splittail and juvenile steelhead.

To provide a more comprehensive range of potential changes in hydraulic habitat availability for other fish species of focused evaluation, simulated wetted extent (area with a water depth greater than 0.0 feet) was estimated for the Yolo Bypass under Alternatives 4a and 4b relative to Existing Conditions. Modeling results indicate that average monthly wetted extent over the entire simulation period and by water year type would be higher or substantially higher from December through March, including during most water year types (Table 8-19). Similar but lower increases in average monthly hydraulic habitat availability would be provided by Alternative 4b (Table 8-20).

Table 8-19. Average Monthly Wetted Area in the Yolo Bypass under Alternative 4a from October through May based on TUFLOW Modeling

Alternative	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)
	October	**November**	**December**	**January**	**February**	**March**	**April**	**May**
Entire Simulation Period[1] (n=16)								
Alternative 4a	48.0	49.5	77.1	120.1	129.1	120.1	86.5	64.1
Existing Conditions	47.8	48.4	64.1	105.0	106.4	107.5	85.9	64.1
Difference	0.2	1.1	13.0	15.1	22.7	12.6	0.6	0.0
Percent Difference[2]	0.4	2.3	20.3	14.4	21.3	11.7	0.7	0.0
Water Year Types[3]								
Wet (n=5)								
Alternative 4a	47.8	51.2	103.4	168.1	177.9	170.8	145.8	77.2
Existing Conditions	47.6	48.6	78.9	154.3	161.7	163.4	145.3	77.5
Difference	0.2	2.6	24.5	13.8	16.2	7.4	0.5	-0.3
Percent Difference[2]	0.4	5.3	31.1	8.9	10.0	4.5	0.3	-0.4
Above Normal (n=3)								
Alternative 4a	48.6	50.1	76.5	125.5	131.0	122.6	72.6	77.3
Existing Conditions	48.5	49.9	68.3	108.0	100.1	111.7	72.5	77.0
Difference	0.1	0.2	8.2	17.5	30.9	10.9	0.1	0.3
Percent Difference[2]	0.2	0.4	12.0	16.2	30.9	9.8	0.1	0.4
Below Normal (n=3)								
Alternative 4a	48.2	48.3	60.3	92.3	113.4	100.7	59.9	52.2
Existing Conditions	47.9	47.9	53.9	79.2	91.7	89.6	59.6	52.3
Difference	0.3	0.4	6.4	13.1	21.7	11.1	0.3	-0.1
Percent Difference[2]	0.6	0.8	11.9	16.5	23.7	12.4	0.5	-0.2
Dry (n=4)								
Alternative 4a	47.9	48.3	64.2	83.8	81.0	80.5	51.2	50.0
Existing Conditions	47.8	47.6	54.5	68.3	56.0	60.3	50.3	49.9
Difference	0.1	0.7	9.7	15.5	25.0	20.2	0.9	0.1
Percent Difference[2]	0.2	1.5	17.8	22.7	44.6	33.5	1.8	0.2
Critical (n=1)								
Alternative 4a	47.2	47.0	48.9	92.9	119.7	76.3	52.1	51.0
Existing Conditions	46.9	46.7	46.6	74.4	95.7	58.1	51.1	50.9
Difference	0.3	0.3	2.3	18.5	24.0	18.2	1.0	0.1
Percent Difference[2]	0.6	0.6	4.9	24.9	25.1	31.3	2.0	0.2

[1] Based on modeled average daily values over a 16-year simulation period (water years 1997 through 2012)

[2] Relative difference of the monthly average

[3] As defined by the Sacramento Valley Index (DWR 2017c)

Key: km^2 = square kilometer

Table 8-20. Average Monthly Wetted Area in the Yolo Bypass under Alternative 4b from October through May based on TUFLOW Modeling

Alternative	Wetted Area (km^2) October	Wetted Area (km^2) November	Wetted Area (km^2) December	Wetted Area (km^2) January	Wetted Area (km^2) February	Wetted Area (km^2) March	Wetted Area (km^2) April	Wetted Area (km^2) May
Entire Simulation Period[1] (n=16)								
Alternative 4b	48.0	49.4	76.9	120.0	128.9	115.5	86.2	64.0
Existing Conditions	47.8	48.4	64.1	105.0	106.4	107.5	85.9	64.1
Difference	0.2	1.0	12.8	15.0	22.5	8.0	0.3	-0.1
Percent Difference[2]	0.4	2.1	20.0	14.3	21.1	7.4	0.3	-0.2
Water Year Types[3]								
Wet (n=5)								
Alternative 4b	47.7	51.1	103.3	168.0	177.8	167.7	145.6	77.1
Existing Conditions	47.6	48.6	78.9	154.3	161.7	163.4	145.3	77.5
Difference	0.1	2.5	24.4	13.7	16.1	4.3	0.3	-0.4
Percent Difference[2]	0.2	5.1	30.9	8.9	10.0	2.6	0.2	-0.5
Above Normal (n=3)								
Alternative 4b	48.6	50.0	76.3	125.3	130.8	119.1	72.3	77.2
Existing Conditions	48.5	49.9	68.3	108.0	100.1	111.7	72.5	77.0
Difference	0.1	0.1	8.0	17.3	30.7	7.4	-0.2	0.2
Percent Difference[2]	0.2	0.2	11.7	16.0	30.7	6.6	-0.3	0.3
Below Normal (n=3)								
Alternative 4b	48.1	48.2	60.3	92.1	113.2	96.0	59.6	52.1
Existing Conditions	47.9	47.9	53.9	79.2	91.7	89.6	59.6	52.3
Difference	0.2	0.3	6.4	12.9	21.5	6.4	0.0	-0.2
Percent Difference[2]	0.4	0.6	11.9	16.3	23.4	7.1	0.0	-0.4
Dry (n=4)								
Alternative 4b	47.9	48.3	64.1	83.6	80.8	73.2	50.7	49.9
Existing Conditions	47.8	47.6	54.5	68.3	56.0	60.3	50.3	49.9
Difference	0.1	0.7	9.6	15.3	24.8	12.9	0.4	0.0
Percent Difference[2]	0.2	1.5	17.6	22.4	44.3	21.4	0.8	0.0
Critical (n=1)								
Alternative 4b	47.2	47.0	48.8	92.7	119.5	70.7	51.8	50.9
Existing Conditions	46.9	46.7	46.6	74.4	95.7	58.1	51.1	50.9
Difference	0.3	0.3	2.2	18.3	23.8	12.6	0.7	0.0
Percent Difference[2]	0.6	0.6	4.7	24.6	24.9	21.7	1.4	0.0

[1] Based on modeled average daily values over a 16-year simulation period (water years 1997 through 2012)
[2] Relative difference of the monthly average
[3] As defined by the Sacramento Valley Index (DWR 2017c)
Key: km^2 = square kilometer

Modeling results indicate that wetted extent would be higher under Alternatives 4a and 4b relative to Existing Conditions over about 50 percent of the probability of exceedance distribution (Figure 8-31). Over the exceedance distribution from November through March, daily wetted extent would be substantially higher (i.e., higher by 10 percent or more) about 55 and 52 percent of the time under Alternatives 4a and 4b, respectively, and would never be lower by 10 percent or more under either alternative.

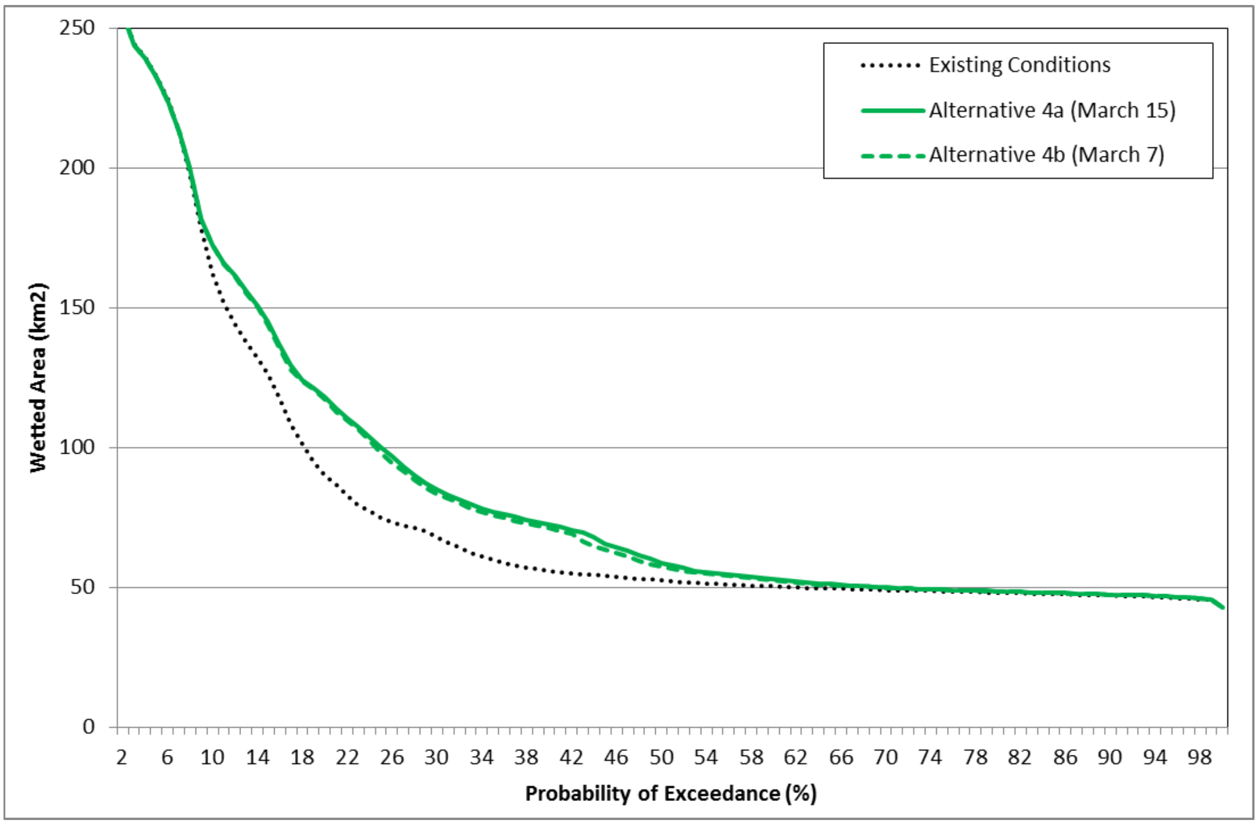

Figure 8-31. Simulated Wetted Area Probability of Exceedance Distributions under Alternatives 4a and 4b and Existing Conditions from October through May based on TUFLOW Modeling

Average annual modeled wetted days in the Sutter Bypass would decrease under Alternative 4 relative to Existing Conditions by approximately one to seven days in the area of Sutter Bypass between the Sacramento River and Sacramento Slough and one to three days over most of the Sutter Bypass between Sacramento Slough and Nelson Slough.

CEQA Conclusion

In the Yolo Bypass under Alternative 4, increased hydraulic habitat availability for fish species of focused evaluation, particularly juvenile Chinook salmon and steelhead and adult and juvenile

Sacramento splittail, is expected to result in more suitable conditions for these and other fish species of focused evaluation. Relatively minor reductions in the number of wetted days in the Sutter Bypass upstream of the Sacramento River at Fremont Weir are not expected to substantially affect rearing or migration of fish species of focused evaluation; therefore, Alternative 4 would be expected to have a **beneficial impact** on flow-dependent hydraulic habitat availability in the Yolo Bypass and a **less than significant impact** on flow-dependent hydraulic habitat availability in the Sutter Bypass.

Impact FISH-13: Impacts to Fisheries Habitat Conditions due to Changes in Water Quality in the Study Area

Modeling results indicate that flows entering the Yolo Bypass from the Sacramento River at Fremont Weir under Alternative 4 relative to Existing Conditions would substantially increase more often from December through March. Therefore, increased flows and the potential for increased wetting and drying of the Yolo Bypass could increase the amount of methylmercury and other contaminants in the Yolo Bypass and in fish prey. Increased concentrations of contaminants in the Yolo Bypass could potentially result in an increase in the exportation of contaminated water to the Delta. However, for juvenile Chinook salmon rearing in the Yolo Bypass, increased concentrations of accumulated methylmercury were reported to be insignificant in the tissues of the eventual adult-sized fish (Henery et al. 2010). Effects of increased methylmercury accumulation could be more substantial on resident fish species such as largemouth bass. Increased flows in the Yolo Bypass also could temporarily increase turbidity levels in the Yolo Bypass.

CEQA Conclusion

Based on higher mean monthly flows entering the Yolo Bypass, increased concentrations of methylmercury and other contaminants may occur in the Yolo Bypass and the Delta. However, the potential for increased concentrations of contaminants is not expected to substantially affect fish species of focused evaluation; therefore, Alternative 4 would have a **less than significant impact**.

Impact FISH-14: Impacts to Aquatic Primary and Secondary Production in the Study Area

Modeling results indicate that Alternative 4 would result in increased frequency and duration of inundation of the Yolo Bypass relative to Existing Conditions. An increase in frequency and duration of inundation of shallow-water habitat in the Yolo Bypass would be expected to increase primary production in the Yolo Bypass (Lehman et al. 2007). Increased primary and associated secondary production in the Yolo Bypass would likely increase food resources for fish species of focused evaluation in the Yolo Bypass. More productive water in the Yolo Bypass also could potentially be exported to the Delta downstream of the Yolo Bypass, which could increase food resources for fish in the Delta.

Modeled wetted area of the Yolo Bypass under Alternative 4 relative to Existing Conditions was used as an indicator of relative changes in inundation and associated primary and secondary production. As described above, increases in average monthly wetted area would occur under Alternative 4 relative to Existing Conditions, particularly from December through March, depending on water year type. Increased food resources in the Yolo Bypass during this period would be expected to improve growth and survival of some fish species of focused evaluation such as Chinook salmon and freshwater resident species. The potential for increased productivity downstream of the Yolo Bypass could improve prey availability conditions for fish species of focused evaluation.

Minor reductions in wetted area in the Sutter Bypass could reduce primary and secondary production in the Sutter Bypass. However, these reductions in wetted area are not expected to substantially affect primary or secondary production in the Sutter Bypass or fish species of focused evaluation in the Sutter Bypass.

CEQA Conclusion

Based on increased wetted extent in the Yolo Bypass during the winter, increased primary and secondary production in the Yolo Bypass (and potentially in localized areas of the Delta) could increase food resources for fish species of focused evaluation. In the Sutter Bypass, slight reductions in wetted area could reduce primary and secondary production, but these reductions are not expected to be sufficient to substantially affect food resources for fish species of focused evaluation. Therefore, Alternative 4 would result in a **beneficial impact** in the Yolo Bypass and a **less than significant impact** in the Sutter Bypass.

Impact FISH-15: Impacts to Fish Species of Focused Evaluation due to Changes in Adult Fish Passage Conditions through the Yolo Bypass

Modeling results indicate that flows entering the Yolo Bypass from the Sacramento River at Fremont Weir would substantially increase more often from December through March under Alternative 4 relative to Existing Conditions. Therefore, the duration of potential adult fish passage from the Yolo Bypass into the Sacramento River may potentially increase for fall/late fall-run Chinook salmon, spring-run Chinook salmon, winter-run Chinook salmon, steelhead, green and white sturgeon, and Pacific and river lamprey, potentially providing for increased spawning opportunities in the Sacramento River and its tributaries and reduced potential for mortality or migration delay in the Yolo Bypass. Increased flows entering the Yolo Bypass also would increase the average number of days that areas adjacent to portions of the west-side tributaries within the Yolo Bypass are inundated, including Cache Creek, Willow Slough and Putah Creek. Therefore, hydraulic connectivity and migration conditions for anadromous fishes in the west-side streams could potentially improve under Alternative 4 relative to Existing Conditions.

There is the potential that increased flows entering the Delta from the Yolo Bypass could attract more adult fish into the Yolo Bypass relative to the Sacramento River. However, adult fish passage would be provided at Fremont Weir more often relative to Existing Conditions. Based on results of the YBPASS Tool, which applied fish passage criteria to modeled hydraulic conditions in the intake facility and transport channel under Alternative 4, adult salmon and sturgeon would be expected to successfully pass upstream through the transport channel and intake structure into the Sacramento River about 18 percent of the days from November through April over the water years 1997 through 2012 simulation period. The bypass channels would be designed and operated to meet the fish passage criteria (when the water control structures are in the closed position) during the same period. The annual average date after which Alternative 4 would no longer meet the fish passage criteria would be March 31.

The potential for straying of anadromous fish species into the Yolo Bypass that are native to watersheds from outside of the upper Sacramento River Basin would be similar to the discussion for Alternative 1 relative to Existing Conditions.

The Project Alternative would be adaptively managed to ensure that biological goals and objectives are met (see Appendix C). For example, management responses would be evaluated if more than one percent of an ESA-listed salmon ESU or green sturgeon annual escapement is found to stray to Wallace Weir during Project operations, or if more than one percent of an ESA-listed salmon ESU or green sturgeon annual escapement or juvenile production estimate are stranded in the Yolo Bypass. Potential management responses are identified in Appendix C. Future management responses would be subject to future environmental compliance documentation, as applicable.

In general, installation of the water control structures and bypass channels create additional potential for delay of adult migratory fishes traveling upstream in the Tule Canal toward Fremont Weir. When the water control structures are in the closed position, adults may have difficulty finding the bypass channels, depending on the flow and hydraulic conditions immediately downstream of the water control structures and at the point of entrance to the bypass channels. The presence of the water control structures also allows the potential for a structural failure and uncontrolled release of sediment and water downstream (Flosi et al. 2010).

The use of a fishway (e.g., bypass channel) around a fish passage barrier is the least favorable option for providing fish passage at a facility (Flosi et al. 2010). Fish passage solutions with diverse hydraulic conditions and passage corridors, such as stream simulation, roughened channels and boulder weirs, are preferred over formal fishways because they provide passage for a broader range of species, often over a broader range of flows (Flosi et al. 2010). A primary key to successful fish passage with a fishway is attracting fish into the fishway, which can also be the greatest challenge in the design of a bypass fishway.

Successful passage at fishways requires that fish can locate and enter the fishway entrance and are able to successfully pass upstream of the fishway. Bunt et al. (2012) compiled and summarized fish passage studies that contained data on fish attraction and passage efficiency following a documented methodology that included tracking fish as they approached and attempted to pass upstream through fishways under natural (i.e., field) conditions. Attraction efficiency was defined as the proportion of tagged fish that were subsequently located within less than approximately three m (~10 ft) from the fishway entrance (Bunt et al. 1999 as cited in Bunt et al. 2012) or close enough to the entrance for fish to detect attraction flow from the fishway (Aarestrup et al., 2003 as cited in Bunt et al. 2012). The available data were generally not sufficient for assessing rates at which fish physically entered the fishways or potential delay (Bunt et al. 2012). Passage efficiency through the fishway was calculated by dividing the number of fish of a species that exited the fishway by the number of fish that were detected at the fishway entrance (Bunt et al., 1999; Aarestrup et al., 2003, both as cited in Bunt et al. 2012). Total passage efficiency was calculated based on the product of the attraction efficiency and passage efficiency.

Bunt et al. (2012) found that the attraction efficiency for “nature-like” fishways was less favorable than for other fishway types (i.e., pool-and-weir, vertical-slot, and Denil), averaging 56 percent among 21 studies (representing clupeids, centrarchids, percids, catastomids, cyprinids, salmonids, lotids, and esocids). Passage efficiency averaged 76 percent for the same studies.

Total efficiency, accounting for both attraction and passage efficiency, was 43 percent, indicating that less than half of the individual fish studied could locate and successfully pass through the fishway.

Nature-like fishways appear to provide better passage conditions for species with reduced swimming performance than other fishway types, potentially due to the typical low slope of nature-like fishways (Bunt et al. 2012). However, attraction flows were often too low at nature-like fishways to attract fish to the entrance; therefore, additional study on the design of nature-like fishways is needed before they can be readily prescribed (Bunt et al. 2012). Overall, based on review of attraction and passage efficiency at all fishway types, Bunt et al. (2012, p.464) reported that "the vast majority of fishway structures do not effectively mitigate the effects of barriers that block access to areas upstream."

Although the studies reviewed did not include sturgeon species, Chinook salmon, or steelhead in nature-like fishways, the data summarized by Bunt et al. (2012) suggests that the bypass channels under Alternative 4 may only attract and pass approximately 50 percent or less of adults migrating up the Tule Canal when the water control structures are in the closed position. Because there are two bypass channels, the cumulative total passage efficiency may be closer to 25 percent or less. Further, an attraction flow of 300 cfs exiting the fishways may be insufficient to attract adult fish, particularly if flows are relatively high in Knights Landing Ridge Cut. If more adults migrate to Wallace Weir due to higher attraction flows at Knights Landing Ridge Cut, they would have to be salvaged and transported to the Sacramento River, which could reduce spawning opportunities and increase the potential for mortality.

The bypass channels would increase the potential for delays to reaching upstream spawning grounds and may increase energy expenditure of adults, which could also negatively affect spawning opportunities. Impeded migration of large fish such as green or white sturgeon also would increase their susceptibility to being stranded or poached.

When the water control structures are lowered (i.e., moved to the open position), there is the potential for a pulse of water to travel downstream to the Delta and attract adults to migrate upstream through the Yolo Bypass when upstream passage may not be available through the transport channels and/or Fremont Weir facilities to the Sacramento River.

CEQA Conclusion

Although increased duration of potential adult fish passage opportunity from the Yolo Bypass below Fremont Weir into the Sacramento River would be expected to improve under Alternative 4 associated with the Fremont Weir facilities, the placement of the water control structures and bypass channels would result in the potential for additional migration delay or an impediment to migration relative to Existing Conditions for fish species of focused evaluation, particularly adult white and green sturgeon. Therefore, Alternative 4 would be expected to have a potentially **significant impact** on adult fish passage conditions through the Yolo Bypass.

Mitigation Measure MM-FISH-5: Adult fish passage monitoring and adaptive management

To mitigate for the potential delay or blockage of adult fish passage in the Tule Canal associated with the proposed water control structures and bypass channels, hydraulic and fish passage monitoring would be conducted downstream of the water control structures and in the bypass channels. Monitoring activities would include telemetry of tagged adult white sturgeon (as a surrogate for green sturgeon) approaching and passing through the bypass channels and measurement of depths and velocities downstream of and within the bypass channels. Monitoring would be conducted for a specified number of years per the MMRP to ensure that the water control structures and fish passage facilities are operating and functioning to provide suitable fish passage conditions. Performance objectives would include providing suitable passage conditions for adult salmon and sturgeon 100 percent of the time that passage is expected to be provided under Existing Conditions and providing successful passage to all tagged adult sturgeon attempting to migrate upstream, as described below.

The percentage of successfully tagged sturgeon will be quantified for the first three years of operation. If less than 100 percent of tagged sturgeon successfully pass through the bypass channels during the first three-year period of operation, operations-related and structural modifications of the facility will be considered and evaluated for an additional three years. If less than 100 percent of tagged sturgeon successfully pass through the modified bypass channel, the Tule Canal water control structures operation will be restricted to an open position during the sturgeon migration period (after February 15) for an additional three-year period. During these initial nine years, the percentage of successfully tagged fish will be quantified. If the percentage of successful pass attempts by tagged sturgeon is greater with the water control structures remaining open, they will be left open when sturgeon are anticipated to be present, beginning February 15 of each year. If sturgeon passage does not increase during this period, structural changes to the water control structures and bypass channels may be scoped and evaluated through an independent NEPA and CEQA process, which is not part of the Project alternative.

As part of this measure, attraction flows in the bypass channels would be monitored in comparison to flows at Knights Landing Ridge Cut to assess whether the attraction flows in the bypass channels were sufficient to attract adult fish species of focused evaluation such as green sturgeon, white sturgeon, Chinook salmon, and steelhead.

In consultation with CDFW, NMFS and USFWS, tagging and monitoring of additional fish species, such as Chinook salmon, steelhead, Sacramento splittail, and Pacific lamprey, would occur to assesses attraction and passage efficiency at the bypass channels.

Implementation of Mitigation Measure MM-FISH-5: Adult Fish Passage Monitoring and Adaptive Management would reduce this impact to **less than significant**.

Impact FISH-16: Impacts to Fish Species due to Changes in Potential for Stranding and Entrainment

Project facilities constructed under Alternative 4, such as the transport, intake and bypass channels, would be graded to provide suitable passage conditions for fish, assuming sufficient water is present. Although Alternative 4 would allow for entrainment of juvenile fish at lower flows relative to Existing Conditions, the design of the transport channel to the Tule Canal is expected to minimize the potential for stranding of juveniles. However, anthropogenic structures that interrupt natural drainage patterns, such as berms and water control structures, create the greatest risk for stranding (Sommer et al. 2005). Therefore, there is some potential for increased juvenile stranding in the Yolo Bypass associated with the operation of the Fremont Weir facilities and transport channels. In addition, because water control structures promote juvenile Chinook salmon stranding due to the occurrence of unusual hydraulic conditions, the presence of the two Tule Canal water control structures, berms, and bypass channels under Alternative 4 could further increase the potential for juvenile fish stranding. In addition, Fremont Weir overtopping events could potentially result in water surface elevations in the Yolo Bypass exceeding the proposed west bypass channel levees, which could increase potential for stranding in the areas between the embankment and the bypass channel as flows recede.

Because Alternative 4 would allow for adult migration into the Sacramento River during periods when adult migration is impeded or blocked at Fremont Weir under Existing Conditions, the potential for adult fish stranding in the Yolo Bypass could be reduced. However, potential migratory delay or impedance downstream of or within the bypass channels may increase the susceptibility of some fish species, such as sturgeon, to being stranded.

CEQA Conclusion

The potential for adult fish stranding may decrease in the northern region of the Yolo Bypass below Fremont Weir but may increase in the Tule Canal, under Alternative 4 relative to Existing Conditions. The potential for juvenile fish stranding may increase due to the presence of substantially different hydraulic conditions associated with the water control structures and berms under Alternative 4, which could result in a **significant and unavoidable impact** on stranding and entrainment. No known actions could be identified to reduce this impact to a less-than-significant level; the creation of unusual hydraulic conditions would not be avoided with the presence of the water control structures, berms, and bypass channels.

Impact FISH-17: Impacts to Fish Species due to Changes in Potential for Predation and Competition

Construction of the intake facility, supplemental fish passage facility, and intake and transport channels lined with rock could increase the potential for predation of fish species of focused evaluation under Alternative 4 relative to Existing Conditions by providing habitat for predatory fish species in these areas. However, the facilities on the Sacramento River are not expected to substantially increase the potential area of refugia for species such as striped bass relative to Existing Conditions. In the Yolo Bypass, increased flow pulses into the Yolo Bypass associated with Alternative 4 during the winter months (primarily December through March) could reduce the potential for predation of fish species such as juvenile salmonids by non-native fish species. For example, Sommer et al. (2014) found that increased connectivity to the Yolo Bypass would provide an overall benefit to native fish species, particularly during the winter, because it is prior to the spawning periods of non-native fish species in the spring. Frantzich et al. (2013) found that native fish species were more widely distributed during wetter years, and low flows may provide more suitable conditions for the spawning and recruitment of non-native centrarchids. Increased flows during February and March under Alternative 4 could increase habitat availability for non-native cyprinids, such as common carp and goldfish, which could result in increased competition for food resources with fish species of focused evaluation relative to Existing Conditions. However, because increased primary and associated secondary production in the Yolo Bypass would likely increase food resources for fish species of focused evaluation in the Yolo Bypass and downstream (see *Impact FISH-14*), increased habitat for non-native cyprinids is not expected to substantially affect fish species of focused evaluation in the Yolo Bypass or in the Delta. Overall, Opperman et al. (2017) argued that flooding the Yolo Bypass from January through April would benefit native fish species. In addition, results of the SBM (evaluated under *Impact*

FISH-18) account for predation associated with the estimated migration path and migration duration for juvenile Chinook salmon in the Yolo Bypass associated with Alternative 4.

However, the proposed water control structures and bypass channels under Alternative 4 may provide increased refuge for predatory fish species such as striped bass relative to Existing Conditions. Based on a review of predation studies and related literature in the Delta region, Grossman et al. (2013) found that most of the predation "hot spots," where substantial predation of juvenile salmonids may consistently occur were located near artificial structures such as bridges, radial gates, and physical obstructions in the channel. Therefore, the presence of the water control structures, which act as blockages in the Tule Canal when the gates are closed, may result in increased predation of juvenile salmonids by piscivorous fish under Alternative 4 relative to Existing Conditions. The water control structures and bypass channels also may provide improved opportunity for marine mammals and river otters to prey on juvenile salmonids. The potential for poaching of adult fish near the water control structures and within the bypass channels also could increase under Alternative 4 relative to Existing Conditions due to the potential migratory delay or impedance caused by the water control structures and bypass channels.

CEQA Conclusion

The potential for predation of fish species of focused evaluation, such as juvenile salmonids, may increase relative to predation rates under Existing Conditions; therefore, Alternative 4 would be expected to have a **significant and unavoidable impact** on predation. No known actions could be identified to reduce this impact to a less-than-significant level; the presence of the water control structures and bypass channels could increase predation rates of juvenile salmonids, which is a stressor to juvenile salmonids under Existing Conditions.

Impact FISH-18: Impacts to Chinook Salmon Species/Runs due to Changes in Viable Salmonid Population Parameters

As previously discussed, model output from the SBM is used to evaluate the VSP parameters (abundance, productivity, diversity, and spatial structure) for fall-run, late fall-run, spring-run, and winter-run Chinook salmon.

Abundance and Productivity

Modeling results indicate that annual average adult Chinook salmon returns under Alternatives 4a and 4b relative to Existing Conditions would be similar or higher over the entire simulation period and by water year type for fall-run and spring-run Chinook salmon but substantially higher during critical water years for fall-run Chinook salmon (Table 8-21). Simulated annual average adult Chinook salmon returns under Alternatives 4a and 4b relative to Existing Conditions would be similar over the entire simulation period and during all water year types for late fall-run and winter-run Chinook salmon.

The adult Chinook salmon returns probability of exceedance distributions for Alternatives 4a and 4b relative to Existing Conditions generally would be higher over the entire distributions for fall-run Chinook salmon and would be similar for late fall-run, spring-run, and winter-run Chinook salmon (Figures 8-32 through 8-35).

In addition, because more juvenile Chinook salmon would enter the Delta from the Yolo Bypass relative to from the Sacramento River, potentially reduced juvenile mortality at the south Delta pumping facilities could increase adult returns under Alternative 4 relative to Existing Conditions (relative to the SBM output).

Table 8-21. Average Annual Chinook Salmon Adult Returns under Alternatives 4a and 4b

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Fall-run Chinook Salmon						
Alternative 4a	179,959	240,972	205,724	84,770	165,766	44,744
Existing Conditions	172,025	232,876	192,956	82,267	158,383	39,065
Difference	7,934	8,097	12,768	2,503	7,383	5,679
Percent Difference[3]	5	3	7	3	5	15
Alternative 4b	179,721	240,349	205,634	84,785	165,712	44,744
Existing Conditions	172,025	232,876	192,956	82,267	158,383	39,065
Difference	7,696	7,474	12,678	2,518	7,330	5,679
Percent Difference[3]	4	3	7	3	5	15
Late Fall-run Chinook Salmon						
Alternative 4a	57,744	59,571	67,635	19,706	61,541	79,821
Existing Conditions	58,390	60,218	68,937	19,914	61,780	81,012
Difference	-647	-647	-1,302	-208	-239	-1,191
Percent Difference[3]	-1	-1	-2	-1	0	-1
Alternative 4b	57,744	59,571	67,635	19,706	61,541	79,821
Existing Conditions	58,390	60,218	68,937	19,914	61,780	81,012
Difference	-647	-647	-1,302	-208	-239	-1,191
Percent Difference[3]	-1	-1	-2	-1	0	-1
Spring-run Chinook Salmon						
Alternative 4a	6,259	9,343	6,002	2,281	5,062	4,357
Existing Conditions	5,960	8,803	5,821	2,174	4,884	4,031
Difference	299	540	181	108	177	326
Percent Difference[3]	5	6	3	5	4	8
Alternative 4b	6,257	9,342	6,000	2,280	5,056	4,357
Existing Conditions	5,960	8,803	5,821	2,174	4,884	4,031
Difference	297	539	179	107	172	326
Percent Difference[3]	5	6	3	5	4	8
Winter-run Chinook Salmon						
Alternative 4a	5,617	5,690	5,571	5,353	6,301	3,188
Existing Conditions	5,518	5,504	5,558	5,334	6,197	3,118
Difference	99	186	13	19	104	70
Percent Difference[3]	2	3	0	0	2	2
Alternative 4b	5,617	5,690	5,571	5,354	6,300	3,188

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Existing Conditions	5,518	5,504	5,558	5,334	6,197	3,118
Difference	99	186	13	20	102	70
Percent Difference[3]	2	3	0	0	2	2

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

[3] Relative difference of the annual average

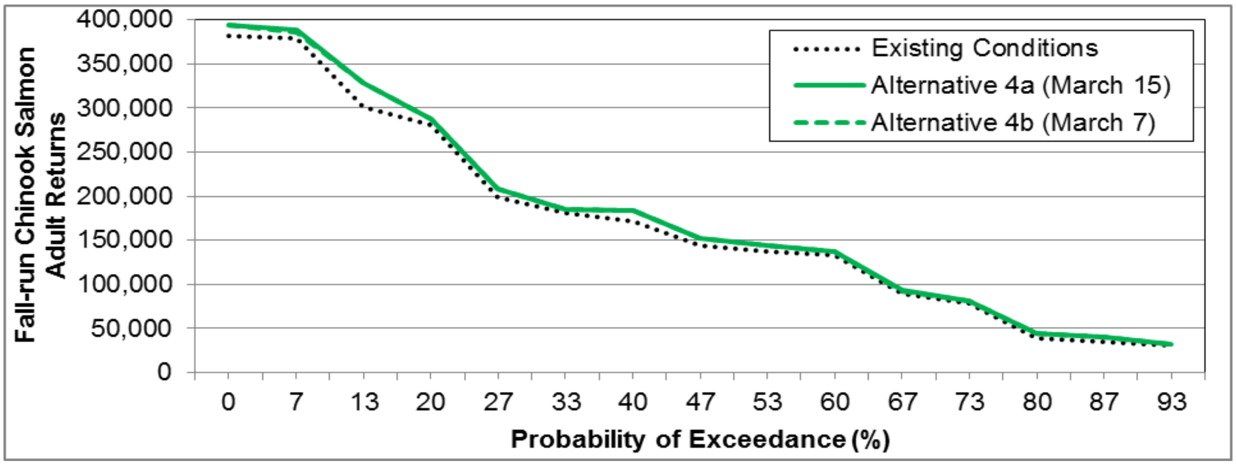

Figure 8-32. Simulated Adult Fall-run Chinook Salmon Returns Probability of Exceedance Distributions under Alternatives 4a and 4b and Existing Conditions

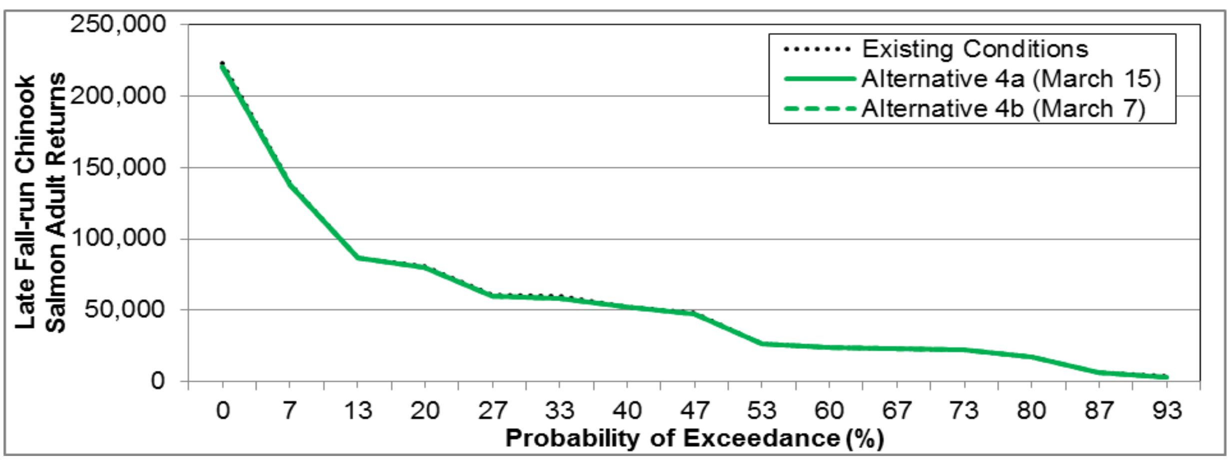

Figure 8-33. Simulated Adult Late Fall-run Chinook Salmon Returns Probability of Exceedance Distributions under Alternatives 4a and 4b and Existing Conditions

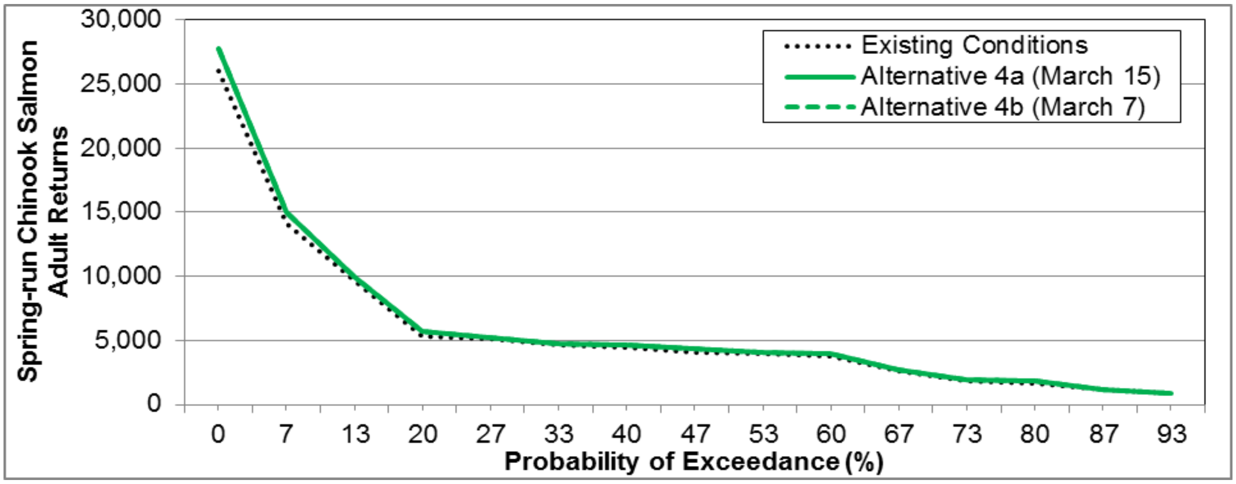

Figure 8-34. Simulated Adult Spring-run Chinook Salmon Returns Probability of Exceedance Distributions under Alternatives 4a and 4b and Existing Conditions

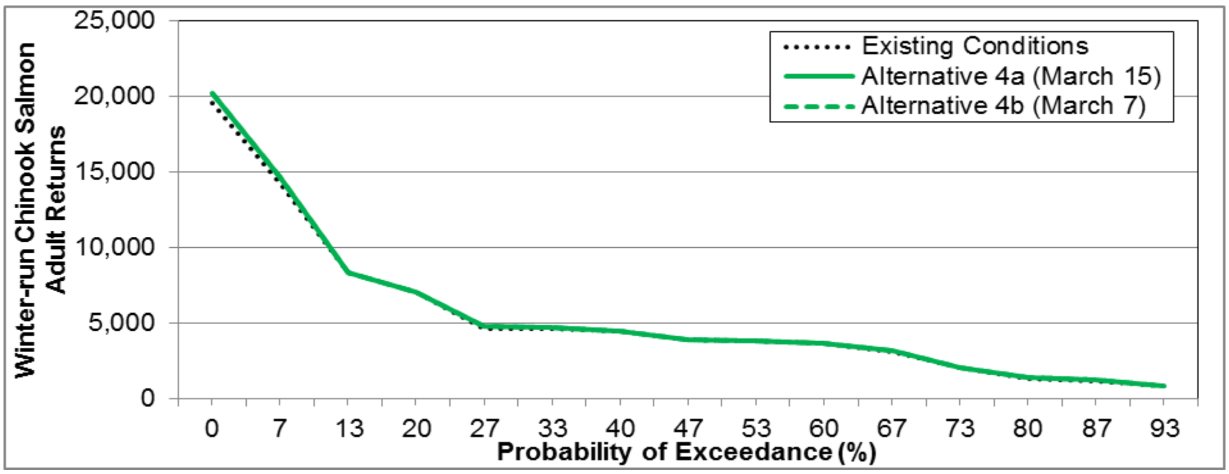

Figure 8-35. Simulated Adult Winter-run Chinook Salmon Returns Probability of Exceedance Distributions under Alternatives 4a and 4b and Existing Conditions

Diversity

VARIATION IN JUVENILE CHINOOK SALMON SIZE

Modeling results indicate that annual average juvenile Chinook salmon coefficient of variation in size (FL) under Alternatives 4a and 4b relative to Existing Conditions would be substantially higher over the entire simulation period and during most water year types for fall-run, spring-run, and winter-run Chinook salmon and would be similar for late fall-run Chinook salmon (Table 8-22).

Similarly, the juvenile Chinook salmon coefficient of variation in size probability of exceedance distributions for Alternatives 4a and 4b relative to Existing Conditions would be higher over most or all of the entire distributions for fall-run, spring-run, and winter-run Chinook salmon and would be similar for late fall-run Chinook salmon (Figures 8-36 through 8-39).

Table 8-22. Average Annual Juvenile Coefficient of Variation in Size under Alternatives 4a and 4b

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Fall-run Chinook Salmon						
Alternative 4a	0.41	0.46	0.40	0.39	0.39	0.37
Existing Conditions	0.35	0.44	0.32	0.35	0.31	0.13
Difference	0.06	0.02	0.08	0.03	0.08	0.24
Percent Difference[3]	18	4	25	9	27	184
Alternative 4b	0.41	0.46	0.40	0.38	0.39	0.37
Existing Condition	0.35	0.44	0.32	0.35	0.31	0.13
Difference	0.06	0.02	0.08	0.03	0.08	0.24
Percent Difference[3]	18	4	25	9	27	184
Late Fall-run Chinook Salmon						
Alternative 4a	0.33	0.41	0.48	0.50	0.11	0.07
Existing Conditions	0.33	0.41	0.48	0.50	0.11	0.07
Difference	0.00	0.00	0.00	0.00	0.00	0.00
Percent Difference[3]	0	0	0	0	0	0
Alternative 4b	0.33	0.41	0.48	0.50	0.11	0.07
Existing Conditions	0.33	0.41	0.48	0.50	0.11	0.07
Difference	0.00	0.00	0.00	0.00	0.00	0.00
Percent Difference[3]	0	1	0	0	0	0
Spring-run Chinook Salmon						
Alternative 4a	0.34	0.44	0.33	0.32	0.26	0.28
Existing Conditions	0.30	0.42	0.30	0.26	0.22	0.18
Difference	0.04	0.03	0.04	0.06	0.04	0.10
Percent Difference[3]	14	7	12	25	16	58
Alternative 4b	0.34	0.44	0.33	0.32	0.26	0.28
Existing Conditions	0.30	0.42	0.30	0.26	0.22	0.18
Difference	0.04	0.03	0.04	0.06	0.04	0.10
Percent Difference[3]	14	7	12	25	16	58
Winter-run Chinook Salmon						
Alternative 4a	0.16	0.22	0.14	0.19	0.12	0.09
Existing Conditions	0.14	0.20	0.12	0.17	0.10	0.06
Difference	0.02	0.02	0.02	0.02	0.02	0.03
Percent Difference[3]	15	11	20	10	21	55
Alternative 4b	0.16	0.22	0.14	0.19	0.12	0.09
Existing Conditions	0.14	0.20	0.12	0.17	0.10	0.06

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Difference	0.02	0.02	0.02	0.02	0.02	0.03
Percent Difference[3]	15	11	20	10	20	55

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

[3] Relative difference of the annual average

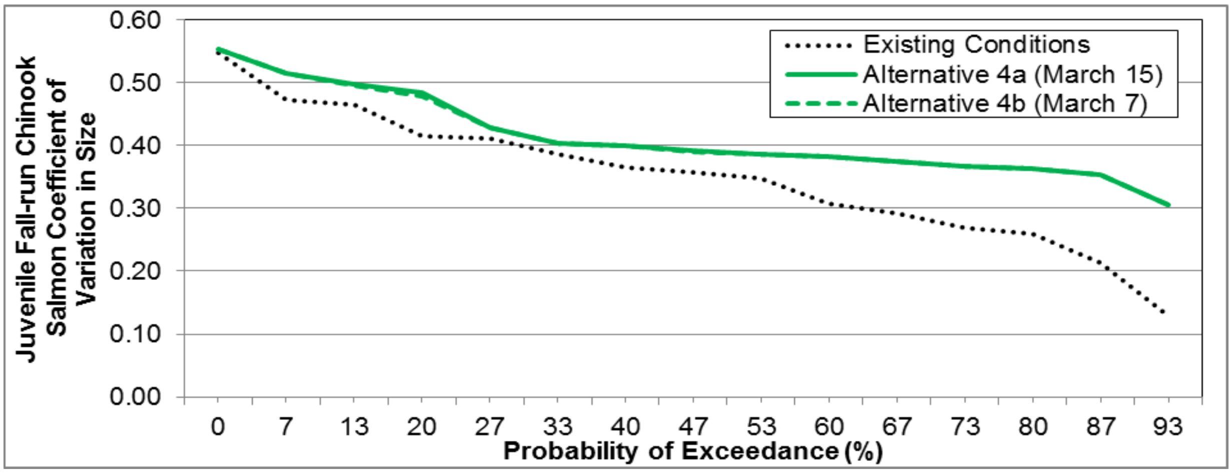

Figure 8-36. Simulated Juvenile Fall-run Chinook salmon Coefficient of Variation in Size Probability of Exceedance Distributions under Alternative 4 and Existing Conditions

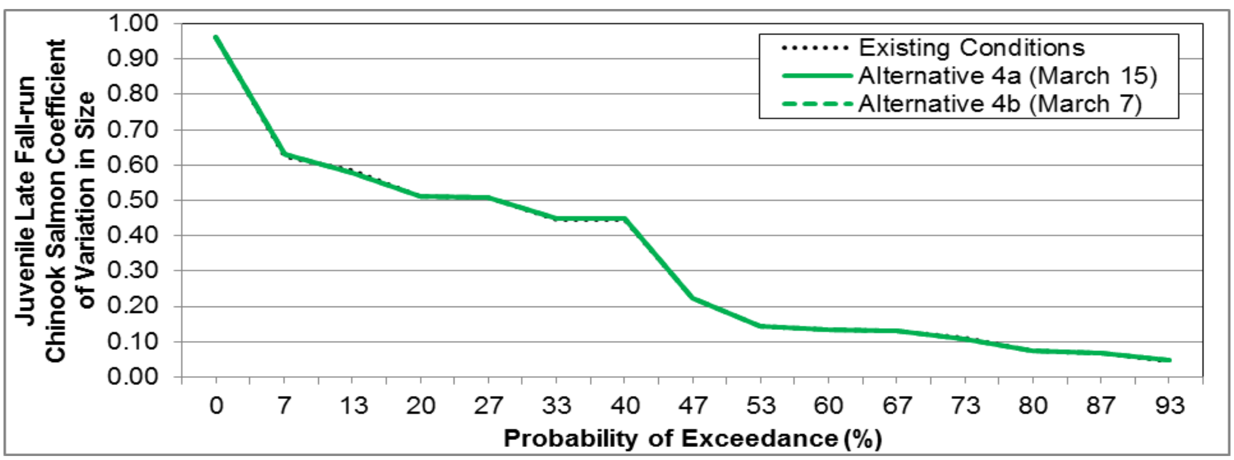

Figure 8-37. Simulated Juvenile Late Fall-run Chinook Salmon Coefficient of Variation in Size Probability of Exceedance Distributions under Alternative 4 and Existing Conditions

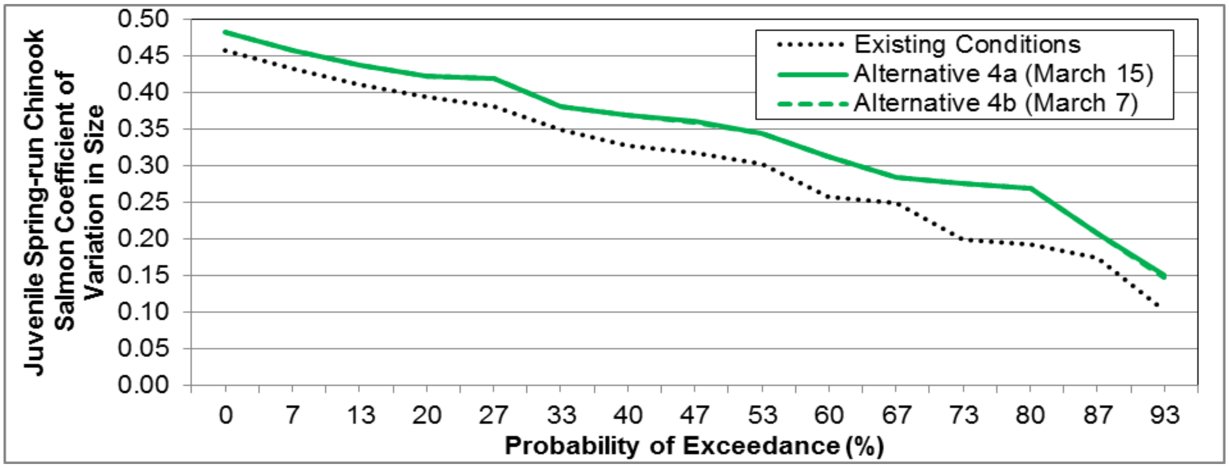

Figure 8-38. Simulated Juvenile Spring-run Chinook salmon Coefficient of Variation in Size Probability of Exceedance Distributions under Alternative 4 and Existing Conditions

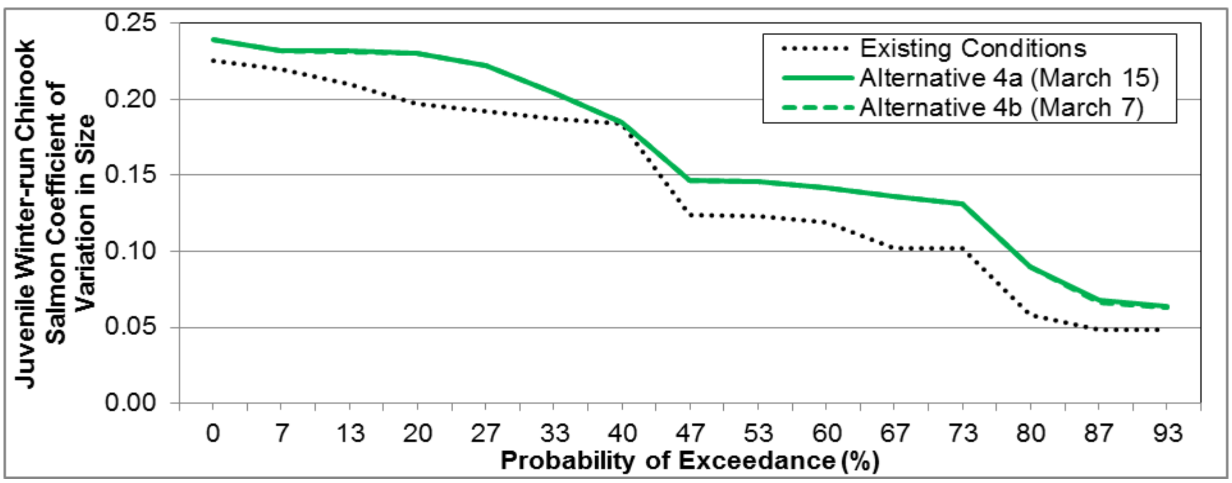

Figure 8-39. Simulated Juvenile Winter-run Chinook Salmon Coefficient of Variation in Size Probability of Exceedance Distributions under Alternative 4 and Existing Conditions

Variation in Juvenile Chinook Salmon Estuary Entry Timing

Modeling results indicate that annual average juvenile Chinook salmon coefficient of variation in estuary entry timing under Alternative 4 relative to Existing Conditions would be higher over the entire simulation period; similar during wet and below normal water years; and higher or substantially higher during above normal, dry, and critical water years for fall-run Chinook salmon (Table 8-23). Annual average juvenile Chinook salmon coefficient of variation in estuary entry timing under Alternative 4 relative to Existing Conditions would be similar over the entire simulation period and during most water year types for late fall-run, spring-run, and winter-run Chinook salmon but would be substantially higher during critical water years for spring-run Chinook salmon.

The juvenile Chinook salmon coefficient of variation in estuary entry timing probability of exceedance distributions would be similar or higher over most of the distributions under

Alternative 4 relative to Existing Conditions for fall-run, spring-run, and winter-run Chinook salmon and would be similar for late fall-run Chinook salmon (Figures 8-40 through 8-43).

Table 8-23. Average Annual Juvenile Chinook Salmon Coefficient of Variation in Estuary Entry Timing under Alternative 4

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Fall-run Chinook Salmon						
Alternative 4a	0.25	0.29	0.24	0.25	0.21	0.20
Existing Conditions	0.24	0.29	0.22	0.25	0.19	0.16
Difference	0.01	0.00	0.02	0.00	0.02	0.04
Percent Difference[3]	5	0	8	1	10	27
Alternative 4b	0.25	0.29	0.24	0.25	0.21	0.20
Existing Conditions	0.24	0.29	0.22	0.25	0.19	0.16
Difference	0.01	0.00	0.02	0.00	0.02	0.04
Percent Difference[3]	5	0	8	1	10	27
Late Fall-run Chinook Salmon						
Alternative 4a	0.33	0.44	0.32	0.21	0.29	0.15
Existing Conditions	0.33	0.44	0.33	0.21	0.29	0.15
Difference	0.00	0.00	0.00	0.00	0.00	0.00
Percent Difference[3]	0	-1	-1	0	0	-1
Alternative 4b	0.33	0.44	0.32	0.21	0.29	0.15
Existing Conditions	0.33	0.44	0.33	0.21	0.29	0.15
Difference	0.00	0.00	0.00	0.00	0.00	0.00
Percent Difference[3]	0	-1	-1	0	0	-1
Spring-run Chinook Salmon						
Alternative 4a	0.30	0.39	0.28	0.27	0.24	0.21
Existing Conditions	0.29	0.38	0.28	0.26	0.23	0.18
Difference	0.01	0.00	0.01	0.01	0.01	0.02
Percent Difference[3]	3	1	2	6	3	13
Alternative 4b	0.30	0.39	0.28	0.27	0.24	0.21
Existing Conditions	0.29	0.38	0.28	0.26	0.23	0.18
Difference	0.01	0.00	0.01	0.01	0.01	0.02
Percent Difference[3]	2	1	2	5	2	13
Winter-run Chinook Salmon						
Alternative 4a	0.28	0.38	0.23	0.31	0.22	0.13
Existing Conditions	0.28	0.38	0.22	0.30	0.21	0.12
Difference	0.01	0.01	0.01	0.01	0.00	0.01

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Percent Difference[3]	2	1	3	2	2	6
Alternative 4b	0.28	0.38	0.23	0.31	0.22	0.13
Existing Conditions	0.28	0.38	0.22	0.30	0.21	0.12
Difference	0.01	0.01	0.01	0.01	0.00	0.01
Percent Difference[3]	2	1	3	2	2	6

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

[3] Relative difference of the annual average

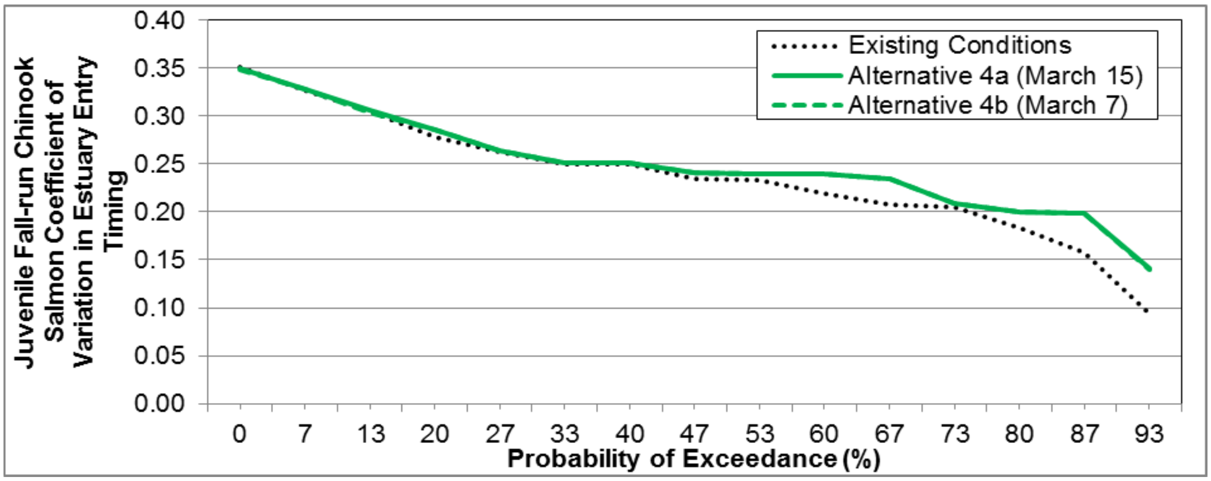

Figure 8-40. Simulated Juvenile Fall-run Chinook Salmon Coefficient of Variation in Estuary Entry Timing Probability of Exceedance Distributions under Alternative 4

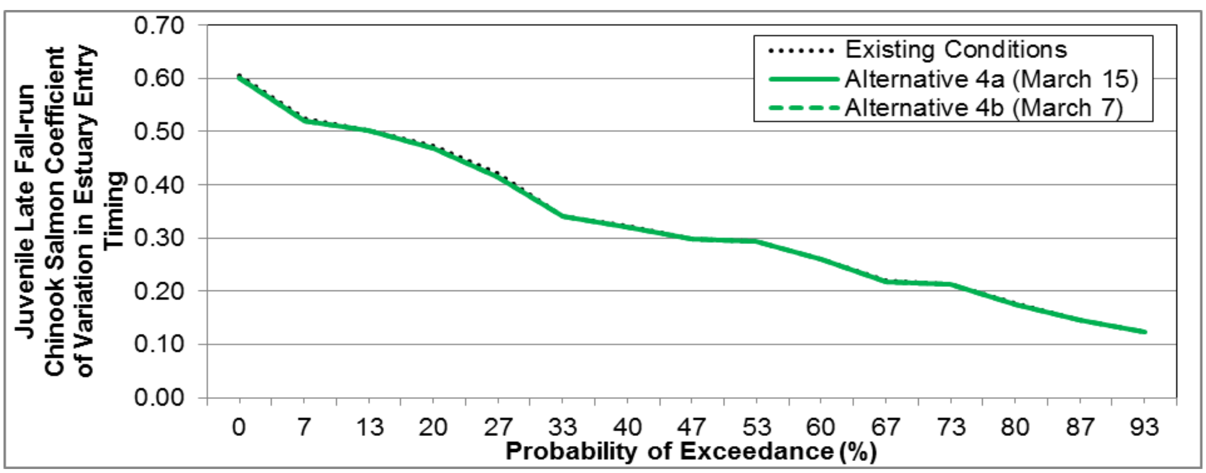

Figure 8-41. Simulated Juvenile Late Fall-run Chinook Salmon Coefficient of Variation in Estuary Entry Timing Probability of Exceedance Distributions under Alternative 4

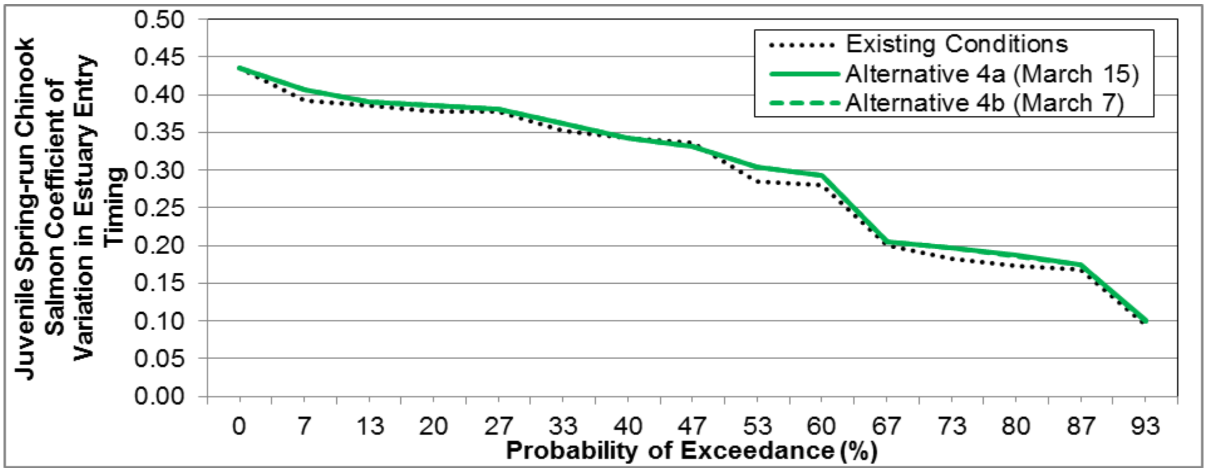

Figure 8-42. Simulated Juvenile Spring-Run Chinook Salmon Coefficient of Variation in Estuary Entry Timing Probability of Exceedance Distributions under Alternative 4

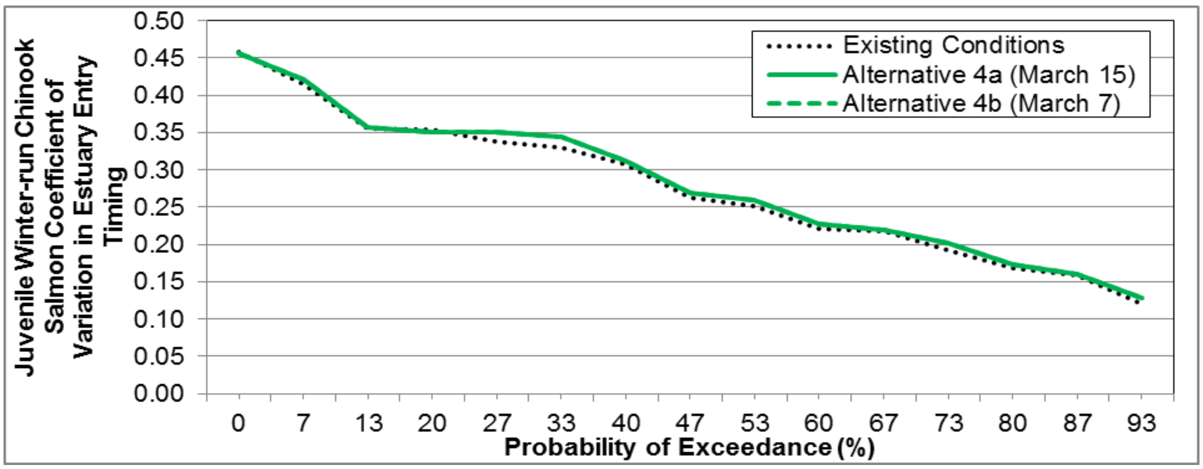

Figure 8-43. Simulated Juvenile Winter-run Chinook salmon Coefficient of Variation in Estuary Entry Timing Probability of Exceedance Distributions under Alternative 4

Spatial Structure

ENTRAINMENT INTO THE YOLO BYPASS

Modeling results indicate that mean monthly flows spilling into the Yolo Bypass from the Sacramento River at Fremont Weir under Alternative 4 relative to Existing Conditions would be higher from November through March and would be similar over the remainder of the year (see Appendix G6). Mean monthly flows would be substantially higher (i.e., higher by 10 percent or more) during at least some water year types in November (wet water years), December (wet and above normal water years), January (above normal, below normal, and dry water years), February (above normal, below normal, dry, and critical water years), and March (below normal and dry water years). Over the entire simulation period, net increases in flows of 10 percent or more occur with substantially higher frequency (i.e., 10 percent or more of the time) from December through March (see Appendix G6).

Based on increases in simulated monthly flows from December through March, it is expected that juvenile salmonids and potentially other fish species would be more likely to be entrained into the Yolo Bypass from December through March under Alternative 4 relative to Existing Conditions.

The estimated average annual percentages of juvenile fall-run, late fall-run, winter-run, and spring-run Chinook salmon (all sizes) entrained into the Yolo Bypass using the proportion of flow approach would be 13, 5.2, 9.5, and 8.4 percent under Alternative 4, respectively (relative to about 7.1, 2.6, 3.9, and 3.1 percent, respectively, under Existing Conditions) (DWR 2017a; Appendix G3). For smaller juveniles (i.e., <80 mm), the percentages of fall-run, late fall-run, winter-run, and spring-run Chinook salmon entrained into the Yolo Bypass would be 13.6, 1.1, 5.9, and 8.9 percent, respectively (DWR 2017a; Appendix G3).

The ELAM modeling indicates that the entrainment-Sacramento River stage relationship under Alternative 4 exhibits a positive relationship as Sacramento River stage increases from 22.32 to 27 ft. The percent of juveniles entrained peaks at about seven percent at a stage of 27 ft and decreases to about five percent at the highest stage modeled (28.83 ft) (Smith et al. 2017; Appendix G1).

The critical streakline analysis for Alternative 4 (critical streakline scenario 2) found that the percentage of the total annual abundance of juveniles entrained by run over the entire simulation period would be about nine percent for fall-run Chinook salmon, four percent for late fall-run Chinook salmon, seven percent for winter-run Chinook salmon, and seven percent for spring-run Chinook salmon.

The entrainment modeling results indicate that the critical streakline analysis-predicted average annual entrainment rates would be about four percent lower for fall-run, one percent lower for late fall-run, 2.5 percent lower for winter-run, and one percent lower for spring-run Chinook salmon relative to the proportion of flow approach estimates (for all sizes of juveniles) for Alternative 4. Because the SBM modeling was conducted using the proportion of flow approach to estimate juvenile entrainment into the Yolo Bypass, the indicators of the VSP parameters presented for Alternative 4 may be less beneficial than shown if the critical streakline entrainment estimates were applied.

Juvenile Rearing in the Yolo Bypass for One or More Days

Modeling results indicate that annual average numbers of juvenile Chinook salmon rearing for one or more days in the Yolo Bypass under Alternatives 4a and 4b relative to Existing Conditions would be substantially higher over the entire simulation period and during all water year types for fall-run, spring-run, and winter-run Chinook salmon and substantially higher over the entire simulation period and during all water year types except for critical water years for late fall-run Chinook salmon (Table 8-24).

The annual number of juvenile Chinook salmon rearing for one or more days in the Yolo Bypass probability of exceedance distributions for Alternatives 4a and 4b relative to Existing Conditions would be higher over the entire distributions for fall-run Chinook salmon, higher over most of the distributions for late fall-run Chinook salmon, and substantially higher over the entire distributions for spring-run and winter-run Chinook salmon (Figures 8-44 through 8-47). In addition, Alternatives 4a and 4b would provide for rearing on the Yolo Bypass over about 20 percent of the distributions when no juvenile fall-run Chinook salmon would be rearing in the

Yolo Bypass and over about 30 percent of the distributions when no juvenile late fall-run, spring-run, and winter-run Chinook salmon rearing would occur in the Yolo Bypass under Existing Conditions.

Table 8-24. Average Annual Number of Juvenile Chinook Salmon that Reared in the Yolo Bypass for One or More Days

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Fall-run Chinook Salmon						
Alternative 4a	4,265,025	9,137,640	4,094,586	834,982	923,737	638,512
Existing Conditions	3,179,250	8,028,286	2,198,294	436,145	20,038	0
Difference	1,085,775	1,109,354	1,896,292	398,838	903,700	638,512
Percent Difference[3]	34	14	86	91	4,510	n/a
Alternative 4b	4,231,370	9,044,105	4,096,970	831,294	914,504	638,512
Existing Conditions	3,179,250	8,028,286	2,198,294	436,145	20,038	0
Difference	1,052,120	1,015,819	1,898,676	395,150	894,466	638,512
Percent Difference[3]	33	13	86	91	4,464	n/a
Late Fall-run Chinook Salmon						
Alternative 4a	235,343	654,318	44,290	14,894	23,973	0
Existing Conditions	190,830	571,919	953	0	0	0
Difference	44,512	82,399	43,336	14,894	23,973	0
Percent Difference[3]	23	14	4,546	n/a	n/a	n/a
Alternative 4b	235,348	654,334	44,291	14,894	23,973	0
Existing Conditions	190,830	571,919	953	0	0	0
Difference	44,518	82,416	43,337	14,894	23,973	0
Percent Difference[3]	23	14	4,546	n/a	n/a	n/a
Spring-run Chinook Salmon						
Alternative 4a	75,020	149,586	70,133	16,564	23,793	38,668
Existing Conditions	32,657	72,311	41,409	1,894	70	0
Difference	42,363	77,275	28,724	14,671	23,723	38,668
Percent Difference[3]	130	107	69	775	33,769	n/a
Alternative 4b	74,738	149,487	70,172	16,343	22,943	38,668
Existing Conditions	32,657	72,311	41,409	1,894	70	0
Difference	42,082	77,176	28,763	14,450	22,873	38,668
Percent Difference[3]	129	107	69	763	32,559	n/a
Winter-run Chinook Salmon						
Alternative 4a	57,512	93,169	76,158	22,429	26,186	18,765
Existing Conditions	28,031	54,261	46,976	3,552	283	0

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Difference	29,481	38,908	29,182	18,877	25,903	18,765
Percent Difference[3]	105	72	62	532	9,145	n/a
Alternative 4b	57,287	93,072	76,121	22,322	25,544	18,765
Existing Conditions	28,031	54,261	46,976	3,552	283	0
Difference	29,256	38,811	29,145	18,770	25,261	18,765
Percent Difference[3]	104	72	62	529	8,918	n/a

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

[3] Relative difference of the annual average

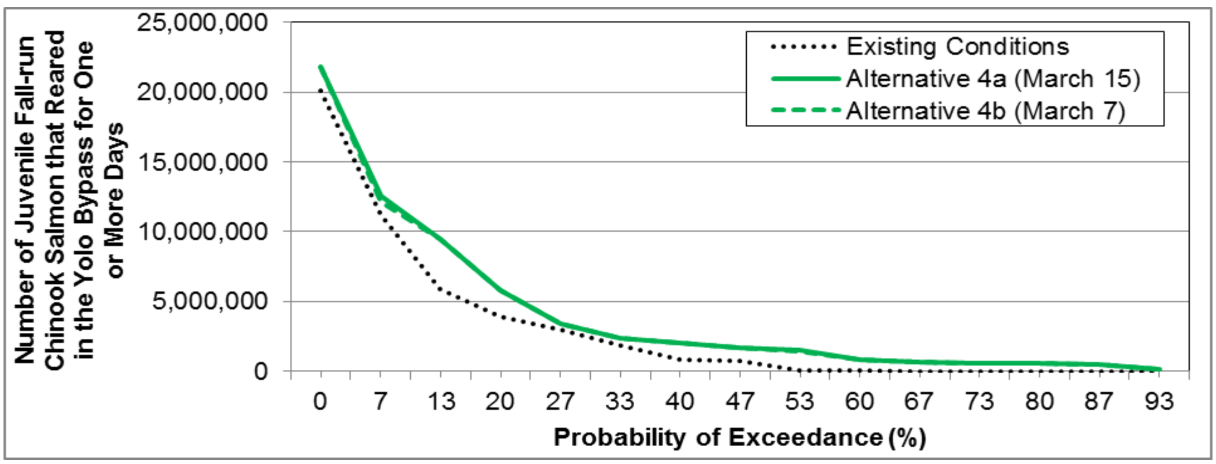

Figure 8-44. Simulated Number of Juvenile Fall-run Chinook Salmon Rearing for One or More Days in the Yolo Bypass Exceedance Distributions under Alternative 4

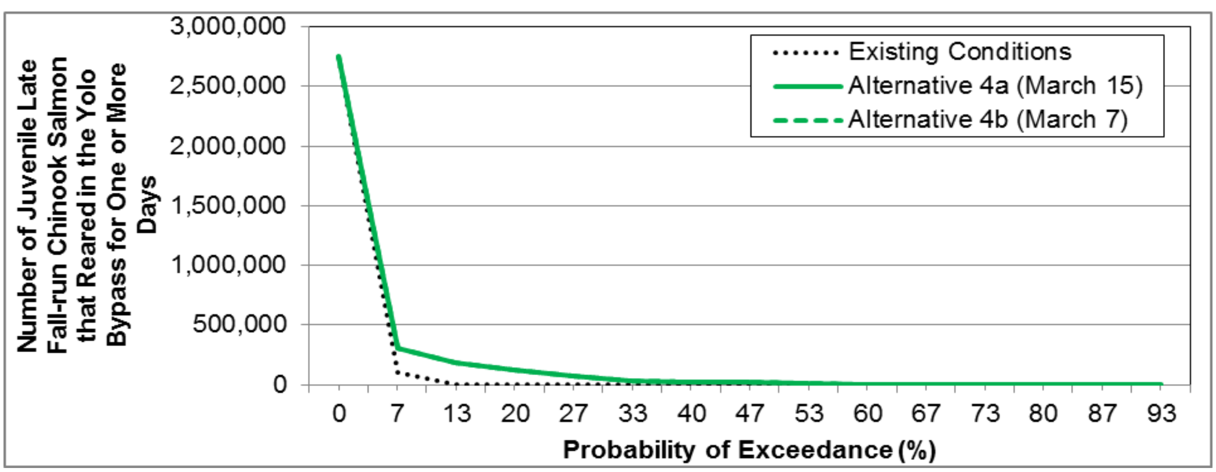

Figure 8-45. Simulated Number of Juvenile Late Fall-run Chinook Salmon Rearing for One or More Days in the Yolo Bypass Exceedance Distributions under Alternative 4

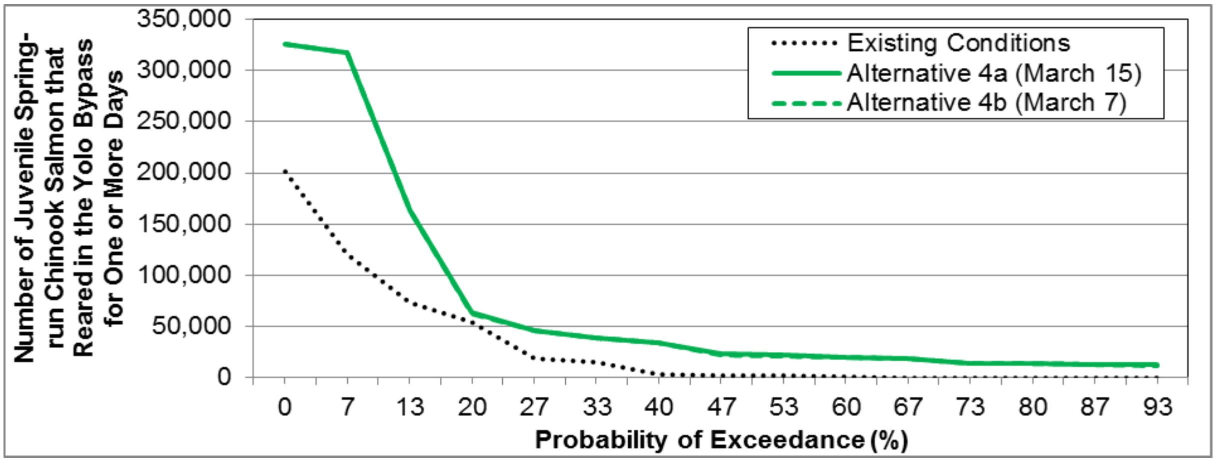

Figure 8-46. Simulated Number of Juvenile Spring-run Chinook Salmon Rearing for one or more days in the Yolo Bypass Exceedance Distributions under Alternative 4

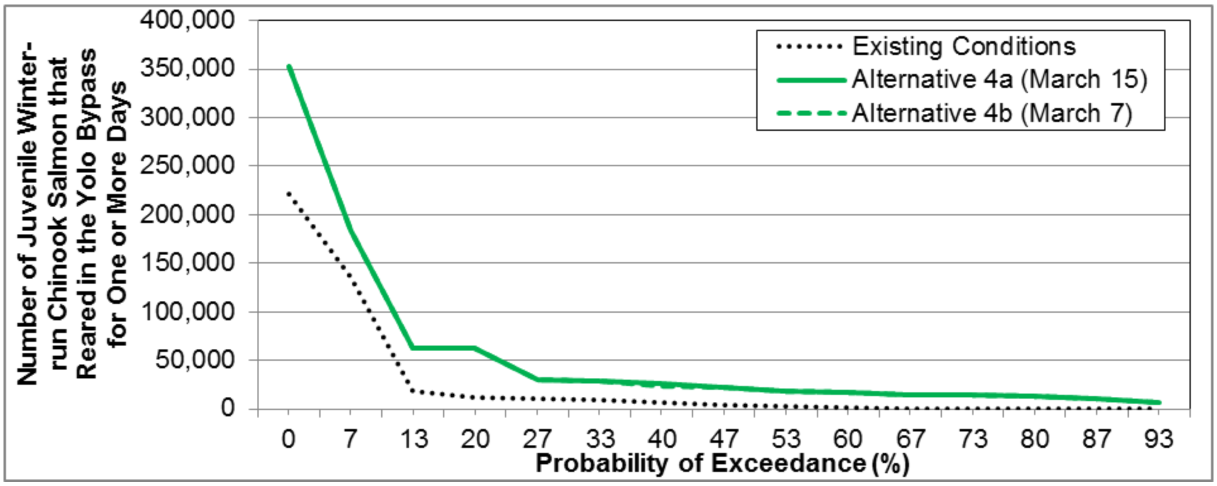

Figure 8-47. Simulated Number of Juvenile Winter-run Chinook Salmon Rearing for One or More Days in the Yolo Bypass Exceedance Distributions under Alternative 4

CEQA Conclusion

Simulated population metric indicators from the SBM were used to evaluate changes in the VSP parameters under Alternatives 4a and 4b relative to Existing Conditions. Except for the abundance and productivity parameters for late fall-run and winter-run Chinook salmon and the diversity parameter for late fall-run Chinook salmon, which indicate generally similar conditions under Alternative 4 and Existing Conditions, the abundance, productivity, diversity, and spatial structure indicators all exhibit improvement for fall-run, late fall-run, spring-run, and winter-run Chinook salmon under Alternatives 4a and 4b relative to Existing Conditions.

Therefore, Alternative 4 would be expected to have a **less than significant impact** on VSP parameters.

Impact FISH-19: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Hydrologic Conditions in the SWP/CVP System

Changes in simulated mean monthly storages in the SWP/CVP system under Alternative 4 relative to the basis of comparison would be similar to those described for Alternative 1. Therefore, simulated changes under Alternative 4 relative to the No Action Alternative (and Existing Conditions) would not result in substantial adverse effects to fish species of focused evaluation and their habitats in the SWP/CVP system.

CEQA Conclusion

Due to similar modeled hydrology in the SWP/CVP system, Alternative 4 would be expected to have a **less than significant impact** due to changes in hydrologic conditions in the SWP/CVP system.

Impact FISH-20: Conflict with Adopted Habitat Conservation Plan; Natural Community Conservation Plan; or Other Approved Local, Regional, or State Habitat Conservation Plan

Although the Yolo County HCP/NCCP does not directly address fish species, it does include goals and policies related to protecting and improving habitat conditions in the Yolo Bypass, which could indirectly benefit fish resources (Yolo Habitat Conservancy 2017). Because Alternative 4 would include mitigation for physical habitat impacts, Alternative 4 would not conflict with HCPs or NCCPs, including the Yolo County HCP/NCCP (Yolo Habitat Conservancy 2017). This impact consideration is addressed for vegetation, wetlands and wildlife resources in Chapter 9 under Impact TERR-11 for each Alternative.

CEQA Conclusion

Alternative 4 is expected to have a **less than significant impact** on habitat conservation plans.

8.3.3.6 Alternative 5: Central Multiple Gated Notches

Alternative 5, Central Multiple Gated Notches, would improve the capture of fish through using multiple gates and intake channels so that the deeper gate could allow more flow to enter the bypass when the river is at lower elevations. Flows would move to other gates when the river is higher to control inflows. Alternative 5 incorporates multiple gated notches in the central location on the existing Fremont Weir that would convey combined flows of up to 3,400 cfs. In addition, because hydraulic conditions upstream of the proposed Fremont Weir notch are not favorable to entraining juvenile Chinook salmon, Alternative 5 includes Sacramento River channel and bank improvements. These improvements include removing pilings in the Sacramento River and re-grading the Sacramento River channel and right bank. These improvements also are expected to fill in a scour hole near the pilings. See Section 2.8 for more details on the alternative features.

8.3.3.6.1 Construction- and Maintenance-related Impacts – Evaluation of Substantial Adverse Effects on Fish Species of Focused Evaluation and their Habitat and Movement

By contrast to the other alternatives, construction of Alternative 5 would likely begin in late 2020 or early 2021 and continue for two seasons. Construction in the first year is estimated to last 28 weeks and would be conducted during the non-flood season of April 15 through November 1. Construction efforts would continue for 13 weeks during the following year after April 15. Construction- and maintenance-related activities evaluated for Alternative 5 are similar to those described for Alternative 2. As described for Alternative 2, Alternative 5 also includes in-river activities just upstream of the proposed Fremont Weir notch. Activities include removing instream piles and re-grading the Sacramento River channel and right bank. In addition, future maintenance may be necessary to maintain the re-graded conditions in the Sacramento River channel and along the right bank to maintain hydraulic conditions that promote entrainment of juvenile Chinook salmon into the Fremont Weir notch.

Impact FISH-1: Potential Disturbance to Fish Species or their Habitat due to Erosion, Sedimentation, and Turbidity

Potential impacts associated with erosion, sedimentation, and turbidity under Alternative 5 are expected to be similar to those described for Alternative 1. However, substantially more excavation would occur in the Yolo Bypass under Alternative 5. As an indicator of the extent of excavation that would occur under Alternative 5 in the Yolo Bypass, the estimated excess amount of spoils to be excavated during construction would be about 4,615,000 CY. As an indicator of maintenance-related impacts, the estimated additional annual amount of sediment removal required in the area between Fremont Weir and Agricultural Road Crossing 1 because of increased flows into the Yolo Bypass under implementation of Alternative 5 is 18,900 CY. This corresponds to an estimated total annual amount of sediment removal required of 315,450 CY under Alternative 5 relative to 296,550 CY under Existing Conditions. However, local deposition patterns will be dependent on the specific design of downstream facilities.

CEQA Conclusion

Erosion, sedimentation, and turbidity impacts would be **significant** because construction and maintenance activities would result in temporary increases in sedimentation and turbidity in the Sacramento River and the Yolo Bypass and could temporarily adversely affect all fish species of focused evaluation.

Development and implementation of Mitigation Measure MM-WQ-2: Implement a Stormwater Pollution and Prevention Plan and Mitigation Measure MM-WQ-3: Develop Turbidity Monitoring Program would reduce this impact to **less than significant**.

Impact FISH-2: Potential Disturbance to Fish Species or their Habitat due to Hazardous Materials and Chemical Spills

Potential impacts associated with hazardous materials and chemical spills under Alternative 5 are expected to be similar to those described for Alternative 1. However, there likely would be increased potential for hazardous spills due to the extended construction period and additional excavation and construction activities relative to Alternative 1.

CEQA Conclusion

Hazardous materials and chemical spills impacts would be **significant** because construction and maintenance activities could potentially result in the release of contaminants to aquatic habitats in the Sacramento River and the Yolo Bypass and could adversely affect all fish species of focused evaluation.

Development and implementation of Mitigation Measure MM-WQ-1: Prepare and Implement a Spill Prevention, Control, and Countermeasure Plan would reduce this impact to **less than significant**.

Impact FISH-3: Potential Disturbance to Fish Species or their Habitat due to Aquatic Habitat Modification

Potential impacts associated with aquatic habitat modification under Alternative 5 are expected to be similar to those described for Alternative 1; however, more acreage of habitat would be affected under Alternative 5 due to more extensive grading and construction of multiple channels between the intake facilities and Tule Pond. In addition, under Alternative 5 only the upper portion of the outlet channels would be lined with rock revetment to promote the formation of meandering channels.

Preliminary estimates based on calculations in ArcGIS indicate that a total of 25.6 acres (temporary impacts) and 85.7 acres (permanent impacts) of vegetated area would have the potential to be disturbed during Alternative 5 construction activities. Specifically, 7.1 acres (temporary impacts) and 11.5 acres (permanent impacts) would be riparian, which would be a potential source of IWM inputs to the Sacramento River or Yolo Bypass (Table 8-25 and Figure 8-48). Table 8-25 does not include acreages for the Tule Canal floodplain improvements as these are being addressed only at a programmatic level in this EIS/EIR.

Table 8-25. Vegetation Communities Potentially Affected by Alternative 5

Vegetation Community					
	Grassland	**Freshwater Aquatic Vegetation**	**Freshwater Emergent Marsh**	**Riparian Forest/Woodland**	**Total**
Acres (Temporary)	17.9	0.1	0.5	7.1	25.6
Acres (Permanent)	66.7	2.6	4.9	11.5	85.7

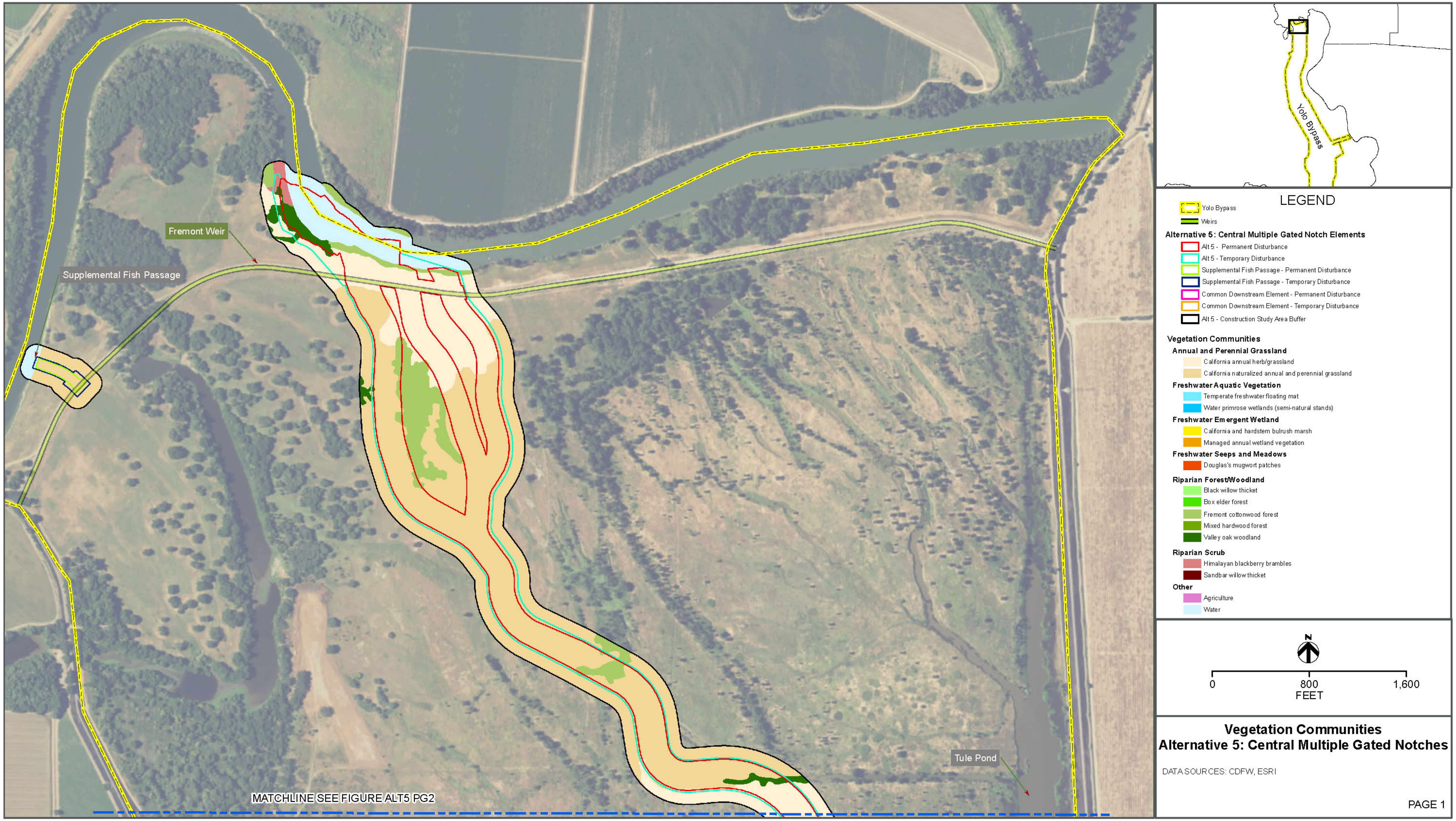

Figure 8-48a. Vegetation Communities Potentially Affected by Alternative 5

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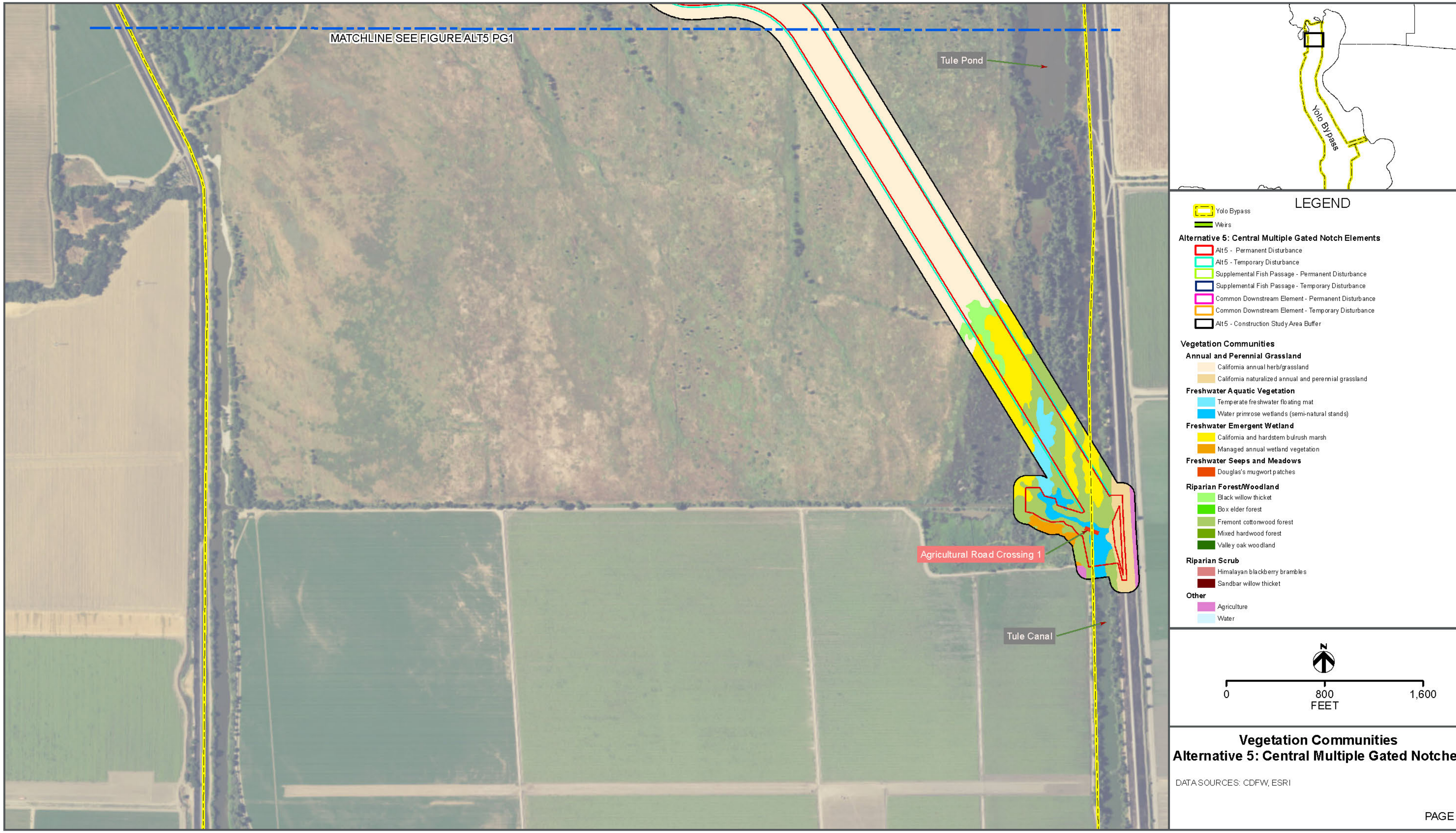

Figure 8-48b. Vegetation Communities Potentially Affected by Alternative 5

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CEQA Conclusion

Aquatic habitat modification adjacent to the Sacramento River and in the Yolo Bypass associated with construction activities would be **significant** because aquatic and riparian habitat would be permanently affected.

Implementation of Mitigation Measures MM-TERR-13, MM-TERR-11, and MM-FISH-1 would reduce this impact to **less than significant**.

Impact FISH-4: Potential Disturbance to Fish Species or their Habitat due to Hydrostatic Pressure Waves, Noise, and Vibration

Potential impacts associated with hydrostatic pressure waves, noise, and vibration under Alternative 5 are expected to be similar to those described for Alternative 1. However, potential impacts due to noise associated with temporary cofferdam construction could occur from mid-May through mid-June due to the increased complexity of the intake facilities under Alternative 5.

CEQA Conclusion

Impacts associated with construction noise would be **less than significant** if a vibratory pile driver can be used for the entire construction of the cofferdam. However, impacts associated with noise would be **significant** if impact pile driving was conducted in the Sacramento River, resulting in direct potential impacts to fish species of focused evaluation.

Implementation of Mitigation Measure MM-FISH-2: Implement an Underwater Noise Reduction and Monitoring Plan would reduce this impact to **less than significant**.

Impact FISH-5: Potential Disturbance to Fish Species or their Habitat due to Stranding and Entrainment

Potential impacts associated with stranding and entrainment under Alternative 5 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Stranding and entrainment impacts would be **significant** because fish species of focused evaluation could be entrained in the temporary cofferdam.

Implementation of Mitigation Measure MM-FISH-3: Prepare a Fish Rescue and Salvage Plan would reduce this impact to **less than significant**.

Impact FISH-6: Potential Disturbance to Fish Species or their Habitat due to Predation Risk

Potential impacts associated with predation risk under Alternative 5 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Predation risk impacts would be **significant** because fish species of focused evaluation could be at increased risk of predation due to potential indirect effects of construction and maintenance activities.

Implementation of Mitigation Measures MM-WQ-2: Implement a Stormwater Pollution and Prevention Plan; MM-WQ-1: Prepare and Implement a Spill Prevention, Control, and Countermeasure Plan; MM-FISH-2: Implement an Underwater Noise Reduction and Monitoring Plan; and MM-FISH-3: Prepare a Fish Rescue and Salvage Plan would reduce this impact to less than significant.

Impact FISH-7: Potential Disturbance to Fish Species due to Changes in Fish Passage Conditions

Potential impacts associated with fish passage under Alternative 5 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Fish passage impacts would be **less than significant** because fish species of focused evaluation would either generally not be present near temporary fish passage blockages or would not be substantially affected by temporary blockages.

Impact FISH-8: Potential Disturbance to Fish Species or their Habitat due to Direct Harm

Potential impacts associated with direct physical injury and/or mortality under Alternative 5 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Direct harm impacts would be **significant** because fish species of focused evaluation could be directly harmed due to construction- and maintenance-related equipment, personnel, or debris.

Implementation of Mitigation Measure MM-FISH-4: Implement General Fish Protection Measures would reduce this impact to **less than significant**.

8.3.3.6.2 Operations-related Impacts

Operations-related impacts associated with Alternative 5 are evaluated in the Yolo Bypass, the Sacramento River at and downstream of the Fremont Weir, the Delta and downstream waterbodies, and the broader SWP/CVP system as appropriate.

Impact FISH-9: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Flows in the Sacramento River

Modeling results indicate that average monthly flows over the entire simulation period under Alternative 5 in the Sacramento River downstream of Fremont Weir would be the same or similar relative to Existing Conditions (see Appendix G6). During relatively low-flow conditions (i.e., lowest 40 percent of flows over the monthly exceedance distributions), no changes in flow of 10 percent or more would occur during any month of the year (see Appendix G6). Therefore, migration and rearing conditions would be similar under Alternative 5 relative to Existing Conditions in the lower Sacramento River for fish species of focused evaluation, including winter-run, spring-run, fall-run, and late fall-run Chinook salmon, steelhead, green sturgeon, white sturgeon, river lamprey, and Pacific lamprey. In addition, there would be minimal potential for reduced flows in the Sacramento River to result in increased exposure of fish species of focused evaluation to predators or to higher concentrations of water quality contaminants and minimal potential to exacerbate the channel homogenization in the lower Sacramento River.

CEQA Conclusion

Alternative 5 would result in the same or similar flows in the Sacramento River downstream of Fremont Weir relative to Existing Conditions; therefore, Alternative 5 would have a **less than significant impact** due to changes in flows in the Sacramento River.

Impact FISH-10: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Water Temperatures in the Sacramento River

Modeling results indicate that simulated mean monthly water temperatures in the Sacramento River at Freeport generally would not exceed species and life stage-specific water temperature index values more often under Alternative 5 relative to Existing Conditions (Appendix G7). Therefore, migration and rearing thermal conditions would not be substantially affected for fish species of focused evaluation expected to occur in the lower Sacramento River, including winter-run, spring-run, fall-run, and late fall-run Chinook salmon, steelhead, green sturgeon, white sturgeon, river lamprey, and Pacific lamprey under Alternative 5 relative to Existing Conditions.

CEQA Conclusion

Alternative 5 would not result in substantial changes to water temperature suitability for fish species of focused evaluation relative to Existing Conditions; therefore, Alternative 5 would have a **less than significant impact** due to changes in water temperatures in the Sacramento River.

Impact FISH-11: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Delta Hydrologic and Water Quality Conditions

Comparison of modeling results for mean monthly Delta hydrologic and water quality parameters with respect to species and life stage-specific time periods indicate that hydrologic and water quality metrics would not be altered under Alternative 5 relative to Existing Conditions (see Appendix G6). Therefore, habitat conditions in the Delta would be similar for all life stages evaluated. In addition, based on mean monthly Delta outflow, fisheries habitat conditions would be the same or similar in Suisun Bay.

CEQA Conclusion

Alternative 5 would result in the same or similar habitat conditions for fish species of focused evaluation in the Delta and in downstream areas relative to Existing Conditions; therefore, Alternative 5 would have a **less than significant impact** due to changes in Delta conditions.

Impact FISH-12: Impacts to Fisheries Habitat Conditions due to Changes in Flow-Dependent Habitat Availability in the Study Area (Yolo Bypass/Sutter Bypass)

Modeling results indicate that flows entering the Yolo Bypass from the Sacramento River at Fremont Weir would substantially increase more often from December through March. Therefore, inundation extent and/or duration of the Yolo Bypass would increase during these months, providing for increased hydraulic habitat availability for fish species of focused evaluation, particularly juvenile salmonids and adult and juvenile Sacramento splittail.

Modeling results indicate that average monthly hydraulic habitat availability over the entire simulation period for Chinook salmon pre-smolts in the Yolo Bypass under Alternative 5 would generally be substantially higher from December through March and similar for the remainder of the October through May evaluation period (Table 8-26). Simulated average monthly hydraulic habitat availability by water year type would be substantially higher under Alternative 5 relative to Existing Conditions during most water year types from December through February, and during March of below normal, dry, and critical water year types.

Modeling results indicate that Chinook salmon pre-smolt hydraulic habitat availability would be higher under Alternative 5 relative to Existing Conditions over about 40 percent of the exceedance distribution (Figure 8-49). Over the exceedance distribution from November through March, daily hydraulic habitat availability would be substantially higher (i.e., higher by 10 percent or more) about 42 percent of the time and would never be lower by 10 percent or more under Alternative 5.

Table 8-26. Average Monthly Area of Pre-smolt Chinook Salmon Hydraulic Habitat in the Yolo Bypass under Alternative 5 from October through May based on TUFLOW Modeling

Alternative	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)
	October	**November**	**December**	**January**	**February**	**March**	**April**	**May**
Entire Simulation Period[1] (n=16)								
Alternative 5	19.8	21.6	38.1	54.9	56.0	52.8	37.4	27.5
Existing Conditions	19.8	21.2	31.1	47.6	43.7	46.9	36.9	27.2
Difference	0.0	0.4	7.0	7.3	12.3	5.9	0.5	0.3
Percent Difference[2]	0.0	1.9	22.5	15.3	28.1	12.6	1.4	1.1
Water Year Types[3]								
Wet (n=5)								
Alternative 5	19.8	22.3	52.1	55.9	68.3	72.6	58.8	32.0
Existing Conditions	19.8	21.1	37.7	48.5	56.9	68.7	58.3	31.8
Difference	0.0	1.2	14.4	7.4	11.4	3.9	0.5	0.2
Percent Difference[2]	0.0	5.7	38.2	15.3	20.0	5.7	0.9	0.6
Above Normal (n=3)								
Alternative 5	20.1	21.7	39.3	78.4	64.6	52.1	36.9	37.8
Existing Conditions	20.1	21.6	36.2	66.6	41.4	48.0	36.5	37.5
Difference	0.0	0.1	3.1	11.8	23.2	4.1	0.4	0.3
Percent Difference[2]	0.0	0.5	8.6	17.7	56.0	8.5	1.1	0.8
Below Normal (n=3)								
Alternative 5	19.7	21.2	29.4	53.7	51.9	44.6	27.0	21.3
Existing Conditions	19.7	21.2	25.1	45.4	41.8	40.0	26.6	21.0
Difference	0.0	0.0	4.3	8.3	10.1	4.6	0.4	0.3
Percent Difference[2]	0.0	0.0	17.1	18.3	24.2	11.5	1.5	1.4
Dry (n=4)								
Alternative 5	19.7	21.0	30.1	38.9	33.7	39.3	22.5	20.3
Existing Conditions	19.8	20.9	25.9	35.7	26.6	29.0	21.8	20.1
Difference	-0.1	0.1	4.2	3.2	7.1	10.3	0.7	0.2
Percent Difference[2]	-0.5	0.5	16.2	9.0	26.7	35.5	3.2	1.0
Critical (n=1)								
Alternative 5	19.6	20.7	21.8	46.7	70.3	33.6	22.7	20.6
Existing Conditions	19.7	20.7	21.4	39.9	57.7	27.6	22.2	20.5
Difference	-0.1	0.0	0.4	6.8	12.6	6.0	0.5	0.1
Percent Difference[2]	-0.5	0.0	1.9	17.0	21.8	21.7	2.3	0.5

[1] Based on modeled average daily values over a 16-year simulation period (water years 1997 through 2012)
[2] Relative difference of the monthly average
[3] As defined by the Sacramento Valley Index (DWR 2017c)
Key: km^2 = square kilometer

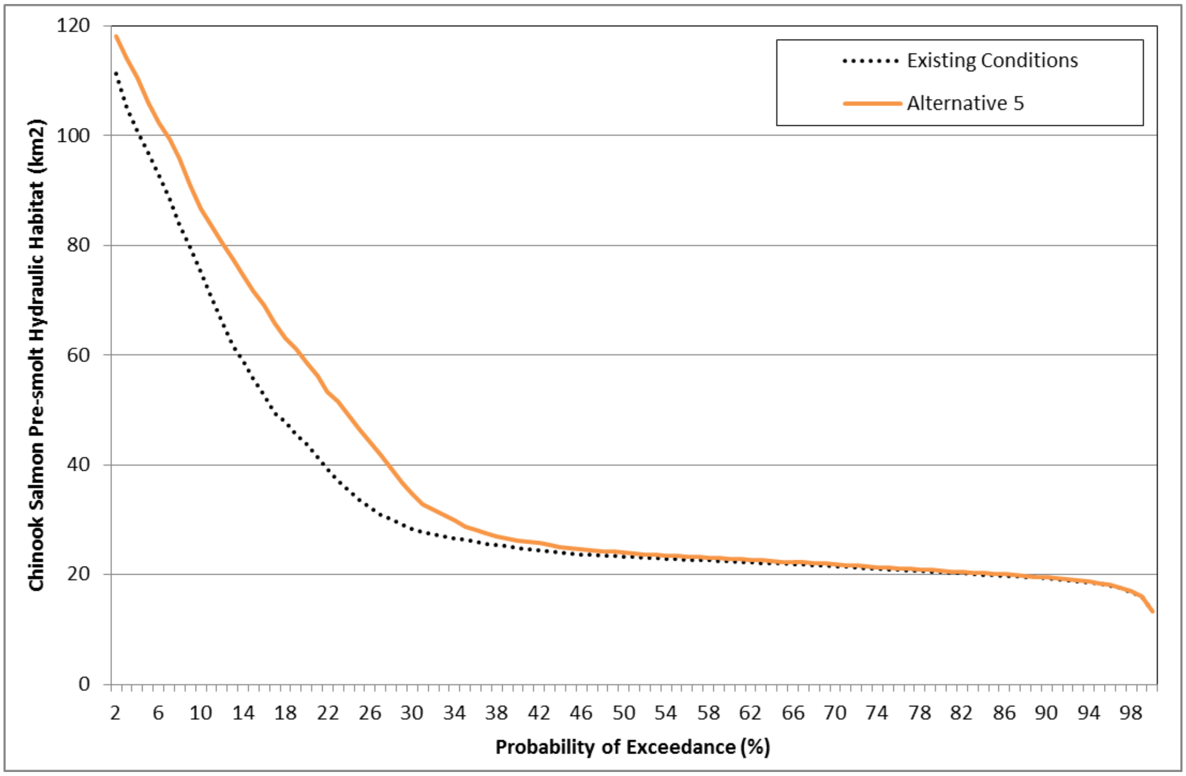

Figure 8-49. Simulated Chinook Salmon Pre-smolt Hydraulic Habitat Availability Probability of Exceedance Distributions under Alternative 5 and Existing Conditions from October through May based on TUFLOW Modeling

Modeling results indicate that average monthly hydraulic habitat availability over the entire simulation period for Chinook salmon smolts in the Yolo Bypass under Alternative 5 relative to Existing Conditions would be substantially higher from December through February, higher by less than 10 percent in March, and similar for the remainder of the October through May evaluation period (Table 8-27). Simulated average monthly hydraulic habitat availability by water year type would be substantially higher during most water year types from December through February and during dry and critical water years in March.

Modeling results indicate that Chinook salmon smolt hydraulic habitat availability would be higher under Alternative 5 relative to Existing Conditions over about 40 percent of the exceedance distribution (Figure 8-50). Over the exceedance distribution from November through March, daily hydraulic habitat availability would be substantially higher (i.e., higher by 10 percent or more) about 36 percent of the time and would never be lower by 10 percent or more under Alternative 5.

Table 8-27. Average Monthly Area of Chinook Salmon Smolt Hydraulic Habitat in the Yolo Bypass under Alternative 5 from October through May based on TUFLOW Modeling

Alternative	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)
	October	November	December	January	February	March	April	May
Entire Simulation Period[1] (n=16)								
Alternative 5	31.5	32.4	51.7	78.7	83.0	82.2	59.3	43.2
Existing Conditions	31.6	32.0	44.2	70.0	69.7	76.0	58.8	43.1
Difference	-0.1	0.4	7.5	8.7	13.3	6.2	0.5	0.1
Percent Difference[2]	-0.3	1.3	17.0	12.4	19.1	8.2	0.9	0.2
Water Year Types[3]								
Wet (n=5)								
Alternative 5	31.3	33.3	70.4	98.5	113.0	123.6	100.3	50.8
Existing Conditions	31.4	32.1	55.4	90.2	100.6	119.0	99.6	50.7
Difference	-0.1	1.2	15.0	8.3	12.4	4.6	0.7	0.1
Percent Difference[2]	-0.3	3.7	27.1	9.2	12.3	3.9	0.7	0.2
Above Normal (n=3)								
Alternative 5	32.0	33.0	52.4	97.0	92.2	80.9	50.6	54.7
Existing Conditions	32.1	32.9	48.3	82.4	68.3	76.6	50.4	54.6
Difference	-0.1	0.1	4.1	14.6	23.9	4.3	0.2	0.1
Percent Difference[2]	-0.3	0.3	8.5	17.7	35.0	5.6	0.4	0.2
Below Normal (n=3)								
Alternative 5	31.6	31.8	40.7	68.3	73.3	67.6	41.0	35.1
Existing Conditions	31.7	31.8	36.2	57.8	62.3	62.6	40.6	34.9
Difference	-0.1	0.0	4.5	10.5	11.0	5.0	0.4	0.2
Percent Difference[2]	-0.3	0.0	12.4	18.2	17.7	8.0	1.0	0.6
Dry (n=4)								
Alternative 5	31.5	31.6	41.0	52.8	45.3	51.7	34.4	33.5
Existing Conditions	31.6	31.5	36.6	48.9	37.9	41.0	33.9	33.4
Difference	-0.1	0.1	4.4	3.9	7.4	10.7	0.5	0.1
Percent Difference[2]	-0.3	0.3	12.0	8.0	19.5	26.1	1.5	0.3
Critical (n=1)								
Alternative 5	30.9	31.2	31.4	59.5	85.2	45.2	34.8	34.0
Existing Conditions	31.0	31.2	30.9	52.1	70.2	39.2	34.4	33.9
Difference	-0.1	0.0	0.5	7.4	15.0	6.0	0.4	0.1
Percent Difference[2]	-0.3	0.0	1.6	14.2	21.4	15.3	1.2	0.3

[1] Based on modeled average daily values over a 16-year simulation period (water years 1997 through 2012)

[2] Relative difference of the monthly average
[3] As defined by the Sacramento Valley Index (DWR 2017c)
Key: km^2 = square kilometer

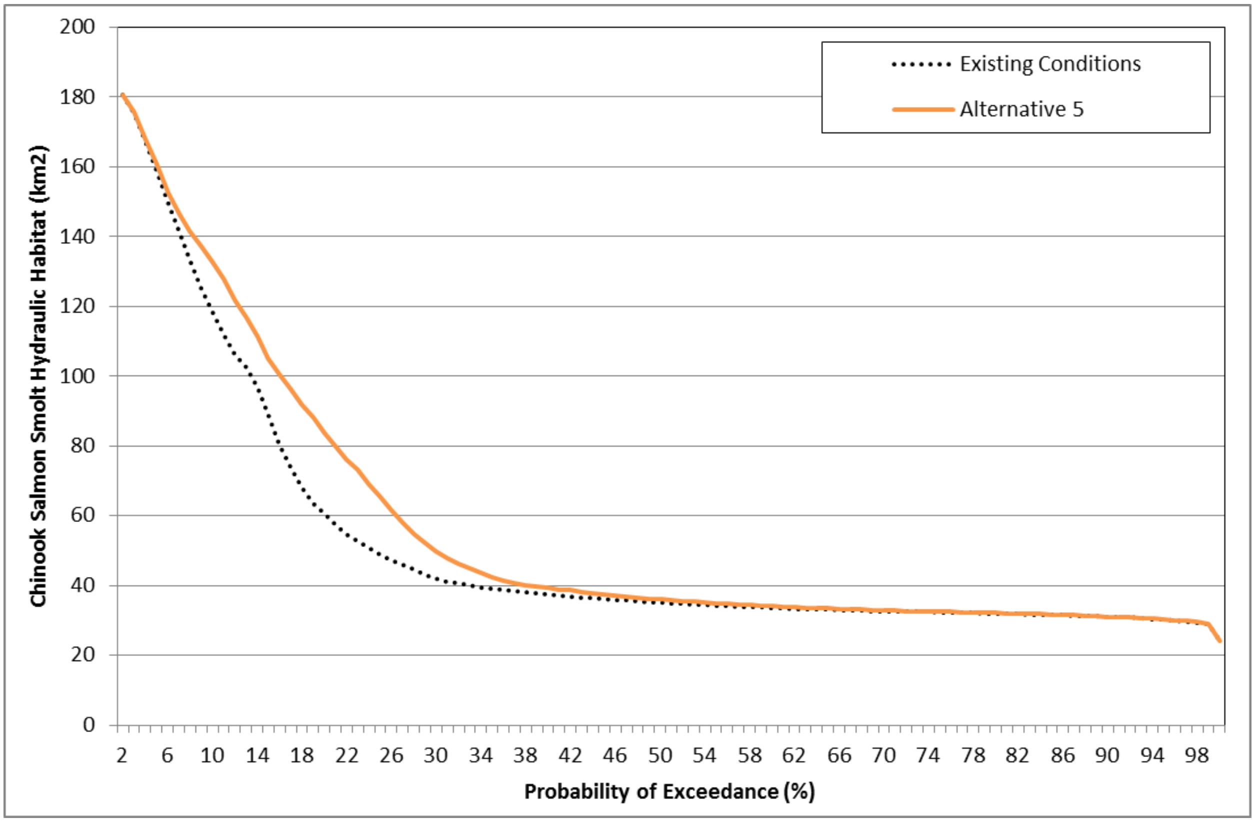

Figure 8-50. Simulated Chinook Salmon Smolt Hydraulic Habitat Availability Probability of Exceedance Distributions under Alternative 5 and Existing Conditions from October through May based on TUFLOW Modeling

As previously discussed, changes in estimated hydraulic habitat availability for Chinook salmon pre-smolts is expected to be generally representative of potential changes in hydraulic habitat availability for juvenile Sacramento splittail, and changes in estimated hydraulic habitat availability for Chinook salmon smolts is generally expected to be representative of potential changes in hydraulic habitat availability for adult spawning Sacramento splittail and juvenile steelhead.

To provide a more comprehensive range of potential changes in hydraulic habitat availability for other fish species of focused evaluation, simulated wetted extent (area with a water depth greater than zero) was estimated for the Yolo Bypass under Alternative 5 relative to Existing Conditions. Modeling results indicate that average monthly wetted extent over the entire simulation period would be substantially higher during December and February, higher by less than 10 percent in January and March, and generally similar for the remainder of the October through May evaluation period under both scenarios (Table 8-28). Average monthly wetted area by water year type would be substantially higher during wet water years in December; during above normal, below normal, and critical water years in January; during all water year types except for wet water years in February; and during dry and critical water years in March.

Table 8-28. Average Monthly Wetted Area in the Yolo Bypass under Alternative 5 from October through May based on TUFLOW Modeling

Alternative	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)
	October	**November**	**December**	**January**	**February**	**March**	**April**	**May**
Entire Simulation Period[1] (n=16)								
Alternative 5	47.6	48.9	72.3	113.9	120.5	114.7	86.3	64.3
Existing Conditions	47.8	48.4	64.1	105.0	106.4	107.5	85.9	64.1
Difference	-0.2	0.5	8.2	8.9	14.1	7.2	0.4	0.2
Percent Difference[2]	-0.4	1.0	12.8	8.5	13.3	6.7	0.5	0.3
Water Year Types[3]								
Wet (n=5)								
Alternative 5	47.4	50.0	95.8	162.8	174.0	168.4	145.5	77.6
Existing Conditions	47.6	48.6	78.9	154.3	161.7	163.4	145.3	77.5
Difference	-0.2	1.4	16.9	8.5	12.3	5.0	0.2	0.1
Percent Difference[2]	-0.4	2.9	21.4	5.5	7.6	3.1	0.1	0.1
Above Normal (n=3)								
Alternative 5	48.3	50.1	72.1	121.6	126.1	116.9	72.7	77.1
Existing Conditions	48.5	49.9	68.3	108.0	100.1	111.7	72.5	77.0
Difference	-0.2	0.2	3.8	13.6	26.0	5.2	0.2	0.1
Percent Difference[2]	-0.4	0.4	5.6	12.6	26.0	4.7	0.3	0.1
Below Normal (n=3)								
Alternative 5	47.8	47.9	58.7	90.0	103.7	95.3	60.1	52.6
Existing Conditions	47.9	47.9	53.9	79.2	91.7	89.6	59.6	52.3
Difference	-0.1	0.0	4.8	10.8	12.0	5.7	0.5	0.3
Percent Difference[2]	-0.2	0.0	8.9	13.6	13.1	6.4	0.8	0.6
Dry (n=4)								
Alternative 5	47.6	47.8	59.7	72.5	64.8	72.7	50.9	50.2
Existing Conditions	47.8	47.6	54.5	68.3	56.0	60.3	50.3	49.9
Difference	-0.2	0.2	5.2	4.2	8.8	12.4	0.6	0.3
Percent Difference[2]	-0.4	0.4	9.5	6.1	15.7	20.6	1.2	0.6
Critical (n=1)								
Alternative 5	46.8	46.6	47.1	83.0	111.2	65.9	51.5	51.0
Existing Conditions	46.9	46.7	46.6	74.4	95.7	58.1	51.1	50.9
Difference	-0.1	-0.1	0.5	8.6	15.5	7.8	0.4	0.1
Percent Difference[2]	-0.2	-0.2	1.1	11.6	16.2	13.4	0.8	0.2

[1] Based on modeled average daily values over a 16-year simulation period (water years 1997 through 2012)

[2] Relative difference of the monthly average

[3] As defined by the Sacramento Valley Index (DWR 2017c)

Key: km^2 = square kilometer

Modeling results indicate that wetted extent would be higher under Alternative 5 relative to Existing Conditions over about 30 percent of the middle to lower portion of the exceedance distribution (Figure 8-51). Over the exceedance distribution from November through March, daily wetted extent would be substantially higher (i.e., higher by 10 percent or more) about 34 percent of the time and would never be lower by 10 percent or more under Alternative 5.

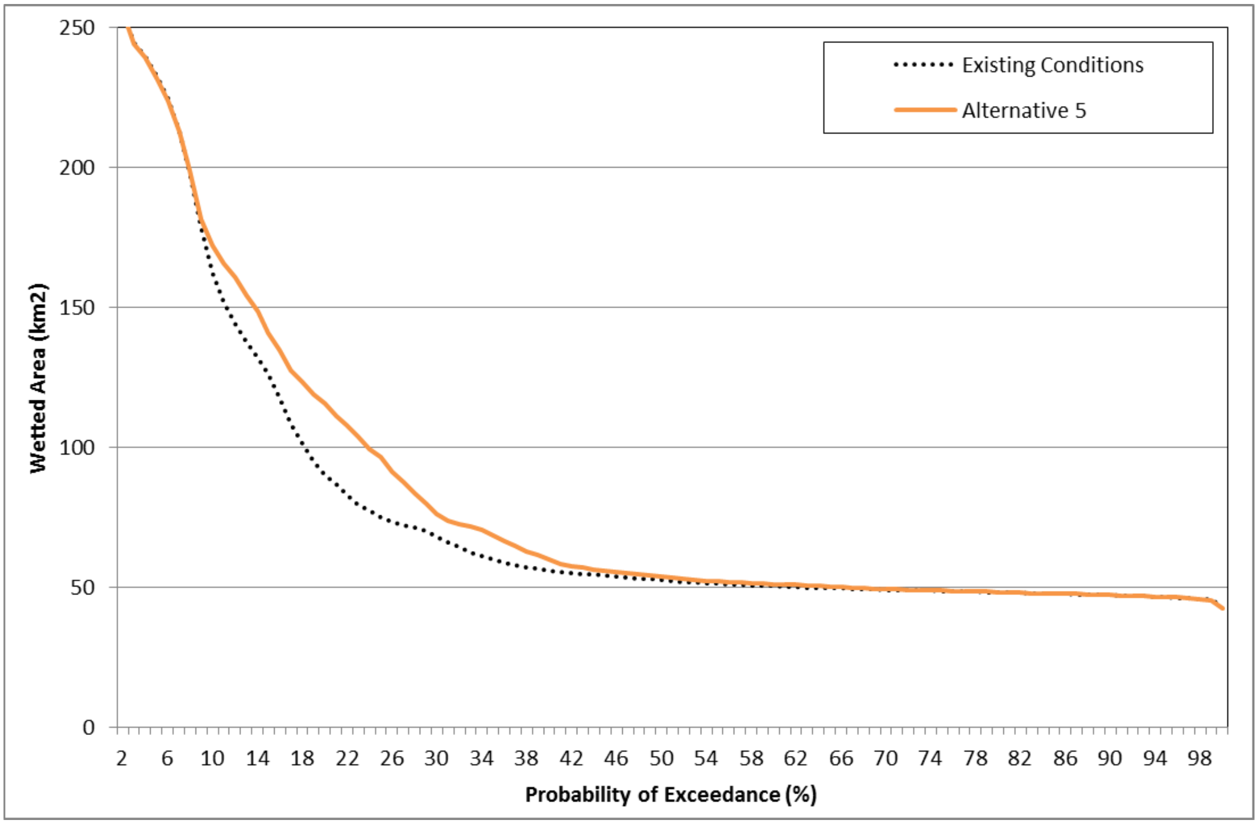

Figure 8-51. Simulated Wetted Area Probability of Exceedance Distributions under Alternative 5 and Existing Conditions from October through May based on TUFLOW Modeling

Average annual modeled wetted days in the Sutter Bypass would decrease under Alternative 5 relative to Existing Conditions by approximately one to seven days in the area of Sutter Bypass between the Sacramento River and Sacramento Slough and one to three days over most of the Sutter Bypass between Sacramento Slough and Nelson Slough.

CEQA Conclusion

In the Yolo Bypass under Alternative 5, increased hydraulic habitat availability for fish species of focused evaluation, particularly juvenile Chinook salmon and steelhead and adult and juvenile Sacramento splittail, is expected to result in more suitable conditions for these and other fish species of focused evaluation. Relatively minor reductions in the number of wetted days in the Sutter Bypass upstream of the Sacramento River at Fremont Weir are not expected to substantially affect rearing or migration of fish species of focused evaluation; therefore, Alternative 5 would be expected to have a **beneficial impact** on flow-dependent hydraulic habitat availability in the Yolo Bypass and a **less than significant impact** on flow-dependent hydraulic habitat availability in the Sutter Bypass.

Impact FISH-13: Impacts to Fisheries Habitat Conditions due to Changes in Water Quality in the Study Area

Modeling results indicate that flows entering the Yolo Bypass from the Sacramento River at Fremont Weir under Alternative 5 relative to Existing Conditions would substantially increase more often from December through March. Therefore, increased flows and the potential for increased wetting and drying of the Yolo Bypass could increase the amount of methylmercury and other contaminants in the Yolo Bypass and in fish prey. Increased concentrations of contaminants in the Yolo Bypass could potentially result in an increase in the exportation of contaminated water to the Delta. However, for juvenile Chinook salmon rearing in the Yolo Bypass, increased concentrations of accumulated methylmercury were reported to be insignificant in the tissues of the eventual adult-sized fish (Henery et al. 2010). Effects of increased methylmercury accumulation could be more substantial on resident fish species such as largemouth bass. Increased flows in the Yolo Bypass also could temporarily increase turbidity levels in the Yolo Bypass.

CEQA Conclusion

Based on higher mean monthly flows entering the Yolo Bypass, increased concentrations of methylmercury and other contaminants may occur in the Yolo Bypass and the Delta. However, the potential for increased concentrations of contaminants is not expected to substantially affect fish species of focused evaluation; therefore, Alternative 5 would have a **less than significant impact**.

Impact FISH-14: Impacts to Aquatic Primary and Secondary Production in the Study Area

Modeling results indicate that Alternative 5 would result in increased frequency and duration of inundation of the Yolo Bypass relative to Existing Conditions. An increase in frequency and duration of inundation of shallow-water habitat in the Yolo Bypass would be expected to increase primary production in the Yolo Bypass (Lehman et al. 2007). Increased primary and associated secondary production in the Yolo Bypass would likely increase food resources for fish species of focused evaluation in the Yolo Bypass. More productive water in the Yolo Bypass also could potentially be exported to the Delta downstream of the Yolo Bypass, which could increase food resources for fish in the Delta.

Modeled wetted area of the Yolo Bypass under Alternative 1 relative to Existing Conditions was used as an indicator of relative changes in inundation and associated primary and secondary production. As described above, increases in average monthly wetted area would occur under Alternative 5 relative to Existing Conditions, particularly from December through March, depending on water year type. Increased food resources in the Yolo Bypass during this period would be expected to improve growth and survival of some fish species of focused evaluation such as Chinook salmon and freshwater resident species. The potential for increased productivity downstream of the Yolo Bypass could improve prey availability conditions for fish species of focused evaluation.

Minor reductions in wetted area in the Sutter Bypass could reduce primary and secondary production in the Sutter Bypass. However, these reductions in wetted area would not be expected to substantially affect primary or secondary production in the Sutter Bypass or substantially affect fish species of focused evaluation in the Sutter Bypass.

CEQA Conclusion

Based on increased wetted extent in the Yolo Bypass during the winter, increased primary and secondary production in the Yolo Bypass (and potentially in localized areas of the Delta) could increase food resources for fish species of focused evaluation. In the Sutter Bypass, slight reductions in wetted area could reduce primary and secondary production, but these reductions are not expected to be sufficient to substantially affect food resources for fish species of focused evaluation. Therefore, Alternative 5 would result in a **beneficial impact** in the Yolo Bypass and a **less than significant impact** in the Sutter Bypass.

Impact FISH-15: Impacts to Fish Species of Focused Evaluation due to Changes in Adult Fish Passage Conditions through the Yolo Bypass

Modeling results indicate that flows entering the Yolo Bypass from the Sacramento River at Fremont Weir would substantially increase more often from December through March under Alternative 5 relative to Existing Conditions. Therefore, the duration of potential adult fish passage from the Yolo Bypass into the Sacramento River may potentially increase for fall/late fall-run Chinook salmon, spring-run Chinook salmon, winter-run Chinook salmon, steelhead, green and white sturgeon, and Pacific and river lamprey, potentially providing for increased spawning opportunities in the Sacramento River and its tributaries and reduced potential for mortality or migration delay in the Yolo Bypass. Increased flows entering the Yolo Bypass would also increase the average number of days that areas adjacent to portions of the west-side tributaries within the Yolo Bypass are inundated, including Cache Creek, Willow Slough, and Putah Creek. Therefore, hydraulic connectivity and migration conditions for anadromous fishes in the west-side streams could potentially improve under Alternative 5 relative to Existing Conditions.

There is the potential that increased flows entering the Delta from the Yolo Bypass could attract more adult fish into the Yolo Bypass relative to the Sacramento River. However, adult fish passage would be provided at Fremont Weir more often relative to Existing Conditions.

Based on results of the YBPASS Tool, which applied fish passage criteria to modeled hydraulic conditions in the intake facility and transport channel under Alternative 5, adult salmon and sturgeon would be expected to successfully pass upstream through the transport channels and intake structures into the Sacramento River about 24 percent of the days from November through April over the water years 1997 through 2012 simulation period. The annual average date after which Alternative 5 would no longer meet the fish passage criteria is April 1.

Because Alternative 5 was designed to entrain more juvenile winter-run Chinook salmon at lower Sacramento River stages, Alternative 5 includes more complicated headworks with three separate notches at different elevations and multiple transport channels in the Yolo Bypass. Because different gates can be opened and closed based on changes in Sacramento River flows, there is the potential to cause delays in upstream migration of adults if gate operations are being modified as adults are attempting to move through the intake facilities.

The potential for straying of anadromous fish species into the Yolo Bypass that are native to watersheds from outside of the upper Sacramento River Basin would be similar to the discussion for Alternative 1 relative to Existing Conditions.

The Project Alternative would be adaptively managed to ensure that biological goals and objectives are met (see Appendix C). For example, management responses would be evaluated if more than one percent of an ESA-listed salmon ESU or green sturgeon annual escapement is found to stray to Wallace Weir during Project operations, or if more than one percent of an ESA-listed salmon ESU or green sturgeon annual escapement or juvenile production estimate are stranded in the Yolo Bypass. Potential management responses are identified in Appendix C. Future management responses would be subject to future environmental compliance documentation, as applicable.

CEQA Conclusion

Increased duration of potential adult fish passage opportunity from the Yolo Bypass into the Sacramento River under Alternative 5 is expected to result in improved upstream spawning opportunities and less potential for mortality or migration delay for fish species of focused evaluation; therefore, Alternative 5 would be expected to have a **beneficial impact** on adult fish passage conditions through the Yolo Bypass.

Impact FISH-16: Impacts to Fish Species due to Changes in Potential for Stranding and Entrainment

Project facilities constructed under Alternative 5, such as the transport and intake channels, would be graded to provide suitable passage conditions for fish, assuming sufficient water is present. Although Alternative 5 would allow for entrainment of juvenile fish at lower flows relative to Existing Conditions, the design of the transport channel to Tule Canal is expected to minimize the potential for stranding of juveniles. However, anthropogenic structures that interrupt natural drainage patterns, such as water control structures, create the greatest risk for stranding (Sommer et al. 2005). Therefore, there is some potential for increased juvenile stranding in the Yolo Bypass.

Because Alternative 5 would allow for adult migration into the Sacramento River during periods when adult migration is impeded or blocked at Fremont Weir under Existing Conditions, the potential for adult fish stranding in the Yolo Bypass would be expected to be reduced. However, because the Fremont Weir notch would be in the central region of the Fremont Weir and the supplemental fish passage facility would be located at the western region of the Fremont Weir, adults located near the eastern portion of Fremont Weir may still have the same likelihood of stranding that occurs under Existing Conditions.

CEQA Conclusion

The overall potential for adult fish stranding would be expected to be reduced under Alternative 5 relative to Existing Conditions. Juvenile stranding may potentially increase under Alternative 5, but design of the project facilities is expected to minimize any increases in juvenile stranding. Therefore, Alternative 5 would be expected to have a **less than significant impact** on stranding and entrainment.

Impact FISH-17: Impacts to Fish Species due to Changes in Potential for Predation and Competition

Construction of the intake facility, supplemental fish passage facility, and intake and transport channels lined with rock could increase the potential for predation of fish species of focused evaluation under Alternative 5 relative to Existing Conditions by providing habitat for predatory fish species in these areas. However, the facilities on the Sacramento River are not expected to substantially increase the potential area of refugia for species such as striped bass relative to Existing Conditions. Increased flow pulses into the Yolo Bypass associated with Alternative 5 during the winter months (primarily December through March) could reduce the potential for predation of fish species such as juvenile salmonids by non-native fish species. For example, Sommer et al. (2014) found that increased connectivity to the Yolo Bypass would provide an overall benefit to native fish species, particularly during the winter, because it is prior to the spawning periods of non-native fish species in the spring. Frantzich et al. (2013) found that native fish species were more widely distributed during wetter years, and low flows may provide more suitable conditions for the spawning and recruitment of non-native centrarchids. Increased flows during February and March under Alternative 5 could increase habitat availability for non-native cyprinids, such as common carp and goldfish, which could result in increased competition for food resources with fish species of focused evaluation relative to Existing Conditions. However, because increased primary and associated secondary production in the Yolo Bypass would likely increase food resources for fish species of focused evaluation in the Yolo Bypass and downstream (see *Impact FISH-14*), increased habitat for non-native cyprinids is not expected to substantially affect fish species of focused evaluation in the Yolo Bypass or in the Delta. Overall, Opperman et al. (2017) argued that flooding the Yolo Bypass from January through April would benefit native fish species. In addition, given the perennial nature of the Tule Canal and its ability to support non-native fish species under Existing Conditions, it is not expected that the proposed facilities under Alternative 5 would increase predation of fish species of focused evaluation above baseline levels in the Yolo Bypass. In addition, results of the SBM (evaluated under *Impact FISH-18*) account for predation associated with the estimated migration path and migration duration for juvenile Chinook salmon in the Yolo Bypass associated with Alternative 5.

CEQA Conclusion

Overall potential for predation of, and competition with, fish species of focused evaluation is not expected to substantially differ relative to predation and competition conditions under Existing Conditions; therefore, Alternative 5 would be expected to have a **less than significant impact** due to changes in predation and competition.

Impact FISH-18: Impacts to Chinook Salmon Species/Runs due to Changes in Viable Salmonid Population Parameters

As previously discussed, model output from the SBM is used to evaluate the VSP parameters (abundance, productivity, diversity, and spatial structure) for fall-run, late fall-run, spring-run, and winter-run Chinook salmon.

Abundance and Productivity

Modeling results indicate that annual average adult Chinook salmon returns under Alternative 5 relative to Existing Conditions would be generally similar or higher over the entire simulation period and during most water year types for fall-run Chinook salmon but would be substantially higher during critical water years. Annual average adult returns would be similar over the entire simulation period and by water year type for late fall-run and winter-run Chinook salmon and similar or higher over the entire simulation period and during most water year types for spring-run Chinook salmon (Table 8-29). Similarly, the adult fall-run Chinook salmon returns probability of exceedance distribution for Alternative 5 is generally similar or higher over the entire distribution relative to Existing Conditions (Figures 8-52 through 8-55). In addition, because more juvenile Chinook salmon would enter the Delta from the Yolo Bypass relative to from the Sacramento River, potentially reduced juvenile mortality at the south Delta pumping facilities could increase adult returns under Alternative 5 relative to Existing Conditions (relative to the SBM output).

Table 8-29. Average Annual Chinook Salmon Adult Returns under Alternative 5

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Fall-run Chinook Salmon						
Alternative 5	180,969	242,555	206,474	85,135	166,718	45,193
Existing Conditions	172,025	232,876	192,956	82,267	158,383	39,065
Difference	8,944	9,679	13,519	2,868	8,336	6,128
Percent Difference[3]	5	4	7	3	5	16
Late Fall-run Chinook Salmon						
Alternative 5	57,645	59,408	67,542	19,686	61,505	79,617
Existing Conditions	58,390	60,218	68,937	19,914	61,780	81,012
Difference	-746	-810	-1,395	-228	-275	-1,395
Percent Difference[3]	-1	-1	-2	-1	0	-2
Spring-run Chinook Salmon						
Alternative 5	6,300	9,425	6,012	2,295	5,088	4,399
Existing Conditions	5,960	8,803	5,821	2,174	4,884	4,031
Difference	340	622	191	121	204	368
Percent Difference[3]	6	7	3	6	4	9
Winter-run Chinook Salmon						
Alternative 5	5,629	5,709	5,570	5,357	6,317	3,197
Existing Conditions	5,518	5,504	5,558	5,334	6,197	3,118
Difference	111	205	13	24	119	79
Percent Difference[3]	2	4	0	0	2	3

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

[3] Relative difference of the annual average

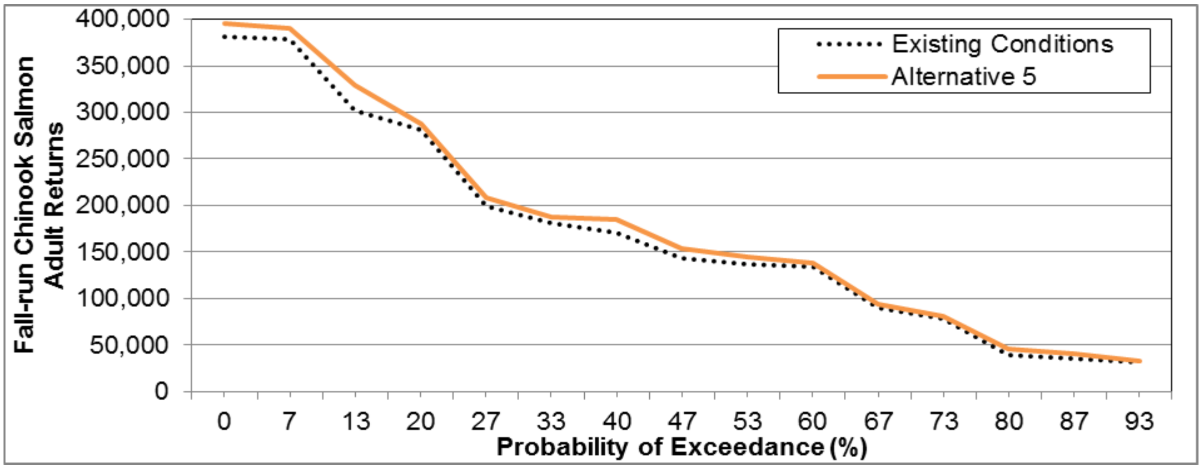

Figure 8-52. Simulated Adult Fall-run Chinook Salmon Returns Probability of Exceedance Distributions under Alternative 5 and Existing Conditions

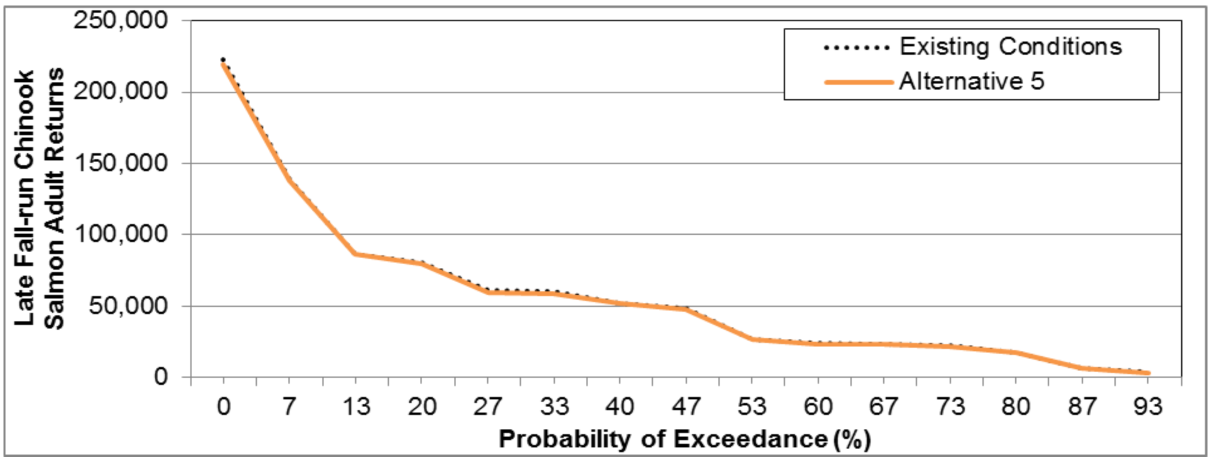

Figure 8-53. Simulated Adult Late Fall-run Chinook Salmon Returns Probability of Exceedance Distributions under Alternative 5 and Existing Conditions

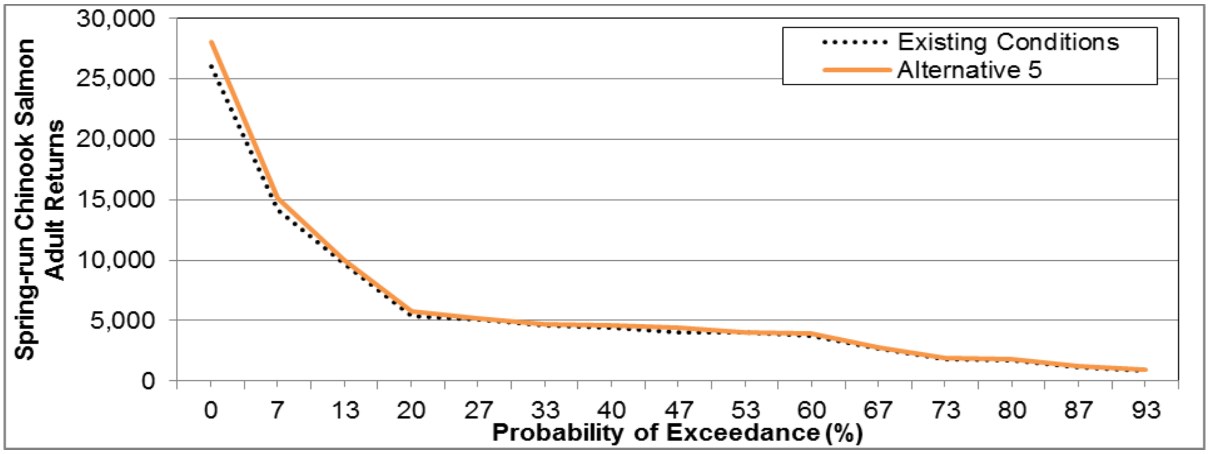

Figure 8-54. Simulated Adult Spring-run Chinook Salmon Returns Probability of Exceedance Distributions under Alternative 5 and Existing Conditions

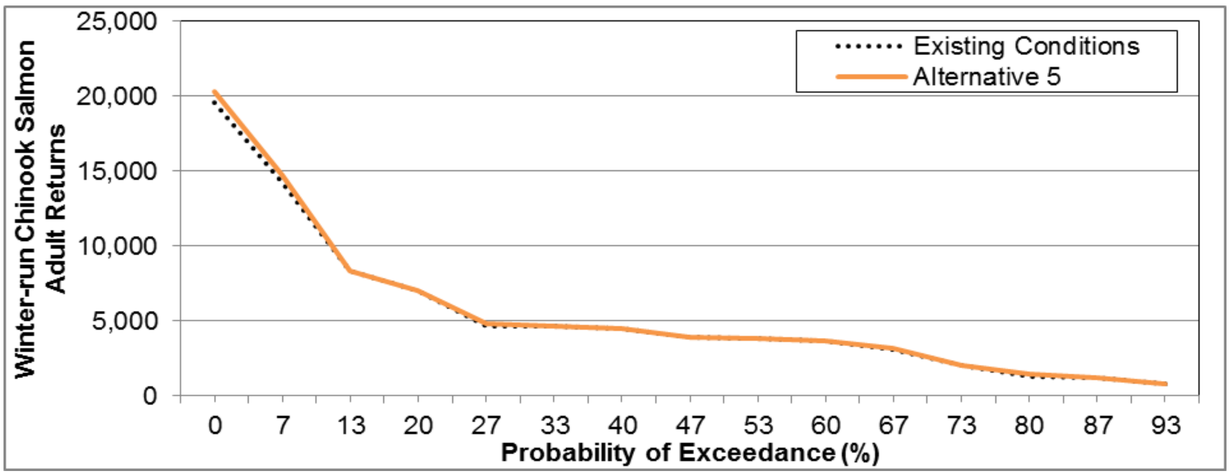

Figure 8-55. Simulated Adult Winter-run Chinook Salmon Returns Probability of Exceedance Distributions under Alternative 5 and Existing Conditions

Diversity

VARIATION IN JUVENILE CHINOOK SALMON SIZE

Modeling results indicate that annual average juvenile fall-run Chinook salmon coefficient of variation in size (FL) under Alternative 5 relative to Existing Conditions would be substantially higher over the entire simulation period and during most water year types for fall-run, spring-run, and winter-run Chinook salmon and would be similar over the entire simulation period and by water year type for late fall-run Chinook salmon (Table 8-30).

The juvenile fall-run Chinook salmon coefficient of variation in size probability of exceedance distribution for Alternative 5 would be substantially higher over most of the distribution for fall-run, spring-run, and winter-run Chinook salmon and would be similar over the entire distribution for late fall-run Chinook salmon (Figures 8-56 through 8-59).

Table 8-30. Average Annual Juvenile Chinook Salmon Coefficient of Variation in Size under Alternative 5

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Fall-run Chinook Salmon						
Alternative 5	0.42	0.46	0.41	0.39	0.40	0.38
Existing Conditions	0.35	0.44	0.32	0.35	0.31	0.13
Difference	0.07	0.02	0.09	0.04	0.09	0.25
Percent Difference[3]	20	4	27	10	29	193
Late Fall-run Chinook Salmon						
Alternative 5	0.33	0.41	0.48	0.50	0.11	0.07
Existing Conditions	0.33	0.41	0.48	0.50	0.11	0.07
Difference	0.00	0.00	0.00	0.00	0.00	0.00
Percent Difference[3]	0	1	0	0	0	0
Spring-run Chinook Salmon						
Alternative 5	0.35	0.45	0.33	0.33	0.26	0.29
Existing Conditions	0.30	0.42	0.30	0.26	0.22	0.18
Difference	0.05	0.03	0.04	0.07	0.04	0.11
Percent Difference[3]	15	8	13	27	18	63
Winter-run Chinook Salmon						
Alternative 5	0.17	0.22	0.14	0.19	0.12	0.09
Existing Conditions	0.14	0.20	0.12	0.17	0.10	0.06
Difference	0.02	0.03	0.02	0.02	0.02	0.04
Percent Difference[3]	17	13	21	11	23	60

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)
[2] As defined by the Sacramento Valley Index (DWR 2017c)
[3] Relative difference of the annual average

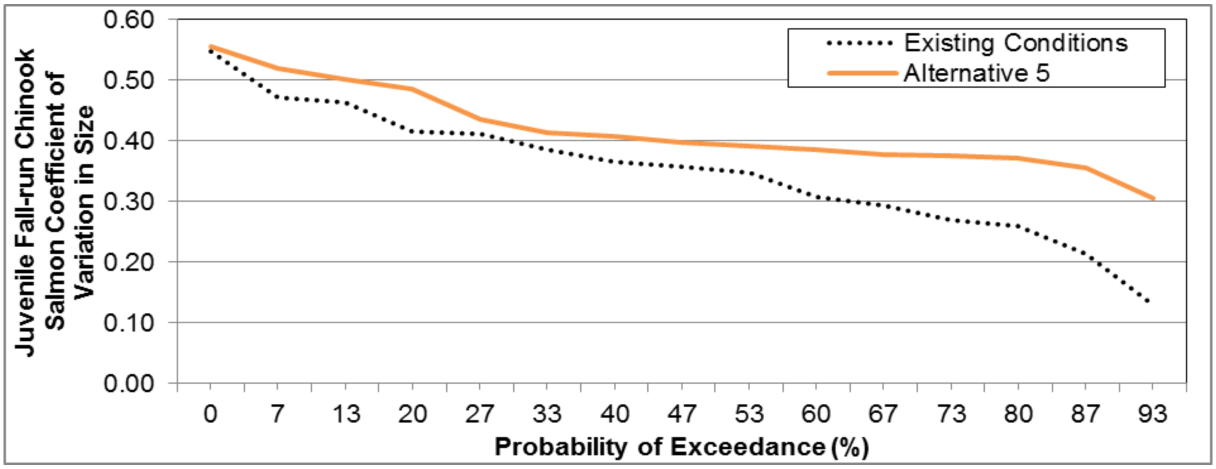

Figure 8-56. Simulated Juvenile Fall-run Chinook Salmon Coefficient of Variation in Size Probability of Exceedance Distributions under Alternative 5 and Existing Conditions

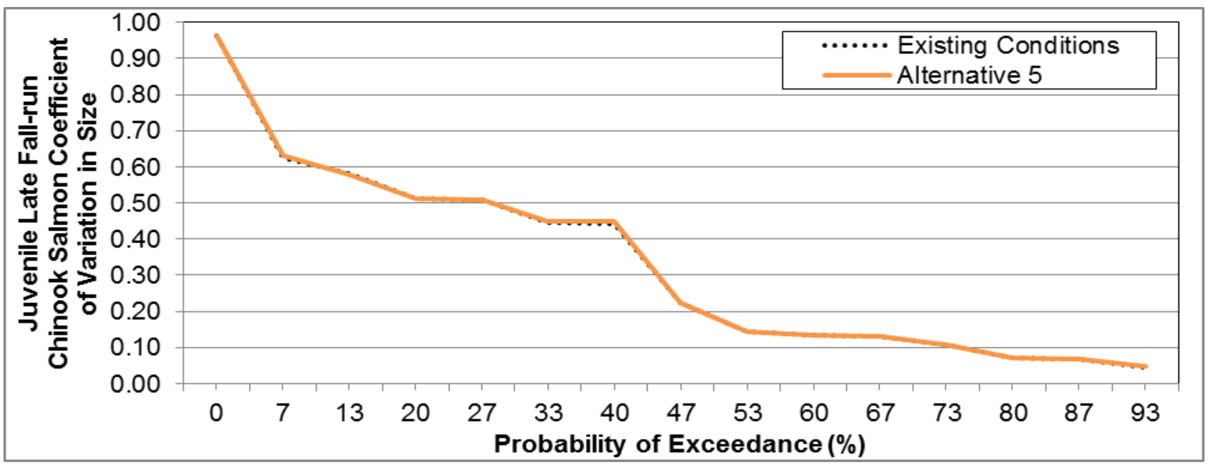

Figure 8-57. Simulated Juvenile Late Fall-run Chinook Salmon Coefficient of Variation in Size Probability of Exceedance Distributions under Alternative 5 and Existing Conditions

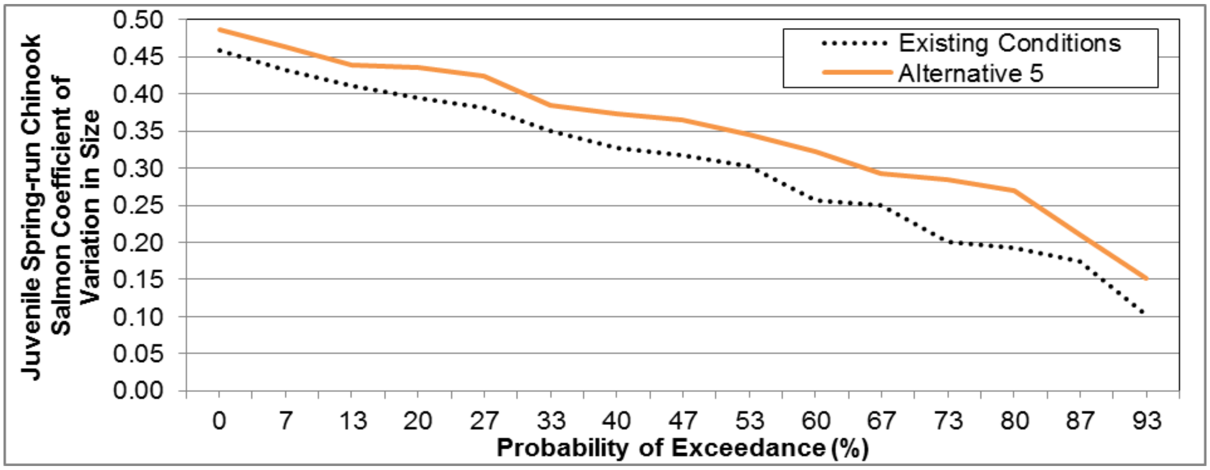

Figure 8-58. Simulated Juvenile Spring-run Chinook Salmon Coefficient of Variation in Size Probability of Exceedance Distributions under Alternative 5 and Existing Conditions

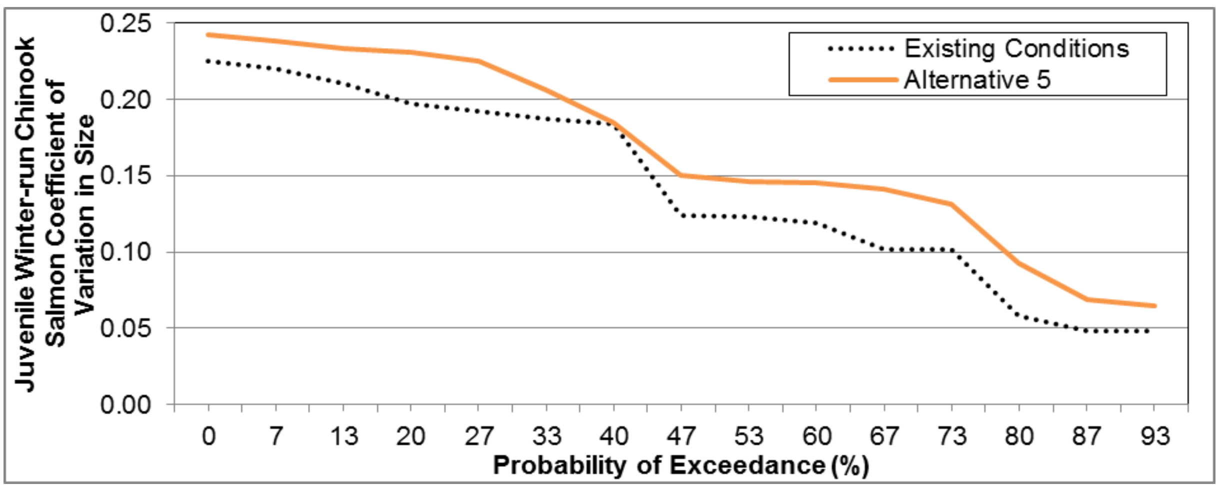

Figure 8-59. Simulated Juvenile Winter-run Chinook Salmon Coefficient of Variation in Size Probability of Exceedance Distributions under Alternative 5 and Existing Conditions

VARIATION IN JUVENILE CHINOOK SALMON ESTUARY ENTRY TIMING

Modeling results indicate that annual average juvenile Chinook salmon coefficient of variation in estuary entry timing under Alternative 5 relative to Existing Conditions would be higher over the entire simulation period; similar during wet and below normal water years; and higher or substantially higher during above normal, dry, and critical water years for fall-run Chinook salmon (Table 8-31). Annual average juvenile Chinook salmon coefficient of variation in estuary entry timing under Alternative 5 relative to Existing Conditions would be similar over the entire simulation period and during most water year types for late fall-run, spring-run, and winter-run Chinook salmon but would be substantially higher during critical water years for spring-run Chinook salmon.

The juvenile Chinook salmon coefficient of variation in estuary entry timing probability of exceedance distributions would be similar or higher over most of the distributions under

Alternative 5 relative to Existing Conditions for fall-run, spring-run, and winter-run Chinook salmon and would be similar for late fall-run Chinook salmon (Figures 8-60 through 8-63).

Table 8-31. Average Annual Juvenile Chinook Salmon Coefficient of Variation in Estuary Entry Timing under Alternative 5

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Fall-run Chinook Salmon						
Alternative 5	0.25	0.29	0.24	0.25	0.21	0.20
Existing Conditions	0.24	0.29	0.22	0.25	0.19	0.16
Difference	0.01	0.00	0.02	0.00	0.02	0.05
Percent Difference[3]	5	0	9	2	11	28
Late Fall-run Chinook Salmon						
Alternative 5	0.33	0.44	0.33	0.21	0.29	0.15
Existing Conditions	0.33	0.44	0.33	0.21	0.29	0.15
Difference	0.00	0.00	0.00	0.00	0.00	0.00
Percent Difference[3]	0	-1	-1	0	0	-1
Spring-run Chinook Salmon						
Alternative 5	0.30	0.39	0.28	0.28	0.24	0.21
Existing Conditions	0.29	0.38	0.28	0.26	0.23	0.18
Difference	0.01	0.01	0.01	0.02	0.01	0.03
Percent Difference[3]	3	1	2	6	3	14
Winter-run Chinook Salmon						
Alternative 5	0.28	0.39	0.23	0.31	0.22	0.13
Existing Conditions	0.28	0.38	0.22	0.30	0.21	0.12
Difference	0.01	0.01	0.01	0.01	0.01	0.01
Percent Difference[3]	2	2	3	2	3	7

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)
[2] As defined by the Sacramento Valley Index (DWR 2017c)
[3] Relative difference of the annual average

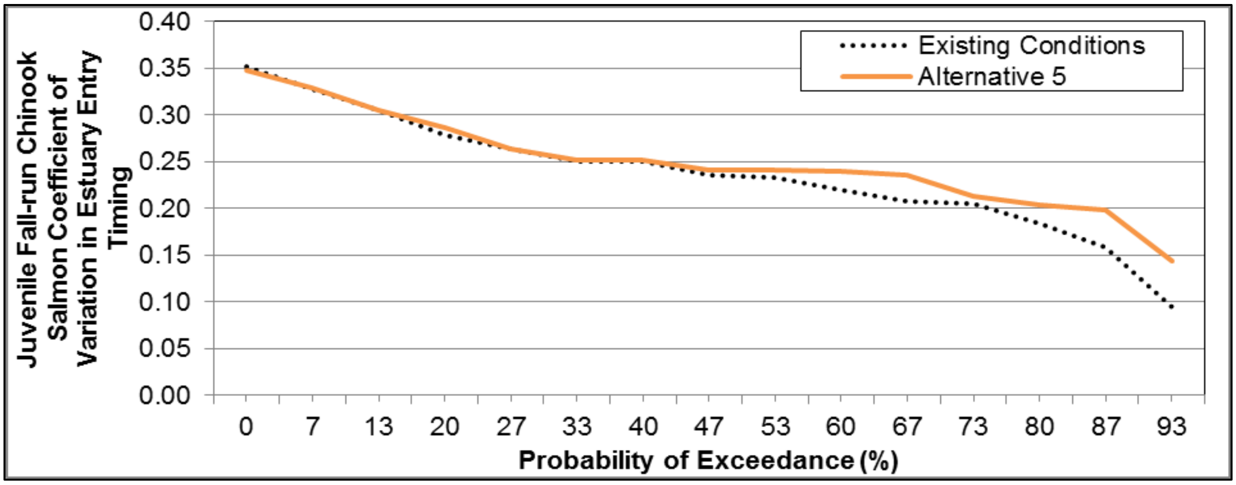

Figure 8-60. Simulated Juvenile Fall-run Chinook Salmon Coefficient of Variation in Estuary Entry Timing Probability of Exceedance Distributions under Alternative 5 and Existing Conditions

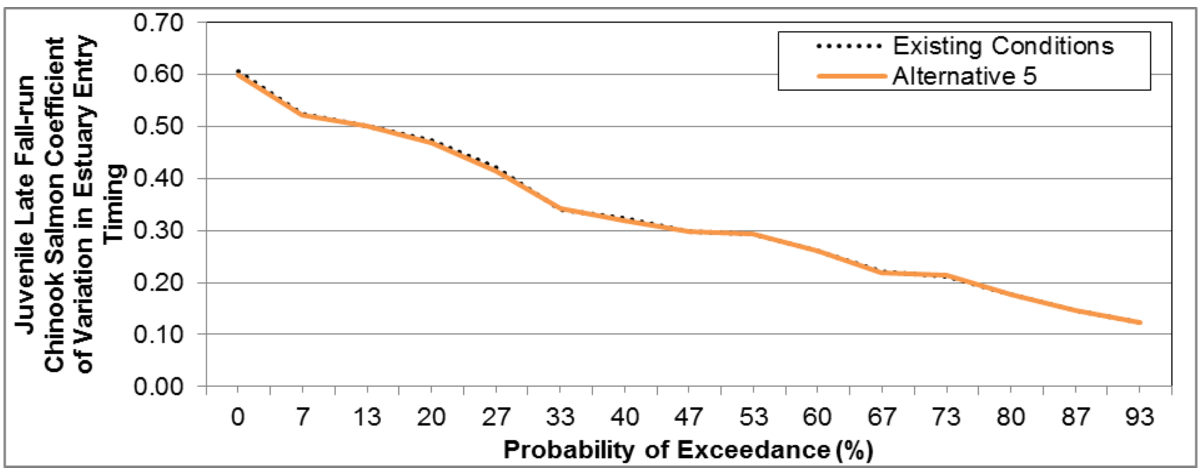

Figure 8-61. Simulated Juvenile Late Fall-run Chinook Salmon Coefficient of Variation in Estuary Entry Timing Exceedance Distributions under Alternative 5

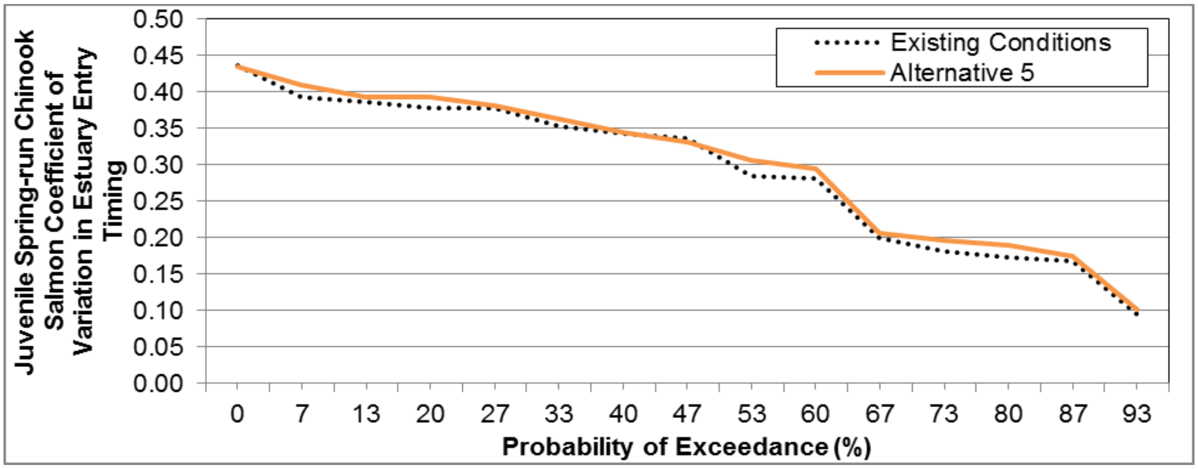

Figure 8-62. Simulated Juvenile Spring-Run Chinook Salmon Coefficient of Variation in Estuary Entry Timing Exceedance Distributions under Alternative 5

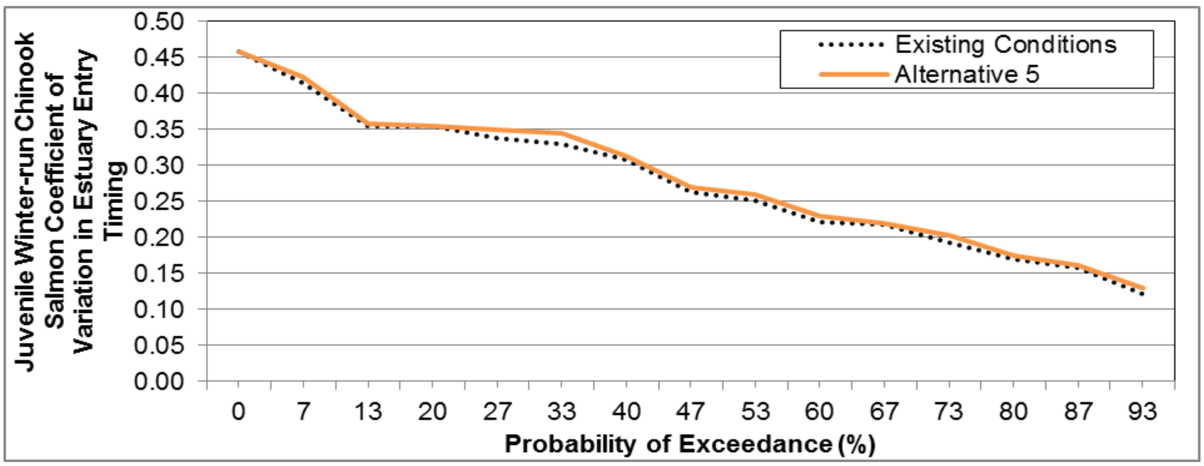

Figure 8-63. Simulated Juvenile Winter-run Chinook Salmon Coefficient of Variation in Estuary Entry Timing Exceedance Distributions under Alternative 5

Spatial Structure

ENTRAINMENT INTO THE YOLO BYPASS

Modeling results indicate that mean monthly flows spilling into the Yolo Bypass from the Sacramento River at Fremont Weir under Alternative 5 relative to Existing Conditions would be higher from November through March and would be similar over the remainder of the year under both scenarios (see Appendix G6). Mean monthly flows would be substantially higher (i.e., higher by 10 percent or more) during at least some water year types in November (wet water years), December (wet and above normal water years), January (above normal, below normal, and dry water years), February (above normal, below normal, dry, and critical water years), and March (below normal and dry water years). Over the entire simulation period, net increases in flows of 10 percent or more would occur with substantially higher frequency (i.e., 10 percent or more of the time) from December through March (see Appendix G6).

Based on increases in simulated monthly flows from December through March, it is expected that juvenile salmonids and potentially other fish species would be more likely to be entrained into the Yolo Bypass from December through March under Alternative 5 relative to Existing Conditions.

The estimated average annual percentages of juvenile fall-run, late fall-run, winter-run, and spring-run Chinook salmon (all sizes) entrained into the Yolo Bypass using the proportion of flow approach would be about 13.3, 5.4, 9.8, and 8.8 percent under Alternative 5, respectively (relative to about 7.1, 2.6, 3.9, and 3.1 percent, respectively, under Existing Conditions) (DWR 2017a; Appendix G3). For smaller juveniles (i.e., <80 mm), the percentages of fall-run, late fall-run, winter-run, and spring-run Chinook salmon entrained into the Yolo Bypass would be 13.8, 1.0, 6.2, and 9.4 percent, respectively (DWR 2017a; Appendix G3).

The ELAM modeling indicates that the entrainment-Sacramento River stage relationship under Alternative 5 exhibits a positive relationship as Sacramento River stage increases from 21.16 to 25.54 ft. Without the proposed Sacramento River channel and bank improvements, the percent of juveniles entrained under Alternative 5 would peak at about 5.6 percent at a stage of 25.54 ft and would decrease to about 2.6 percent at the highest stage modeled (28.83 ft) (Smith et al. 2017; Appendix G1). However, including the proposed modifications to the Sacramento River channel and bank to improve hydraulic entrainment conditions suggests that Alternative 5 could entrain up to about 10 percent of juveniles (see Smith et al. 2017).

Juvenile Rearing in the Yolo Bypass for One or More Days

Modeling results indicate that annual average numbers of juvenile fall-run Chinook salmon rearing for one or more days in the Yolo Bypass under Alternative 5 relative to Existing Conditions would be substantially higher over the entire simulation period and during all water year types for fall-run, late fall-run, spring-run, and winter-run Chinook salmon (Table 8-32).

The annual proportion of juvenile Chinook salmon rearing for one or more days in the Yolo Bypass exceedance distribution for Alternative 5 would be substantially higher over the entire distribution relative to Existing Conditions for fall-run, spring-run, and winter-run Chinook salmon and would be higher over most of the distribution for late fall-run Chinook salmon (Figures 8-64 through 8-67).

In addition, Alternative 5 would allow for juvenile rearing in the Yolo Bypass over about 20 percent of the distribution when no juvenile fall-run Chinook salmon would be rearing in the Yolo Bypass, over about 40 percent of the distribution when no juvenile late fall-run Chinook salmon would be rearing in the Yolo Bypass, and over about 30 percent of the distribution when no juvenile spring-run and winter-run Chinook salmon would be rearing in the Yolo Bypass under Existing Conditions.

Table 8-32. Average Annual Number of Juvenile Fall-run Chinook Salmon that Reared in the Yolo Bypass for One or More Days under Alternative 5

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Fall-run Chinook Salmon						

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Alternative 5	4,409,403	9,343,903	4,247,306	889,485	1,052,912	688,990
Existing Conditions	3,179,250	8,028,286	2,198,294	436,145	20,038	0
Difference	1,230,153	1,315,617	2,049,011	453,341	1,032,874	688,990
Percent Difference[3]	39	16	93	104	5,155	n/a
Late Fall-run Chinook Salmon						
Alternative 5	237,623	659,907	44,622	15,584	24,807	551
Existing Conditions	190,830	571,919	953	0	0	0
Difference	46,793	87,988	43,668	15,584	24,807	551
Percent Difference[3]	25	15	4,581	n/a	n/a	n/a
Spring-run Chinook Salmon						
Alternative 5	80,948	161,542	72,070	18,363	27,482	43,648
Existing Conditions	32,657	72,311	41,409	1,894	70	0
Difference	48,291	89,231	30,660	16,470	27,411	43,648
Percent Difference[3]	148	123	74	870	39,020	n/a
Winter-run Chinook Salmon						
Alternative 5	61,011	97,614	77,902	26,558	29,824	20,975
Existing Conditions	28,031	54,261	46,976	3,552	283	0
Difference	32,979	43,353	30,926	23,006	29,541	20,975
Percent Difference[3]	118	80	66	648	10,429	n/a

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

[3] Relative difference of the annual average

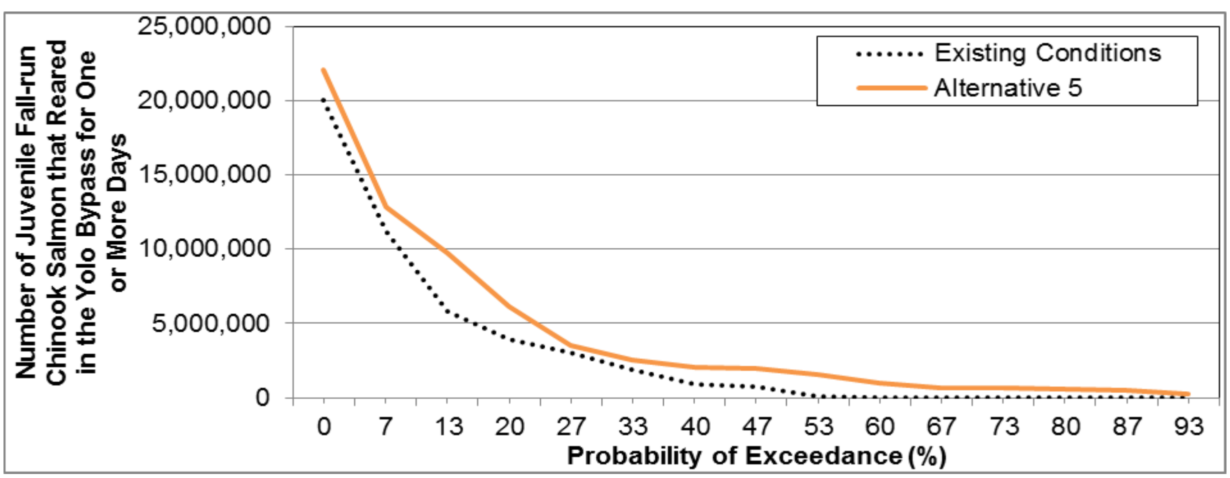

Figure 8-64. Simulated Number of Juvenile Fall-run Chinook Salmon that Reared in the Yolo Bypass for One or More Days Exceedance Distributions under Alternative 5

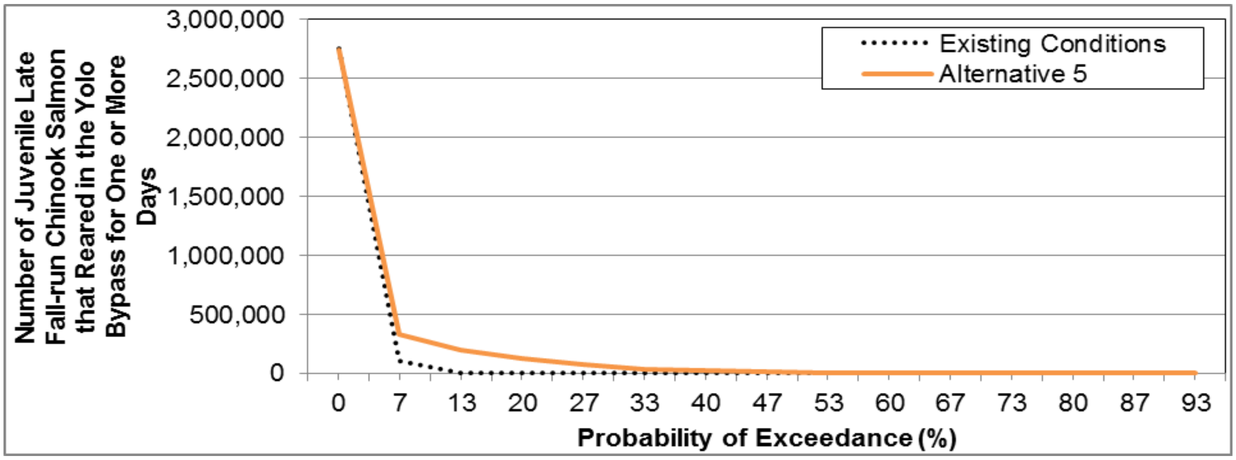

Figure 8-65. Simulated Number of Juvenile Late Fall-run Chinook Salmon that Reared in the Yolo Bypass for One or More Days Exceedance Distributions under Alternative 5

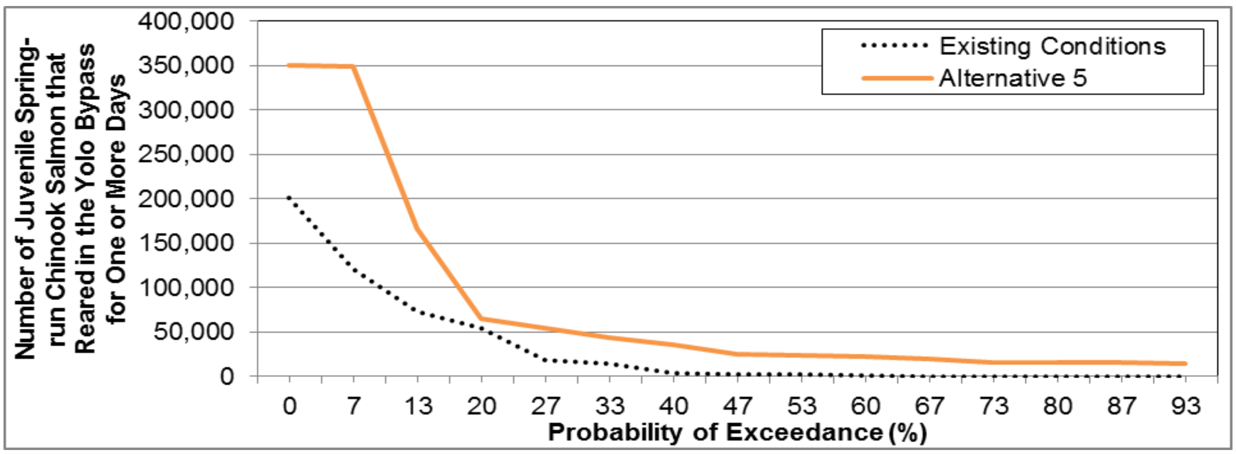

Figure 8-66. Simulated Number of Juvenile Spring-run Chinook Salmon that Reared in the Yolo Bypass for One or More Days Exceedance Distributions under Alternative 5

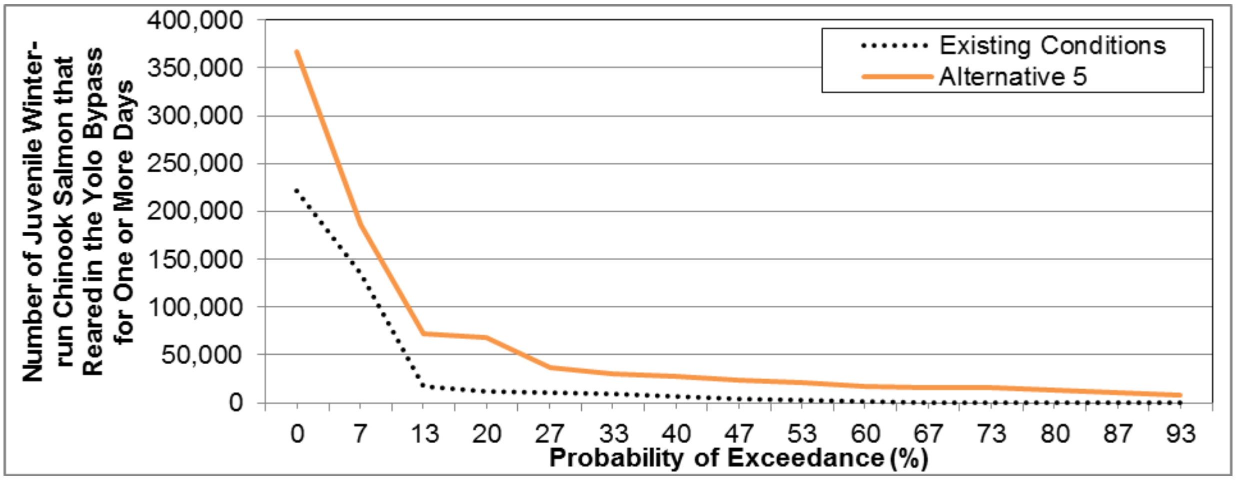

Figure 8-67. Simulated Number of Juvenile Winter-run Chinook Salmon that Reared in the Yolo Bypass for One or More Days Exceedance Distributions under Alternative 5

CEQA Conclusion

Simulated population metric indicators from the SBM were used to evaluate changes in the VSP parameters under Alternative 5 relative to Existing Conditions. Except for the abundance and productivity parameters for late fall-run and winter-run Chinook salmon and the diversity parameter for late fall-run Chinook salmon, which indicate generally similar conditions under Alternative 5 and Existing Conditions, the abundance, productivity, diversity, and spatial structure indicators all exhibit improvement for fall-run, late fall-run, spring-run, and winter-run Chinook salmon under Alternative 5 relative to Existing Conditions.

Therefore, Alternative 5 would be expected to have a **less than significant impact**.

Impact FISH-19: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Hydrologic Conditions in the SWP/CVP System

Changes in simulated mean monthly storages in the SWP/CVP system under Alternative *5* relative to the basis of comparison would be similar to those described for Alternative 1. Therefore, simulated changes under Alternative 5 relative to the No Action Alternative (and Existing Conditions) would not result in substantial adverse effects to fish species of focused evaluation and their habitats in the SWP/CVP system.

CEQA Conclusion

Due to similar modeled hydrology in the SWP/CVP system, Alternative 5 would be expected to have a **less than significant impact**.

Impact FISH-20: Conflict with Adopted Habitat Conservation Plan; Natural Community Conservation Plan; or Other Approved Local, Regional, or State Habitat Conservation Plan

Although the Yolo County HCP/NCCP does not directly address fish species, it does include goals and policies related to protecting and improving habitat conditions in the Yolo Bypass that could indirectly benefit fish resources (Yolo Habitat Conservancy 2017). Because Alternative 5 would include mitigation for physical habitat impacts, Alternative 5 would not conflict with HCPs or NCCPs, including the Yolo County HCP/NCCP (Yolo Habitat Conservancy 2017). This impact consideration is addressed for vegetation, wetlands and wildlife resources in Chapter 9 under Impact TERR-11 for each Alternative.

CEQA Conclusion

Alternative 5 is expected to have a **less than significant impact** relative to Existing Conditions.

Impact FISH-21: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Tule Canal Floodplain Improvements (Program Level)

As described in Section 2.8.1.7, Alternative 5 would include floodplain improvements along Tule Canal, just north of I-80. These improvements would not be constructed at the same time as the remaining facilities. They would not be necessary for the project-level components to function but would enhance the performance of the overall alternatives. They are included at a program level of detail to consider all the potential impacts and benefits of Alternative 5. Subsequent consideration of environmental impacts would be necessary before construction could begin.

The floodplain improvements would develop a series of secondary channels that connect to Tule Canal north of I-80 (see Figure 2-21 in Chapter 2, *Description of Alternatives*). These channels would increase inundation and available fish rearing habitat in the surrounding areas, which are currently managed as wetland habitat for waterfowl. The floodplain improvement channels would have a 30-foot bottom width with 3:1 side slopes (horizontal to vertical). An operable weir in the Tule Canal would help increase the water surface elevation upstream and move water into these channels. These improvements also include a bypass channel around the weir with a 10-foot bottom width and 3:1 side slopes (horizontal to vertical). The bypass channel would be about 2,100 feet long and convey up to 300 cfs. These channels would increase inundation in the surrounding areas, which are currently managed as wetland habitat for waterfowl.

Implementation of Tule Canal floodplain improvements would have the potential to adversely impact the same species and habitats identified above in impacts FISH-1 through FISH-8 (i.e., construction- and maintenance-related impacts) and FISH-12 through FISH-18 (i.e., operations-related impacts in the Yolo Bypass). When final plans and specifications of the improvements are determined, impacts will need to be quantified, and appropriate avoidance, minimization, and compensatory mitigation measures will be applied.

CEQA Conclusion

Construction-related impacts associated with the Tule Canal floodplain improvements would be **significant** because construction of the Tule Canal floodplain improvements could result in direct and indirect construction-related effects on species and associated suitable habitats. However, implementation of MM-WQ-1: Prepare and Implement a Spill Prevention, Control, and Countermeasure Plan, MM-WQ-2: Implement a Stormwater Pollution and Prevention Plan, MM-WQ-3: Develop Turbidity Monitoring Program, MM-TERR-13: Restore Temporarily Disturbed Giant Garter Snake Aquatic and Upland Habitat, MM-TERR-11: Prepare and Implement a Compensatory Restoration Plan for Sensitive Vegetation Communities, MM-FISH-1: Restore Degraded Riparian and SRA Habitat, MM-FISH-2: Implement an Underwater Noise

Reduction and Monitoring Plan, MM-FISH-3: Prepare a Fish Rescue and Salvage Plan, and MM-FISH-4: Implement General Fish Protection Measures would reduce construction-related impacts to **less than significant**.

Impacts from operations could cause adverse effects. The operable weir and bypass channels could result in passage delays for migratory fish species moving through the Tule Canal, which would be a **significant impact**. However, implementation of MM-FISH-5: Adult Fish Passage Monitoring and Adaptive Management would reduce this to a **less than significant impact**.

Additional operations-related impacts under the Tule Canal floodplain improvements relative to Existing Conditions include increased potential for stranding and predation of fish species of focused evaluation, which would be **significant and unavoidable impacts** No mitigation measures could be identified to reduce these impacts to less than significant. Increasing potential levels of standing and predation of fish species of focused evaluation, particularly juvenile Chinook salmon, would exacerbate existing stressors under Existing Conditions.

8.3.3.7 Alternative 6: West Side Large Gated Notch

Alternative 6, West Side Large Gated Notch, is a large notch in the western location that would allow flows up to 12,000 cfs. It was designed with the goal of entraining more fish, with the strategy of allowing more flow into the bypass when the Sacramento River is at lower elevations. See Section 2.9 for more details on the alternative features.

8.3.3.7.1 Construction- and Maintenance-related Impacts

Impact FISH-1: Potential Disturbance to Fish Species or their Habitat due to Erosion, Sedimentation, and Turbidity

Potential impacts associated with erosion, sedimentation, and turbidity under Alternative 6 are expected to be similar to those described for Alternative 1. However, substantially more excavation would occur in the Yolo Bypass under Alternative 6. As an indicator of the extent of excavation that would occur under Alternative 6 in the Yolo Bypass, the estimated excess amount of spoils to be excavated during construction would be about 1,711,000 CY. As an indicator of maintenance-related impacts, the estimated additional annual amount of sediment removal required in the area between Fremont Weir and Agricultural Road Crossing 1 because of increased flows into the Yolo Bypass under implementation of Alternative 6 is 75,600 CY. This corresponds to an estimated total annual amount of sediment removal required of 372,150 CY under Alternative 6 relative to 296,550 CY under Existing Conditions. However, local deposition patterns will be dependent on the specific design of downstream facilities.

CEQA Conclusion

Erosion, sedimentation, and turbidity impacts would be **significant** because construction and maintenance activities would result in temporary increases in sedimentation and turbidity in the Sacramento River and the Yolo Bypass and could temporarily adversely affect all fish species of focused evaluation.

Development and implementation of Mitigation Measure MM-WQ-2: Implement a Stormwater Pollution and Prevention Plan and Mitigation Measure MM-WQ-3: Develop Turbidity Monitoring Program would reduce this impact to **less than significant**.

Impact FISH-2: Potential Disturbance to Fish Species or their Habitat due to Hazardous Materials and Chemical Spills

Potential impacts associated with hazardous materials and chemical spills under Alternative 6 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Hazardous materials and chemical spills impacts would be **significant** because construction and maintenance activities could potentially result in the release of contaminants to aquatic habitats in the Sacramento River and the Yolo Bypass and could adversely affect all fish species of focused evaluation.

Development and implementation of Mitigation Measure MM-WQ-1: Prepare and Implement a Spill Prevention, Control, and Countermeasure Plan would reduce this impact to **less than significant**.

Impact FISH-3: Potential Disturbance to Fish Species or their Habitat due to Aquatic Habitat Modification

Potential impacts associated with aquatic habitat modification under Alternative 6 are expected to be similar to those described for Alternative 1, except as described below.

Preliminary estimates based on calculations in ArcGIS indicate that a total of 32.3 acres (temporary impacts) and 107.2 acres (permanent impacts) of vegetated area would have the potential to be disturbed during Alternative 6 construction activities. Specifically, 8.1 acres (temporary impacts) and 26.8 acres (permanent impacts) would be riparian vegetation, which would be a potential source of IWM inputs to the Sacramento River or Yolo Bypass (Table 8-33 and Figure 8-68).

Table 8-33. Vegetation Communities Potentially Affected by Alternative 6

Vegetation Community						
	Grassland	Freshwater Aquatic Vegetation	Freshwater Emergent Marsh	Marsh/Seep	Riparian Forest/Woodland	Total
Acres (Temporary)	20.6	1.0	2.0	0.6	8.1	32.3
Acres (Permanent)	60.2	4.3	10.5	5.4	26.8	107.2

Figure 8-68a. Vegetation Communities Potentially Affected by Alternative 6

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Figure 8-68b. Vegetation Communities Potentially Affected by Alternative 6

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CEQA Conclusion

Aquatic habitat modification adjacent to the Sacramento River and in the Yolo Bypass associated with construction activities would be **significant** because aquatic and riparian habitat would be permanently affected.

Implementation of Mitigation Measures MM-TERR-13 and MM-FISH-1 would reduce this impact to **less than significant**.

Impact FISH-4: Potential Disturbance to Fish Species or their Habitat due to Hydrostatic Pressure Waves, Noise, and Vibration

Potential impacts associated with hydrostatic pressure waves, noise, and vibration under Alternative 6 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Impacts associated with construction noise would be **less than significant** if a vibratory pile driver can be used for the entire construction of the cofferdam. However, impacts associated with noise would be **significant** if impact pile driving was conducted in the Sacramento River, resulting in direct potential impacts to fish species of focused evaluation.

Implementation of Mitigation Measure MM-FISH-2: Implement an Underwater Noise Reduction and Monitoring Plan would reduce this impact to **less than significant**.

Impact FISH-5: Potential Disturbance to Fish Species or their Habitat due to Stranding and Entrainment

Potential impacts associated with stranding and entrainment under Alternative 6 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Stranding and entrainment impacts would be **significant** because fish species of focused evaluation could be entrained in the temporary cofferdam.

Implementation of Mitigation Measure MM-FISH-3: Prepare a Fish Rescue and Salvage Plan would reduce this impact to **less than significant**.

Impact FISH-6: Potential Disturbance to Fish Species or their Habitat due to Predation Risk

Potential impacts associated with predation risk under Alternative 6 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Predation risk impacts would be **significant** because fish species of focused evaluation could be at increased risk of predation due to potential indirect effects of construction and maintenance activities.

Implementation of Mitigation Measures MM-WQ-2: Implement a Stormwater Pollution and Prevention Plan; MM-WQ-1: Prepare and Implement a Spill Prevention, Control, and Countermeasure Plan; MM-FISH-2: Implement an Underwater Noise Reduction and Monitoring Plan; and MM-FISH-3: Prepare a Fish Rescue and Salvage Plan would reduce this impact to **less than significant**.

Impact FISH-7: Potential Disturbance to Fish Species or their Habitat due to Changes in Fish Passage Conditions

Potential impacts associated with fish passage under Alternative 6 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Fish passage impacts would be **less than significant** because fish species of focused evaluation would either generally not be present near temporary fish passage blockages or would not be substantially affected by temporary blockages.

Impact FISH-8: Potential Disturbance to Fish Species or their Habitat due to Direct Harm

Potential impacts associated with direct physical injury and/or mortality under Alternative 6 are expected to be similar to those described for Alternative 1.

CEQA Conclusion

Direct harm impacts would be **significant** because fish species of focused evaluation could be directly harmed due to construction- and maintenance-related equipment, personnel, or debris.

Implementation of Mitigation Measure MM-FISH-4: Implement General Fish Protection Measures would reduce this impact to **less than significant**.

8.3.3.7.2 Operations-related Impacts

Operations-related impacts associated with Alternative 6 are evaluated in the Yolo Bypass, the Sacramento River at and downstream of the Fremont Weir, the Delta and downstream waterbodies, and the broader SWP/CVP system as appropriate.

Impact FISH-9: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Flows in the Sacramento River

Modeling results indicate that average monthly flows over the entire simulation period under Alternative 6 in the Sacramento River downstream of Fremont Weir would be the same or similar during most months but lower by two to six percent from November through March. During relatively low-flow conditions (i.e., lowest 40 percent of flows over the monthly exceedance distributions), no changes in flow of 10 percent or more would occur during any month of the year. Therefore, migration and rearing conditions would be similar under Alternative 6 relative to Existing Conditions in the lower Sacramento River for fish species of focused evaluation, including winter-run, spring-run, fall-run, and late fall-run Chinook salmon, steelhead, green sturgeon, white sturgeon, river lamprey, and Pacific lamprey. In addition, there would be minimal potential for reduced flows in the Sacramento River to result in increased exposure of fish species of focused evaluation to predators or to higher concentrations of water quality contaminants and minimal potential to exacerbate the channel homogenization in the lower Sacramento River.

CEQA Conclusion

Alternative 6 would result in the same or similar flows during relatively low-flow conditions in the Sacramento River downstream of Fremont Weir relative to Existing Conditions; therefore, Alternative 6 would have a **less than significant impact** due to changes in flows in the Sacramento River.

Impact FISH-10: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Water Temperatures in the Sacramento River

Modeling results indicate that simulated mean monthly water temperatures in the Sacramento River at Freeport would generally not exceed species and life stage-specific water temperature index values more often under Alternative 6 relative to Existing Conditions (see Appendix G7). Therefore, migration and rearing thermal conditions would not be substantially affected for fish species of focused evaluation expected to occur in the lower Sacramento River, including winter-run, spring-run, fall-run, and late fall-run Chinook salmon, steelhead, green sturgeon, white sturgeon, river lamprey, and Pacific lamprey under Alternative 6 relative to Existing Conditions.

CEQA Conclusion

Alternative 6 would not result in substantial changes to water temperature suitability for fish species of focused evaluation relative to Existing Conditions; therefore, Alternative 6 would have a **less than significant impact** due to changes in water temperatures in the Sacramento River.

Impact FISH-11: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Delta Hydrologic and Water Quality Conditions

Evaluation of modeling results for mean monthly Delta hydrologic and water quality parameters with respect to species and life stage-specific time periods indicate that hydrologic and water quality metrics would not be altered under Alternative 6 relative to Existing Conditions. Therefore, habitat conditions in the Delta would be similar for all life stages evaluated. In addition, based on mean monthly Delta outflow, fisheries habitat conditions would be the same or similar in Suisun Bay.

CEQA Conclusion

Alternative 6 would result in the same or similar habitat conditions for fish species of focused evaluation in the Delta and in downstream areas relative to Existing Conditions; therefore, Alternative 6 would have a **less than significant impact** due to changes in Delta conditions.

Impact FISH-12: Impacts to Fisheries Habitat Conditions due to Changes in Flow-Dependent Habitat Availability in the Study Area (Yolo Bypass/Sutter Bypass)

Modeling results indicate that flows entering the Yolo Bypass from the Sacramento River at Fremont Weir would substantially increase more often from December through March. Therefore, inundation extent and/or duration of the Yolo Bypass would increase during these months, providing for increased hydraulic habitat availability for fish species of focused evaluation, particularly juvenile salmonids and adult and juvenile Sacramento splittail.

Modeling results indicate that average monthly hydraulic habitat availability over the entire simulation period for Chinook salmon pre-smolts in the Yolo Bypass under Alternative 6 would generally be substantially higher (i.e., higher by 10 percent or more) from December through March and similar for the remainder of the October through May evaluation period (Table 8-34). Simulated average monthly hydraulic habitat availability by water year type would generally be substantially higher during most water year types for December through March.

Modeling results indicate that Chinook salmon pre-smolt hydraulic habitat availability would be higher under Alternative 6 relative to Existing Conditions over about 40 percent of the exceedance distribution (Figure 8-69). Over the exceedance distribution from November through March, daily hydraulic habitat availability would be substantially higher (i.e., higher by 10 percent or more) about 50 percent of the time and would never be lower by 10 percent or more under Alternative 6.

Table 8-34. Average Monthly Area of Pre-smolt Chinook Salmon Hydraulic Habitat in the Yolo Bypass under Alternative 6 from October through May based on TUFLOW Modeling

Alternative	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)
	October	**November**	**December**	**January**	**February**	**March**	**April**	**May**
Entire Simulation Period[1] (n=16)								
Alternative 6	20.0	21.9	42.3	58.2	61.9	55.7	37.3	27.1
Existing Conditions	19.8	21.2	31.1	47.6	43.7	46.9	36.9	27.2
Difference	0.2	0.7	11.2	10.6	18.2	8.8	0.4	-0.1
Percent Difference[2]	1.0	3.3	36.0	22.3	41.6	18.8	1.1	-0.4
Water Year Types[3]								
Wet (n=5)								
Alternative 6	20.1	23.1	61.8	61.4	72.9	74.1	58.5	31.7
Existing Conditions	19.8	21.1	37.7	48.5	56.9	68.7	58.3	31.8
Difference	0.3	2.0	24.1	12.9	16.0	5.4	0.2	-0.1
Percent Difference[2]	1.5	9.5	63.9	26.6	28.1	7.9	0.3	-0.3
Above Normal (n=3)								
Alternative 6	20.3	21.8	39.8	82.0	75.7	54.6	36.7	37.5

Alternative	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)
	October	**November**	**December**	**January**	**February**	**March**	**April**	**May**
Existing Conditions	20.1	21.6	36.2	66.6	41.4	48.0	36.5	37.5
Difference	0.2	0.2	3.6	15.4	34.3	6.6	0.2	0.0
Percent Difference[2]	1.0	0.9	9.9	23.1	82.9	13.8	0.5	0.0
Below Normal (n=3)								
Alternative 6	19.9	21.4	31.9	55.6	56.4	46.6	27.0	21.1
Existing Conditions	19.7	21.2	25.1	45.4	41.8	40.0	26.6	21.0
Difference	0.2	0.2	6.8	10.2	14.6	6.6	0.4	0.1
Percent Difference[2]	1.0	0.9	27.1	22.5	34.9	16.5	1.5	0.5
Dry (n=4)								
Alternative 6	20.0	21.1	32.8	40.2	37.9	45.2	22.4	20.0
Existing Conditions	19.8	20.9	25.9	35.7	26.6	29.0	21.8	20.1
Difference	0.2	0.2	6.9	4.5	11.3	16.2	0.6	-0.1
Percent Difference[2]	1.0	1.0	26.6	12.6	42.5	55.9	2.8	-0.5
Critical (n=1)								
Alternative 6	19.8	20.9	21.8	51.5	77.2	37.0	22.5	20.3
Existing Conditions	19.7	20.7	21.4	39.9	57.7	27.6	22.2	20.5
Difference	0.1	0.2	0.4	11.6	19.5	9.4	0.3	-0.2
Percent Difference[2]	0.5	1.0	1.9	29.1	33.8	34.1	1.4	-1.0

[1] Based on modeled average daily values over a 16-year simulation period (water years 1997 through 2012)

[2] Relative difference of the monthly average

[3] As defined by the Sacramento Valley Index (DWR 2017c)

Key: km^2 = square kilometer

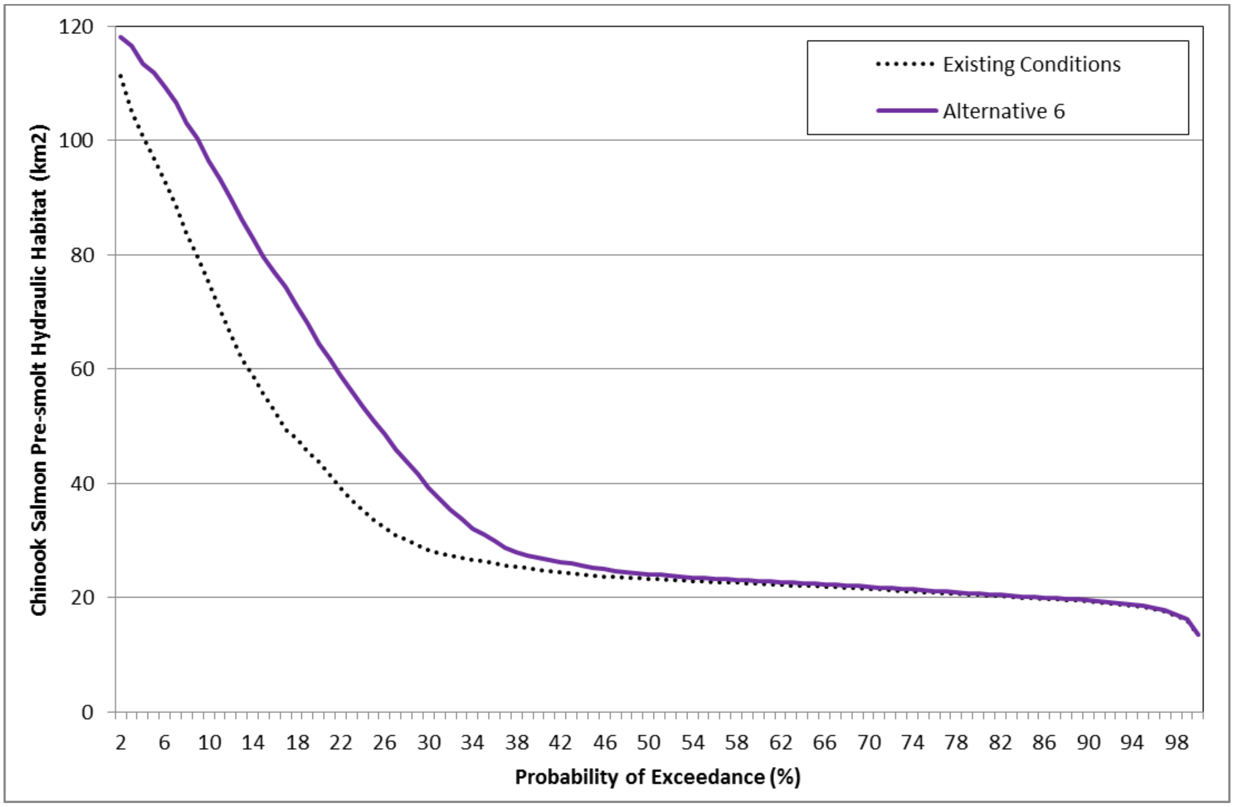


Figure 8-69. Simulated Chinook Salmon Pre-smolt Hydraulic Habitat Availability Probability of Exceedance Distributions under Alternative 6 and Existing Conditions from October through May based on TUFLOW Modeling

Modeling results indicate that average monthly hydraulic habitat availability over the entire simulation period for Chinook salmon smolts in the Yolo Bypass under Alternative 6 relative to Existing Conditions would generally be substantially higher (i.e., higher by 10 percent or more) from December through March and would be similar for the remainder of the October through May evaluation period under both scenarios (Table 8-35). Simulated average monthly hydraulic habitat availability by water year type also would be substantially higher during most water year types from December through March.

Modeling results indicate that Chinook salmon smolt hydraulic habitat availability would be higher under Alternative 6 relative to Existing Conditions over about 40 percent of the exceedance distribution (Figure 8-70). Over the exceedance distribution from November through March, daily hydraulic habitat availability would be substantially higher (i.e., higher by 10 percent or more) about 44 percent of the time and would never be lower by 10 percent or more under Alternative 6.

Table 8-35. Average Monthly Area of Chinook Salmon Smolt Hydraulic Habitat in the Yolo Bypass under Alternative 6 from October through May based on TUFLOW Modeling

Alternative	Area (km^2) October	Area (km^2) November	Area (km^2) December	Area (km^2) January	Area (km^2) February	Area (km^2) March	Area (km^2) April	Area (km^2) May
Entire Simulation Period[1] (n=16)								
Alternative 6	31.7	32.7	57.9	85.7	90.6	86.3	59.1	42.9
Existing Conditions	31.6	32.0	44.2	70.0	69.7	76.0	58.8	43.1
Difference	0.1	0.7	13.7	15.7	20.9	10.3	0.3	-0.2
Percent Difference[2]	0.3	2.2	31.0	22.4	30.0	13.6	0.5	-0.5
Water Year Types[3]								
Wet (n=5)								
Alternative 6	31.5	34.1	85.1	107.1	120.8	126.8	99.9	50.4
Existing Conditions	31.4	32.1	55.4	90.2	100.6	119.0	99.6	50.7
Difference	0.1	2.0	29.7	16.9	20.2	7.8	0.3	-0.3
Percent Difference[2]	0.3	6.2	53.6	18.7	20.1	6.6	0.3	-0.6
Above Normal (n=3)								
Alternative 6	32.2	33.1	54.6	107.0	104.9	83.5	50.5	54.4
Existing Conditions	32.1	32.9	48.3	82.4	68.3	76.6	50.4	54.6
Difference	0.1	0.2	6.3	24.6	36.6	6.9	0.1	-0.2
Percent Difference[2]	0.3	0.6	13.0	29.9	53.6	9.0	0.2	-0.4
Below Normal (n=3)								
Alternative 6	31.9	32.0	43.6	75.4	79.2	71.1	41.0	34.8
Existing Conditions	31.7	31.8	36.2	57.8	62.3	62.6	40.6	34.9
Difference	0.2	0.2	7.4	17.6	16.9	8.5	0.4	-0.1
Percent Difference[2]	0.6	0.6	20.4	30.4	27.1	13.6	1.0	-0.3
Dry (n=4)								
Alternative 6	31.7	31.7	43.8	55.9	49.9	58.6	34.4	33.2
Existing Conditions	31.6	31.5	36.6	48.9	37.9	41.0	33.9	33.4
Difference	0.1	0.2	7.2	7.0	12.0	17.6	0.5	-0.2
Percent Difference[2]	0.3	0.6	19.7	14.3	31.7	42.9	1.5	-0.6
Critical (n=1)								
Alternative 6	31.1	31.4	31.5	65.1	94.3	48.7	34.5	33.7
Existing Conditions	31.0	31.2	30.9	52.1	70.2	39.2	34.4	33.9
Difference	0.1	0.2	0.6	13.0	24.1	9.5	0.1	-0.2
Percent Difference[2]	0.3	0.6	1.9	25.0	34.3	24.2	0.3	-0.6

[1] Based on modeled average daily values over a 16-year simulation period (water years 1997 through 2012)

[2] Relative difference of the monthly average
[3] As defined by the Sacramento Valley Index (DWR 2017c)
Key: km² = square kilometer

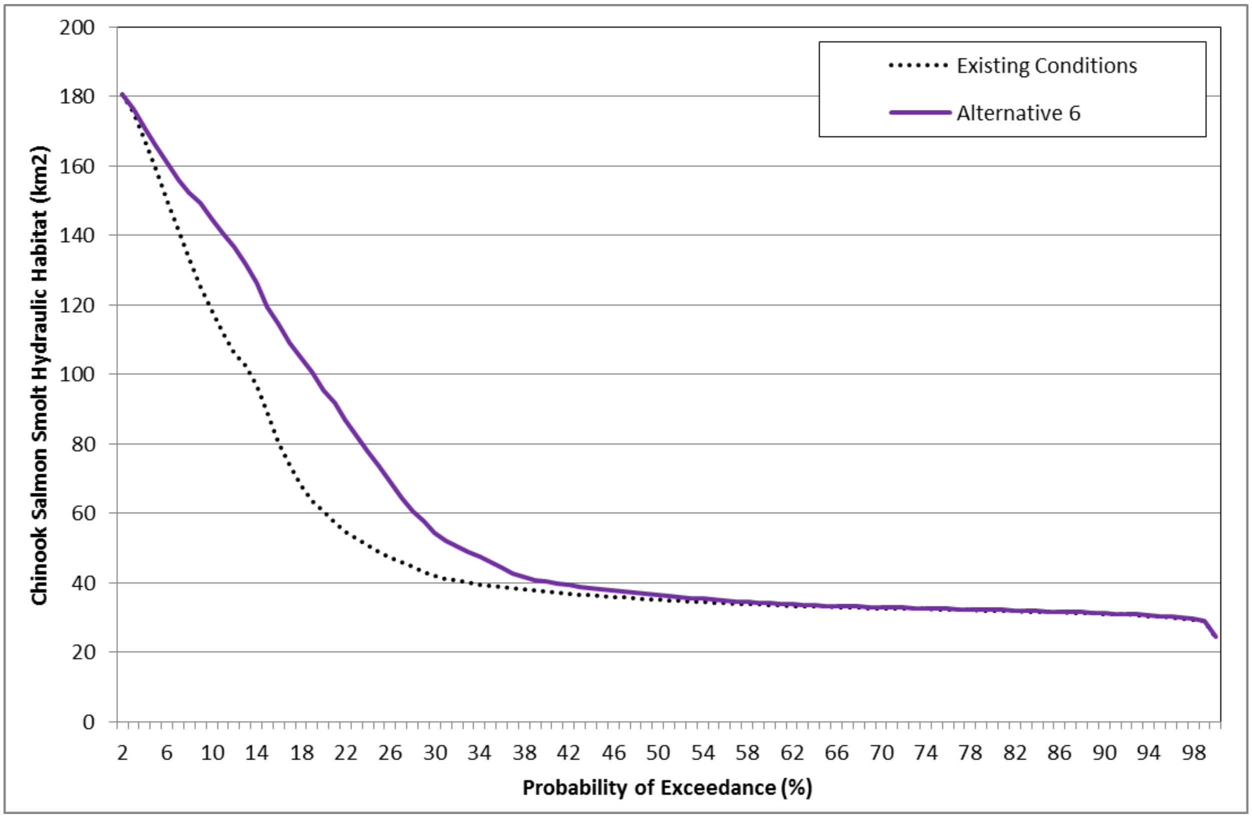


Figure 8-70. Simulated Chinook Salmon Smolt Hydraulic Habitat Availability Probability of Exceedance Distributions under Alternative 6 and Existing Conditions from October through May based on TUFLOW Modeling

As previously discussed, changes in estimated hydraulic habitat availability for Chinook salmon pre-smolts is expected to be generally representative of potential changes in hydraulic habitat availability (based only on hydraulics) for juvenile Sacramento splittail, and changes in estimated hydraulic habitat availability for Chinook salmon smolts is generally expected to be representative of potential changes in habitat availability for adult spawning Sacramento splittail and juvenile steelhead.

To provide a more comprehensive range of potential changes in hydraulic habitat availability for other fish species of focused evaluation, simulated wetted extent (area with a water depth greater than 0.0 ft) was estimated for the Yolo Bypass under Alternative 6 relative to Existing Conditions. Modeling results indicate that average monthly wetted extent over the entire simulation period would be substantially higher from December through March (Table 8-36). Monthly average wetted extent by water year type would be substantially higher (i.e., higher by 10 percent or more) during most water year types for December through March.

Table 8-36. Average Monthly Wetted Area in the Yolo Bypass under Alternative 6 from October through May based on TUFLOW Modeling

Alternative	Wetted Area (km^2) October	Wetted Area (km^2) November	Wetted Area (km^2) December	Wetted Area (km^2) January	Wetted Area (km^2) February	Wetted Area (km^2) March	Wetted Area (km^2) April	Wetted Area (km^2) May
Entire Simulation Period[1] (n=16)								
Alternative 6	48.1	49.4	78.9	121.3	128.8	119.4	86.1	63.9
Existing Conditions	47.8	48.4	64.1	105.0	106.4	107.5	85.9	64.1
Difference	0.3	1.0	14.8	16.3	22.4	11.9	0.2	-0.2
Percent Difference[2]	0.6	2.1	23.1	15.5	21.1	11.1	0.2	-0.3
Water Year Types[3]								
Wet (n=5)								
Alternative 6	47.8	51.1	110.6	172.0	182.2	172.1	145.0	77.0
Existing Conditions	47.6	48.6	78.9	154.3	161.7	163.4	145.3	77.5
Difference	0.2	2.5	31.7	17.7	20.5	8.7	-0.3	-0.5
Percent Difference[2]	0.4	5.1	40.2	11.5	12.7	5.3	-0.2	-0.6
Above Normal (n=3)								
Alternative 6	48.7	50.2	74.3	131.4	139.2	120.2	72.4	76.7
Existing Conditions	48.5	49.9	68.3	108.0	100.1	111.7	72.5	77.0
Difference	0.2	0.3	6.0	23.4	39.1	8.5	-0.1	-0.3
Percent Difference[2]	0.4	0.6	8.8	21.7	39.1	7.6	-0.1	-0.4
Below Normal (n=3)								
Alternative 6	48.2	48.2	61.9	97.4	110.3	99.1	59.9	52.1
Existing Conditions	47.9	47.9	53.9	79.2	91.7	89.6	59.6	52.3
Difference	0.3	0.3	8.0	18.2	18.6	9.5	0.3	-0.2
Percent Difference[2]	0.6	0.6	14.8	23.0	20.3	10.6	0.5	-0.4
Dry (n=4)								
Alternative 6	48.0	48.1	63.1	76.1	70.1	80.6	50.9	49.8
Existing Conditions	47.8	47.6	54.5	68.3	56.0	60.3	50.3	49.9
Difference	0.2	0.5	8.6	7.8	14.1	20.3	0.6	-0.1
Percent Difference[2]	0.4	1.1	15.8	11.4	25.2	33.7	1.2	-0.2
Critical (n=1)								
Alternative 6	47.2	47.0	47.3	89.2	121.4	70.2	51.2	50.7
Existing Conditions	46.9	46.7	46.6	74.4	95.7	58.1	51.1	50.9
Difference	0.3	0.3	0.7	14.8	25.7	12.1	0.1	-0.2
Percent Difference[2]	0.6	0.6	1.5	19.9	26.9	20.8	0.2	-0.4

[1] Based on modeled average daily values over a 16-year simulation period (water years 1997 through 2012)

[2] Relative difference of the monthly average

[3] As defined by the Sacramento Valley Index (DWR 2017c)

Key: km^2 = square kilometer

Modeling results indicate that wetted extent would be higher under Alternative 6 relative to Existing Conditions over about 40 percent of the middle to lower portion of the exceedance distribution (Figure 8-71). Over the exceedance distribution from November through March, daily wetted extent would be substantially higher (i.e., higher by 10 percent or more) about 41 percent of the time and would never be lower by 10 percent or more under Alternative 6.

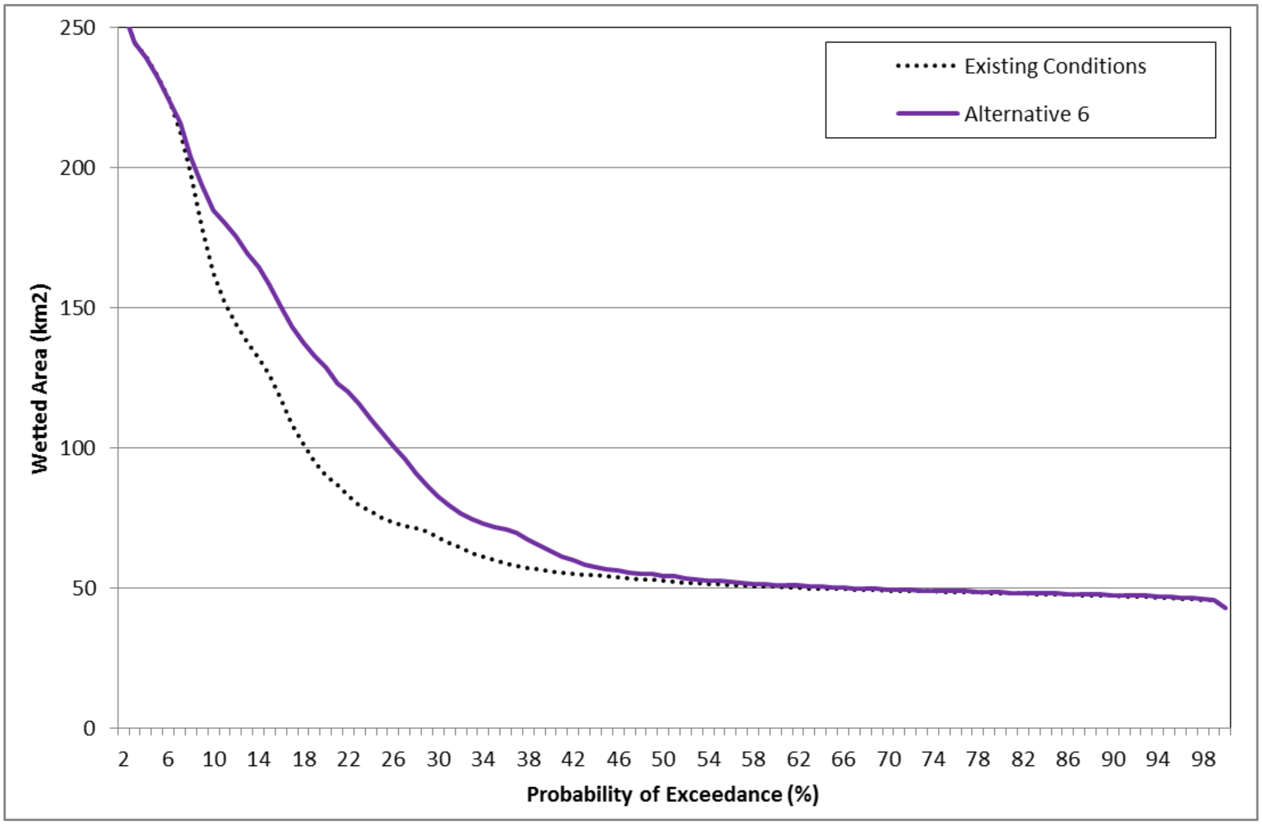


Figure 8-71. Simulated Wetted Area Probability of Exceedance Distributions under Alternative 6 and Existing Conditions from October through May based on TUFLOW Modeling

Average annual modeled wetted days in the Sutter Bypass would decrease under Alternative 6 relative to Existing Conditions by approximately three to seven days in most of the area of Sutter Bypass between the Sacramento River and Sacramento Slough and by approximately three to seven days over most of the Sutter Bypass between Sacramento Slough and Nelson Slough.

CEQA Conclusion

In the Yolo Bypass under Alternative 6, increased hydraulic habitat availability for fish species of focused evaluation, particularly juvenile Chinook salmon and steelhead and adult and juvenile Sacramento splittail, is expected to result in more suitable conditions for these and other fish species of focused evaluation. Relatively minor reductions in the number of wetted days in the Sutter Bypass upstream of the Sacramento River at Fremont Weir are not expected to substantially affect rearing or migration of fish species of focused evaluation; therefore, Alternative 6 would be expected to have a **beneficial impact** on flow-dependent hydraulic habitat availability in the Yolo Bypass and a **less than significant impact** on flow-dependent hydraulic habitat availability in the Sutter Bypass.

Impact FISH-13: Impacts to Fisheries Habitat Conditions due to Changes in Water Quality in the Study Area

Modeling results indicate that flows entering the Yolo Bypass from the Sacramento River at Fremont Weir under Alternative 6 relative to Existing Conditions would substantially increase more often from December through March. Therefore, increased flows and the potential for increased wetting and drying of the Yolo Bypass could increase the amount of methylmercury and other contaminants in the Yolo Bypass and in fish prey. Increased concentrations of contaminants in the Yolo Bypass could potentially result in an increase in the exportation of contaminated water to the Delta. However, for juvenile Chinook salmon rearing in the Yolo Bypass, increased concentrations of accumulated methylmercury were reported to be insignificant in the tissues of the eventual adult-sized fish (Henery et al. 2010). Effects of increased methylmercury accumulation could be more substantial on resident fish species such as largemouth bass. Increased flows in the Yolo Bypass also could temporarily increase turbidity levels in the Yolo Bypass.

CEQA Conclusion

Based on higher mean monthly flows entering the Yolo Bypass, increased concentrations of methylmercury and other contaminants may occur in the Yolo Bypass and the Delta. However, the potential for increased concentrations of contaminants is not expected to substantially affect fish species of focused evaluation; therefore, Alternative 6 would have a **less than significant impact**.

Impact FISH-14: Impacts to Aquatic Primary and Secondary Production in the Study Area

Modeling results indicate that Alternative 6 would result in increased frequency and duration of inundation of the Yolo Bypass relative to Existing Conditions. An increase in frequency and duration of inundation of shallow-water habitat in the Yolo Bypass would be expected to increase primary production in the Yolo Bypass (Lehman et al. 2007). Increased primary and associated secondary production in the Yolo Bypass would likely increase food resources for fish species of focused evaluation in the Yolo Bypass. More productive water in the Yolo Bypass also could potentially be exported to the Delta downstream of the Yolo Bypass, which could increase food resources for fish in the Delta.

Modeled wetted area of the Yolo Bypass under Alternative 6 relative to Existing Conditions was used as an indicator of relative changes in inundation and associated primary and secondary production. As described above, increases in average monthly wetted area would occur under Alternative 6 relative to Existing Conditions, particularly from December through March, depending on water year type. Increased food resources in the Yolo Bypass during this period would be expected to improve growth and survival of some fish species of focused evaluation, such as Chinook salmon and freshwater resident species. The potential for increased productivity downstream of the Yolo Bypass could improve prey availability conditions for fish species of focused evaluation.

Minor reductions in wetted area in the Sutter Bypass could reduce primary and secondary production in the Sutter Bypass. However, these reductions in wetted area are not expected to substantially affect primary or secondary production in the Sutter Bypass or fish species of focused evaluation in the Sutter Bypass.

CEQA Conclusion

Based on increased wetted extent in the Yolo Bypass during the winter, increased primary and secondary production in the Yolo Bypass (and potentially in localized areas of the Delta) could increase food resources for fish species of focused evaluation. In the Sutter Bypass, slight reductions in wetted area could reduce primary and secondary production, but these reductions are not expected to be sufficient to substantially affect food resources for fish species of focused evaluation. Therefore, Alternative 6 would result in a **beneficial impact** in the Yolo Bypass and a **less than significant impact** in the Sutter Bypass.

Impact FISH-15: Impacts to Fish Species of Focused Evaluation due to Changes in Adult Fish Passage Conditions through the Yolo Bypass

Modeling results indicate that flows entering the Yolo Bypass from the Sacramento River at Fremont Weir would substantially increase more often from December through March under Alternative 6 relative to Existing Conditions. Therefore, the duration of potential adult fish passage from the Yolo Bypass into the Sacramento River may potentially increase for fall/late fall-run Chinook salmon, spring-run Chinook salmon, winter-run Chinook salmon, steelhead, green and white sturgeon, and Pacific and river lamprey, potentially providing for increased spawning opportunities in the Sacramento River and its tributaries and reduced potential for mortality or migration delay in the Yolo Bypass. Increased flows entering the Yolo Bypass also would increase the average number of days that areas adjacent to portions of the west-side tributaries within the Yolo Bypass are inundated, including Cache Creek, Willow Slough and Putah Creek. Therefore, hydraulic connectivity and migration conditions for anadromous fishes in the west-side streams could potentially improve under Alternative 6 relative to Existing Conditions.

Based on results of the YBPASS Tool, which applied fish passage criteria to modeled hydraulic conditions in the intake facility and transport channel under Alternative 6, adult salmon and sturgeon would be expected to successfully pass upstream through the transport channels and intake structures into the Sacramento River for about 19 percent of the days from November through April over the water years 1997 through 2012 simulation period. The annual average date after which Alternative 6 would no longer meet the fish passage criteria is March 3.

Increased flows entering the Delta from the Yolo Bypass under Alternative 6 relative to Existing Conditions could potentially result in increased straying of anadromous adult fish native to watersheds outside of the upper Sacramento River Basin, which could result in hybridization and associated genetic effects to anadromous fish populations in the Sacramento River Basin north of Fremont Weir. However, as described in Section 8.1.4.2.1, flow rates downstream of the Yolo Bypass in Cache Slough are highly variable and include large and rapid increases in flow under existing conditions during the December through March period. Despite future potential adaptive management actions (see Appendix C), because Alternative 6 allows for up to 12,000 cfs to pass through the proposed notch, there could be increased potential for adult salmon, sturgeon and other migratory fish species to be attracted into the Yolo Bypass during their upstream migration relative to Existing Conditions. However, hydraulic conditions may impede passage of adults by the time they reach the intake facility, which could result in additional adults becoming stranded in the Yolo Bypass below Fremont Weir relative to Existing Conditions. In addition, because Alternative 6 would no longer meet adult fish passage criteria after March 3, adult winter-run and spring-run Chinook salmon and green sturgeon that entered the Yolo Bypass after late February may be unable to reach their upstream spawning grounds.

CEQA Conclusion

Alternative 6 could potentially attract more adult salmon and sturgeon into the Yolo Bypass, but because of the relatively high flow capacity of the proposed notch, hydraulic conditions may impede or prevent passage at the intake facility or in the transport channel and could strand more adult salmon and sturgeon in the Yolo Bypass relative to Existing Conditions. In addition, Alternative 6 would not provide improved adult fish passage conditions from the Yolo Bypass into the Sacramento River after about early March and could result in more stranding of adult salmonids and sturgeon entering the Yolo Bypass in March. Therefore, Alternative 6 would be expected to have a **potentially significant and unavoidable impact** due to changes in adult fish passage conditions through the Yolo Bypass. No mitigation measures could be identified to reduce this potential impact to a less-than-significant level; a potential reduction in adult passage suitability would exacerbate an existing stressor to adult Chinook salmon and sturgeon.

Impact FISH-16: Impacts to Fish Species due to Changes in Potential for Stranding and Entrainment

Project facilities constructed under Alternative 6, such as the transport and intake channels, would be graded to provide suitable passage conditions for fish, assuming sufficient water is present. Although Alternative 6 would allow for entrainment of juvenile fish at lower flows relative to Existing Conditions, the design of the transport channel to Tule Canal is expected to minimize the potential for stranding of juveniles. However, anthropogenic structures that interrupt natural drainage patterns, such as water control structures, create the greatest risk for stranding (Sommer et al. 2005). Therefore, there is some potential for increased juvenile stranding in the Yolo Bypass.

Because Alternative 6 would allow for adult migration into the Sacramento River during periods when adult migration is impeded or blocked at Fremont Weir under Existing Conditions, the potential for adult fish stranding in the Yolo Bypass would be expected to be reduced.

CEQA Conclusion

The potential for adult fish stranding would be expected to be reduced under Alternative 6 relative to Existing Conditions. Juvenile stranding may potentially increase under Alternative 6, but design of the project facilities is expected to minimize any increases in juvenile stranding. Therefore, Alternative 6 would be expected to have a **less than significant impact** on stranding and entrainment.

Impact FISH-17: Impacts to Fish Species due to Changes in Potential for Predation and Competition

Construction of the intake facility, supplemental fish passage facility, and intake and transport channels lined with rock could increase the potential for predation of fish species of focused evaluation under Alternative 6 relative to Existing Conditions by providing habitat for predatory fish species in these areas. However, the facilities on the Sacramento River are not expected to substantially increase the potential area of refugia for species such as striped bass relative to Existing Conditions. In the Yolo Bypass, increased flow pulses into the Yolo Bypass associated with Alternative 6 during the winter months (primarily December through March) could reduce the potential for predation of fish species such as juvenile salmonids by non-native fish species. For example, Sommer et al. (2014) found that increased connectivity to the Yolo Bypass would provide an overall benefit to native fish species, particularly during the winter, because it is prior to the spawning periods of non-native fish species in the spring. Frantzich et al. (2013) found that native fish species were more widely distributed during wetter years, and low flows may provide more suitable conditions for the spawning and recruitment of non-native centrarchids. Increased flows during February and March under Alternative 6 could increase habitat availability for non-native cyprinids, such as common carp and goldfish, which could result in increased competition for food resources with fish species of focused evaluation relative to Existing Conditions. However, because increased primary and associated secondary production in the Yolo Bypass would likely increase food resources for fish species of focused evaluation in the Yolo Bypass and downstream (see *Impact FISH-14*), increased habitat for non-native cyprinids is not expected to substantially affect fish species of focused evaluation in the Yolo Bypass or in the Delta. Overall, Opperman et al. (2017) argued that flooding the Yolo Bypass from January through April would benefit native fish species. In addition, given the perennial nature of the Tule Canal and its ability to support non-native fish species under Existing Conditions, it is not expected that the proposed facilities under Alternative 6 would increase predation of fish species of focused evaluation above baseline levels in the Yolo Bypass. In addition, results of the SBM (evaluated under *Impact FISH-18*) account for predation associated with the estimated migration path and migration duration for juvenile Chinook salmon in the Yolo Bypass associated with Alternative 6.

CEQA Conclusion

Overall potential for predation of, and competition with, fish species of focused evaluation is not expected to substantially differ relative to predation and competition conditions under Existing Conditions; therefore, Alternative 6 would be expected to have a **less than significant impact** due to changes in predation and competition.

Impact FISH-18: Impacts to Chinook Salmon Species/Runs due to Changes in Viable Salmonid Population Parameters

As previously discussed, model output from the SBM is used to evaluate the VSP parameters (abundance, productivity, diversity, and spatial structure) for fall-run, late fall-run, spring-run, and winter-run Chinook salmon.

Abundance and Productivity

Modeling results indicate that annual average adult Chinook salmon returns under Alternative 6 relative to Existing Conditions would be higher or substantially higher over the entire simulation period and by water year type for fall-run and spring-run Chinook salmon and would be similar for late fall-run and winter-run Chinook salmon (Table 8-37). The adult Chinook salmon returns probability of exceedance distribution under Alternative 6 relative to Existing Conditions would be higher or substantially higher over the entire distribution for fall-run Chinook salmon, higher over most of the distribution for spring-run Chinook salmon, and similar for late fall-run and winter-run Chinook salmon (Figures 8-72 through 8-75). In addition, because more juvenile Chinook salmon would enter the Delta from the Yolo Bypass relative to from the Sacramento River, potentially reduced juvenile mortality at the south Delta pumping facilities could increase adult returns under Alternative 6 relative to Existing Conditions (relative to the SBM output).

Table 8-37. Average Annual Fall-run Chinook Salmon Adult Returns under Alternative 6

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Fall-run Chinook Salmon						
Alternative 6	190,605	257,137	218,206	88,613	173,057	49,314
Existing Conditions	172,025	232,876	192,956	82,267	158,383	39,065
Difference	18,580	24,261	25,251	6,346	14,675	10,249
Percent Difference[3]	11	10	13	8	9	26
Late Fall-run Chinook Salmon						
Alternative 6	56,969	58,660	66,218	19,378	61,256	78,812
Existing Conditions	58,390	60,218	68,937	19,914	61,780	81,012
Difference	-1,421	-1,558	-2,719	-536	-524	-2,200
Percent Difference[3]	-2	-3	-4	-3	-1	-3
Spring-run Chinook Salmon						
Alternative 6	6,690	10,230	6,184	2,507	5,244	4,658
Existing Conditions	5,960	8,803	5,821	2,174	4,884	4,031
Difference	730	1,427	363	334	360	627
Percent Difference[3]	12	16	6	15	7	16
Winter-run Chinook Salmon						
Alternative 6	5,746	5,947	5,582	5,363	6,433	3,253
Existing Conditions	5,518	5,504	5,558	5,334	6,197	3,118
Difference	228	443	24	29	236	135
Percent Difference[3]	4	8	0	1	4	4

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)
[2] As defined by the Sacramento Valley Index (DWR 2017c)
[3] Relative difference of the annual average

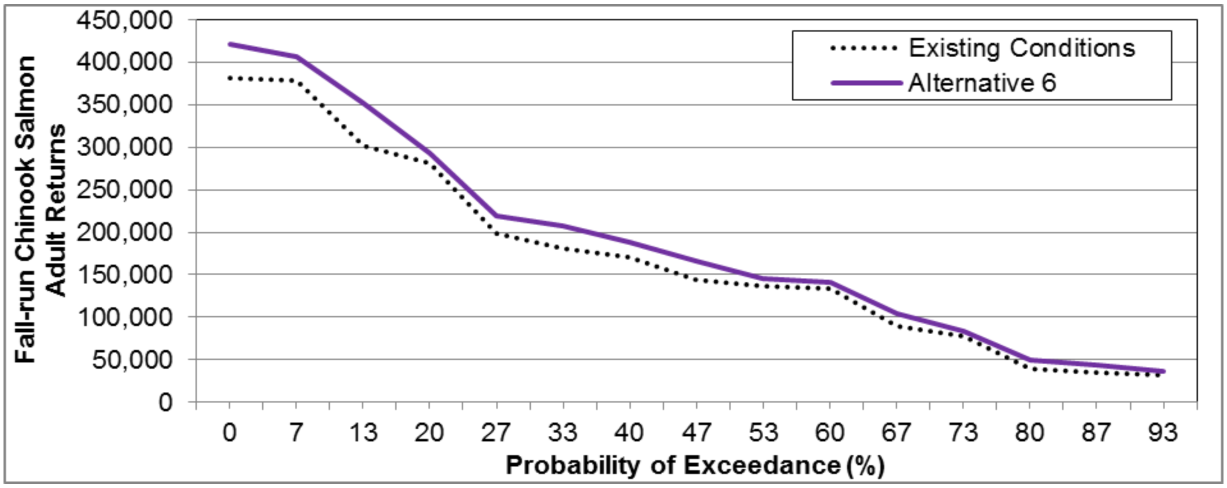


Figure 8-72. Simulated Adult Fall-run Chinook Salmon Returns Exceedance Distributions under Alternative 6 and Existing Conditions

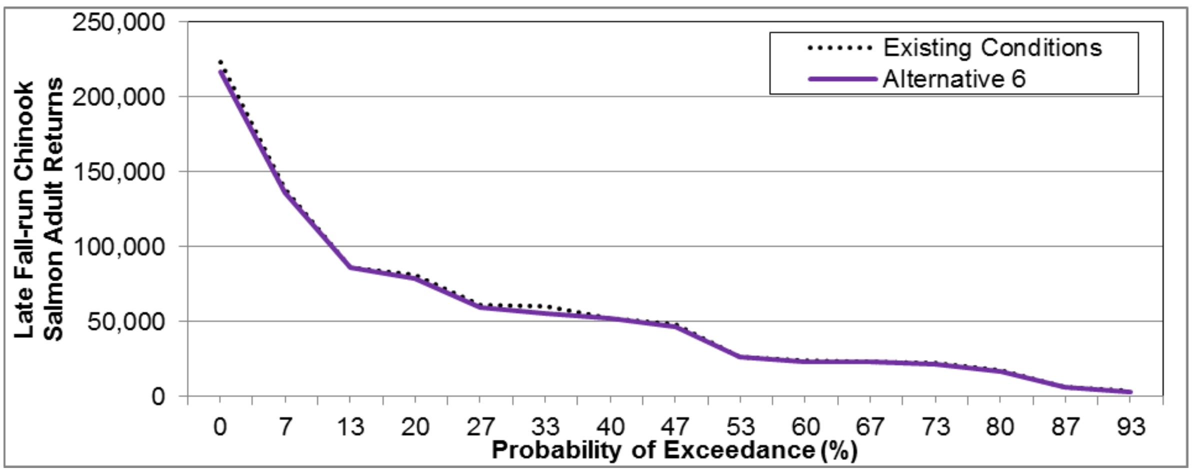


Figure 8-73. Simulated Adult Late Fall-run Chinook Salmon Returns Exceedance Distributions under Alternative 6 and Existing Conditions

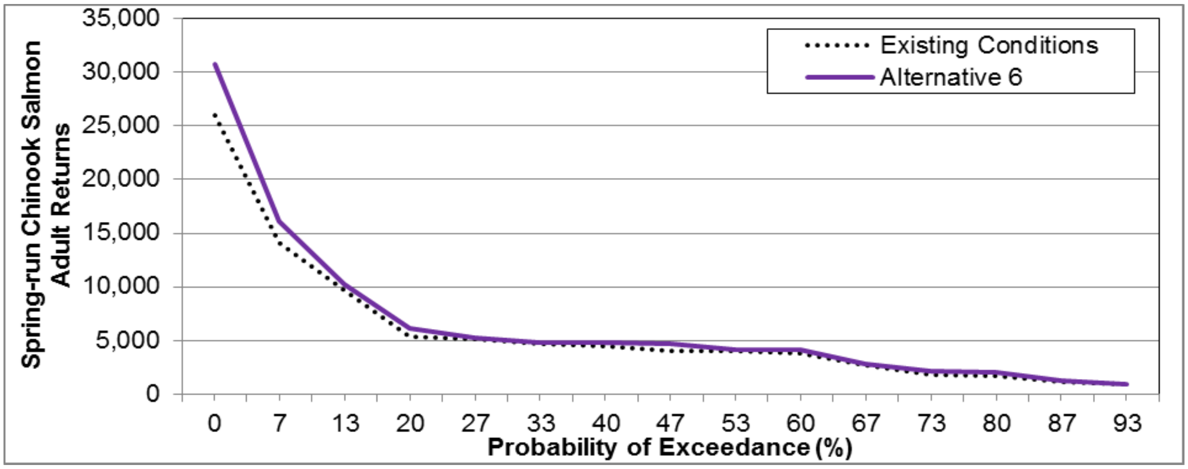


Figure 8-74. Simulated Adult Spring-run Chinook Salmon Returns Exceedance Distributions under Alternative 6 and Existing Conditions

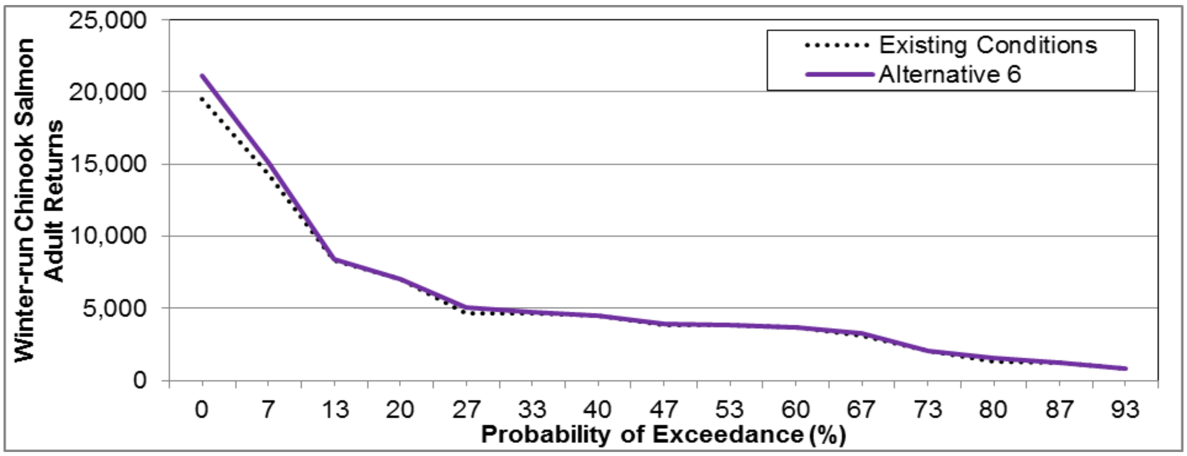


Figure 8-75. Simulated Adult Winter-run Chinook Salmon Returns Exceedance Distributions under Alternative 6 and Existing Conditions

Diversity

VARIATION IN JUVENILE CHINOOK SALMON SIZE

Modeling results indicate that annual average juvenile Chinook salmon coefficient of variation in size (FL) under Alternative 6 relative to Existing Conditions would be substantially higher over the entire simulation period and during most water year types for fall-run, spring-run, and winter-run Chinook salmon and would be similar for late fall-run Chinook salmon (Table 8-38). Similarly, the juvenile Chinook salmon coefficient of variation in size probability of exceedance distribution for Alternative 6 relative to Existing Conditions would be substantially higher over most of the distribution for fall-run, spring-run, and winter-run Chinook salmon and would be similar for late fall-run Chinook salmon (Figures 8-76 through 8-79).

Table 8-38. Average Annual Juvenile Chinook Salmon Coefficient of Variation in Size under Alternative 6

Alternative	Entire Simulation Period[1]	Water Year Types[2] Wet	Water Year Types[2] Above Normal	Water Year Types[2] Below Normal	Water Year Types[2] Dry	Water Year Types[2] Critical
Fall-run Chinook Salmon						
Alternative 6	0.46	0.47	0.47	0.42	0.44	0.46
Existing Conditions	0.35	0.44	0.32	0.35	0.31	0.13
Difference	0.11	0.03	0.15	0.07	0.13	0.33
Percent Difference[3]	30	7	45	19	43	257
Late Fall-run Chinook Salmon						
Alternative 6	0.34	0.41	0.48	0.51	0.11	0.07
Existing Conditions	0.33	0.41	0.48	0.50	0.11	0.07
Difference	0.00	0.00	0.00	0.00	0.00	0.00
Percent Difference[3]	1	1	0	0	1	0
Spring-run Chinook Salmon						
Alternative 6	0.38	0.47	0.36	0.40	0.29	0.34
Existing Conditions	0.30	0.42	0.30	0.26	0.22	0.18
Difference	0.08	0.06	0.07	0.14	0.06	0.16
Percent Difference[3]	26	14	23	54	29	92
Winter-run Chinook Salmon						
Alternative 6	0.19	0.25	0.16	0.21	0.14	0.11
Existing Conditions	0.14	0.20	0.12	0.17	0.10	0.06
Difference	0.04	0.05	0.05	0.04	0.04	0.05
Percent Difference[3]	31	24	39	24	40	90

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

[3] Relative difference of the annual average

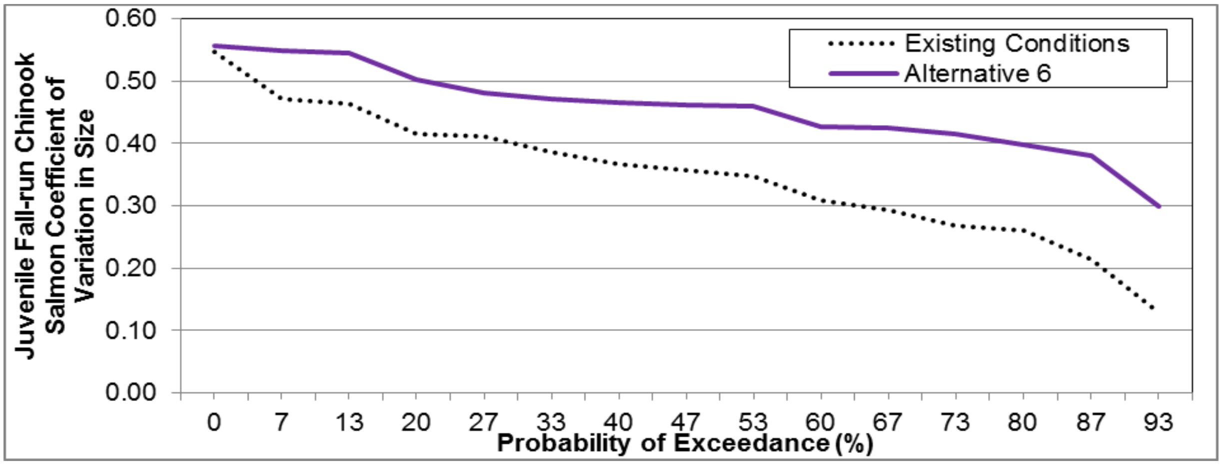


Figure 8-76. Simulated Juvenile Fall-run Chinook Salmon Coefficient of Variation in Size Exceedance Distributions under Alternative 6 and Existing Conditions

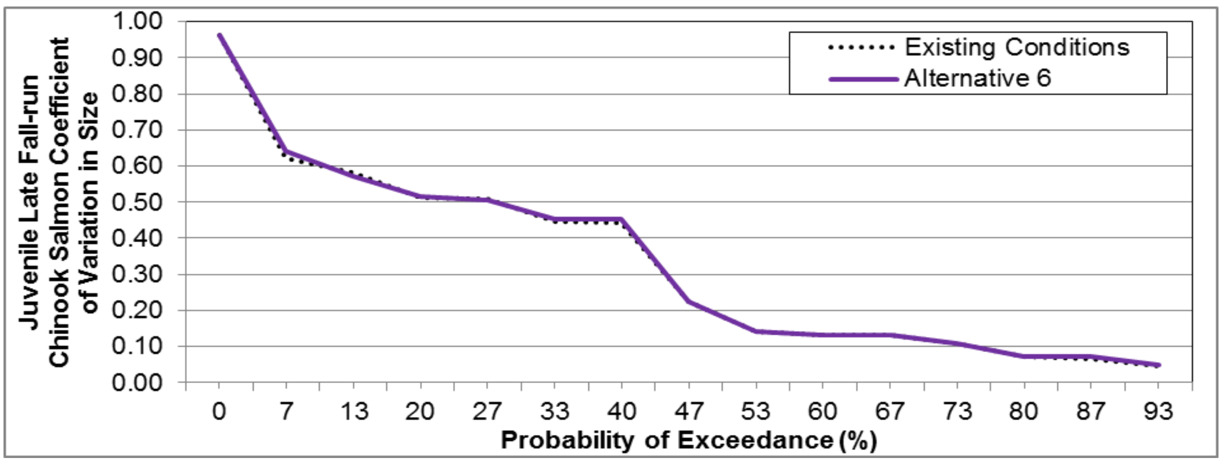


Figure 8-77. Simulated Juvenile Late Fall-run Chinook Salmon Coefficient of Variation in Size Exceedance Distributions under Alternative 6 and Existing Conditions

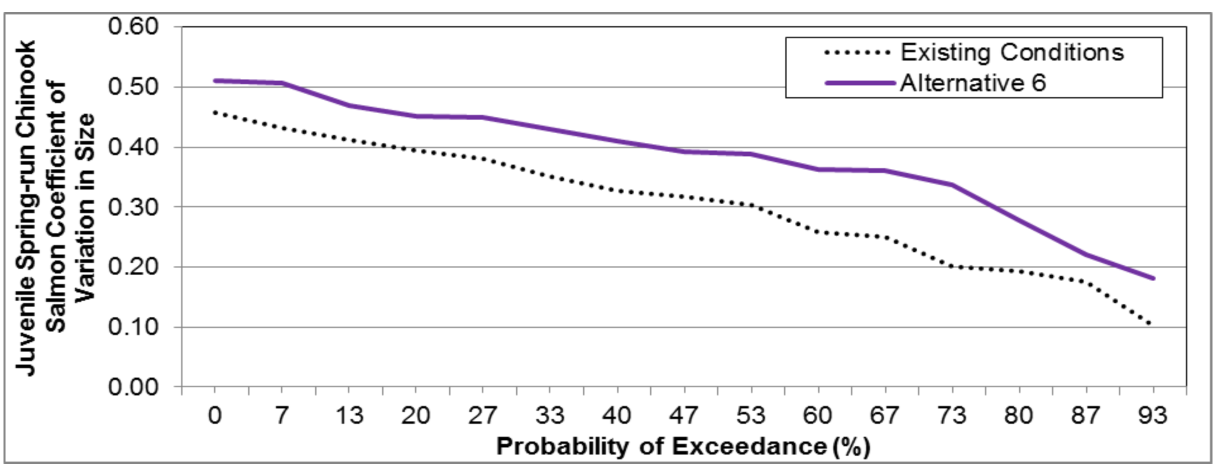


Figure 8-78. Simulated Juvenile Spring-run Chinook Salmon Coefficient of Variation in Size Exceedance Distributions under Alternative 6 and Existing Conditions

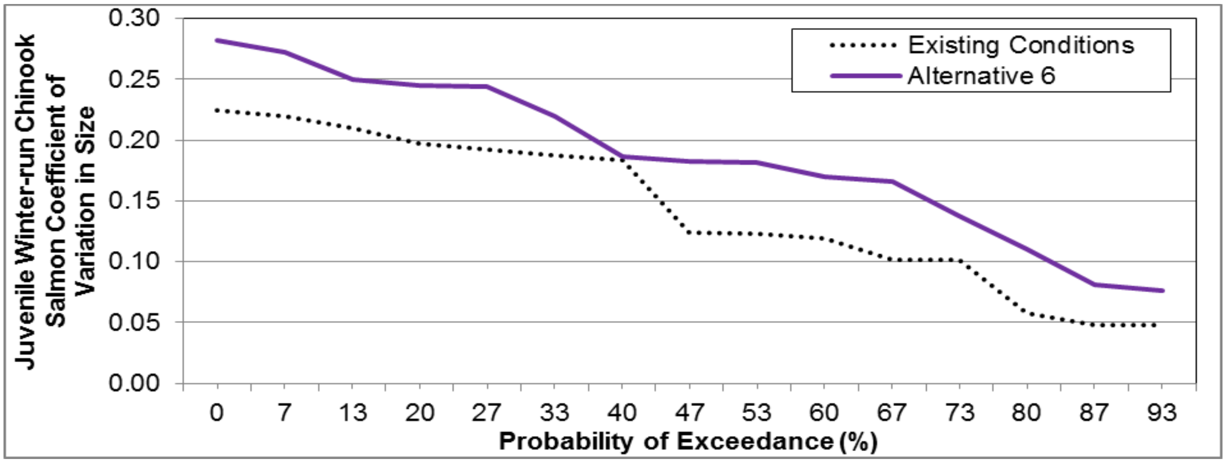


Figure 8-79. Simulated Juvenile Winter-run Chinook Salmon Coefficient of Variation in Size Exceedance Distributions under Alternative 6 and Existing Conditions

VARIATION IN JUVENILE CHINOOK SALMON ESTUARY ENTRY TIMING

Modeling results indicate that annual average juvenile Chinook salmon coefficient of variation in estuary entry timing under Alternative 6 relative to Existing Conditions would be higher over the entire simulation period; similar during wet and below normal water years; and substantially higher during above normal, dry, and critical water years for fall-run Chinook salmon (Table 8-39). Annual average juvenile Chinook salmon coefficient of variation in estuary entry timing under Alternative 6 relative to Existing Conditions would be similar over the entire simulation period and during most water year types for late fall-run, spring-run, and winter-run Chinook salmon but would be substantially higher during below normal and critical water years for spring-run Chinook salmon and during critical water years for winter-run Chinook salmon.

The juvenile Chinook salmon coefficient of variation in estuary entry timing exceedance distributions would be higher or substantially higher over most of the distributions under Alternative 6 relative to Existing Conditions for fall-run, spring-run, and winter-run Chinook salmon and would be similar for late fall-run Chinook salmon (Figures 8-80 through 8-83).

Table 8-39. Average Annual Juvenile Chinook Salmon Coefficient of Variation in Estuary Entry Timing under Alternative 6

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Fall-run Chinook Salmon						
Alternative 6	0.26	0.29	0.26	0.25	0.23	0.23
Existing Conditions	0.24	0.29	0.22	0.25	0.19	0.16
Difference	0.02	-0.01	0.04	0.00	0.03	0.07
Percent Difference[3]	8	-3	16	1	16	44

Alternative	Entire Simulation Period[1]	Water Year Types[2] Wet	Water Year Types[2] Above Normal	Water Year Types[2] Below Normal	Water Year Types[2] Dry	Water Year Types[2] Critical
Late Fall-run Chinook Salmon						
Alternative 6	0.33	0.44	0.32	0.21	0.29	0.15
Existing Conditions	0.33	0.44	0.33	0.21	0.29	0.15
Difference	0.00	-0.01	0.00	0.00	0.00	0.00
Percent Difference[3]	-1	-1	-1	0	0	-1
Spring-run Chinook Salmon						
Alternative 6	0.31	0.39	0.29	0.30	0.25	0.22
Existing Conditions	0.29	0.38	0.28	0.26	0.23	0.18
Difference	0.01	0.00	0.01	0.04	0.01	0.04
Percent Difference[3]	5	1	4	14	5	23
Winter-run Chinook Salmon						
Alternative 6	0.29	0.39	0.24	0.32	0.23	0.13
Existing Conditions	0.28	0.38	0.22	0.30	0.21	0.12
Difference	0.01	0.02	0.01	0.02	0.01	0.01
Percent Difference[3]	5	4	6	5	5	11

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

[3] Relative difference of the annual average

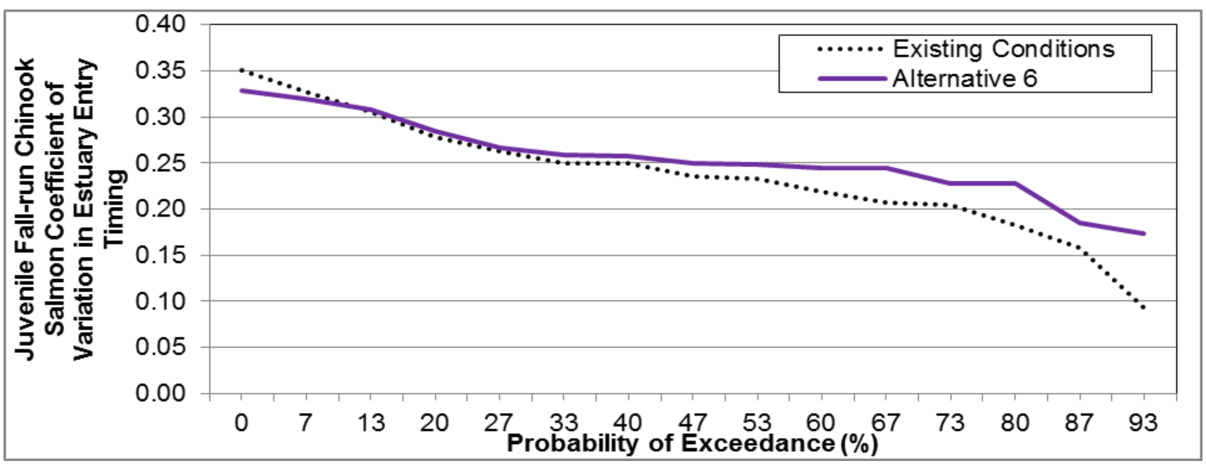


Figure 8-80. Simulated Juvenile Fall-run Chinook Salmon Coefficient of Variation in Estuary Entry Timing Exceedance Distributions under Alternative 6

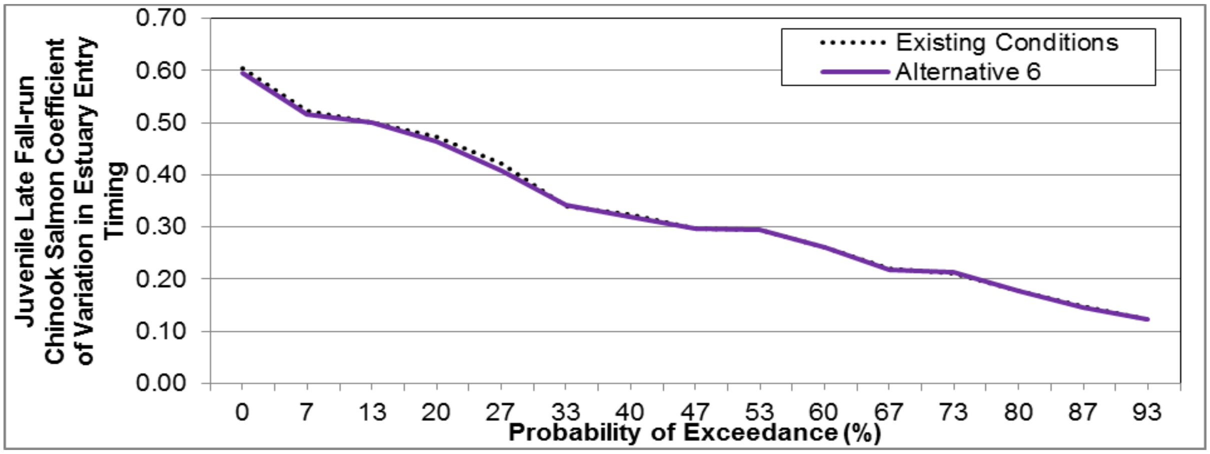


Figure 8-81. Simulated Juvenile Late Fall-run Chinook Salmon Coefficient of Variation in Estuary Entry Timing Exceedance Distributions under Alternative 6

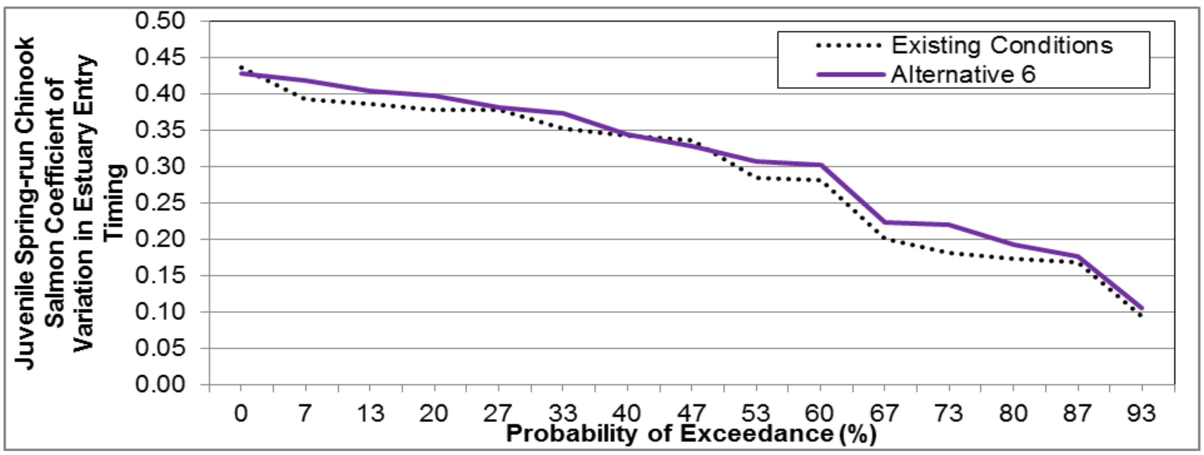


Figure 8-82. Simulated Juvenile Spring-Run Chinook Salmon Coefficient of Variation in Estuary Entry Timing Exceedance Distributions under Alternative 6

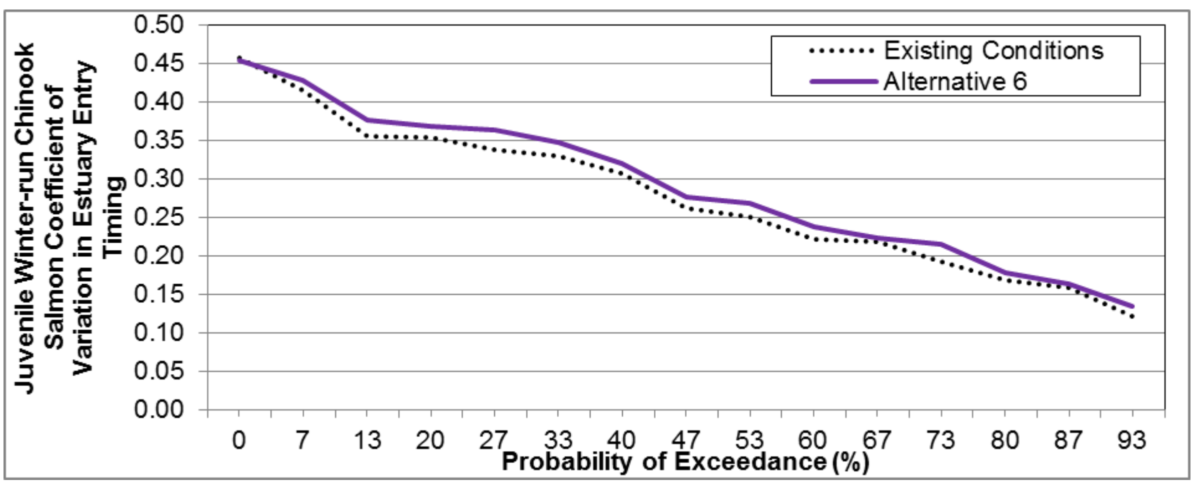


Figure 8-83. Simulated Juvenile Winter-run Chinook Salmon Coefficient of Variation in Estuary Entry Timing Exceedance Distributions under Alternative 6

Spatial Structure

ENTRAINMENT INTO THE YOLO BYPASS

Modeling results indicate that mean monthly flows spilling into the Yolo Bypass from the Sacramento River at Fremont Weir under Alternative 6 relative to the Existing Conditions would be substantially higher from November through March and similar over the remainder of the year under both scenarios (see Appendix G6). Mean monthly flows would be substantially higher (by 10 percent or more) during at least some water year types in November (wet water years), December (wet and above normal water years), January (wet, above normal, below normal, and dry water years), February (above normal, below normal, dry, and critical water years), and March (above normal, below normal, and dry water years). Over the entire simulation period, net increases in flows of 10 percent or more would occur with substantially higher frequency (10 percent or more often) from December through March (see Appendix G6).

Based on increases in simulated monthly flows from December through March, it is expected that juvenile salmonids and potentially other fish species would be more likely to be entrained into the Yolo Bypass from December through March under Alternative 6 relative to the Existing Conditions.

The estimated average annual percentages of juvenile fall-run, late fall-run, winter-run, and spring-run Chinook salmon (all sizes) entrained into the Yolo Bypass using the proportion of flow approach would be about 21.3, 8.5, 17.4, and 16.1 percent under Alternative 6, respectively (relative to about 7.1, 2.6, 3.9, and 3.1 percent, respectively, under Existing Conditions) (DWR 2017a; Appendix G3). For smaller juveniles (i.e., <80 mm), the percentages of fall-run, late fall-run, winter-run, and spring-run Chinook salmon entrained into the Yolo Bypass would be 20.0, 1.2, 12.0, and 16.1 percent, respectively (DWR 2017a; Appendix G3).

The ELAM modeling indicates that the entrainment-Sacramento River stage relationship under Alternative 6 exhibits a positive relationship over the range of modeled Sacramento River stages (20.23 to 28.83 ft). The percent of juveniles entrained would peak at about 37 percent at the highest stage modeled (28.83 ft) (Smith et al. 2017; Appendix G1).

The critical streakline analysis for Alternative 6 (critical streakline scenario 3) found that the percentage of the total annual abundance of juveniles entrained by run over the entire simulation period was about 28 percent (CI 12-43%) for fall-run Chinook salmon, 11 percent (CI 0-38%) for late fall-run Chinook salmon, 23 (CI 4-42%) percent for winter-run Chinook salmon, and about 22 percent (CI 6-42%) for spring-run Chinook salmon.

The entrainment modeling results indicate that the critical streakline analysis-predicted average annual entrainment rates would be about seven percent higher for fall-run, 2.5% higher for late fall-run, six percent higher for winter-run, and six percent higher for spring-run Chinook salmon relative to proportion of flow approach estimates for Alternative 6. Because the SBM modeling was conducted using the proportion of flow approach to estimate juvenile entrainment into the Yolo Bypass, the indicators of the VSP parameters presented for Alternative 6 may be more beneficial than shown if the critical streakline entrainment estimates were applied.

Juvenile Rearing in the Yolo Bypass for One or More Days

Modeling results indicate that annual average numbers of juvenile Chinook salmon rearing for one or more days in the Yolo Bypass under Alternative 6 relative to Existing Conditions would be substantially higher over the entire simulation period and during all water year types for fall-run, late fall-run, spring-run, and winter-run Chinook salmon (Table 8-40). Similarly, the annual number of juvenile Chinook salmon rearing for one or more days in the Yolo Bypass probability of exceedance distribution for Alternative 6 would be substantially higher over the entire distribution for fall-run, spring-run, and winter-run Chinook salmon and would be substantially higher over nearly the entire distribution for late fall-run Chinook salmon (Figures 8-84 through 8-87). In addition, Alternative 6 would provide for juvenile rearing in the Yolo Bypass over about 20 percent of the distribution when no juvenile fall-run Chinook salmon would be rearing in the Yolo Bypass, over about 40 percent of the distribution when no juvenile late fall-run Chinook salmon would be rearing in the Yolo Bypass, and over about 30 percent of the distributions when no juvenile spring-run or winter-run Chinook salmon would be rearing in the Yolo Bypass under Existing Conditions.

Table 8-40. Average Annual Number of Juvenile Chinook Salmon that Reared in the Yolo Bypass for One or More Days under Alternative 6

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Fall-run Chinook Salmon						
Alternative 6	5,855,293	11,391,404	6,415,522	1,435,798	1,899,505	1,156,192
Existing Conditions	3,179,250	8,028,286	2,198,294	436,145	20,038	0
Difference	2,676,043	3,363,118	4,217,227	999,654	1,879,468	1,156,192
Percent Difference[3]	84	42	192	229	9,380	n/a
Late Fall-run Chinook Salmon						
Alternative 6	293,159	772,096	90,228	34,898	48,934	698
Existing Conditions	190,830	571,919	953	0	0	0
Difference	102,329	200,178	89,274	34,898	48,934	698
Percent Difference[3]	54	35	9,364	n/a	n/a	n/a
Spring-run Chinook Salmon						
Alternative 6	135,799	274,475	101,164	46,113	48,635	74,347
Existing Conditions	32,657	72,311	41,409	1,894	70	0
Difference	103,142	202,164	59,755	44,219	48,565	74,347
Percent Difference[3]	316	280	144	2,335	69,132	n/a
Winter-run Chinook Salmon						
Alternative 6	100,687	149,659	112,109	79,044	57,938	35,845
Existing Conditions	28,031	54,261	46,976	3,552	283	0
Difference	72,656	95,398	65,133	75,492	57,654	35,845
Percent Difference[3]	259	176	139	2,126	20,355	n/a

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

[3] Relative difference of the annual average

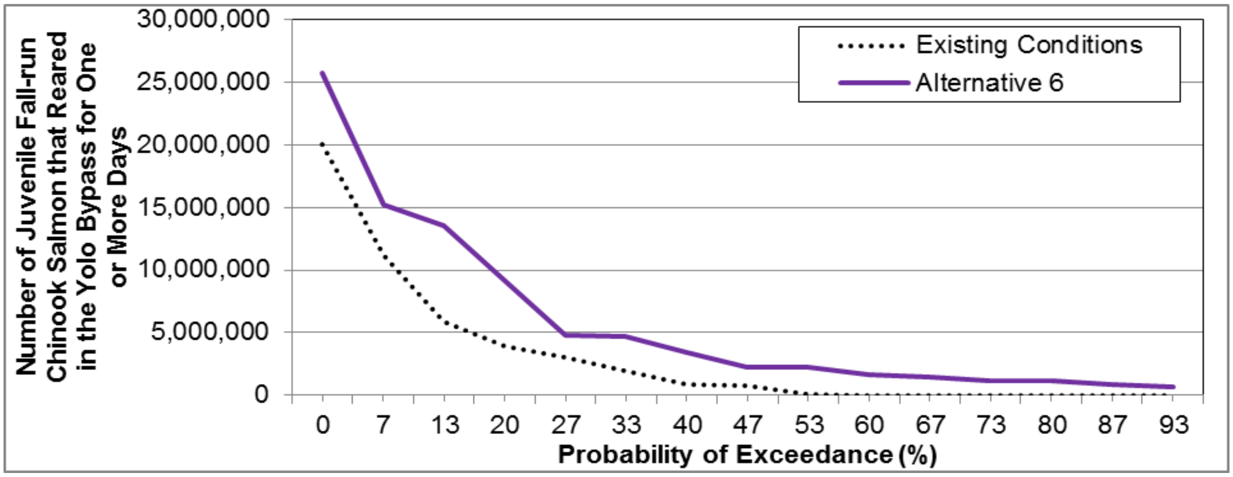


Figure 8-84. Simulated Number of Juvenile Fall-run Chinook Salmon that Reared in the Yolo Bypass for One or More Days Exceedance Distributions under Alternative 6

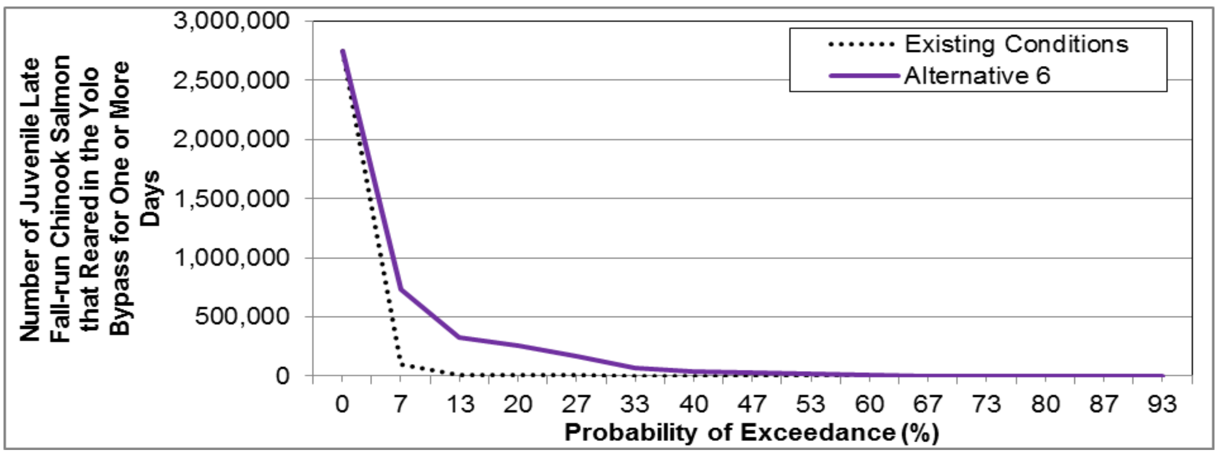


Figure 8-85. Simulated Number of Juvenile Late Fall-run Chinook Salmon that Reared in the Yolo Bypass for One or More Days Exceedance Distributions under Alternative 6

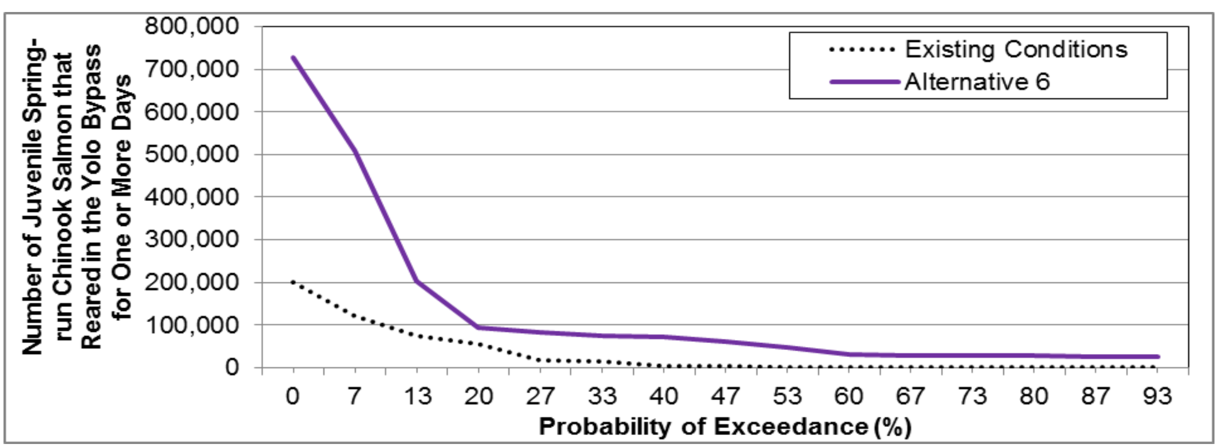


Figure 8-86. Simulated Number of Juvenile Spring-run Chinook Salmon that Reared in the Yolo Bypass for One or More Days Exceedance Distributions under Alternative 6

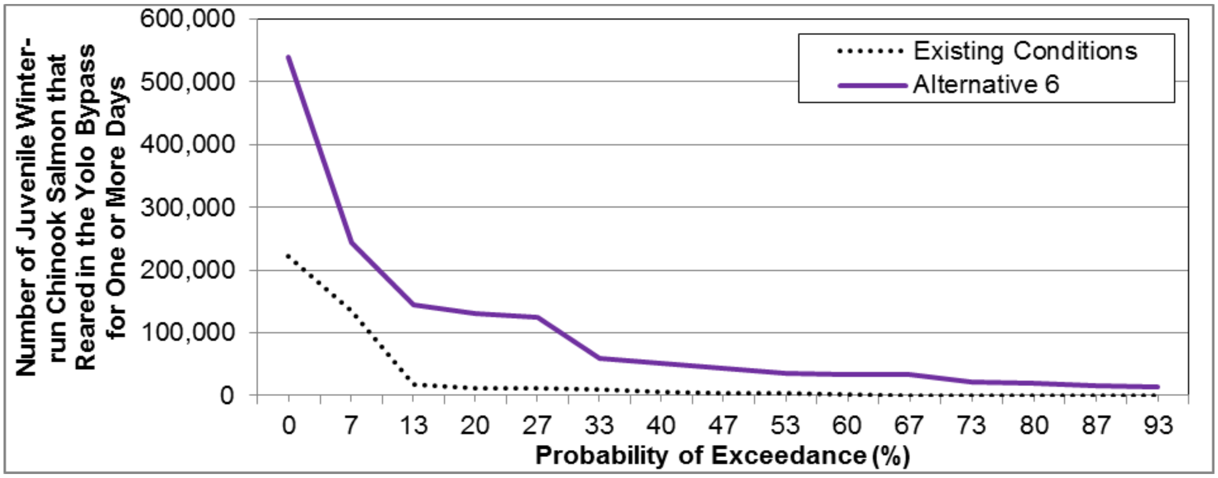


Figure 8-87. Simulated Number of Juvenile Winter-run Chinook Salmon that Reared in the Yolo Bypass for One or More Days Exceedance Distributions under Alternative 6

CEQA Conclusion

Simulated population metric indicators from the SBM were used to evaluate changes in the VSP parameters under Alternative 6 relative to Existing Conditions. Except for the abundance and productivity parameters for late fall-run and winter-run Chinook salmon and the diversity parameter for late fall-run Chinook salmon, which indicate generally similar conditions under Alternative 6 and Existing Conditions, the abundance, productivity, diversity, and spatial structure indicators all exhibit improvement for fall-run, late fall-run, spring-run, and winter-run Chinook salmon under Alternative 6 relative to Existing Conditions.

Therefore, Alternative 6 would be expected to have a **less than significant impact** on VSP parameters.

Impact FISH-19: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Hydrologic Conditions in the SWP/CVP System

Modeling results indicate that changes in simulated mean monthly storages in the SWP/CVP system under Alternative 6 relative to the basis of comparison would be similar to those described for Alternative 1. Therefore, simulated changes under Alternative 6 relative to the No Action Alternative (and Existing Conditions) would not result in substantial adverse effects to fish species of focused evaluation and their habitats in the SWP/CVP system.

CEQA Conclusion

Due to similar modeled hydrology in the SWP/CVP system, Alternative 6 would be expected to have a **less than significant impact** due to changes in hydrologic conditions in the SWP/CVP system.

Impact FISH-20: Conflict with Adopted Habitat Conservation Plan; Natural Community Conservation Plan; or Other Approved Local, Regional, or State Habitat Conservation Plan

Although the Yolo County HCP/NCCP does not directly address fish species, it does include goals and policies related to protecting and improving habitat conditions in the Yolo Bypass that could indirectly benefit fish resources (Yolo Habitat Conservancy 2017). Because Alternative 6 would include mitigation for physical habitat impacts, Alternative 6 would not conflict with HCPs or NCCPs, including the Yolo County HCP/NCCP (Yolo Habitat Conservancy 2017). This impact consideration is addressed for vegetation, wetlands and wildlife resources in Chapter 9 under Impact TERR-11 for each Alternative.

CEQA Conclusion

Alternative 6 is expected to have a **less than significant impact** on habitat conservation plans.

8.3.4 Summary of Impacts

Table 8-41 summarizes the identified impacts to aquatic resources and fisheries in the study area.

Table 8-41. Summary of Impacts and Mitigation Measures – Aquatic Resources and Fisheries

Impact	Alternative	Level of Significance before Mitigation	Mitigation Measures	Level of Significance after Mitigation
Impact FISH-1: Potential Disturbance to Fish Species or their Habitat due to Erosion, Sedimentation, and Turbidity	No Action	NI	—	NI
	All Action Alternatives	S	MM-WQ-2; MM-WQ-3	LTS
Impact FISH-2: Potential Disturbance to Fish Species or their Habitat due to Hazardous Materials and Chemical Spills	No Action	NI	—	NI
	All Action Alternatives	S	MM-WQ-1	LTS
Impact FISH-3: Potential Disturbance to Fish Species or their Habitat due to Aquatic Habitat Modification	No Action	NI	—	NI
	All Action Alternatives	S	MM-TERR-13; MM-TERR-11; MM-FISH-1	LTS
Impact FISH-4: Potential Disturbance to Fish Species or their Habitat due to Hydrostatic Pressure Waves, Noise, and Vibration	No Action	NI	—	NI
	All Action Alternatives	S	MM-FISH-2	LTS

Impact	Alternative	Level of Significance before Mitigation	Mitigation Measures	Level of Significance after Mitigation
Impact FISH-5: Potential Disturbance to Fish Species or their Habitat due to Stranding and Entrainment	No Action	NI	—	NI
	All Action Alternatives	S	MM-FISH-3	LTS
Impact FISH-6: Potential Disturbance to Fish Species or their Habitat due to Predation Risk	No Action	NI	—	NI
	All Action Alternatives	S	MM-WQ-1; MM-WQ-2; MM-WQ-3; MM-FISH-2; MM-FISH-3	LTS
Impact FISH-7: Potential Disturbance to Fish Species due to Changes in Fish Passage Conditions	No Action	NI	—	NI
	All Action Alternatives	LTS	—	LTS
Impact FISH-8: Potential Disturbance to Fish Species or Their Habitat due to Direct Harm	No Action	NI	—	NI
	All Action Alternatives	S	MM-FISH-3; MM-FISH-4	LTS
Impact FISH-9: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Flows in the Sacramento River	No Action	S	—	SU
	All Action Alternatives	LTS	—	LTS
Impact FISH-10: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Water Temperatures in the Sacramento River	No Action	S	—	SU
	All Action Alternatives	LTS	—	LTS
Impact FISH-11: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Delta Hydrologic and Water Quality Conditions	No Action	S	—	SU
	All Action Alternatives	LTS	—	LTS

Impact	Alternative	Level of Significance before Mitigation	Mitigation Measures	Level of Significance after Mitigation
Impact FISH-12: Impacts to Fisheries Habitat Conditions due to Changes in Flow-dependent Habitat Availability in the Study Area (Yolo Bypass/Sutter Bypass)	No Action	B	—	B
	All Action Alternatives	B/LTS	—	B/LTS
Impact FISH-13: Impacts to Fisheries Habitat Conditions due to Changes in Water Quality in the Study Area	No Action	LTS	—	LTS
	All Action Alternatives	LTS	—	LTS
Impact FISH-14: Impacts to Aquatic Primary and Secondary Production in the Study Area	No Action	B	—	B
	All Action Alternatives	LTS	—	LTS
Impact FISH-15: Impacts to Fish Species of Focused Evaluation due to Changes in Adult Fish Passage Conditions through the Yolo Bypass	No Action	B	—	B
	1, 2, 3, 5	B	—	B
	4	S	MM-FISH-5	LTS
	6	S	—	SU
Impact FISH-16: Impacts to Fish Species due to Changes in Potential for Stranding and Entrainment	No Action	LTS	—	LTS
	1, 2, 3, 5, 6	LTS	—	LTS
	4	S	—	SU
Impact FISH-17: Impacts to Fish Species due to Changes in Potential for Predation and Competition	No Action	LTS	—	LTS
	1, 2, 3, 5, 6	LTS	—	LTS
	4	S	—	SU
Impact FISH-18: Impacts to Chinook Salmon Species/Runs due to Changes in Viable Salmonid Population Parameters	No Action	LTS	—	LTS
	All Action Alternatives	LTS	—	LTS

Impact	Alternative	Level of Significance before Mitigation	Mitigation Measures	Level of Significance after Mitigation
Impact FISH-19: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Changes in Hydrologic Conditions in the SWP/CVP System	No Action	S	—	SU
	All Action Alternatives	LTS	—	LTS
Impact FISH-20: Conflict with Adopted Habitat Conservation Plan; Natural Community Conservation Plan; or Other Approved Local, Regional, or State Habitat Conservation Plan	No Action	LTS	—	LTS
	All Action Alternatives	LTS	—	LTS
Impact FISH-21: Impacts to Fish Species of Focused Evaluation and Fisheries Habitat Conditions due to Tule Canal Floodplain Improvements (Program Level)	No Action	NI	—	NI
	1, 2, 3, 4, 5 (Project), 6	N/A	N/A	N/A
	5 (Program)	S	MM-WQ-1, 2, 3; MM-TERR-11, 13; MM-FISH-1, 2, 3, 4, 5	SU

Key: B = beneficial; LTS = less than significant; NI = no impact; N/A= not applicable; S = significant; SU = significant and unavoidable

8.4 Cumulative Impacts Analysis

This section describes the cumulative impacts analysis for fisheries and aquatic resources. Section 3.3, *Cumulative Impacts*, presents an overview of the cumulative impacts analysis, including the methodology and the projects, plans, and programs considered in the cumulative impacts analysis.

8.4.1 Methodology

This evaluation of cumulative impacts considers the effects of the Project and how they might combine with the effects of other past, present, and future projects or actions to create significant impacts on specific resources. The area of analysis for these cumulative impacts includes both the Yolo Bypass area and the larger Sacramento River system. The timeframe for this cumulative impacts analysis includes the past, present, and probable future projects producing related or cumulative impacts that have been identified in the area of analysis. Several related and reasonably foreseeable projects and actions could result in impacts to fisheries and aquatic resources in the Project area, such as the following:

- American River Common Features General Reevaluation Report
- Bay-Delta Water Quality Control Plan Update
- Central Valley Flood Management Planning Program
- The Folsom Dam Water Control Manual Update
- The Liberty Island Conservation Bank
- California Water Fix
- Environmental Permitting for Operation and Maintenance, Oroville Facilities Federal Energy Regulatory Commission Relicensing and License Implementation
- EchoWater Project
- Delta Plan
- Delta Wetlands Project
- Lower Cache Creek Flood Risk Management Feasibility Study and the Woodland Flood Risk Reduction Project
- Lower Elkhorn Basin Levee Setback Project
- Lower Putah Creek 2 North American Wetlands Conservation Act Project
- Lower Yolo Restoration Project
- North Bay Aqueduct Alternative Intake Project
- North Delta Fish Conservation Bank
- North Delta Flood Control and Ecosystem Restoration Project
- Sacramento River Bank Protection Project
- Sacramento River General Reevaluation Report
- Sacramento-San Joaquin Delta Estuary Total Maximum Daily Load for Methylmercury
- Shasta Lake Water Resources Investigation
- Sites Reservoir Project
- Upstream Sacramento River Fisheries Projects
- The Yolo HCP/NCCP and Yolo Local Conservation Plan
- EcoRestore projects, including Agricultural Road Crossing 4 Fish Passage Improvement Project, Cache Slough Area Restoration – Prospect Island, Fremont Weir Adult Fish Passage Modification Project, Knights Landing Outfall Gate Project, Lisbon Weir Modification Project, Lower Putah Creek Realignment Project, Prospect Island Tidal Habitat Restoration Project, Tule Red Tidal Marsh Restoration Project, and Wallace Weir Fish Rescue Facility Project

8.4.2 Cumulative Impacts

All potential impacts associated with construction- and maintenance-related activities and operations-related activities would be less than significant after mitigation or beneficial to fish species of focused evaluation and their habitats under Alternatives 1, 2, and 3. Therefore, **Alternatives 1, 2, and 3 would not result in cumulatively considerable impacts** to fish and aquatic resources. **Alternatives 4, 5, and 6 could result in cumulatively considerable impacts** to fish and aquatic resources due to potentially significant impacts associated with stranding and predation under Alternatives 4 and 5 and from potentially significant impacts associated with adult fish passage under Alternative 6. Increasing levels of juvenile Chinook salmon stranding and predation above existing levels could reduce survival of juvenile Chinook salmon rearing in the Yolo Bypass under Alternatives 4 and 5. Decreasing the suitability of adult fish passage conditions through the Yolo Bypass for green and white sturgeon, Chinook salmon, and steelhead under Alternative 6 could increase mortality of adults and reduce spawning opportunities.

8.5 Alternatives Comparison

This section conducts a relative assessment of the expected performance of each of the alternatives with respect to the project objectives and the potential for significant impacts relative to Existing Conditions.

As previously described in Chapter 1, specific biological objectives of the Project pertain to improving habitat and passage conditions for winter-run Chinook salmon, spring-run Chinook salmon, steelhead, and green sturgeon, as summarized below.

- Increase the availability of floodplain fisheries rearing habitat for juvenile Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead.
  - Improve access onto seasonal floodplain fisheries rearing habitat through volitional entry
  - Increase acreage of seasonal floodplain fisheries rearing habitat
  - Reduce stranding and presence of migration barriers
  - Increase aquatic primary and secondary biotic production to provide food through an ecosystem approach
- Reduce migratory delays and loss of fish at Fremont Weir and other structures in the Yolo Bypass.
  - Improve connectivity within the Yolo Bypass for passage of salmonids and green sturgeon
  - Improve connectivity between the Sacramento River and Yolo Bypass to provide safe and timely passage for:
    - Adult Sacramento River winter-run Chinook salmon between mid-November and May when elevations in the Sacramento River are amenable to fish passage

- ○ Adult Central Valley spring-run Chinook salmon between January and May when elevations in the Sacramento River are amenable to fish passage
- ○ Adult California Central Valley steelhead in the event their presence overlaps with the defined seasonal window for other target species when elevations in the Sacramento River are amenable to fish passage
- ○ Adult Southern DPS green sturgeon between February and May when elevations in the Sacramento River are amenable to fish passage

Although not specifically identified as project objectives, additional pertinent objectives evaluated include the following.

- – Improve phenotypic diversity of juvenile winter-run and spring-run Chinook salmon
- – Increase abundances of returning adult winter-run and spring-run Chinook salmon

The following sections describe the estimated relative extent to which each alternative promotes the project objectives relative to Existing Conditions.

8.5.1 Improve Access to Seasonal Habitat Through Volitional Entry

The improvement in access of juvenile Chinook salmon to seasonal habitat in the Yolo Bypass through volitional entry was evaluated based on multiple methods that were applied by the Lead Agencies. Methodologies included the proportion of flow approach (DWR 2017a; Appendix G3), ELAM modeling (Smith et al. 2017), and a critical streakline analysis (Blake et al. 2017; Appendix G2). The proportion of flow approach was used to simulate entrainment benefits as input to the SBM, because it provides a consistent methodology to apply to all Alternatives, and is the only entrainment method available which simulates entrainment under Existing Conditions.

8.5.1.1 Proportion of Flow Approach

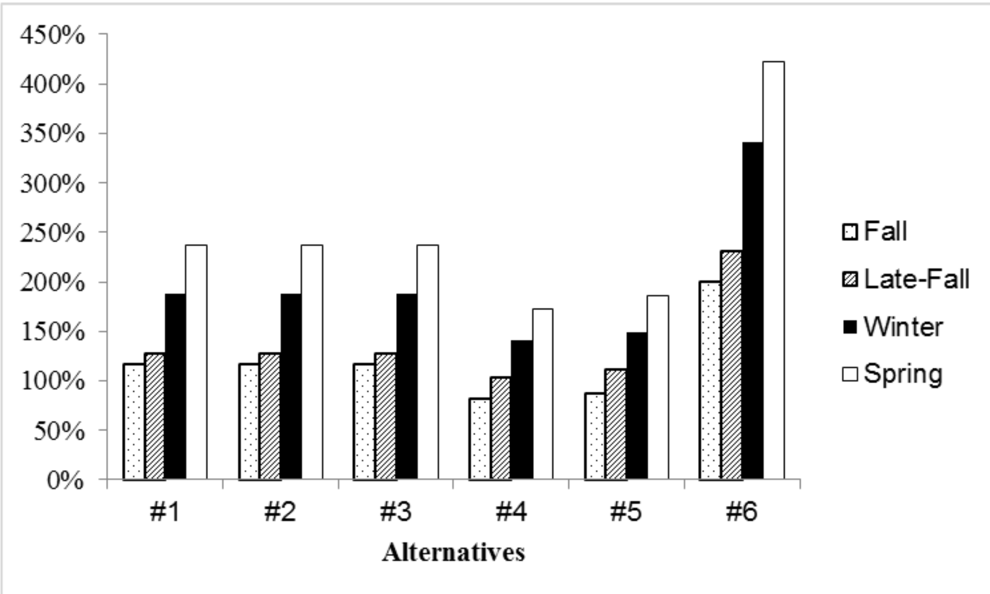
Average annual entrainment estimates indicate that Alternative 6 would entrain the largest percentage of juvenile Chinook salmon (all size classes) for all runs and a substantially larger percentage of juvenile fall-run, winter-run, and spring-run Chinook salmon than the other alternatives (Table 8-42). Alternatives 1 through 3 would entrain the second-largest percentage of juvenile Chinook salmon for each run. Average entrainment of each run would be similar under Alternatives 4 and 5 but higher under Alternative 5. The average annual increase in estimated entrainment of each Chinook salmon run for each alternative relative to Existing Conditions is shown in Figure 8-88.

Table 8-42. Average Annual Percentages of Juvenile Chinook Salmon Runs (All Sizes) Entrained onto the Yolo Bypass under the Alternatives and Existing Conditions (Proportion of Flow)

Run	Existing Conditions	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Fall	7.11%	15.40%	15.40%	15.40%	12.97%	13.27%	21.33%
Late Fall	2.57%	5.86%	5.86%	5.86%	5.23%	5.44%	8.53%
Winter	3.94%	11.33%	11.33%	11.33%	9.49%	9.78%	17.37%

Run	Existing Conditions	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Spring	3.07%	10.33%	10.33%	10.33%	8.35%	8.80%	16.06%

Source: DWR 2017a; Appendix G3

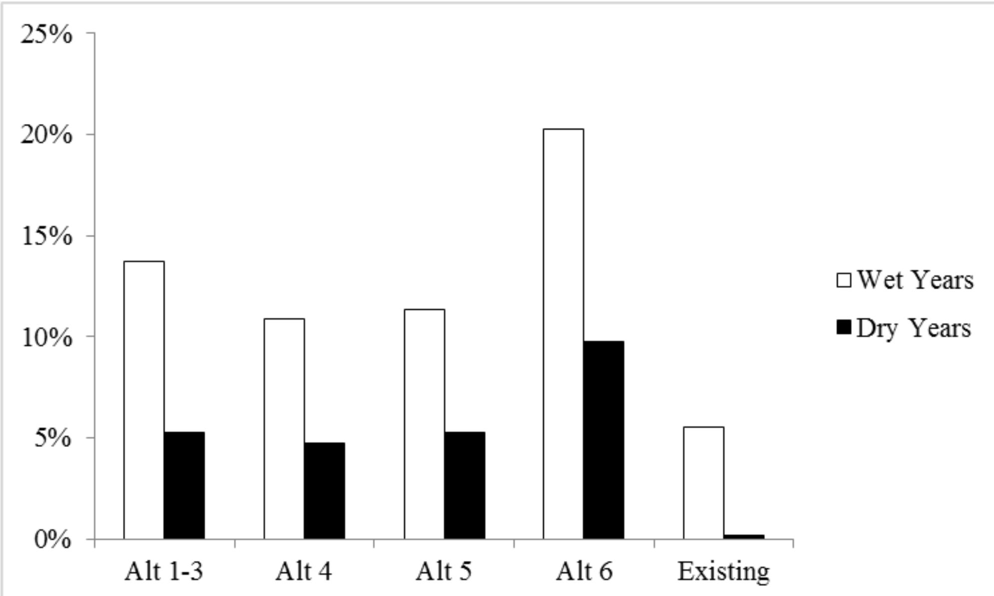


Source: DWR 2017a; Appendix G3

Figure 8-88. Average Annual Increase in the Percentage of the Total Population Index of Juvenile Chinook Salmon (All Sizes) Entrained onto the Yolo Bypass relative to Existing Conditions by Run (Proportion of Flow)

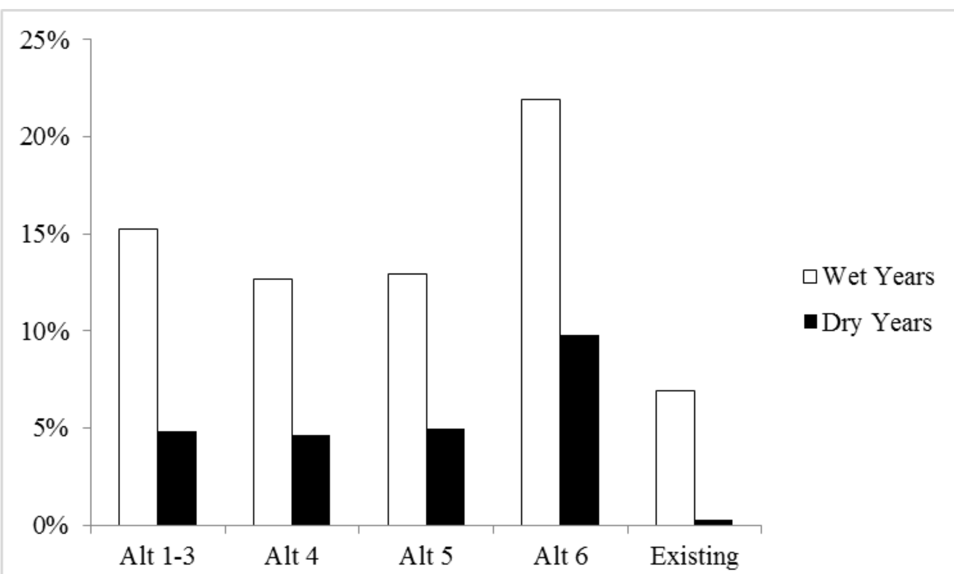
Average annual estimated entrainment of spring-run and winter-run Chinook salmon during wet (i.e., wet and above normal) water years and dry (i.e., dry and critical) water years among alternatives exhibits similar relative patterns as described for the average entrainment estimates over the entire simulation period (Figures 8-89 and 8-90) (DWR 2017a; Appendix G3). During wet and above normal water years, entrainment of spring-run and winter-run Chinook salmon would be highest under Alternative 6, second-highest under Alternatives 1 through 3, and lowest under Alternatives 4 and 5. However, during dry and critical water years, although entrainment would be highest under Alternative 6, entrainment would be generally similar under Alternatives 1 through 5. All alternatives would be particularly effective at increasing entrainment during dry and critical water years relative to Existing Conditions. During dry and critical years, naturally occurring spills over Fremont Weir would be rare and often short in duration, providing minimal opportunity for juveniles to access the Yolo Bypass (DWR 2017a; Appendix G3).

Based on the temporal distribution of juvenile spring-run Chinook salmon emigrating through the Sacramento River, juvenile spring-run Chinook salmon could still be migrating downstream into the Yolo Bypass after the end of the alternative's operational period in mid-March (DWR 2017a; Appendix G3). Because all alternatives except for Alternative 6 include the potential for extended but limited operation of the gates (up to available Tule Canal capacity, or about 300 cfs) into late March or early April as conditions allow, juvenile spring-run Chinook salmon may have an opportunity to enter the Yolo Bypass after mid-March under all alternatives except Alternative 6 (DWR 2017a; Appendix G3).



Source: DWR 2017a; Appendix G3

Figure 8-89. Mean Annual Entrainment of Juvenile Spring-run Chinook Salmon (All Sizes) onto the Yolo Bypass under the Alternatives and Existing Conditions (Proportion of Flow)



Source: DWR 2017a; Appendix G3

Figure 8-90. Mean Annual Entrainment of Juvenile Winter-run Chinook salmon (All Sizes) onto the Yolo Bypass under the Alternatives and Existing Conditions (Proportion of Flow)

Because it is assumed that entraining smaller juvenile Chinook salmon into the Yolo Bypass would be more beneficial due to the higher likelihood of smaller juveniles taking advantage of improved rearing habitat in the Yolo Bypass, DWR (2017a) also estimated the average annual percentages of each run entrained into the Yolo Bypass for juveniles less than 80 mm FL (Table 8-43).

Table 8-43. Average Annual Percentages of Juvenile Chinook Salmon (<80 mm FL) Runs Entrained onto the Yolo Bypass under the Alternatives and Existing Conditions (Proportion of Flow)

Run	Existing Conditions	Alternative 1	Alternative 2	Alternative 3	Alternative 4a	Alternative 4b	Alternative 5	Alternative 6
Fall	9.2%	15.3%	15.3%	15.3%	13.6%	12.9%	13.8%	20.0%
Late Fall	1.0%	1.1%	1.1%	1.1%	1.1%	1.1%	1.0%	1.2%
Winter	1.2%	7.1%	7.1%	7.1%	5.9%	5.9%	6.2%	12.0%
Spring	3.6%	10.6%	10.6%	10.6%	8.9%	8.7%	9.4%	16.1%

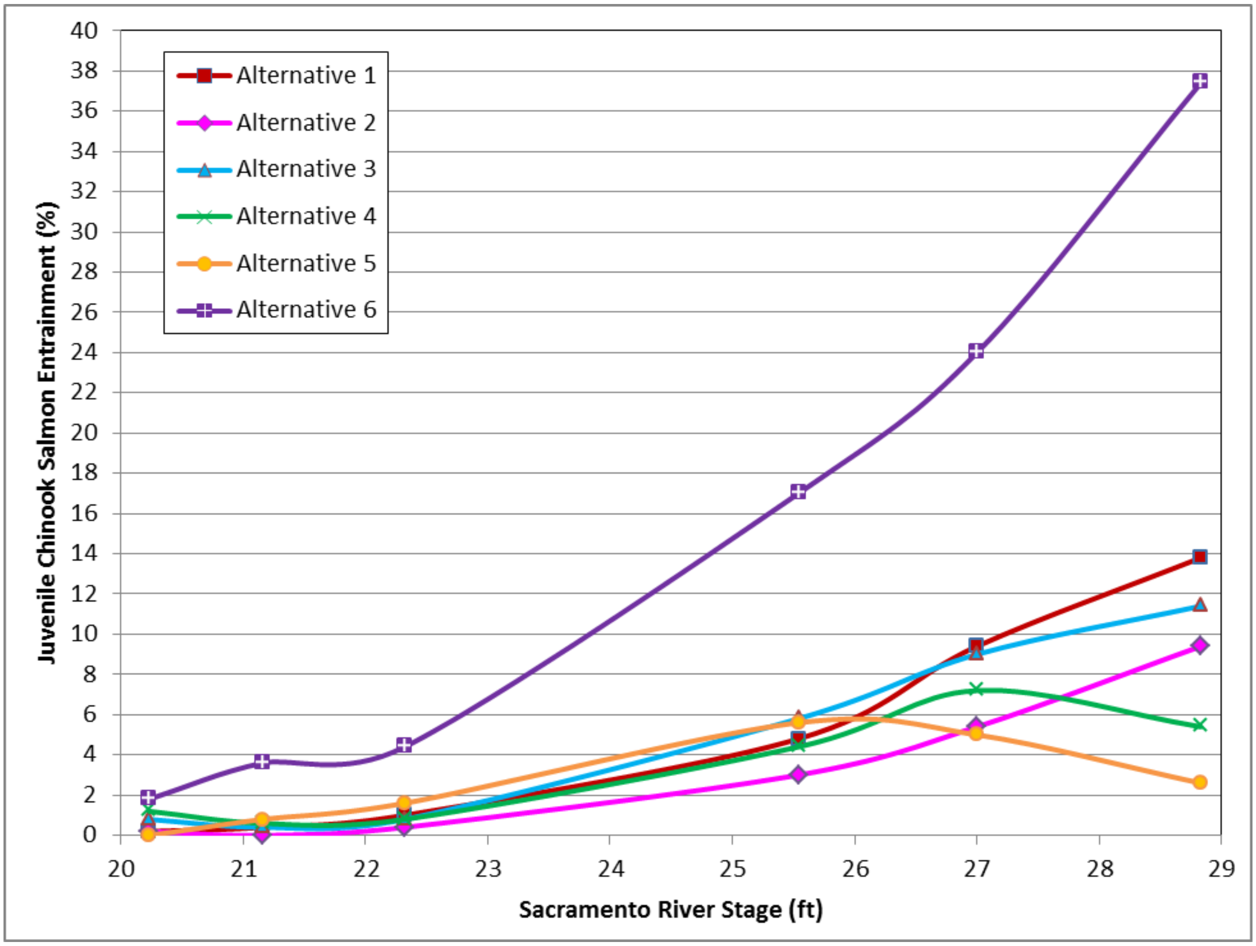
Source: DWR 2017a; Appendix G3

Relative to simulated entrainment of all sizes of juveniles, the proportion of flow entrainment approach indicates that for smaller juveniles (<80 mm), similar percentages of fall-run and spring-run Chinook salmon would be entrained under all alternatives, and fewer late fall-run and winter-run Chinook salmon would be entrained under all alternatives.

8.5.1.2 ELAM

The ELAM modeling also was used by the Lead Agencies to estimate relative entrainment rates of juvenile salmonids into the Yolo Bypass for each Alternative (see Appendix 1 of Smith et al. 2017). ELAM modeled relationships between the percentage of juvenile Chinook salmon entrained into the Yolo Bypass and Sacramento River stage at Fremont Weir are shown for all alternatives in Figure 8-91. However, the entrainment-discharge relationships shown for Alternatives 2 and 5 do not account for the proposed Sacramento River channel and bank improvements. With the improvements, entrainment under Alternative 5 would be expected to peak at approximately 10 percent (instead of six percent), and entrainment under Alternative 2 would be expected to peak at a rate higher than 10 percent.

The ELAM modeling indicates that larger notch flows generally entrain greater numbers of juveniles but not in proportion to the flow volume through the notch. Alternative 6 exhibits the strongest positive relationship between Sacramento River stage and entrainment rate across the entire range of modeled stages and would entrain more juveniles than the other alternatives. Alternative 1 would have the second-highest maximum entrainment rate (about 14 percent), followed by Alternatives 2 (greater than 10 percent), 3 (about 11 percent), and 5 (about 10 percent). Alternative 4 would have a relatively low maximum entrainment rate relative to other alternatives of about seven percent and would have a lower entrainment rate at the highest stage modeled (28.83 feet).



Reproduced from: Smith et al. 2017

Figure 8-91. Juvenile Entrainment-Sacramento River Stage Relationships for each Alternative (ELAM)

Overall, Alternative 6 would allow for the greatest entrainment rates with the greatest certainty based on the consistently positive entrainment-discharge relationship. Alternatives 1, 2, and 3 would provide the next-highest maximum entrainment rates, followed by Alternative 5. Alternative 4 would exhibit the lowest maximum entrainment rates.

8.5.1.3 Critical Streakline Analysis

The critical streakline analysis was conducted for Alternatives 3, 4, 5, and 6. However, although Alternative 5 would be located near the central portion of Fremont Weir, Alternative 5 was modeled at the western edge of Fremont Weir. Therefore, critical streakline entrainment estimates for Alternative 5 are not used for comparing entrainment rates among alternatives.

The critical streakline analysis estimated the average percentage of the total annual abundances of Chinook salmon juveniles by run entrained over the entire simulation period (Appendix G2, Table 8-44). Ninety percent confidence intervals are shown in parenthesis.

Table 8-44. Estimated Total Entrainment of each Chinook Salmon Run over the Entire Simulation Period (Critical Streakline)

Alternative	Estimated Total Entrainment (%)	Estimated Total Entrainment (%)	Estimated Total Entrainment (%)	Estimated Total Entrainment (%)
	Fall-run	**Late Fall-run**	**Winter-run**	**Spring-run**
3	12 (6-21)	5 (-12)	9 (2-17)	9 (4-15)
4	9 (2-21)	4 (0-11)	7 (2-15)	7 (4-14)
6	28 (12-43)	11 (0-38)	23 (4-42)	22 (6-42)

Reproduced from: Blake et al. 2017; Appendix G2

Consistent with the proportion of flow approach and the ELAM modeling, Alternative 6 was estimated to provide the greatest rates of entrainment for all runs due to the higher flow capacity of the notch. Alternative 3 would provide the second-highest rates of entrainment, followed by Alternatives 4 and 5, which would provide similar rates of entrainment for most runs, including winter-run and spring-run Chinook salmon.

8.5.1.4 Entrainment Summary

Entrainment results for each of the three methods by run and alternative are provided in Table 8-45. Alternative 6 would consistently entrain the highest percentages of each run, followed by Alternative 1, followed by Alternatives 2 and 3, then by Alternatives 4 and 5.

It should be noted that a modified version of Alternative 4 was modeled using the critical streakline analysis, assuming a lower rating curve to entrain water at a lower Sacramento River stage. This modified alternative scenario resulted in substantially higher entrainment benefits (14, 9, 16, and 13 percent for fall-run, late fall-run, winter-run, and spring-run, respectively) than shown for Alternative 4. Similar improvements in entrainment could be modeled for other Alternatives by making similar types of modifications.

Because the proportion of flow entrainment estimates were assumed in the SBM modeling, application of the critical streakline or ELAM entrainment estimates could result in reduced numbers of juveniles entrained into the Yolo Bypass and therefore could result in different benefits to juvenile and adult metrics than shown in this assessment for most alternatives.

Because the critical streakline entrainment analysis estimated a comparable annual entrainment metric for each run as the proportion of flow approach, relative differences in the SBM metrics were estimated based on using the critical streakline entrainment estimates relative to the proportion of flow entrainment estimates (for Alternatives 3, 4, and 6). For Alternatives 3 and 4, reduced critical streakline entrainment estimates relative to the proportion of flow estimates indicate that fewer juveniles would be entrained into the Yolo Bypass; therefore, benefits shown for the SBM juvenile and adult metrics would be reduced with the critical streakline entrainment rates. However, for Alternative 6, application of the proportion of flow entrainment estimates underestimate the number of juveniles entrained into the Yolo Bypass relative to the critical streakline analysis; therefore, the SBM output may underestimate the benefits of Alternative 6 with respect to the juvenile and adult metrics relative to the other alternatives.

Table 8-45. Summary of Entrainment Estimates by Alternative and Chinook Salmon Run (All Sizes)

Method	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Fall-run Chinook Salmon						
Proportion of Flow[1]	15.4%	15.4%	15.4%	13.0%	13.3%	21.3%
ELAM[2]	14%	>10%	11%	7%	10%	37%
Critical Streakline[3]	n/a	n/a	12%	9%	n/a	28%
Late Fall-run Chinook Salmon						
Proportion of Flow	5.9%	5.9%	5.9%	5.2%	5.4%	8.5%
ELAM	14%	>10%	11%	7%	10%	37%
Critical Streakline	n/a	n/a	5%	4%	n/a	11%
Winter-run Chinook Salmon						
Proportion of Flow	11.3%	11.3%	11.3%	9.5%	9.8%	17.4%
ELAM	14%	>10%	11%	7%	10%	37%
Critical Streakline	n/a	n/a	9%	7%	n/a	23%
Spring-run Chinook Salmon						
Proportion of Flow	10.3%	10.3%	10.3%	8.4%	8.8%	16.1%
ELAM	14%	>10%	11%	7%	10%	37%
Critical Streakline	n/a	n/a	9%	7%	n/a	22%

[1] Estimated total entrainment percentage of each run over the simulation period

[2] Maximum entrainment rate on the entrainment-Sacramento River stage relationship (not run-specific)

[3] Estimated average annual percentages of each run entrained over the simulation period

8.5.2 Increase Access to and Acreage of Seasonal Floodplain Fisheries Rearing Habitat

Changes in access to and use of seasonal floodplain habitat in the Yolo Bypass were evaluated for each alternative based on the potential for juvenile entrainment into the Yolo Bypass (discussed above) and modeled abundance of juveniles rearing on the Yolo Bypass for one or more days. Because not all juveniles entrained into the Yolo Bypass would necessarily spend time rearing in the Yolo Bypass, the simulated number of juveniles rearing in the Yolo Bypass would differ from the number of juveniles entrained into the Yolo Bypass. Changes in acreage of floodplain habitat were evaluated for each alternative based on the modeled changes in area of habitat in the Yolo Bypass based on hydraulic habitat suitability criteria applied for Chinook salmon pre-smolts and smolts. Because the proportion of flow approach was used to estimate juvenile entrainment into the Yolo Bypass for the SBM, the following model results shown for Alternative 1 also apply to Alternatives 2 and 3.

8.5.2.1 Rearing in the Yolo Bypass

8.5.2.1.1 Spring-run Chinook Salmon

Modeling results indicate that annual average abundance of juvenile spring-run Chinook salmon rearing for one or more days in the Yolo Bypass would be highest under Alternative 6 and second-highest under Alternatives 1 through 3 (Table 8-46). Annual average abundance of juveniles rearing for one or more days in the Yolo Bypass under Alternatives 4a, 4b, and 5 would be similar over the entire simulation period and by water year type and generally lower than under Alternatives 6 and 1 through 3. The largest differences (increases) in numbers of juveniles rearing under Alternatives 1 through 3 relative to Alternatives 4a, 4b, and 5 would occur during wet, above normal, and below normal water years, with less differences during dry and critical water years.

Table 8-46. Average Annual Abundance of Juvenile Spring-run Chinook Salmon that Reared in the Yolo Bypass for One or More Days under each Alternative and Existing Conditions

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Existing Conditions	32,657	72,311	41,409	1,894	70	0
Alternatives 1-3	93,719	193,287	78,417	24,560	28,243	42,004
Alternative 4a	75,020	149,586	70,133	16,564	23,793	38,668
Alternative 4b	74,738	149,487	70,172	16,343	22,943	38,668
Alternative 5	80,948	161,542	72,070	18,363	27,482	43,648
Alternative 6	135,799	274,475	101,164	46,113	48,635	74,347

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

Similar to the results described for the annual average number of juvenile spring-run Chinook salmon rearing for one or more days in the Yolo Bypass, the probability of exceedance distributions shows similar differences among alternatives (Figure 8-92[10]). The number of juvenile spring-run Chinook salmon rearing in the Yolo Bypass for one or more days would be highest under Alternative 6 over the entire distribution, followed by Alternatives 1 through 3, which would result in similar or higher numbers of juveniles rearing in the Yolo Bypass over the distribution relative to Alternatives 4a, 4b, and 5. The numbers of juveniles rearing in the Yolo Bypass for one or more days would be generally similar over most of the distribution under Alternatives 4a, 4b, and 5 but higher over portions of the distribution under Alternative 5.

All alternatives would provide for substantially higher numbers of juvenile spring-run Chinook salmon rearing in the Yolo Bypass for one or more days over the entire distribution relative to Existing Conditions. All alternatives would provide for some spring-run Chinook salmon juvenile rearing in the Yolo Bypass over about 30 percent of the distribution when very few or no juveniles would be rearing in the Yolo Bypass under Existing Conditions.

[10] Inset figure is displaying the same data with a truncated y-axis to allow for better visual observation of the differences among the alternatives and Existing Conditions

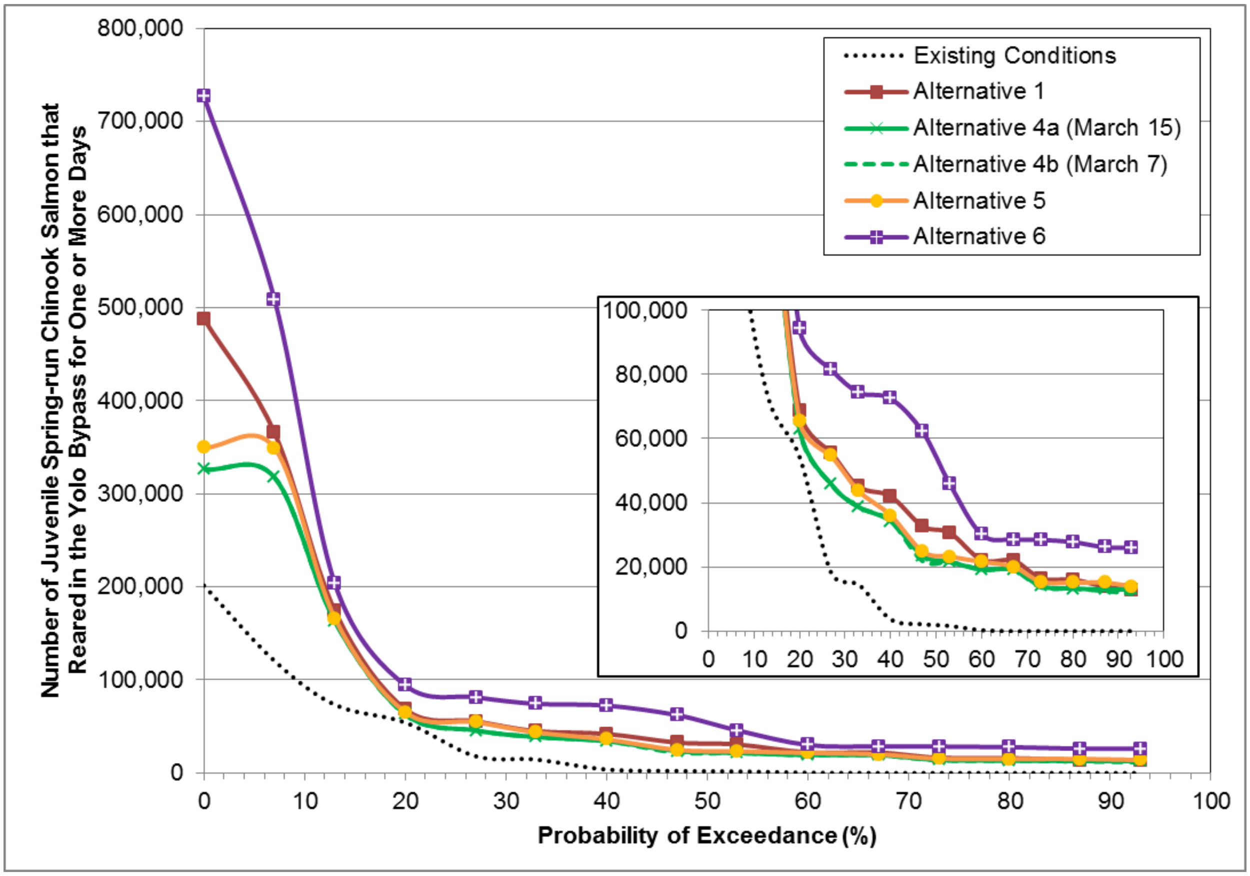


Figure 8-92. Simulated Number of Juvenile Spring-run Chinook Salmon that Reared in the Yolo Bypass for One or More Days Probability of Exceedance Distributions under each Alternative and Existing Conditions

8.5.2.1.2 Winter-run Chinook Salmon

Modeling results indicate that annual average abundance of juvenile winter-run Chinook salmon rearing for one or more days in the Yolo Bypass would be highest under Alternative 6 and second-highest under Alternatives 1 through 3 over the entire simulation period and during most water year types (Table 8-47). Simulated annual average abundance of juveniles rearing for one or more days in the Yolo Bypass would be higher under Alternative 5 relative to Alternatives 4a and 4b over the entire simulation period and by water year type. During dry and critical water years, Alternative 5 would result in higher numbers of juveniles rearing in the Yolo Bypass relative to Alternatives 1 through 3.

Table 8-47. Average Annual Number of Juvenile Winter-run Chinook Salmon that Reared in the Yolo Bypass for One or More Days under each Alternative and Existing Conditions

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Existing Conditions	28,031	54,261	46,976	3,552	283	0
Alternatives 1-3	66,153	104,777	85,621	38,842	28,468	19,998
Alternative 4a	57,512	93,169	76,158	22,429	26,186	18,765
Alternative 4b	57,287	93,072	76,121	22,322	25,544	18,765
Alternative 5	61,011	97,614	77,902	26,558	29,824	20,975
Alternative 6	100,687	149,659	112,109	79,044	57,938	35,845

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

Similar to the results described for the annual average abundance of juvenile winter-run Chinook salmon rearing for one or more days in the Yolo Bypass, the probability of exceedance distributions shows similar differences among alternatives (Figure 8-93). The number of juvenile winter-run Chinook salmon rearing in the Yolo Bypass would be highest under Alternative 6 over the entire distribution, followed by Alternatives 1 through 3, then Alternative 5, and followed by Alternatives 4a and 4b.

All alternatives would provide for substantially higher numbers of juvenile winter-run Chinook salmon rearing on the Yolo Bypass over the entire distribution relative to Existing Conditions. All alternatives would provide for some winter-run Chinook salmon juvenile rearing on the Yolo Bypass over about 30 percent of the distribution when very few or no juveniles would be rearing in the Yolo Bypass under Existing Conditions.

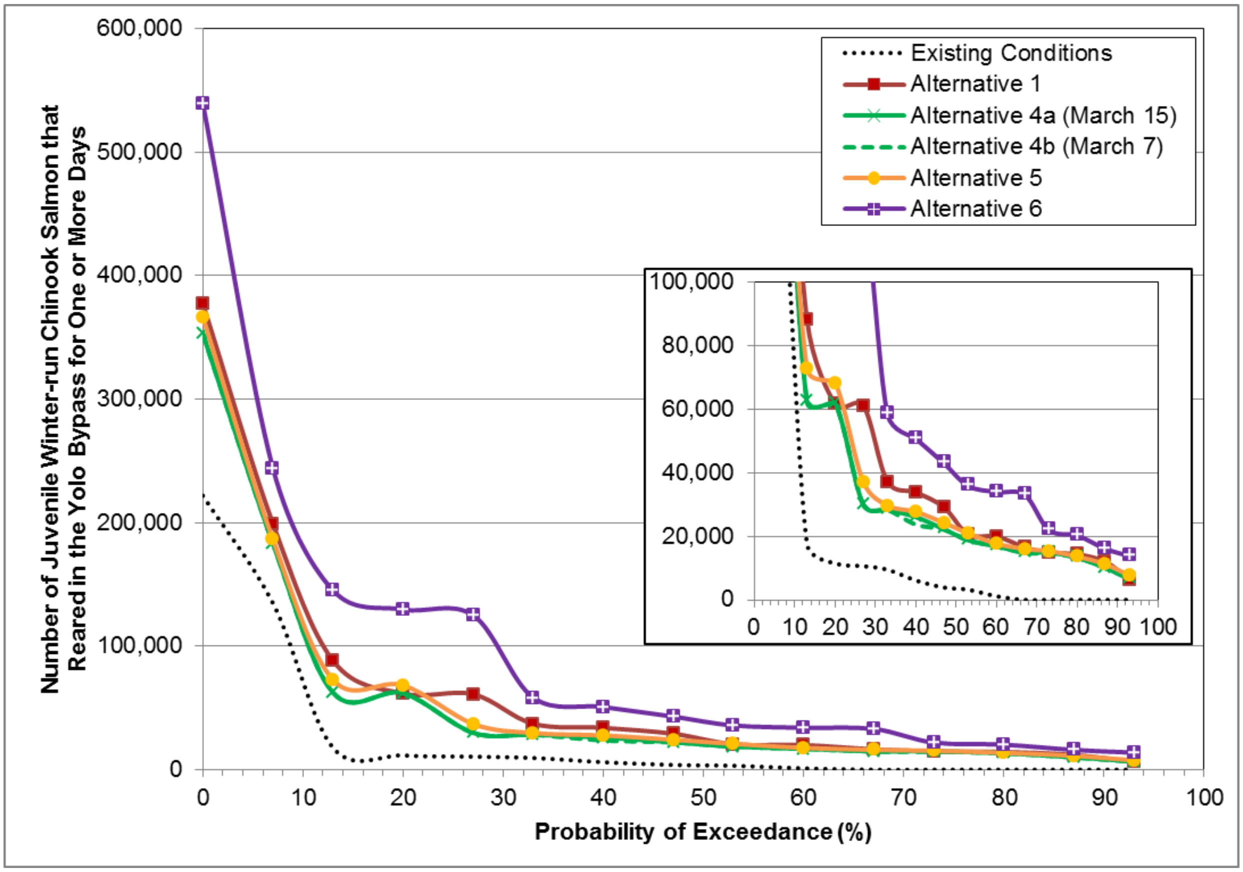


Figure 8-93. Simulated Number of Juvenile Winter-Run Chinook Salmon that Reared in the Yolo Bypass for One or More Days Probability of Exceedance Distributions under each Alternative and Existing Conditions

8.5.2.2 Flow-Dependent Habitat Availability

8.5.2.2.1 Chinook Salmon Pre-Smolt Habitat

Modeling results indicate that average monthly hydraulic habitat availability over the entire simulation period for Chinook salmon pre-smolts in the Yolo Bypass would be generally similar under all alternatives and Existing Conditions in October, November, April, and May and higher under all alternatives from December through March relative to Existing Conditions (Table 8-48). Average monthly pre-smolt hydraulic habitat availability would be generally higher from December through March under Alternatives 4a, 4b, and 6 than the other alternatives over the entire simulation period and during most water year types.

Table 8-48. Average Monthly Area of Pre-smolt Chinook Salmon Hydraulic Habitat in the Yolo Bypass from October through May based on TUFLOW Modeling (Water Year 1997 to 2012)

Alternative	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)
	October	**November**	**December**	**January**	**February**	**March**	**April**	**May**
Entire Simulation Period[1] (n=16)								
Existing Conditions	20	21	31	48	44	47	37	27
Alternative 1	20	22	39	56	56	52	37	27
Alternative 4a	20	22	42	60	63	57	38	28
Alternative 4b	20	22	42	60	63	53	37	27
Alternative 5	20	22	38	55	56	53	37	28
Alternative 6	20	22	42	58	62	56	37	27
Water Year Types[2]								
Wet (n=5)								
Existing Conditions	20	21	38	49	57	69	58	32
Alternative 1	20	22	56	59	70	72	58	32
Alternative 4a	20	23	59	60	71	74	59	32
Alternative 4b	20	23	59	60	71	72	59	32
Alternative 5	20	22	52	56	68	73	59	32
Alternative 6	20	23	62	61	73	74	59	32
Above Normal (n=3)								
Existing Conditions	20	22	36	67	41	48	37	38
Alternative 1	20	22	39	79	65	51	36	37
Alternative 4a	20	22	43	81	69	57	37	38
Alternative 4b	20	22	43	81	69	54	37	38
Alternative 5	20	22	39	78	65	52	37	38
Alternative 6	20	22	40	82	76	55	37	38
Below Normal (n=3)								
Existing Conditions	20	21	25	45	42	40	27	21
Alternative 1	20	21	29	54	51	44	27	21
Alternative 4a	20	21	31	56	60	49	27	21
Alternative 4b	20	21	31	56	60	45	27	21
Alternative 5	20	21	29	54	52	45	27	21
Alternative 6	20	21	32	56	56	47	27	21
Dry (n=4)								
Existing Conditions	20	21	26	36	27	29	22	20
Alternative 1	20	21	29	38	33	40	22	20

Alternative	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)
	October	**November**	**December**	**January**	**February**	**March**	**April**	**May**
Alternative 4a	20	21	34	48	48	46	23	20
Alternative 4b	20	21	34	48	48	40	22	20
Alternative 5	20	21	30	39	34	39	23	20
Alternative 6	20	21	33	40	38	45	22	20
Critical (n=1)								
Existing Conditions	20	21	21	40	58	28	22	21
Alternative 1	20	21	22	46	70	33	22	20
Alternative 4a	20	21	23	56	78	42	23	21
Alternative 4b	20	21	23	56	78	37	23	20
Alternative 5	20	21	22	47	70	34	23	21
Alternative 6	20	21	22	52	77	37	23	20

[1] Based on modeled average daily values over a 16-year simulation period (water years 1997 through 2012)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

Key: km^2 = square kilometer

Chinook salmon pre-smolt hydraulic habitat availability would be similar over the exceedance distributions for all alternatives and Existing Conditions over the highest ~40 percent of the distribution (when habitat availability is lowest) (Figure 8-94). Alternatives 4a and 4b would provide substantially more hydraulic habitat than the other alternatives over the middle ~25 percent of the distributions. Over the lowest ~25 percent of the distributions (when habitat availability is highest), Alternative 6 would provide more pre-smolt hydraulic habitat relative to the other alternatives, whereas Alternatives 1 through 5 would provide similar amounts of hydraulic habitat. All alternatives would provide substantially more pre-smolt hydraulic habitat relative to Existing Conditions over about 30 to 50 percent of the distributions.

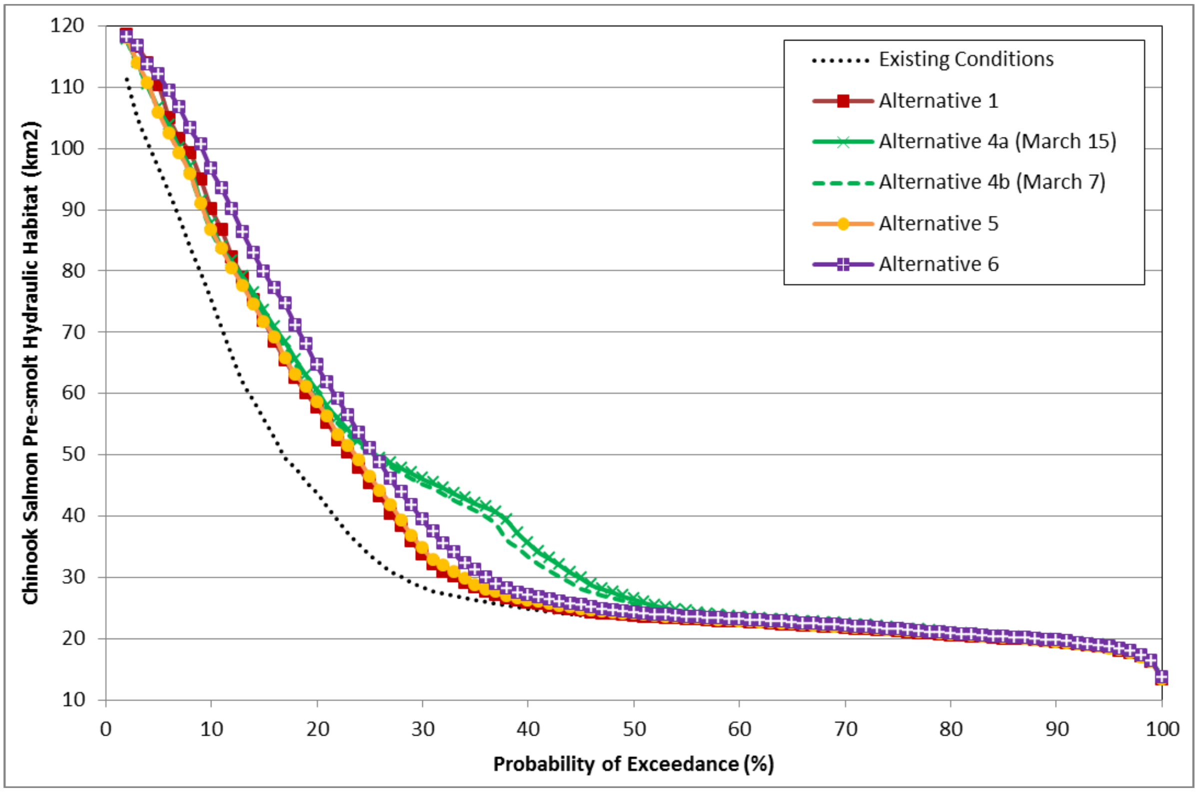


Figure 8-94. Simulated Chinook Salmon Pre-Smolt Hydraulic Habitat Availability Probability of Exceedance Distributions under All Alternatives and Existing Conditions from October through May based on TUFLOW Modeling (Water Years 1997 through 2012)

8.5.2.2.2 Chinook Salmon Smolt Habitat

Modeling results indicate that average monthly hydraulic habitat availability over the entire simulation period for Chinook salmon smolts in the Yolo Bypass would be generally similar under all alternatives and Existing Conditions in October, November, April, and May and higher under all alternatives from December through March relative to Existing Conditions (Table 8-49). Average monthly smolt hydraulic habitat availability would be generally higher under Alternatives 4a, 4b, and 6 relative to the other alternatives over the entire simulation period and by water year type.

Table 8-49. Average Monthly Area of Chinook Salmon Smolt Hydraulic Habitat in the Yolo Bypass from October through May based on TUFLOW Modeling (Water Years 1997 through 2012)

Alternative	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)
	October	**November**	**December**	**January**	**February**	**March**	**April**	**May**
Entire Simulation Period[1] (n=16)								
Existing Conditions	32	32	44	70	70	76	59	43
Alternative 1	32	32	53	81	83	82	59	43
Alternative 4a	32	33	56	85	91	87	60	43
Alternative 4b	32	33	56	85	91	83	59	43
Alternative 5	32	32	52	79	83	82	59	43
Alternative 6	32	33	58	86	91	86	59	43
Water Year Types[2]								
Wet (n=5)								
Existing Conditions	31	32	55	90	101	119	100	51
Alternative 1	32	33	75	102	115	124	100	50
Alternative 4a	32	34	78	104	116	126	101	51
Alternative 4b	32	34	78	103	116	123	101	51
Alternative 5	31	33	70	99	113	124	100	51
Alternative 6	32	34	85	107	121	127	100	50
Above Normal (n=3)								
Existing Conditions	32	33	48	82	68	77	50	55
Alternative 1	32	33	53	100	93	80	50	54
Alternative 4a	32	33	57	101	98	86	51	55
Alternative 4b	32	33	57	101	98	83	51	55
Alternative 5	32	33	52	97	92	81	51	55
Alternative 6	32	33	55	107	105	84	51	54
Below Normal (n=3)								
Existing Conditions	32	32	36	58	62	63	41	35
Alternative 1	32	32	40	70	72	67	41	35
Alternative 4a	32	32	42	71	83	72	41	35
Alternative 4b	32	32	42	71	83	68	41	35
Alternative 5	32	32	41	68	73	68	41	35
Alternative 6	32	32	44	75	79	71	41	35
Dry (n=4)								
Existing Conditions	32	32	37	49	38	41	34	33
Alternative 1	32	32	40	53	45	52	34	33

Alternative	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)
	October	**November**	**December**	**January**	**February**	**March**	**April**	**May**
Alternative 4a	32	32	45	63	61	59	35	33
Alternative 4b	32	32	45	63	60	52	34	33
Alternative 5	32	32	41	53	45	52	34	34
Alternative 6	32	32	44	56	50	59	34	33
Critical (n=1)								
Existing Conditions	31	31	31	52	70	39	34	34
Alternative 1	31	31	31	59	85	44	34	34
Alternative 4a	31	31	33	70	94	54	35	34
Alternative 4b	31	31	33	70	94	49	35	34
Alternative 5	31	31	31	60	85	45	35	34
Alternative 6	31	31	32	65	94	49	35	34

[1] Based on modeled average daily values over a 16-year simulation period (water years 1997 through 2012)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

Key: km^2 = square kilometer

Chinook salmon smolt hydraulic habitat availability would be similar over the cumulative probability of exceedance distributions for all alternatives and Existing Conditions over the highest ~40 percent of the distribution (when habitat availability is lowest) (Figure 8-95). Alternatives 4a and 4b would provide more hydraulic habitat than the other alternatives over the middle ~25 percent of the distributions. Over the lowest ~25 percent of the distributions (when habitat availability is highest), Alternative 6 would provide more smolt hydraulic habitat relative to the other alternatives, whereas Alternatives 1 through 5 would provide similar amounts of hydraulic habitat. All alternatives would provide substantially more smolt hydraulic habitat relative to Existing Conditions over about 30 to 50 percent of the distributions.

As previously discussed, changes in estimated hydraulic habitat availability for Chinook salmon smolts is expected to be generally representative of potential changes in hydraulic habitat availability for juvenile steelhead.

Overall, there would not be substantial differences in average monthly hydraulic habitat availability over the entire simulation period for Chinook salmon pre-smolts and smolts among the alternatives. However, Alternatives 4 and 6 would provide more hydraulic habitat than the other alternatives during some months and water years. Because Alternative 6 would provide more hydraulic habitat than the other alternatives when hydraulic habitat availability is relatively high (i.e., >70 km^2) and Alternative 4 would provide more hydraulic habitat when hydraulic habitat availability is relatively low (i.e., about 40-60 km^2), Alternative 4 may be the best-performing alternative in providing increased amounts of suitable hydraulic floodplain habitat, followed by Alternative 6. Alternatives 1 through 3 and 5 would provide less but similar amounts of hydraulic habitat. However, the programmatic floodplain improvements associated with Alternative 5 may provide increased hydraulic habitat for a longer duration in the area upstream of the proposed water control structure relative to Alternatives 1 through 3.

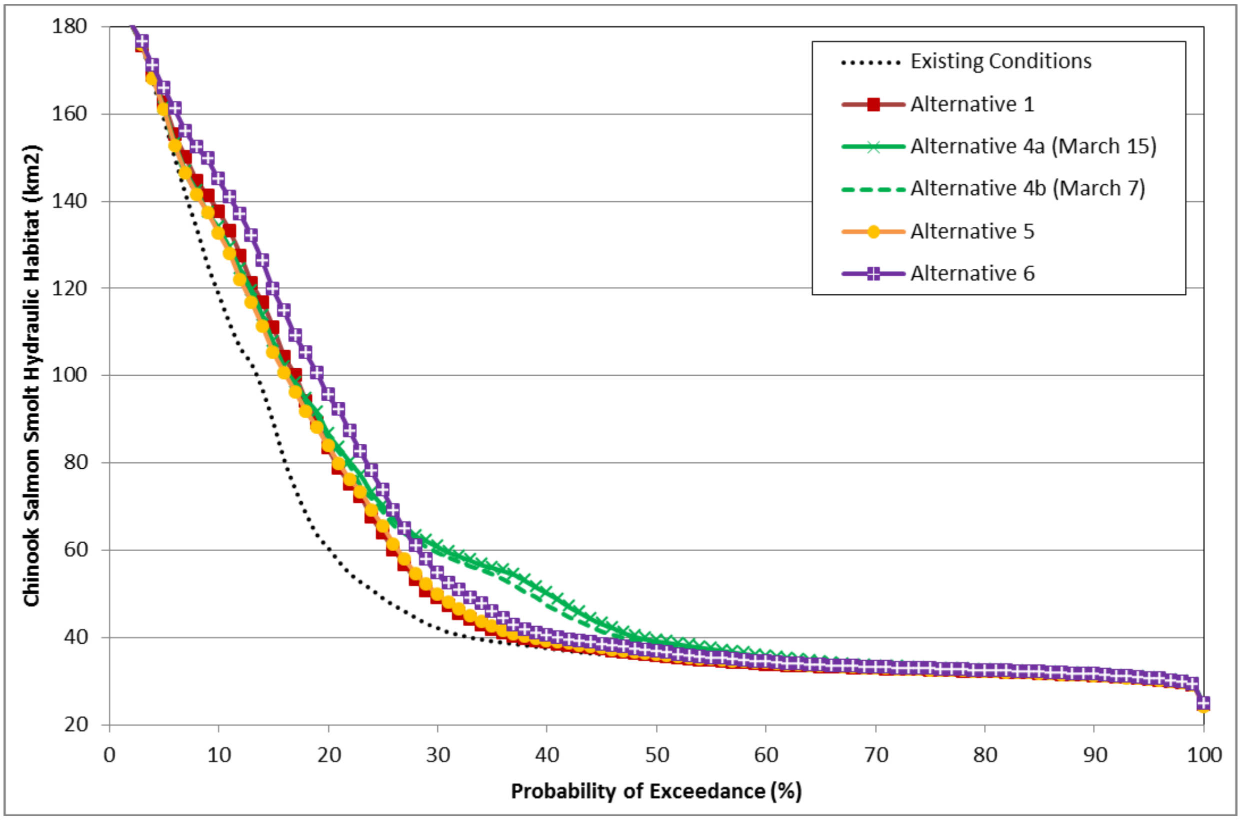


Figure 8-95. Simulated Chinook Salmon Smolt Hydraulic Habitat Availability Probability of Exceedance Distributions under All Alternatives and Existing Conditions based on TUFLOW Modeling (Water Years 1997to 2012)

Although not quantitatively evaluated, it should be noted that retaining water on the floodplain under Alternative 4 (and the programmatic improvements under Alternative 5) would have higher potential for creating less suitable water temperature, dissolved oxygen, and piscivorous predation conditions for juvenile Chinook salmon relative to the other alternatives.

8.5.3 Reduce Stranding and Presence of Migration Barriers

All Project alternatives include construction of at least one transport channel in the Yolo Bypass to allow migration of juvenile and adult fishes between one or more intake facilities and the Tule Pond. Therefore, during conditions when water is not overtopping the Fremont Weir and sufficient water is flowing through the intake facilities and transport channel, all Project alternatives would reduce the potential for temporary or permanent juvenile and adult stranding in the upper region of Yolo Bypass relative to Existing Conditions. In addition, all Project alternatives include the remediation of Agricultural Road Crossing 1 on the Tule Canal to provide for more suitable passage conditions through Tule Canal more frequently relative to Existing Conditions.

Variables that differ among alternatives that could potentially influence stranding include the size of the transport channels, the complexity of the intake facilities, the location of the intake facilities and supplemental passage facilities, and additional alternative-specific features such as the water control structures and bypass channels under Alternative 4 and under the programmatic elements of Alternative 5.

For alternatives with a wider transport channel or with multiple transport channels, there is the potential that under relatively low-flow conditions, there could be increased potential for stranding relative to alternatives with one transport channel that is relatively smaller. Therefore, based on the size and complexity of the transport channel(s), there may be relatively less potential for fish stranding in the transport channels under Alternatives 1 through 4 relative to Alternatives 5 and 6 (Table 8-50). Alternative 5 includes multiple transport channels of varying widths that are greater than the transport channel widths under Alternatives 1 through 4, which may result in less consistent flows through each of the transport channels. In addition, because Alternative 5 has substantially more gates being operated at the intake facility than the other alternatives, there could be additional potential for more variable flows through one or more of the transport channels, resulting in a higher potential for fish stranding relative to the other alternatives. Alternative 6 has a relatively wider transport channel than all other alternatives, resulting in a greater potential for fish stranding during low-flow conditions in the transport channel.

The locations of the intake facilities and supplemental passage facilities for Alternatives 2 and 5 may allow for increased potential for adult fish stranding relative to the other alternatives near Fremont Weir. The intake facility would be in the central portion of the weir, and the supplemental passage facility would be located at the western portion of the weir, which could result in continued stranding of adult fish near the eastern portion of Fremont Weir as flows recede.

In addition to differences in the potential for fish stranding in the transport channels, Alternative 4 includes two water control structures on the Tule Canal and two bypass channels going around the water control structures. The operation of the water control structures and bypass channels allow for additional potential for fish stranding in the Tule Canal or in the bypass channels under variable or low-flow conditions. The programmatic component of Alternative 5 also includes a water control structure on the Tule Canal and a bypass channel, increasing the potential for fish stranding under variable or low-flow conditions.

Overall, it is expected that Alternatives 1 and 3 would provide the least potential for stranding and fish passage impediments, followed by Alternatives 2 and 6, then by Alternatives 4 and 5. Adult fish passage through the Yolo Bypass into the Sacramento River is addressed in Section 8.5.6.

Table 8-50. Dimensions of the Notches and Transport Channels under each Alternative

Alternative		Maximum Design Discharge (cfs)	Gated Notch	Description	Transport Channel Description	Transport Channel Description	Transport Channel Description
			Dimensions	Invert elevations	Bottom width (ft)	Bench bottom width (ft)	Side slope
1.	Eastern Alignment	6,000	Gate 1: 18 x 34 ft; Gates 2 & 3: 14 x 27 ft	Gate 1: 14-ft; Gates 2 & 3: 18-ft	30	30	3:1
2.	Central Alignment	6,000	Gate 1: 17 x 40 ft; Gates 2 & 3: 13 x 27 ft	Gate 1: 14.8-ft; Gates 2 & 3: 18.8-ft	50	30	3:1
3.	Western Alignment	6,000	Gate 1: 16 x 40 ft; Gates 2 & 3: 12 x 27 ft	Gate 1: 16.1-ft; Gates 2 & 3: 20.1-ft	60	30	3:1
4.	Western Alignment	3,000	Gate 1: 16 x 40 ft; Gates 2 & 3: 12 x 27 ft	Gate 1: 16.1-ft; Gates 2 & 3: 20.1-ft	60	30	3:1
5.	Central Alignment	3,400	27 Gates; Intakes A, B & C: 10 ft x 10 ft; Intake D: 10 ft x 7 ft	Intake A: 14-ft; Intake B: 17-ft; Intake C: 20-ft; Intake D: 23-ft	Intakes A & B: 80; Intake C: 130; Intake D: 142	N/A	3:1
6.	Western Alignment	12,000	Gates 1-5: 14 x 40 ft	16.1-ft Invert	200	N/A	3:1

Source: DWR 2017b; Appendix G5

Key: cfs= cubic feet per second; ft= feet

8.5.4 Increase Aquatic Primary and Secondary Biotic Production to Provide Food Through an Ecosystem Approach

All Project alternatives would result in increased frequency and duration of inundation of the Yolo Bypass relative to Existing Conditions. An increase in frequency and duration of inundation of shallow-water habitat in the Yolo Bypass would be expected to increase primary production in the Yolo Bypass (Lehman et al. 2007). Therefore, all Project alternatives would be expected to increase primary and potentially secondary production in the Yolo Bypass relative to Existing Conditions.

Modeled wetted extent of the Yolo Bypass (i.e., area with a water depth greater than zero ft) under the alternatives was used as an indicator of relative changes in inundation and associated primary and secondary production. Average monthly wetted area over the entire simulation period would be similar among all alternatives in October, November, April, and May (Table 8-51). From December through March, Alternatives 4a, 4b, and 6 would provide more average monthly wetted area than Alternatives 1 through 3 and 5 over the entire simulation period. Similar trends in wetted area among the alternatives would occur during wetter water years. During dry and critical water years, Alternatives 4a and 4b would provide more wetted area than all other alternatives during most months between December and March.

Table 8-51. Average Monthly Wetted Area in the Yolo Bypass from October through May based on TUFLOW Modeling

Alternative	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)	Wetted Area (km^2)
	October	**November**	**December**	**January**	**February**	**March**	**April**	**May**
Entire Simulation Period[1] (n=16)								
Existing Conditions	48	48	64	105	106	108	86	64
Alternatives 1-3	48	49	73	116	121	115	86	64
Alternative 4a	48	50	77	120	129	120	87	64
Alternative 4b	48	49	77	120	129	116	86	64
Alternative 5	48	49	72	114	121	115	86	64
Alternative 6	48	49	79	121	129	119	86	64
Water Year Types[2]								
Wet (n=5)								
Existing Conditions	48	49	79	154	162	163	145	78
Alternatives 1-3	48	50	100	167	177	169	145	77
Alternative 4a	48	51	103	168	178	171	146	77
Alternative 4b	48	51	103	168	178	168	146	77
Alternative 5	47	50	96	163	174	168	146	78
Alternative 6	48	51	111	172	182	172	145	77
Above Normal (n=3)								
Existing Conditions	49	50	68	108	100	112	73	77
Alternatives 1-3	49	50	72	124	127	116	72	77
Alternative 4a	49	50	77	126	131	123	73	77
Alternative 4b	49	50	76	125	131	119	72	77
Alternative 5	48	50	72	122	126	117	73	77
Alternative 6	49	50	74	131	139	120	72	77
Below Normal (n=3)								
Existing Conditions	48	48	54	79	92	90	60	52
Alternatives 1-3	48	48	58	91	103	95	60	52
Alternative 4a	48	48	60	92	113	101	60	52
Alternative 4b	48	48	60	92	113	96	60	52
Alternative 5	48	48	59	90	104	95	60	53
Alternative 6	48	48	62	97	110	99	60	52
Dry (n=4)								
Existing Conditions	48	48	55	68	56	60	50	50
Alternatives 1-3	48	48	59	72	64	73	51	50

Alternative	Wetted Area (km²)	Wetted Area (km²)	Wetted Area (km²)	Wetted Area (km²)	Wetted Area (km²)	Wetted Area (km²)	Wetted Area (km²)	Wetted Area (km²)
	October	**November**	**December**	**January**	**February**	**March**	**April**	**May**
Alternative 4a	48	48	64	84	81	81	51	50
Alternative 4b	48	48	64	84	81	73	51	50
Alternative 5	48	48	60	73	65	73	51	50
Alternative 6	48	48	63	76	70	81	51	50
Critical (n=1)								
Existing Conditions	47	47	47	74	96	58	51	51
Alternatives 1-3	47	47	47	82	111	65	51	51
Alternative 4a	47	47	49	93	120	76	52	51
Alternative 4b	47	47	49	93	120	71	52	51
Alternative 5	47	47	47	83	111	66	52	51
Alternative 6	47	47	47	89	121	70	51	51

[1] Based on modeled average daily values over a 16-year simulation period (water years 1997 through 2012)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

Key: km^2 = square kilometer

Wetted area would be similar over the cumulative probability of exceedance distributions for all alternatives and Existing Conditions over the highest ~60 percent of the distributions (when wetted area is lowest) (Figure 8-96). Wetted area would be highest under Alternatives 4a and 4b over about the middle ~25 percent of the distributions. Over the lowest ~30 percent of the distributions (when wetted area is highest), Alternative 6 would provide more wetted area than the other alternatives. Alternatives 1 through 3 and 5 would provide similar amounts of wetted area over most of the distributions but would provide more wetted area than Existing Conditions.

Overall, there would not be substantial differences in average monthly wetted area over the entire simulation period in the Yolo Bypass among the alternatives. However, Alternatives 4 and 6 would provide more wetted area than the other alternatives during some months and water years. Because Alternative 6 would provide more wetted area than the other alternatives when wetted area is relatively high and Alternative 4 would provide more wetted area when wetted area is relatively lower, Alternative 4 may be the best-performing alternative in providing increased amounts of wetted area, followed by Alternative 6.

Although the probability of exceedance distributions facilitates the assessment of general changes in simulated wetted area among the alternatives, assessing the wetted area daily time series may better inform potential differences in promoting primary and secondary production in the Yolo Bypass among the alternatives. In contrast to exceedance distributions, daily time series allow for a visual assessment of the duration of a given wetted area during a particular year. As previously described in the Environmental Setting section, promoting primary (and secondary) production in the Yolo Bypass requires that areas be inundated for sufficient duration and reduced residence time of water moving through the Yolo Bypass has reduced primary and secondary productivity under Existing Conditions. Therefore, increased duration of a given wetted area may increase primary and secondary production in the Yolo Bypass.

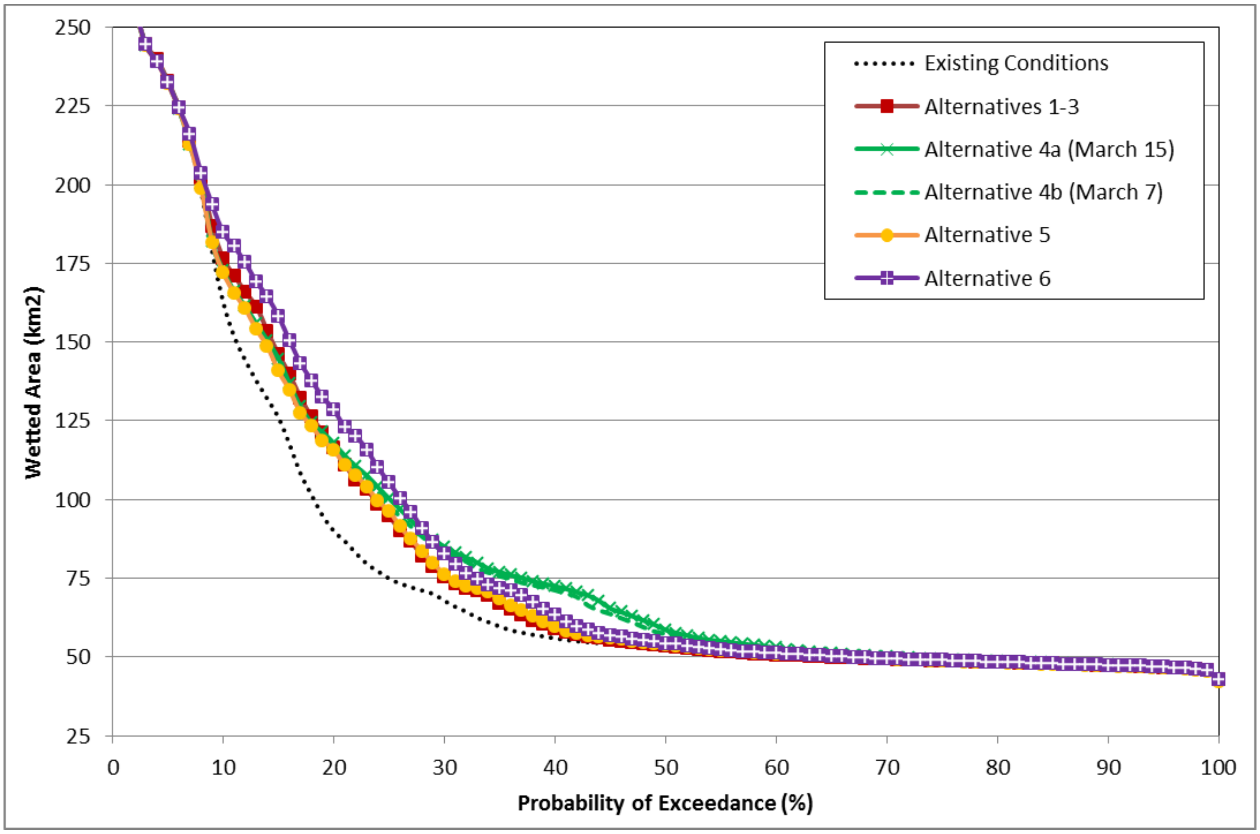


Figure 8-96. Simulated Wetted Area Probability of Exceedance Distributions from October through May under All Alternatives and Existing Conditions based on 16 years of TUFLOW Modeling (Water Years 1997 through 2012).

As shown in Figures 8-97 through 8-104, regardless of water year type, all alternatives would provide more wetted area relative to Existing Conditions for approximately one to three months during most years. When wetted area is relatively higher under all alternatives (e.g., during peaks in the wetted area time series), Alternative 6 typically would provide the most wetted area. This phenomenon is not associated with particular water year types and is most observable during water years 1999, 2000, 2001, 2003, 2004, 2008, 2009, 2010, and 2011. When wetted area is relatively lower under all alternatives, Alternative 4 typically would provide more wetted area most often, particularly in the early portion of the wet season (i.e., water years 1997, 2000, 2006, 2008, and 2009), during late portions of the wet season (i.e., water years 1997, 2002, 2003, 2005, 2007, 2008, and 2012), and during troughs in the wetted area time series, which are most easily observed during water years 1998, 2001, 2005, 2007, 2008, 2011, and 2012.

Although Alternative 6 would provide more wetted area when there is more wetted area available, Alternative 4 would extend the ascending and descending limbs of the wetted area time series, increasing the duration of increases in wetted area. More area wetted for a longer duration under Alternative 4 could result in increased primary and secondary production in the Yolo Bypass relative to the other alternatives.

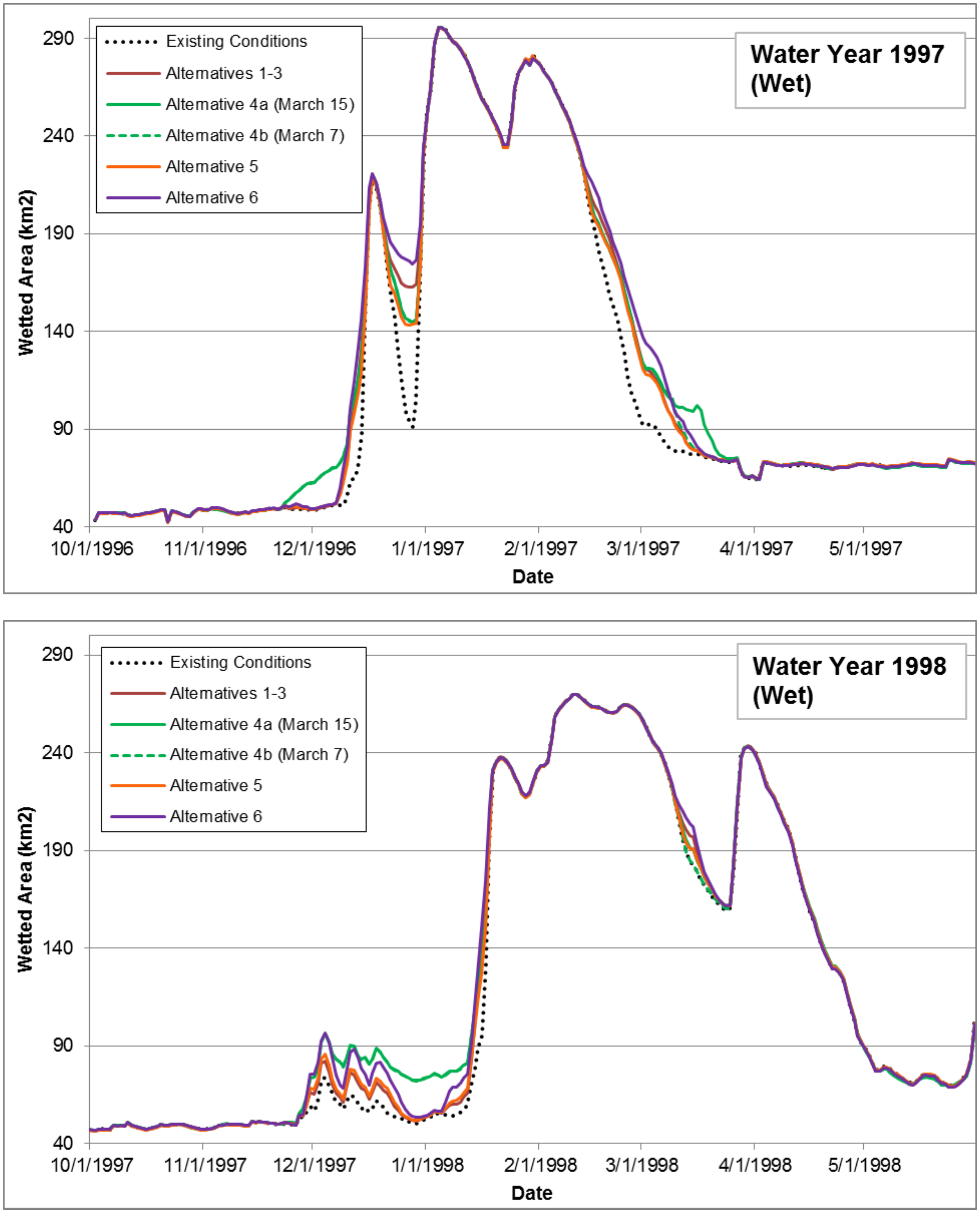
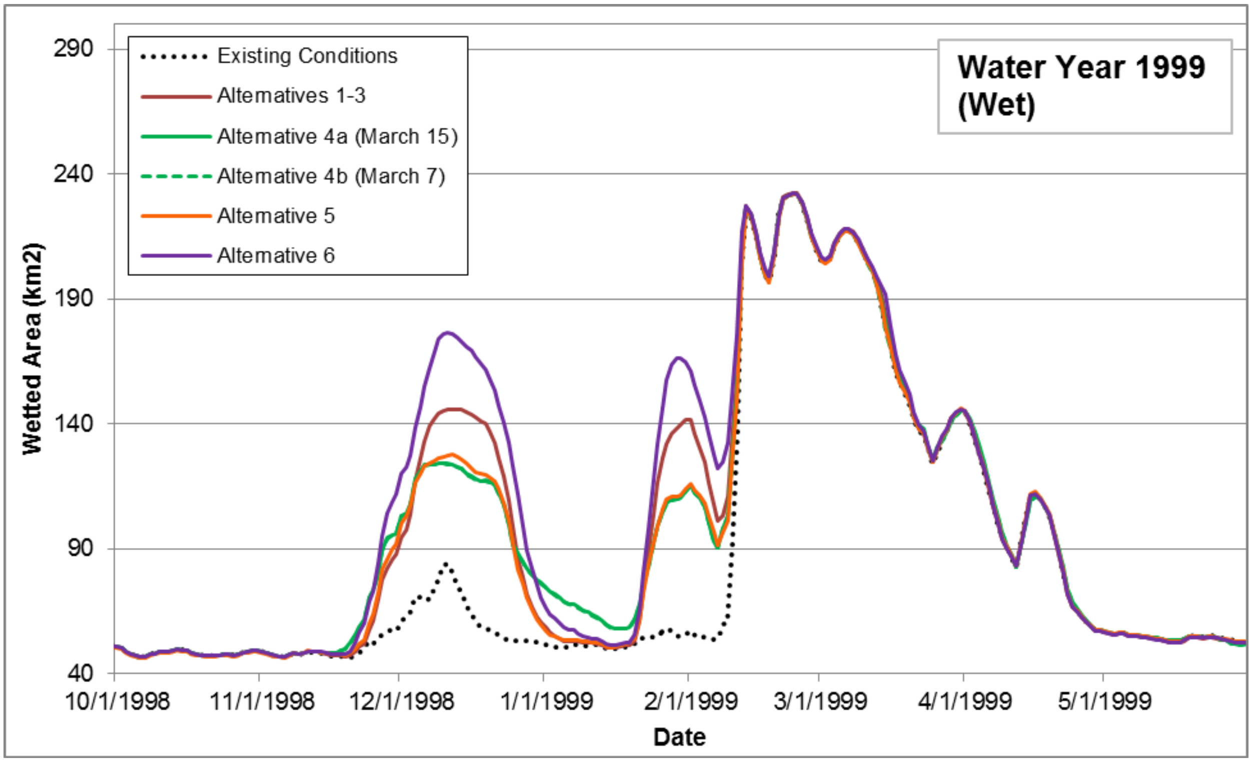


Figure 8-97. Simulated Wetted Area Time Series from October through May under All Alternatives and Existing Conditions based on TUFLOW Modeling (Water Years 1997 and 1998).



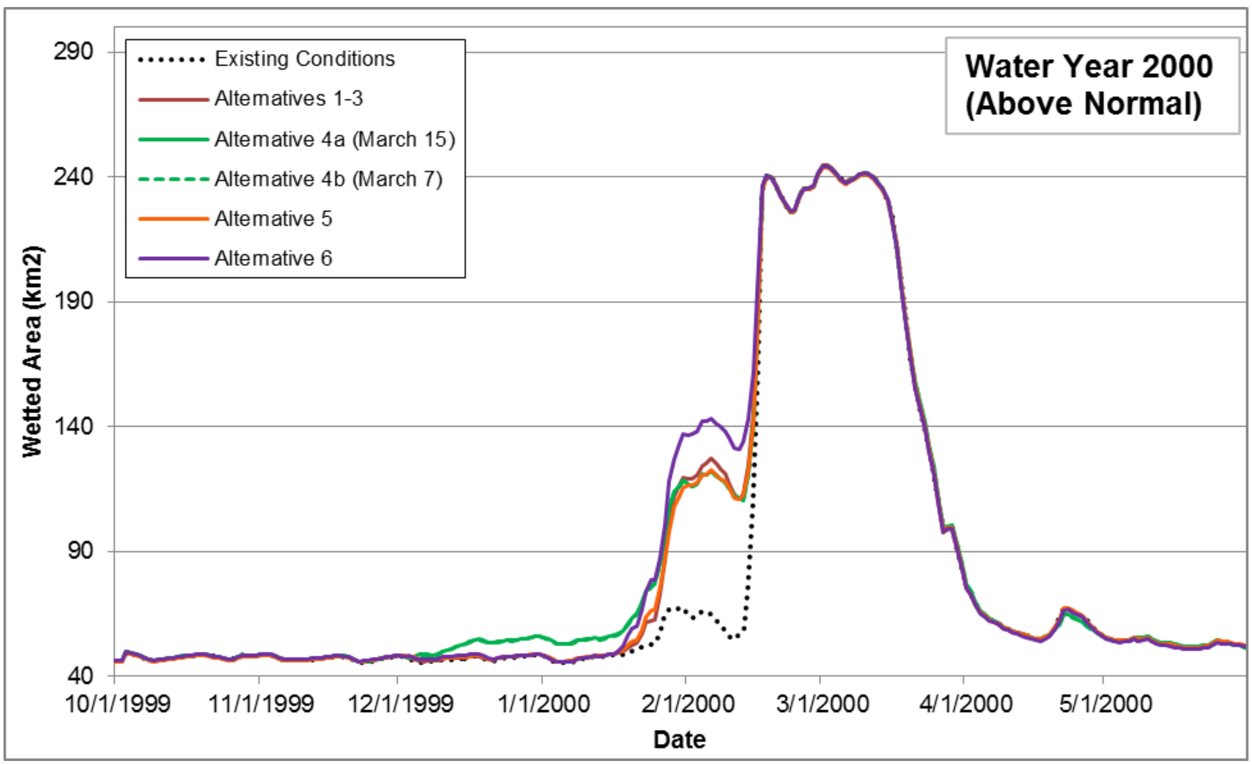
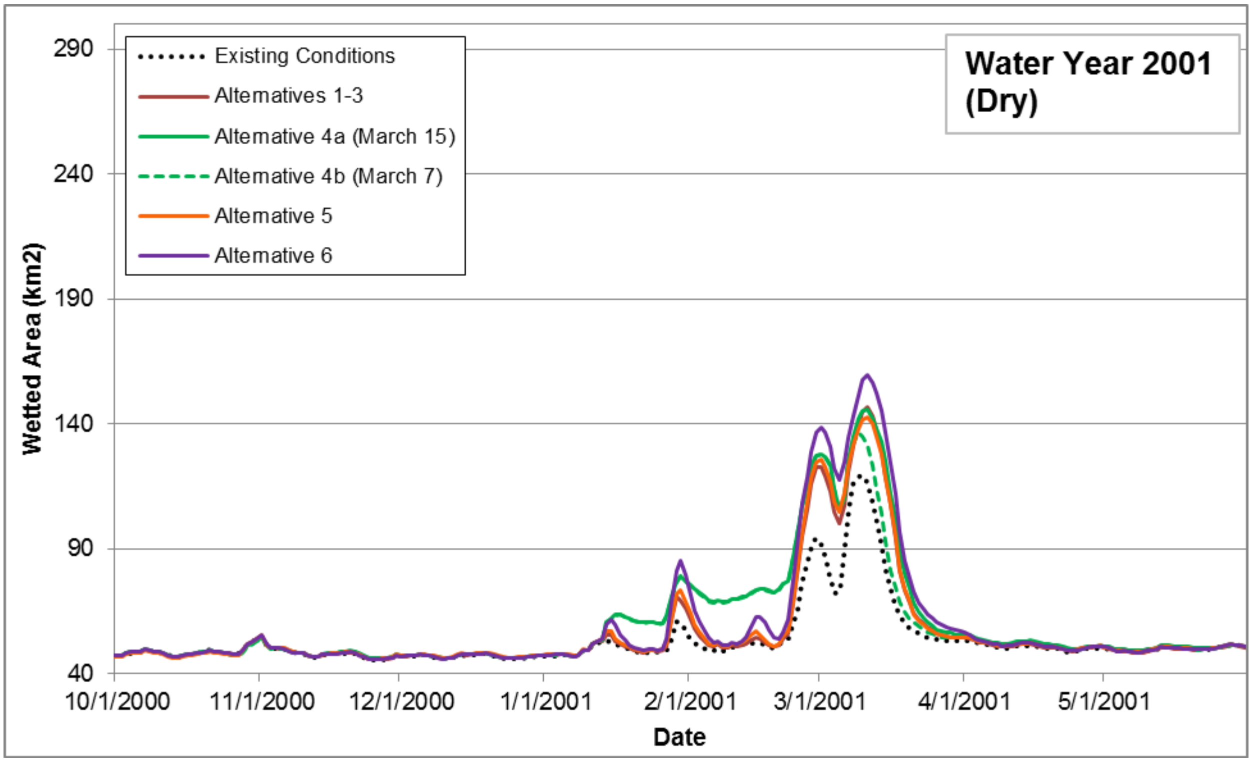


Figure 8-98. Simulated Wetted Area Time Series from October through May under All Alternatives and Existing Conditions based on TUFLOW Modeling (Water Years 1999 and 2000).



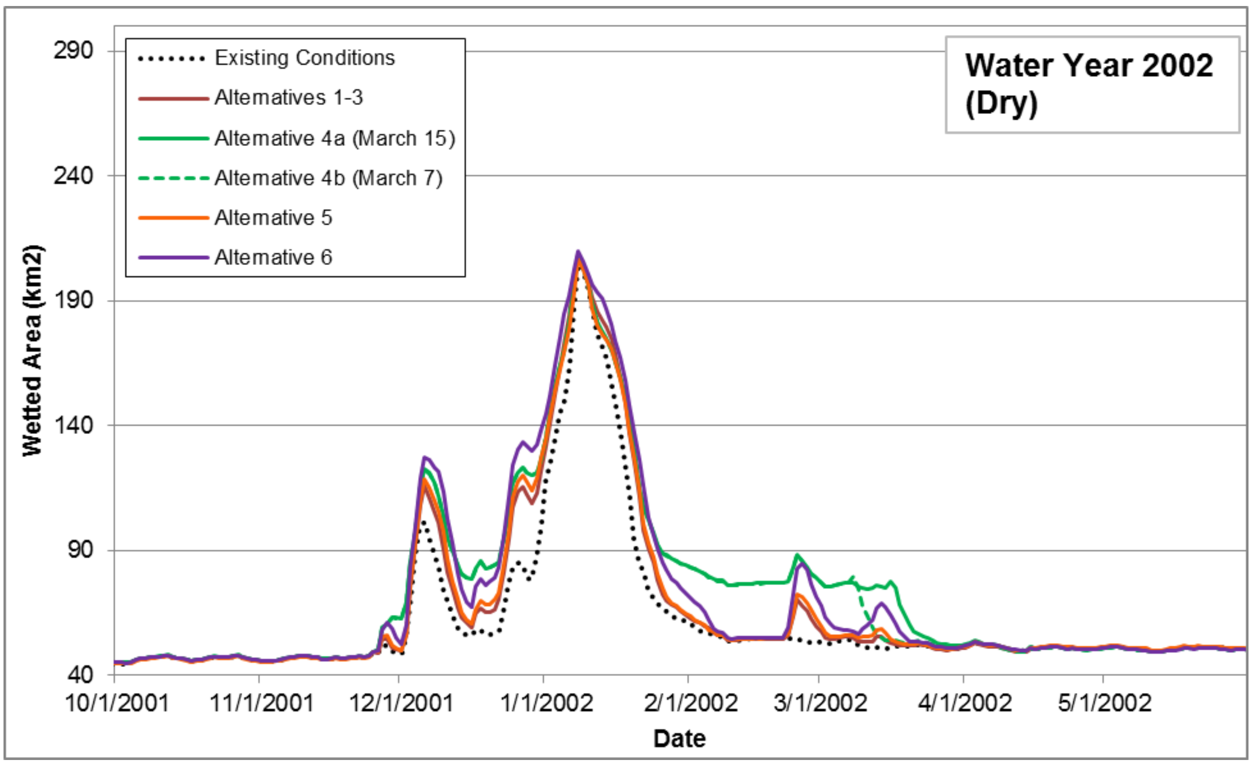
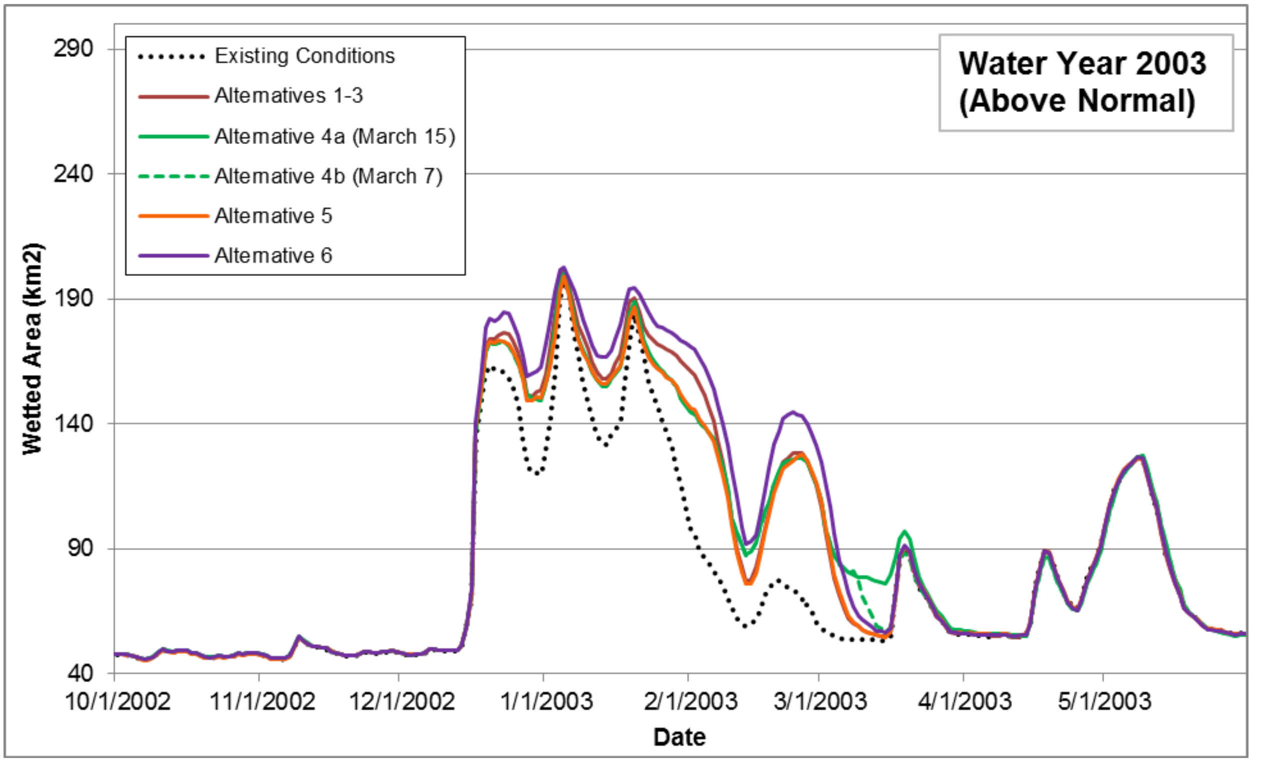


Figure 8-99. Simulated Wetted Area Time Series from October through May under All Alternatives and Existing Conditions based on TUFLOW Modeling (Water Years 2001 and 2002).



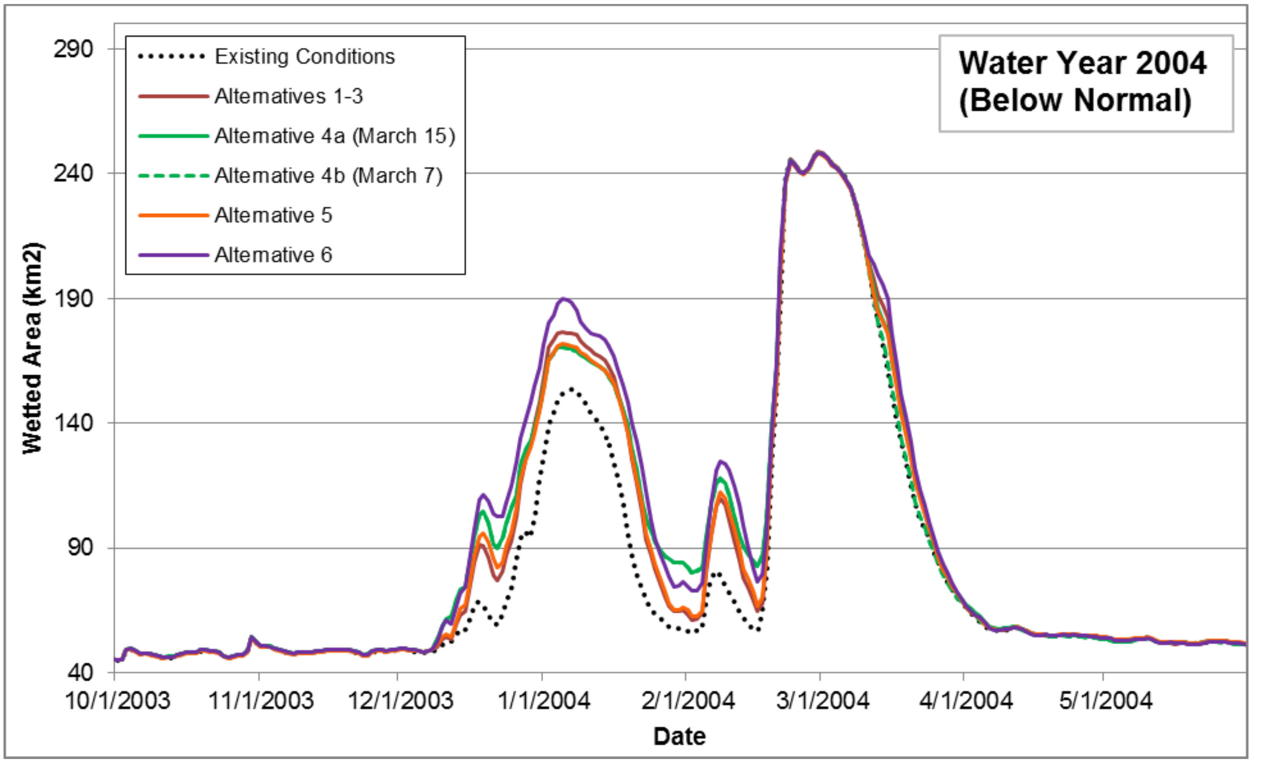


Figure 8-100. Simulated Wetted Area Time Series from October through May under All Alternatives and Existing Conditions based on TUFLOW Modeling (Water Years 2003 and 2004).

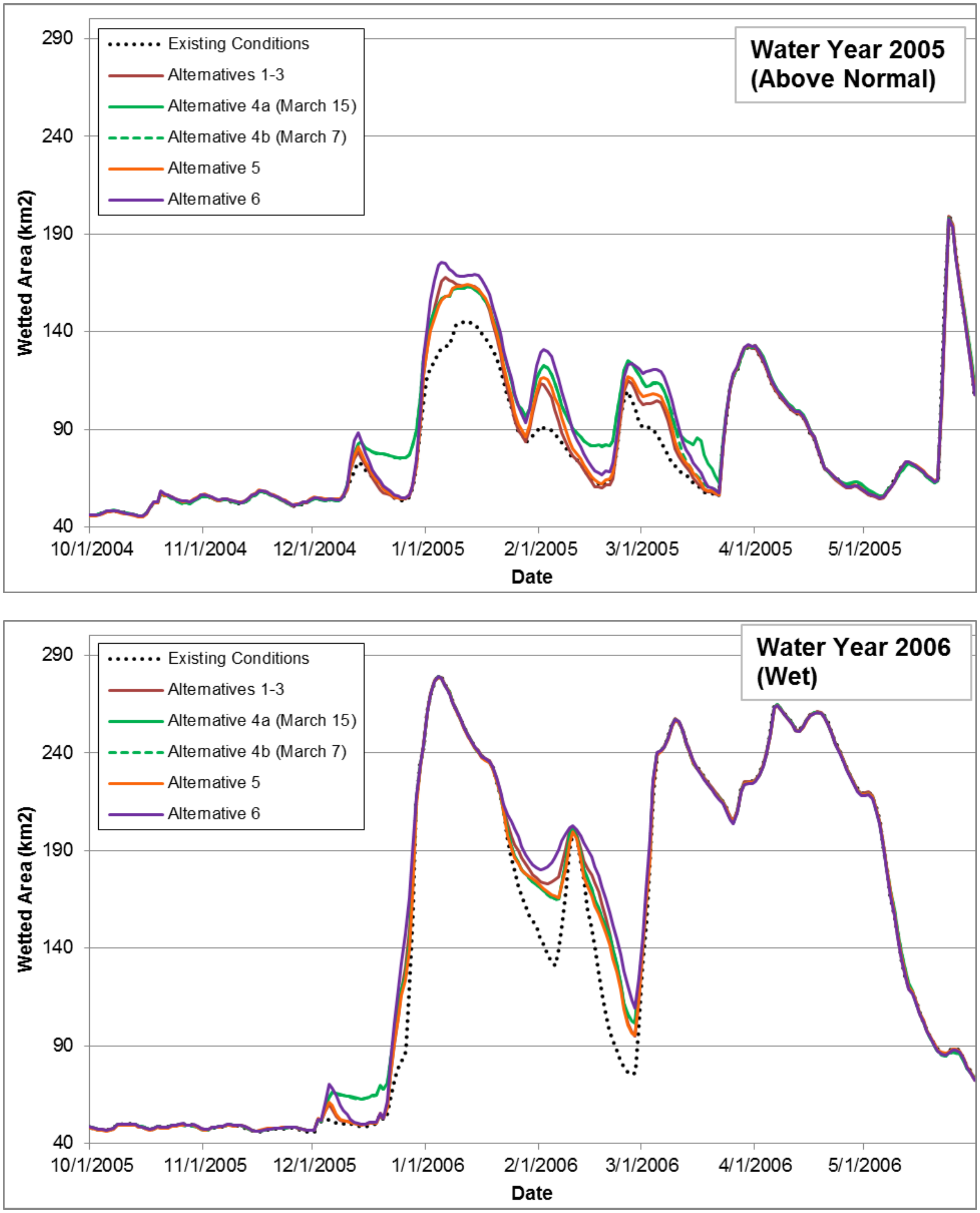


Figure 8-101. Simulated Wetted Area Time Series from October through May under All Alternatives and Existing Conditions based on TUFLOW Modeling (Water Years 2005 and 2006).

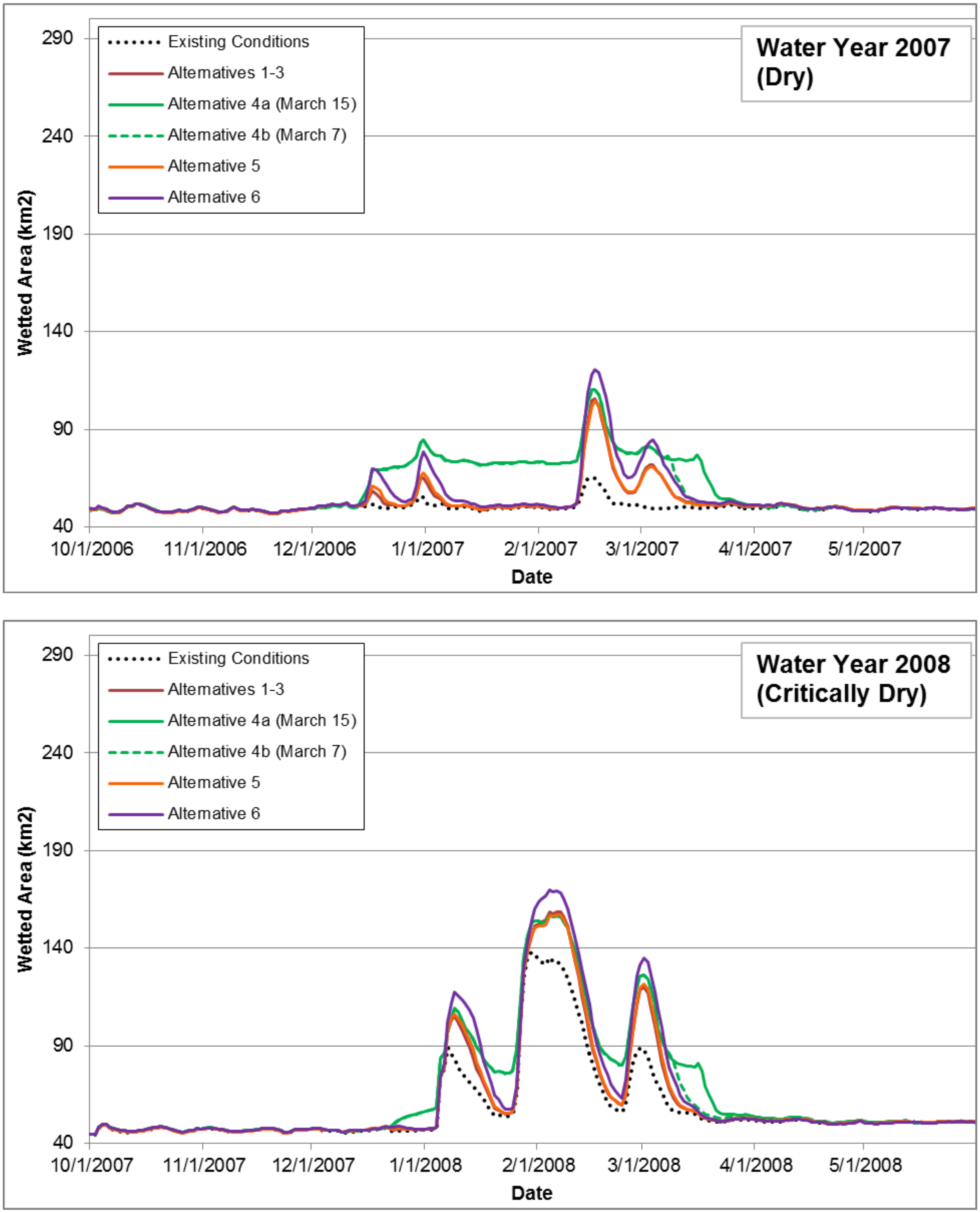


Figure 8-102. Simulated Wetted Area Time Series from October through May under All Alternatives and Existing Conditions based on TUFLOW Modeling (Water Years 2007 and 2008).

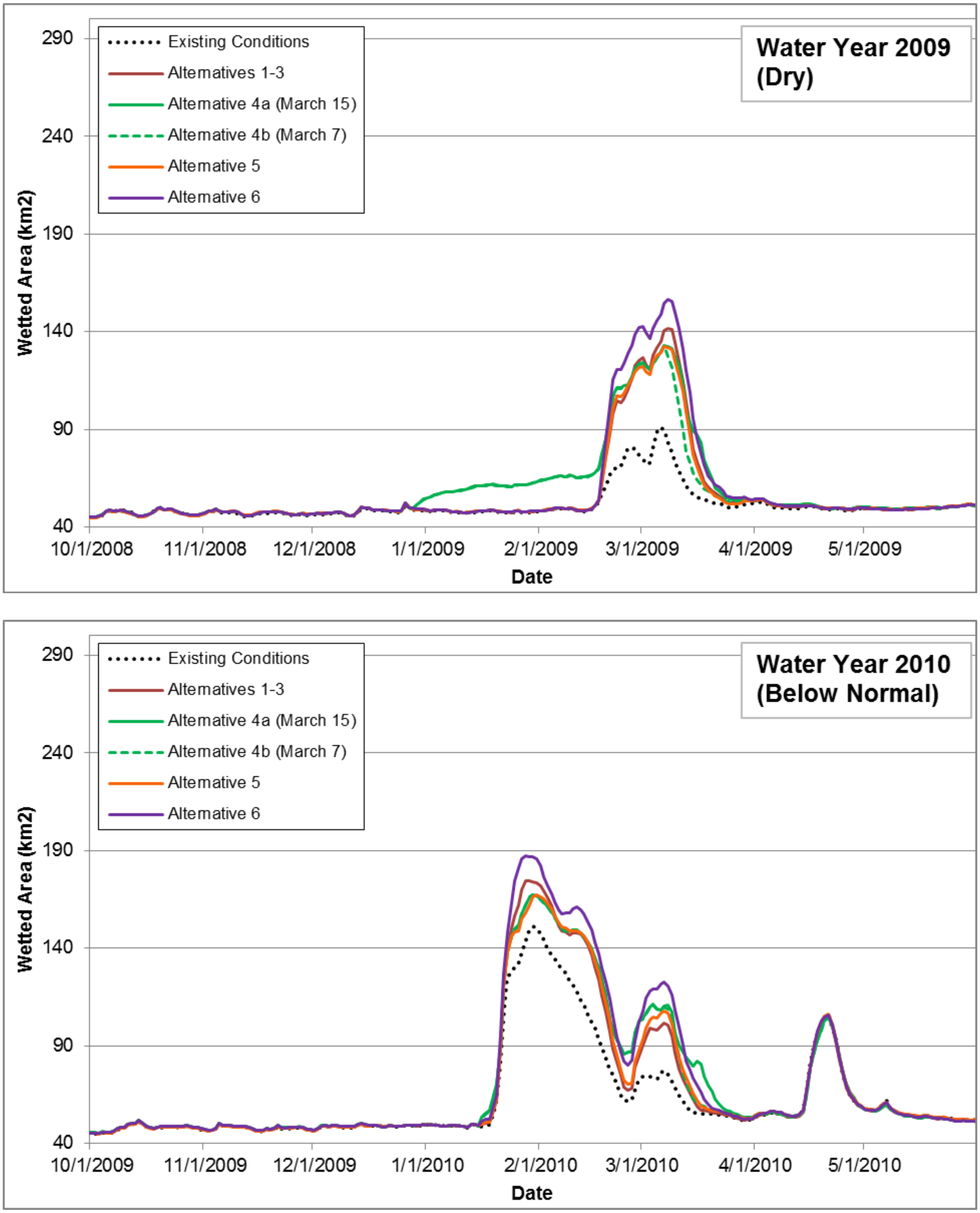
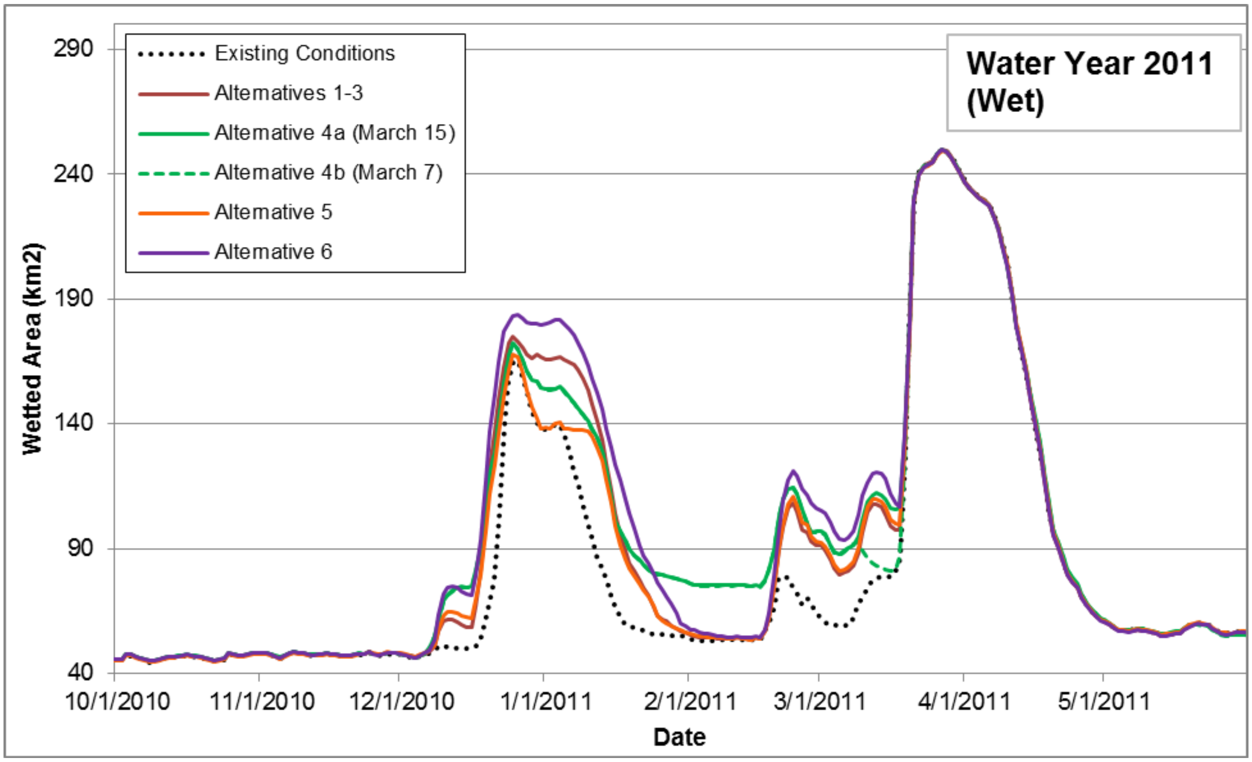


Figure 8-103. Simulated Wetted Area Time Series from October through May under All Alternatives and Existing Conditions based on TUFLOW Modeling (Water Years 2009 and 2010).



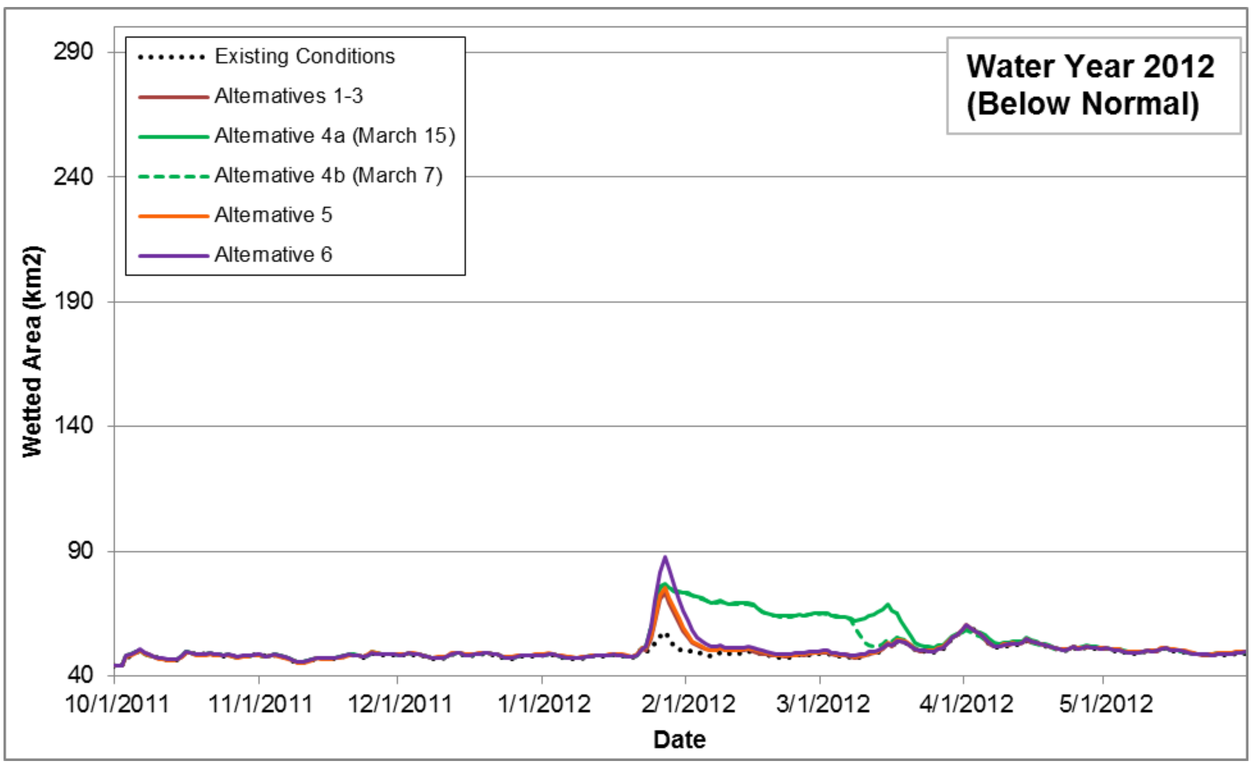


Figure 8-104. Simulated Wetted Area Time Series from October through May under All Alternatives and Existing Conditions based on TUFLOW Modeling (Water Years 2011 and 2012).

Increasing a given amount of wetted area for a longer duration prior to a flow pulse could increase the exportation of phytoplankton and zooplankton into the Delta downstream of the Yolo Bypass under all alternatives relative to Existing Conditions. Examination of the wetted area time series suggests that, relative to the other alternatives, Alternative 4 has the best potential to export more productive water to the Delta during most years, particularly during water years 1998, 2000, 2001, 2005, 2007, 2008, 2009, and 2011. Alternative 6 also has the potential to export more productive water to the Delta relative to the other alternatives, including during water years 1997, 1999, 2000, 2008, and 2011. Although no modeling is available, the programmatic floodplain improvements associated with Alternative 5 would likely result in increased productivity in the area upstream of the water control structure relative to other alternatives.

8.5.5 Improve Connectivity within the Yolo Bypass for Passage of Salmonids and Green Sturgeon

As described above, connectivity would be improved within the Yolo Bypass for the passage of juvenile and adult salmonids and green sturgeon due to the remediation of Agricultural Road Crossing 1 under all alternatives. In addition, construction and maintenance of the transport channels under all alternatives would provide more suitable connectivity for fish passage between Fremont Weir and Tule Pond when the Yolo Bypass is not inundated. However, as previously described (see Impact FISH-15 for Alternatives 5 and 6), due to the multiple transport channels under Alternative 5 and the relatively wider transport channel under Alternative 6, Alternatives 5 and 6 may potentially provide less optimal fish passage conditions within the Yolo Bypass under low-flow conditions relative to Alternatives 1 through 4. In addition, as previously described (see Impact FISH-15 for Alternative 4), the water control structures and bypass channels on Tule Canal under Alternative 4 may act as impediments to fish passage, particularly for adult green sturgeon, under low-flow conditions. Therefore, Alternatives 1 through 3 may provide for improved connectivity within the Yolo Bypass for fish passage with the greatest certainty. Alternative 6 may be the next most suitable alternative for improving connectivity in the Yolo Bypass, followed by Alternatives 4 and 5.

8.5.6 Improve Connectivity Between the Sacramento River and Yolo Bypass to Provide Safe and Timely Adult Fish Passage

This objective is to improve adult fish passage conditions between the Sacramento River and the Yolo Bypass when Sacramento River elevations are amenable to fish passage for winter-run Chinook salmon (between mid-November and May), spring-run Chinook salmon (between January and May), steelhead (when presence overlaps with windows for other species), and green sturgeon (between February and May)

The YBPASS Tool applied fish passage criteria to modeled hydraulic conditions in the intake facilities and transport channels under all alternatives to evaluate the daily frequency with which water depth and velocity were suitable for passage of adult salmonids and sturgeon over the water years 1997 through 2012 period (DWR 2017b; Appendix G5). Results of the YBPASS Tool indicate that adult salmon and sturgeon would be able to successfully pass upstream through the transport channel and intake structure into the Sacramento River from November through April, with the highest daily frequency under Alternative 5 (24 percent of the time), followed by Alternatives 1 through 3 (23 percent of the time), then Alternative 6 (19 percent of the time) and Alternative 4 (18 percent of the time) (Table 8-52) (DWR 2017b; Appendix G5). However, the standard deviation of the average passage window (22 percent of season) was three percent across all six alternatives, making it difficult to distinguish differences among alternatives. The annual average date after which each alternative would no longer meet the fish passage criteria would be similar for Alternatives 1 through 5 (end of March or beginning of April) but would occur about one month sooner under Alternative 6 (beginning of March). Adult fish passage under Alternative 6 would be temporally constrained because of a lack of operation after March 15 due to depth and velocity barriers that would occur at a lower notch discharge (DWR 2017b; Appendix G5).

Table 8-52. YPBASS Tool Summary Results for Water Years 1997 through 2012 Assessing Adult Fish Passage from November through April for all Alternatives at the Fremont Weir

Alternative		Average number of days depth barrier exists	Average number of days velocity barrier exists	Average number of days alternative meets criteria	Average percent of season alternative meets criteria	Average last date alternative meets criteria
1.	Eastern Alignment	107 ± 41	32 ± 31	42 ± 15	23%	2-April
2.	Central Alignment	108 ± 41	31 ± 30	42 ± 15	23%	2-April
3.	Western Alignment	109 ± 41	30 ± 29	42 ± 17	23%	1-April
4.	Western Alignment	109 ± 41	39 ± 32	33 ± 12	18%	31-March
5.	Central Alignment	106 ± 41	32 ± 31	43 ± 16	24%	1-April
6.	Western Alignment	111 ± 41	36 ± 34	34 ± 14	19%	3-March

Source: DWR 2017b; Appendix G5

It should be noted that the YBPASS Tool results do not account for other components of the alternatives such as the water control structures and bypass channels in the Tule Canal associated with Alternative 4. Although these structures would be designed to provide for fish passage and would be adaptively managed, they create additional uncertainty in providing suitable fish passage conditions in the Yolo Bypass and would require monitoring and potential future actions under the adaptive management program to provide suitable fish passage conditions.

In addition, the YBPASS Tool does not consider fish behavior nor the operational reliability of the structure (DWR 2017b; Appendix G5). Based on YBPASS Tool results, Alternatives 1 through 3 and 5 would all perform similarly. However, the YBPASS Tool does not account for the complexity of design for each alternative that could influence fish behavior and thus fish passage efficiency. For instance, Alternatives 1 through 3 have three gates and one transport channel, whereas Alternative 5 has 27 gates and four transport channels. Because of this complexity, Alternative 5 has a greater possibility to confuse migratory fish due to the additional gates and channels. The YBPASS Tool does not evaluate the possibility of gate closure and rerouting of fish nor the increase in potential stranding with the addition of multiple channels. In addition to fish behavior, the operational reliability of the structure could also impact adult fish passage efficiency. For example, the gates could malfunction or the transport channel could get clogged up with debris, which would reduce fish passage efficiency (DWR 2017b; Appendix G5).

The YBPASS Tool also does not address the potential for increased attraction of adult salmonids and sturgeon into the Yolo Bypass. Because Alternative 6 would allow for substantially higher flows to enter the Yolo Bypass when Fremont Weir is not overtopping relative to the other alternatives and would provide for adult fish passage at the proposed facilities with lower frequency relative to Alternatives 1 through 3 and 5, Alternative 6 may result in increased numbers of adult fish entering the Yolo Bypass that cannot enter the Sacramento River relative to the other alternatives.

Based on the relative results of the YBPASS Tool and hydraulic modeling, as well as considerations described above related to the complexity of the intake facilities and transport channels and other alternative-specific effects, Alternatives 1 through 3 may provide the most suitable adult fish passage conditions between the Yolo Bypass and the Sacramento River with the greatest certainty. Alternative 6 would be expected to provide the least suitable adult fish passage conditions between the Yolo Bypass and the Sacramento River due to the increased potential for attraction of adults along with the relatively low frequency of fish passage provided. Further, Alternative 6 may be particularly less suitable for adult green sturgeon passage due to the lack of gate operations after the beginning of March.

8.5.7 Improve Phenotypic Diversity of Juvenile Winter-run and Spring-run Chinook Salmon

As previously described, the SBM simulated juvenile Chinook salmon variation in lengths at the time of emigration to the estuary (at Chipps Island in the Delta) as well as variation in time of estuary entry. Therefore, the coefficient of variation in size (length) and the coefficient of variation in estuary entry timing were used as indicators of phenotypic diversity in juvenile spring-run and winter-run Chinook salmon.

8.5.7.1 Spring-run Chinook Salmon

8.5.7.1.1 Variation in Juvenile Spring-run Chinook Salmon Size

Modeling results indicate that annual average juvenile spring-run Chinook salmon coefficient of variation in size (FL) would be higher under all alternatives relative to Existing Conditions over the entire simulation period and by water year type (Table 8-53). Average coefficient of variation in size would be highest under Alternative 6, followed by Alternatives 1 through 3, then Alternative 5 and Alternative 4. However, differences among the alternatives are generally insubstantial.

Table 8-53. Average Annual Juvenile Spring-run Chinook Salmon Coefficient of Variation in Size under all Alternatives and Existing Conditions

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Existing Conditions	0.30	0.42	0.30	0.26	0.22	0.18
Alternatives 1-3	0.36	0.45	0.34	0.35	0.27	0.28
Alternative 4a	0.34	0.44	0.33	0.32	0.26	0.28
Alternative 4b	0.34	0.44	0.33	0.32	0.26	0.28
Alternative 5	0.35	0.45	0.33	0.33	0.26	0.29
Alternative 6	0.38	0.47	0.36	0.40	0.29	0.34

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

The juvenile spring-run Chinook salmon coefficient of variation in size probability of exceedance distributions indicates that all alternatives would result in increased size variability relative to Existing Conditions, particularly when the coefficient of variation is relatively low (Figure 8-105). Alternative 6 would provide higher coefficients of variation over the entire distribution relative to the other alternatives. Alternatives 1 through 3 would provide higher coefficients of variation over small portions of the distribution relative to Alternatives 4 and 5.

8.5.7.1.2 Variation in Juvenile Spring-run Chinook Salmon Estuary Entry Timing

Modeling results indicate that annual average juvenile spring-run Chinook salmon coefficient of variation in estuary entry timing would be similar or higher under all alternatives relative to Existing Conditions over the entire simulation period and by water year type (Table 8-54). Average coefficient of variation in estuary entry timing would be highest under Alternative 6, followed by Alternatives 1 through 5. However, differences among the alternatives are generally insubstantial.

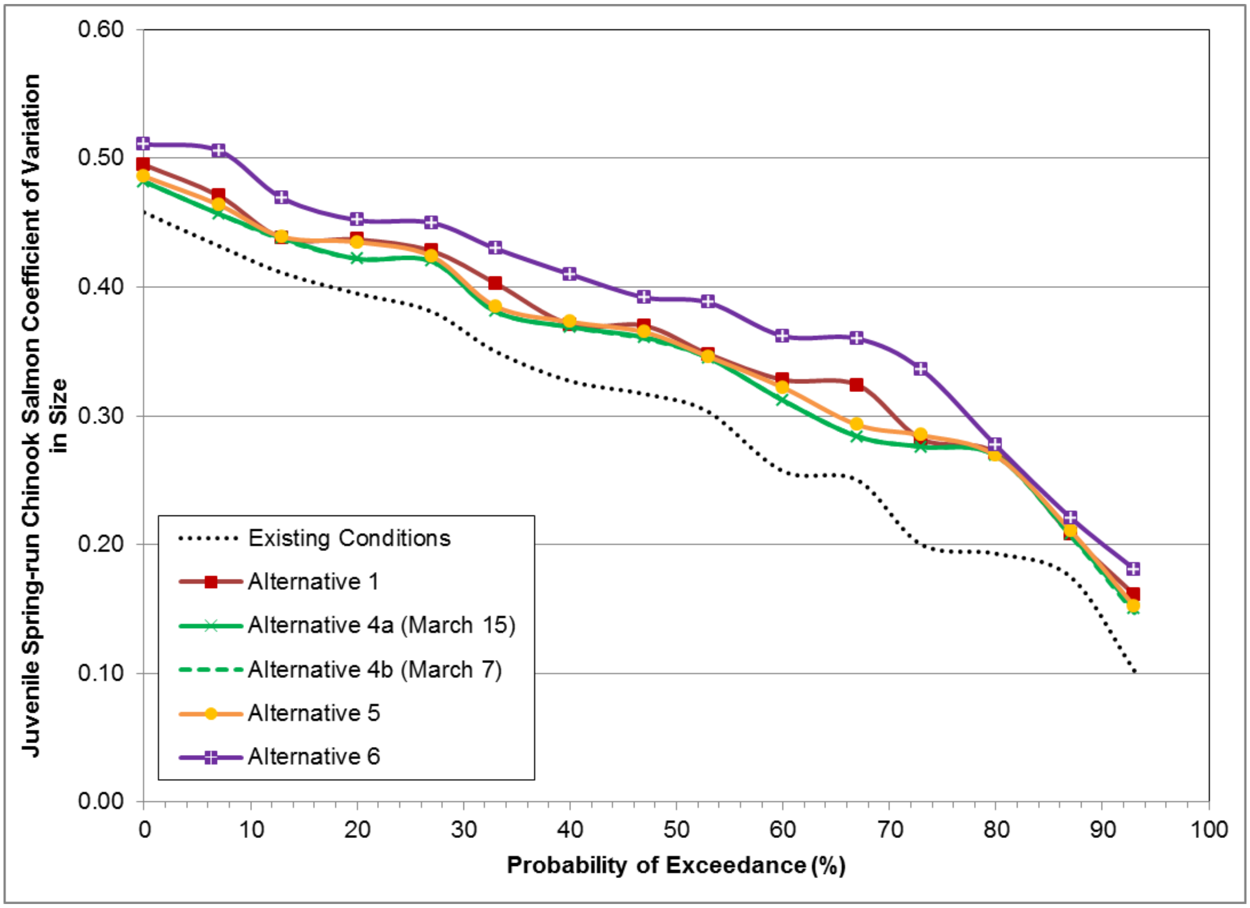


Figure 8-105. Simulated Juvenile Spring-Run Chinook Salmon Coefficient of Variation in Size Probability of Exceedance Distributions under All Alternatives and Existing Conditions

Table 8-54. Average Annual Juvenile Spring-run Chinook Salmon Coefficient of Variation in Estuary Entry Timing under all Alternatives and Existing Conditions

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Existing Conditions	0.29	0.38	0.28	0.26	0.23	0.18
Alternative 1	0.30	0.39	0.28	0.28	0.24	0.21
Alternative 4a	0.30	0.39	0.28	0.27	0.24	0.21
Alternative 4b	0.30	0.39	0.28	0.27	0.24	0.21
Alternative 5	0.30	0.39	0.28	0.28	0.24	0.21
Alternative 6	0.31	0.39	0.29	0.30	0.25	0.22

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

The juvenile spring-run Chinook salmon coefficient of variation in estuary entry timing probability of exceedance distributions indicates that all alternatives would result in similar or increased estuary entry timing variability relative to Existing Conditions (Figure 8-106). Alternative 6 would provide higher coefficients of variation over about half of the distribution relative to the other alternatives.

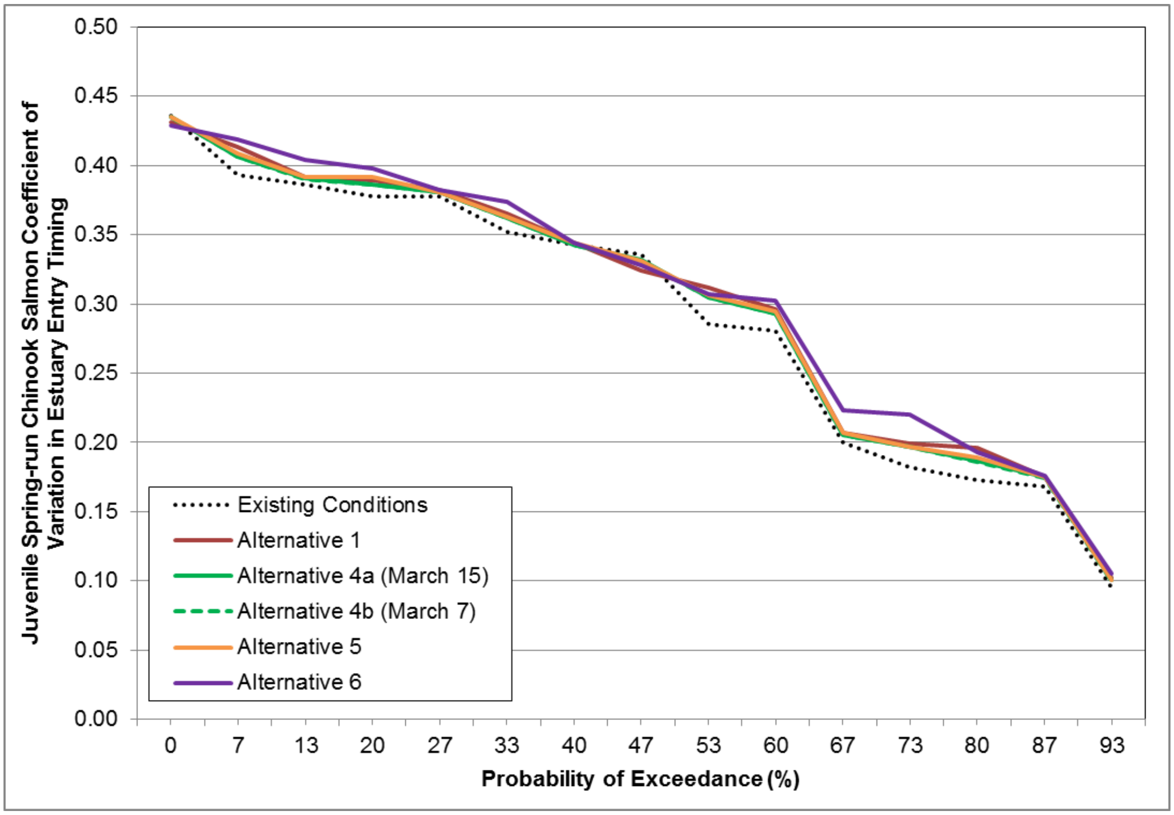


Figure 8-106. Simulated Juvenile Spring-Run Chinook Salmon Coefficient of Variation in Estuary Entry Timing Probability of Exceedance Distributions under All Alternatives and Existing Conditions

8.5.7.2 Winter-run Chinook Salmon

8.5.7.2.1 Variation in Juvenile Winter-run Chinook Salmon Size

Modeling results indicate that annual average juvenile winter-run Chinook salmon coefficient of variation in size would be higher under all alternatives relative to Existing Conditions over the entire simulation period and by water year type (Table 8-55). Among the alternatives, average annual variation in size would be higher over the entire simulation period and by water year type under Alternative 6 relative to Alternatives 1 through 5 and similar among Alternatives 1 through 5.

Table 8-55. Average Annual Juvenile Winter-run Chinook Salmon Coefficient of Variation in Size under All Alternatives and Existing Conditions

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Existing Conditions	0.14	0.20	0.12	0.17	0.10	0.06
Alternatives 1-3	0.17	0.23	0.15	0.19	0.12	0.09
Alternative 4a	0.16	0.22	0.14	0.19	0.12	0.09
Alternative 4b	0.16	0.22	0.14	0.19	0.12	0.09
Alternative 5	0.17	0.22	0.14	0.19	0.12	0.09
Alternative 6	0.19	0.25	0.16	0.21	0.14	0.11

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

The juvenile winter-run Chinook salmon coefficient of variation in size probability of exceedance distributions indicates that all alternatives would result in increased size variability relative to Existing Conditions (Figure 8-107). Among the alternatives, Alternative 6 would provide higher coefficients of variation over most of the distribution relative to Alternatives 1 through 5, and Alternatives 1 through 3 would provide more variation than Alternatives 4 and 5 over portions of the distribution. Overall, variation in size of juvenile winter-run Chinook salmon would be greater under Alternative 6 and not substantially different among Alternatives 1 through 5.

8.5.7.2.2 Variation in Juvenile Winter-run Chinook Salmon Estuary Entry Timing

Modeling results indicate that annual average juvenile winter-run Chinook salmon coefficient of variation in estuary entry timing would be similar or higher under all alternatives relative to Existing Conditions over the entire simulation period and by water year type (Table 8-56). Average coefficient of variation in estuary entry timing would be highest under Alternative 6, followed by Alternatives 1 through 5. However, differences among the alternatives are generally insubstantial.

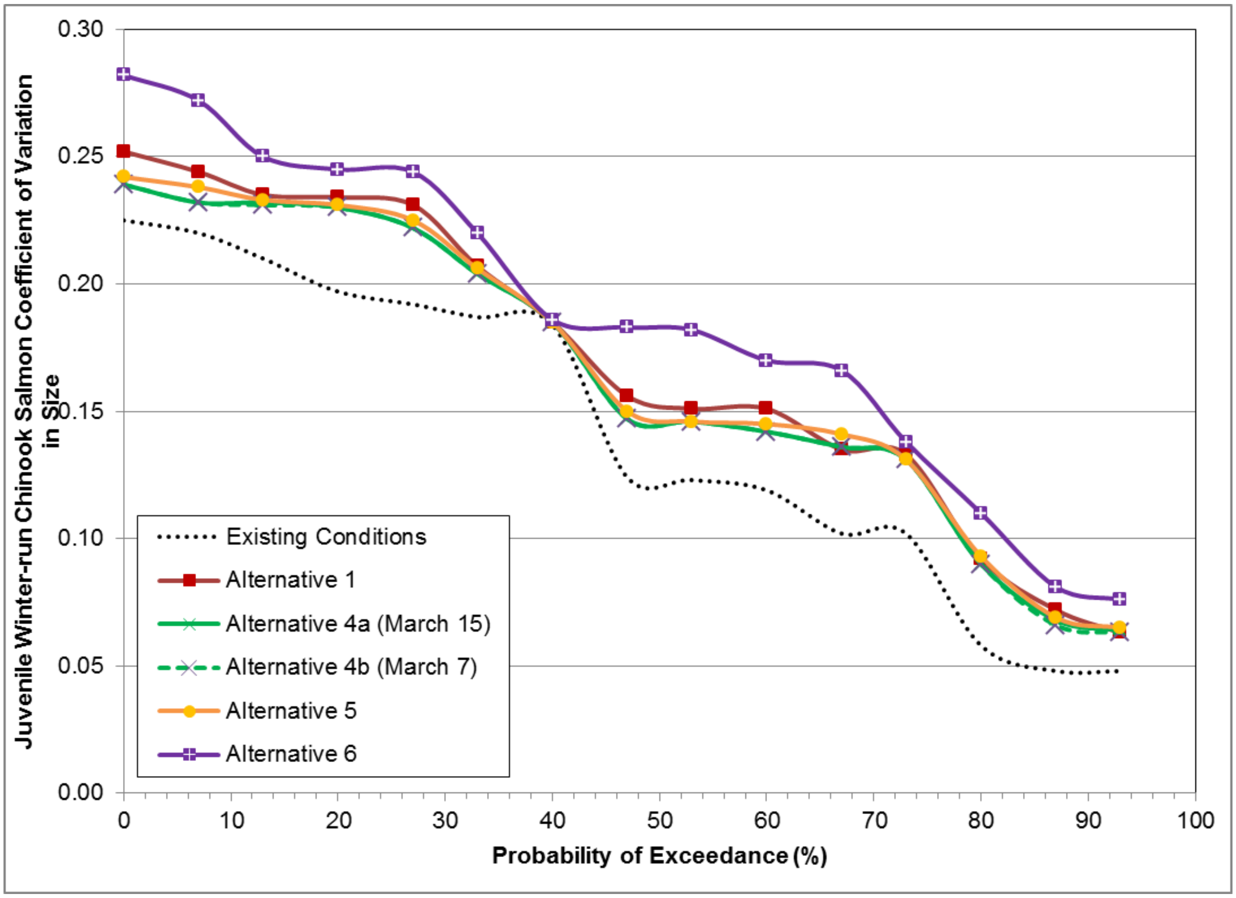


Figure 8-107. Simulated Juvenile Winter-run Chinook Salmon Coefficient of Variation in Size Probability of Exceedance Distributions under All Alternatives and Existing Conditions

Table 8-56. Average Annual Juvenile Winter-run Chinook Salmon Coefficient of Variation in Estuary Entry Timing under all Alternatives and Existing Conditions

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Existing Conditions	0.28	0.38	0.22	0.30	0.21	0.12
Alternative 1	0.28	0.39	0.23	0.31	0.22	0.13
Alternative 4a	0.28	0.38	0.23	0.31	0.22	0.13
Alternative 4b	0.28	0.38	0.23	0.31	0.22	0.13
Alternative 5	0.28	0.39	0.23	0.31	0.22	0.13
Alternative 6	0.29	0.39	0.24	0.32	0.23	0.13

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

The juvenile winter-run Chinook salmon coefficient of variation in estuary entry timing probability of exceedance distributions indicates that all alternatives would result in similar or increased estuary entry timing variability relative to Existing Conditions (Figure 8-108). Alternative 6 would provide higher coefficients of variation over most of the distribution relative to the other alternatives.

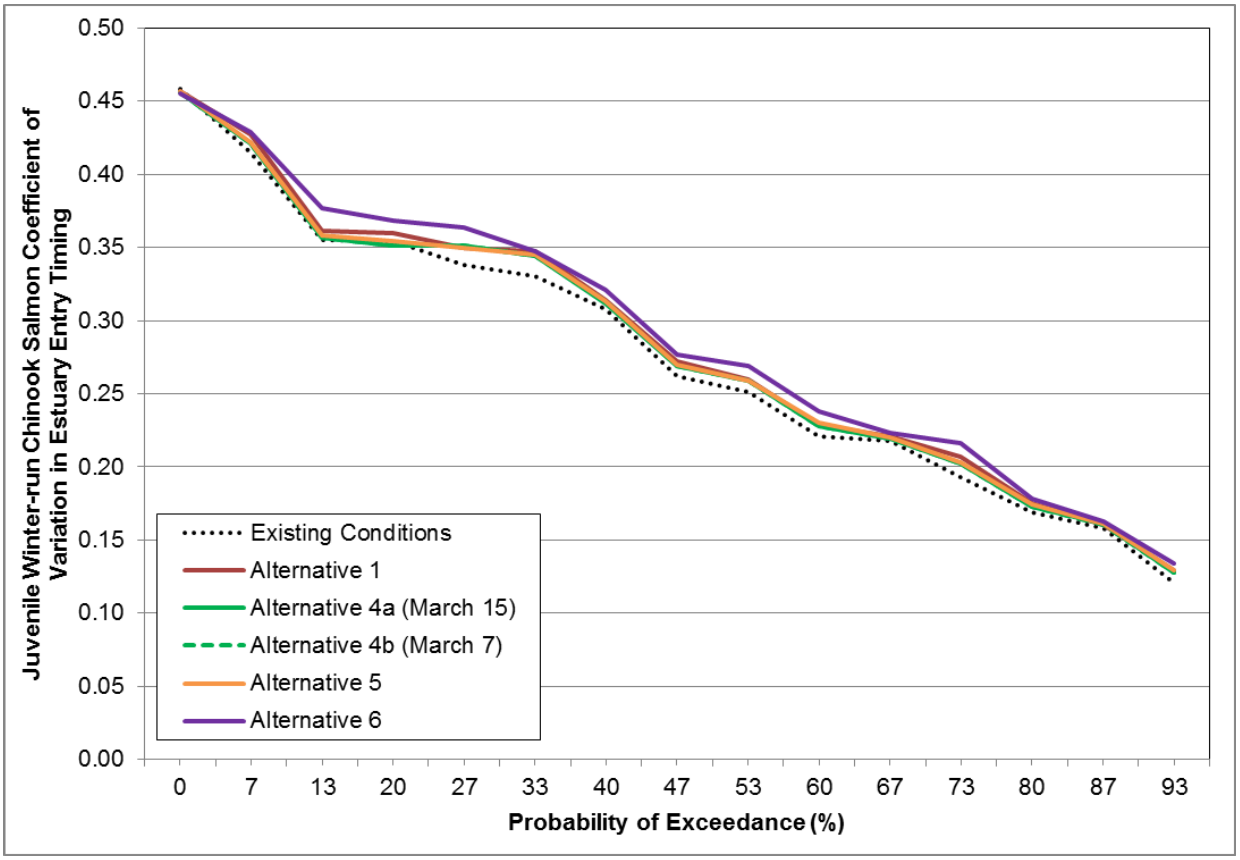


Figure 8-108. Simulated Juvenile Winter-Run Chinook Salmon Coefficient of Variation in Estuary Entry Timing Probability of Exceedance Distributions under All Alternatives and Existing Conditions

8.5.8 Increase Abundances of Returning Adult Winter-run and Spring-run Chinook Salmon

As previously described, the SBM simulated adult Chinook salmon returns under each alternative and Existing Conditions. Relative differences in simulated adult returns for spring-run and winter-run Chinook salmon were used as indicators of the impact of the alternatives on relative abundance of Sacramento River spring-run and winter-run Chinook salmon.

8.5.8.1 Spring-Run Chinook Salmon

Modeling results indicate that annual average adult spring-run Chinook salmon returns would be higher under all alternatives relative to Existing Conditions over the entire simulation period and during all water year types (Table 8-57). Average annual adult returns would be higher under Alternative 6 relative to Alternatives 1 through 5. In addition, because more juvenile Chinook salmon would enter the Delta from the Yolo Bypass relative to from the Sacramento River, potentially reduced juvenile mortality at the south Delta pumping facilities could further increase adult returns under the Alternatives relative to Existing Conditions.

Table 8-57. Average Annual Spring-run Chinook Salmon Adult Returns under All Alternatives and Existing Conditions

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Existing Conditions	5,960	8,803	5,821	2,174	4,884	4,031
Alternatives 1-3	6,391	9,652	6,049	2,345	5,094	4,385
Alternative 4a	6,259	9,343	6,002	2,281	5,062	4,357
Alternative 4b	6,257	9,342	6,000	2,280	5,056	4,357
Alternative 5	6,300	9,425	6,012	2,295	5,088	4,399
Alternative 6	6,690	10,230	6,184	2,507	5,244	4,658

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)

[2] As defined by the Sacramento Valley Index (DWR 2017c)

The adult spring-run Chinook salmon returns probability of exceedance distributions indicate that there would not be substantial differences among the alternatives although Alternative 6 would result in higher adult returns over most of the distribution relative to Alternatives 1 through 5 (Figure 8-109).

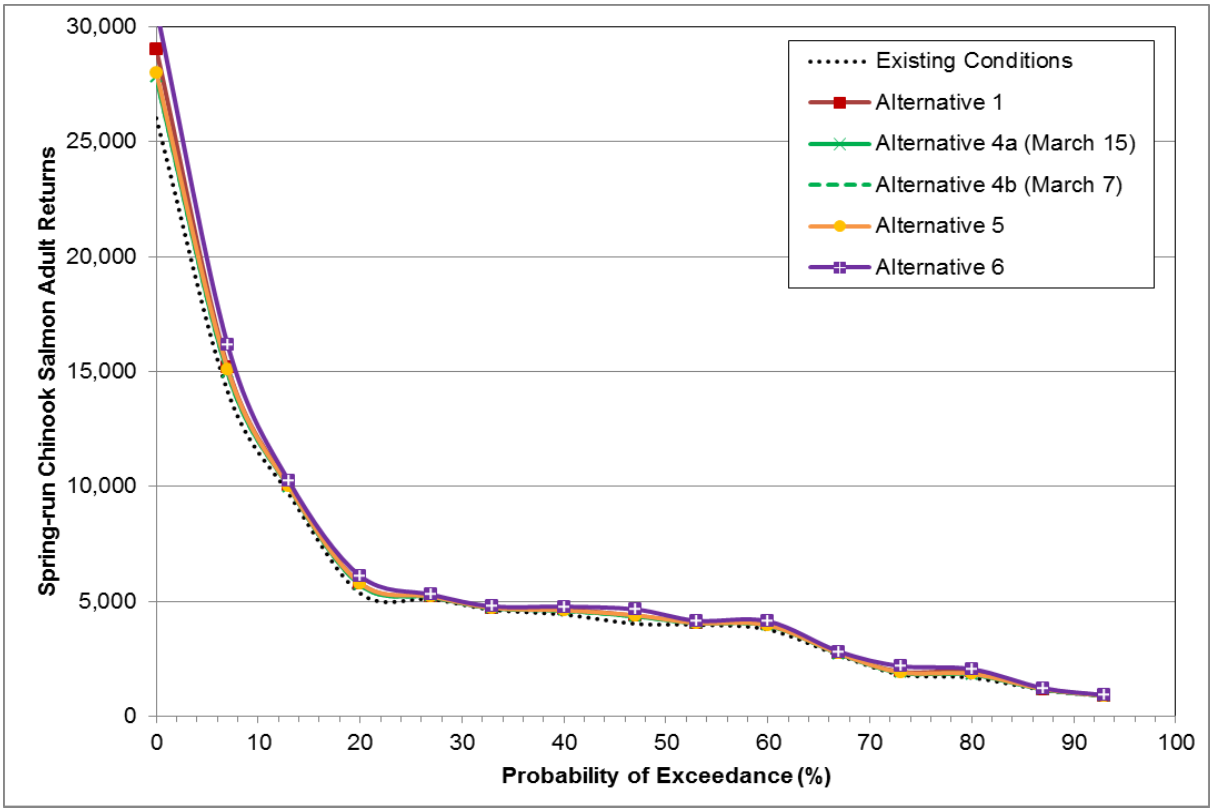


Figure 8-109. Simulated Adult Spring-run Chinook Salmon Returns Probability of Exceedance Distributions under All Alternatives and Existing Conditions

8.5.8.2 Winter-Run Chinook Salmon

Modeling results indicate that annual average adult winter-run Chinook salmon returns would be higher under all alternatives relative to Existing Conditions over the entire simulation period and during all water year types (Table 8-58). Although there would be no substantial differences among the alternatives, Alternative 6 would result in higher average annual adult returns over the entire simulation and by water year type. In addition, because more juvenile Chinook salmon would enter the Delta from the Yolo Bypass relative to from the Sacramento River, potentially reduced juvenile mortality at the south Delta pumping facilities could further increase adult returns under the Alternatives relative to Existing Conditions.

Table 8-58. Average Annual Winter-run Chinook Salmon Adult Returns under All Alternatives and Existing Conditions

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Existing Conditions	5,518	5,504	5,558	5,334	6,197	3,118
Alternatives 1-3	5,630	5,732	5,574	5,344	6,297	3,192
Alternative 4a	5,617	5,690	5,571	5,353	6,301	3,188

Alternative	Entire Simulation Period[1]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]	Water Year Types[2]
		Wet	Above Normal	Below Normal	Dry	Critical
Alternative 4b	5,617	5,690	5,571	5,354	6,300	3,188
Alternative 5	5,629	5,709	5,570	5,357	6,317	3,197
Alternative 6	5,746	5,947	5,582	5,363	6,433	3,253

[1] Based on modeled annual values over a 15-year simulation period (water years 1997 through 2011)
[2] As defined by the Sacramento Valley Index (DWR 2017c)

The adult winter-run Chinook salmon returns probability of exceedance distributions indicates that all alternatives would provide similar or higher adult returns relative to Existing Conditions (Figure 8-110). All alternatives would provide similar numbers of adult winter-run Chinook salmon returns over most of the distributions; however, Alternative 6 would result in higher adult returns over portions of the distributions relative to the other alternatives.

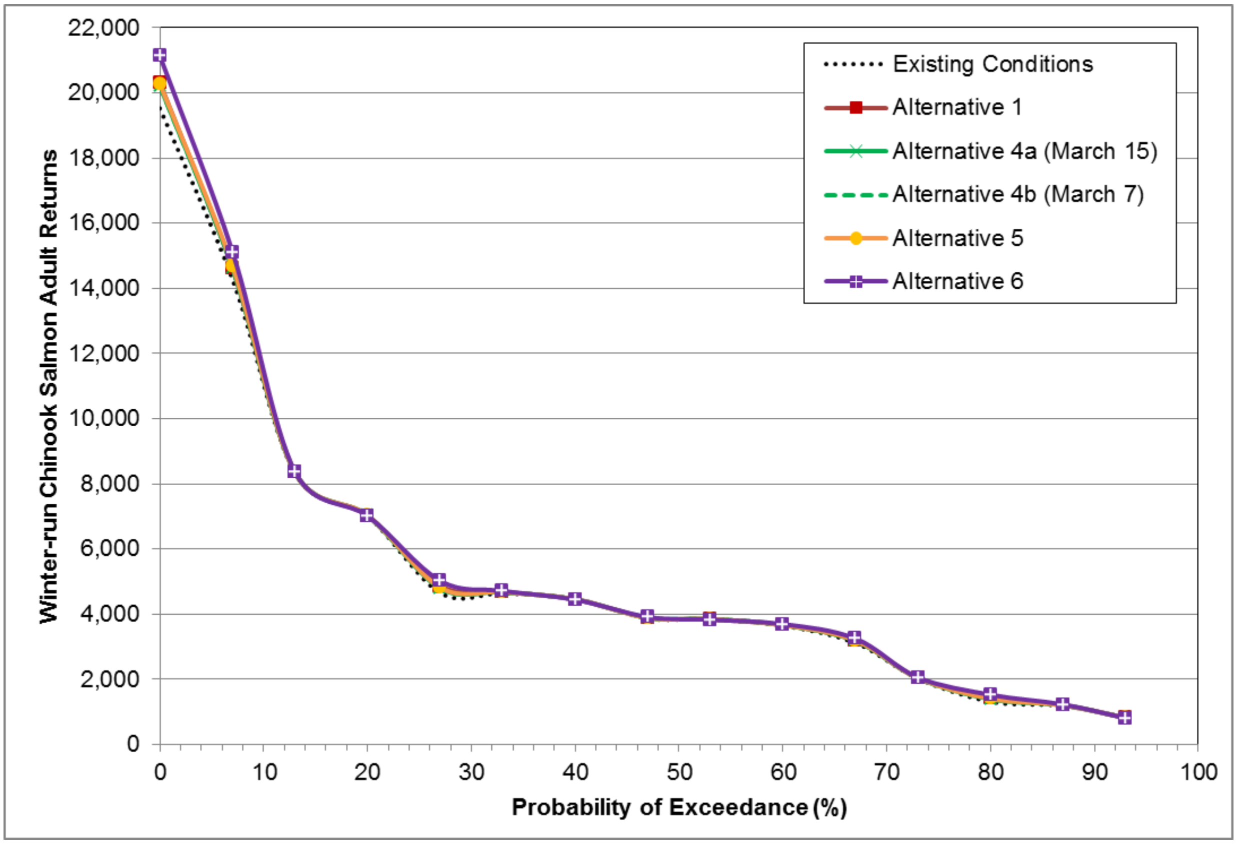


Figure 8-110. Simulated Adult Winter-run Chinook Salmon Returns Probability of Exceedance Distributions under All Alternatives and Existing Conditions

8.5.9 Additional Considerations

In addition to the assessment of the relative performance of each alternative with respect to the objectives described above, additional pertinent considerations not previously addressed in this section include the relative potential for predation not accounted for in the existing fisheries modeling, the potential for future adaptive management and flexibility in operating the Project, and the abundance of the four target species and their timing in the Project Area.

8.5.9.1 Predation

The primary difference in the potential for changes in predation in the Yolo Bypass among the alternatives is expected to be associated with the construction of the water control structures under Alternative 4 and the programmatic Tule Canal floodplain improvements associated with Alternative 5. Because predatory fishes, such as striped bass, black bass, white catfish, channel catfish, and Sacramento pikeminnow, are observed in the perennial Tule Canal, the water control structures may provide suitable locations for predatory fish to inhabit and facilitate their predation on downstream migrating juvenile salmonids. Based on a review of predation studies and related literature in the Delta region, Grossman et al. (2013) found that most of the predation hot spots, where substantial predation of juvenile salmonids may consistently occur, were located near artificial structures such as bridges, radial gates, and physical obstructions in the channel. Therefore, the presence of the water control structures may result in increased predation of juvenile salmonids (and other native fish species of focused evaluation) under Alternative 4 and the Tule Canal Floodplain Improvements associated with Alternative 5 relative to the other alternatives.

8.5.9.2 Adaptive Management Potential

It is expected that the FETT will learn new information over time regarding juvenile entrainment, floodplain habitat conditions, and species responses associated with operations of the proposed Fremont Weir facilities. Therefore, alternatives with greater long-term flexibility would better allow for refining (adaptively managing) operations for the purposes of meeting the project objectives and avoiding or minimizing significant impacts. Given the uncertainties associated with estimating entrainment of size-specific juvenile Chinook salmon into the Yolo Bypass, multiple gates at the intake facilities under Alternative 5 would potentially allow for optimizing levels of juvenile Chinook salmon entrainment into the Yolo Bypass under various hydraulic conditions. Similarly, the wider notch (and associated higher flow capacity) under Alternative 6 could be adaptively managed to better optimize juvenile Chinook salmon entrainment into the Yolo Bypass relative to other Alternatives. Therefore, Alternatives 5 and 6 would have better potential for future adaptive management to meet project objectives relative to the other alternatives.

Components of Alternative 4 also may facilitate the adaptive management of operations to better meet some of the project objectives. Operations of the water control structures could potentially be managed and refined over time to increase inundation duration during appropriate times to increase the suitability of habitat conditions for juvenile salmonids and juvenile and adult Sacramento splittail while increasing primary and secondary productivity in the Yolo Bypass and potentially exporting more productive water to localized areas in the Delta. For example, Henning et al. (2007) found that seasonally flooded freshwater wetlands with water control structures on a floodplain provided juvenile coho salmon more time for rearing relative to unmodified wetlands. Although relatively more intensive studies and monitoring may be required, components of Alternative 4 could provide additional opportunity for future adaptive management relative to the other alternatives.

8.5.9.3 Target Species' Abundance

Abundance counts of winter-run and spring-run Chinook Salmon, steelhead, and green sturgeon were compiled, and graphs were generated using data from the CDFW GrandTab database. These abundance counts include all adult Winter-Run Chinook (Figure 8-111) and Spring-Run Chinook Salmon (Figure 8-112), including hatchery fish. The data set was compiled by CDFW on 4/9/2018 and accessed by DWR on 4/16/2019. Data from the years 2009 through 2017 is still preliminary. More details on special-status species can be found in section 8.1.2.2.

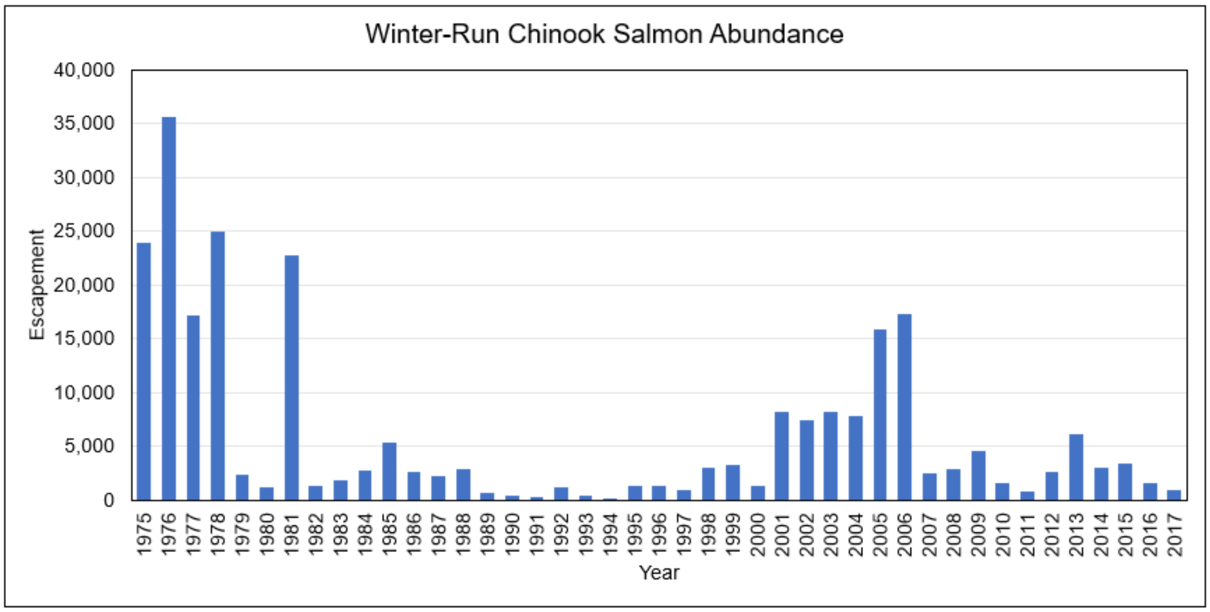


Figure 8-111. Winter-run Chinook Salmon Abundance

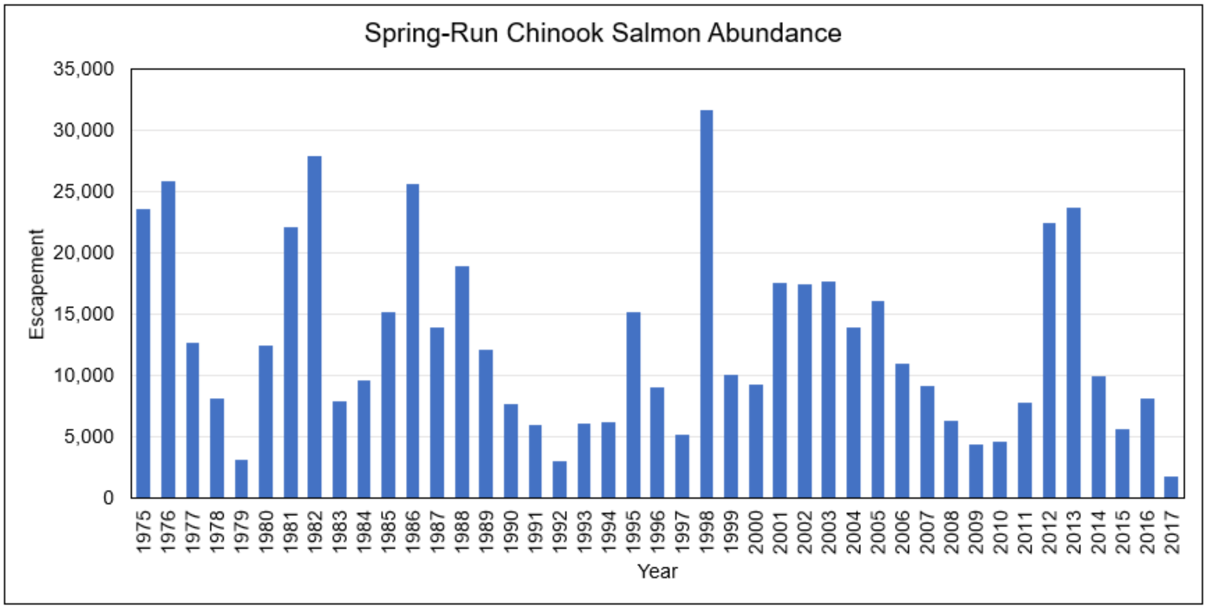


Figure 8-112. Spring-run Chinook Salmon Abundance

Adult steelhead counts at Red Bluff Diversion Dam on the upper Sacramento River (1967-1993) are included in Figure 8-113 (CDFG 1996). In the 1950s, steelhead populations numbered approximately 40,000 fish, in the mid-1960s estimated 27,000 fish, and estimated less than 10,000 fish by the early 1990s (CDFG 1965, as cited in CDFG 1996; CDFG 1996). Additional info is provided in Figure 8-113 and 8-114 on steelhead hatchery returns.

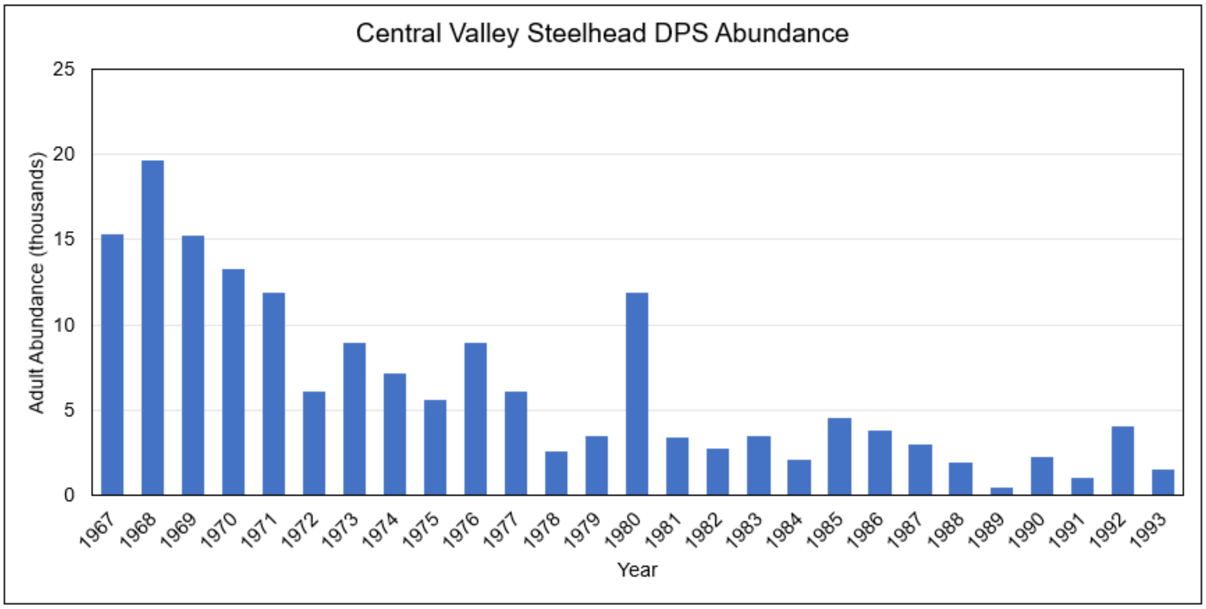


Figure 8-113. Central Valley Steelhead DPS Abundance

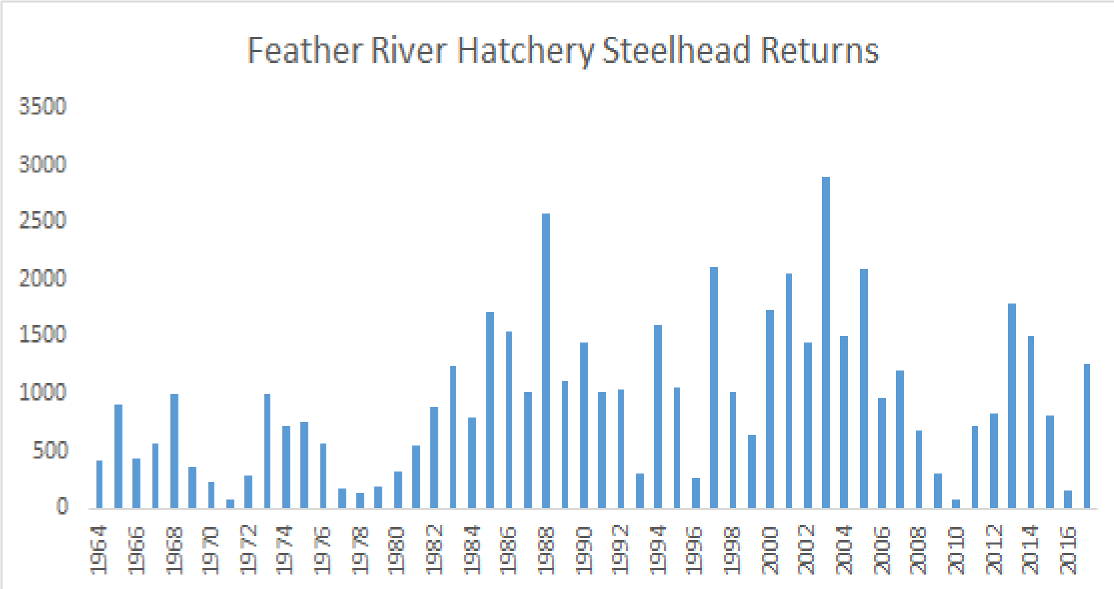


Figure 8-114. Steelhead Returns to the Feather River Hatchery, 1964–2016

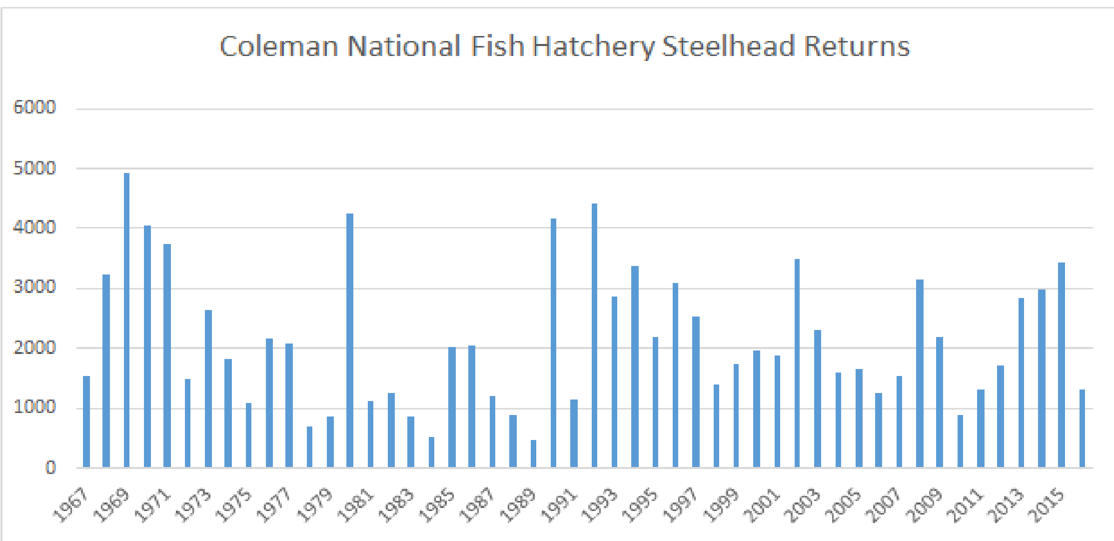


Figure 8-115. Steelhead Returns to the Coleman National Fish Hatchery, 1967–2015

Historic annual abundance trend data for the southern DPS of North American green sturgeon is not readily available due to their complex life-histories and difficulty in sampling for both juvenile and adult sturgeon with the typical sampling methods used for monitoring salmonid populations. Although salvage data was referenced as “the only existing information regarding changes in abundance of the Southern DPS of green sturgeon” in the NMFS BO, there has been several changes in the operations and collection of salvage data that preclude this data from being a reliable source for determining abundance trends for green sturgeon. For example, fish count duration and, as a result, the expansion factor applied to actual green sturgeon counts have not remained consistent throughout the 1981-2018 operational period depicted above (Technical

Report 85, 2013). Additionally, consistent species identification during each fish count was not implemented until 1992 (Technical Report 85, 2013).

Another source of relative abundance trends is the total harvest of green sturgeon from California, Oregon, and Washington from 1985-2003, graphically depicted in the Figure 8-116 below (data pulled from Adams et al. 2006). However, this harvest data includes both the distinct population segments (northern and southern) of North American Green Sturgeon.

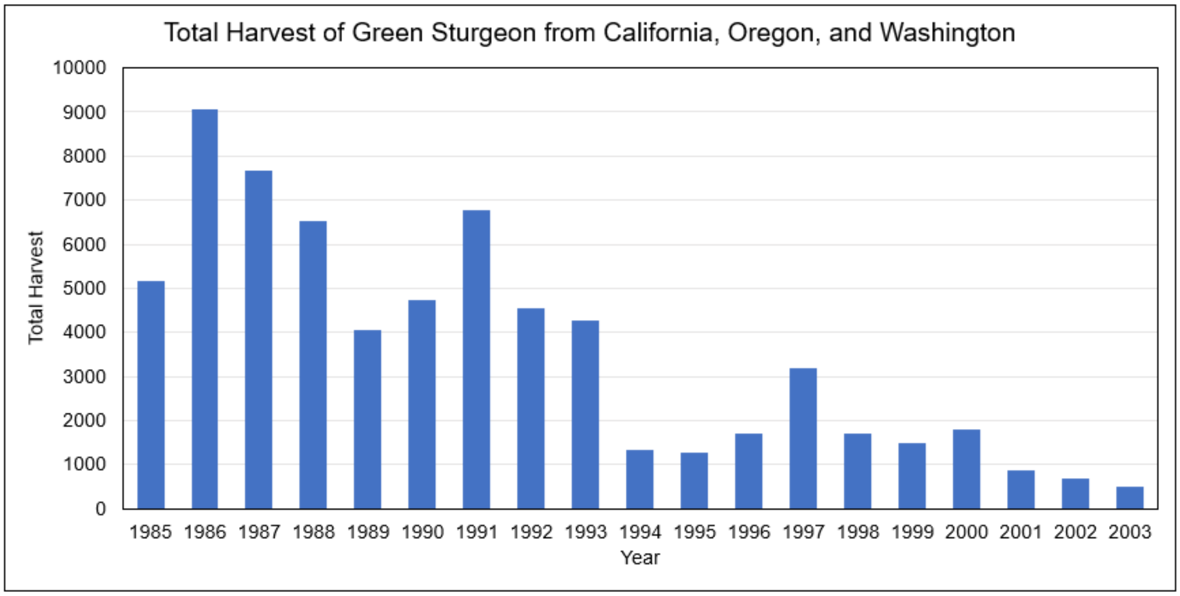


Figure 8-116. Total Harvest of Green Sturgeon from California, Oregon, and Washington

8.5.9.4 Target Species' Timing

Adult fish passage at the Fremont Weir for the target fish species was evaluated over the expected migration periods in the Yolo Bypass (Table 8-3) (DWR 2017b; Appendix G5). Based on these migration timings, the target fish species could be present near Fremont Weir from October through May. However, the Fremont Weir notch gates are not proposed to be operational in October and May under the alternatives. In addition, because flow conditions at Fremont Weir are generally too low to allow for fish migration between the Sacramento River and the Yolo Bypass (DWR 2017b; Appendix G5) and because project operations are unlikely to affect flow conditions at Fremont Weir during May, the evaluation period selected for adult fish passage at Fremont Weir extends from November through April.

Juvenile fish presence at Knights Landing Ridge Cut Slough is included in Figure 8-117. Dark blue bars represent average first to last fish presence data (from years 2003 – 2018), and light blue bars represent absolute first to last fish data. Data were obtained from "SacPas Cohort Juvenile Migration Timing and Conditions" (Columbia Basin Research 2019). Steelhead data backed up by findings of Snider and Titus 2000.

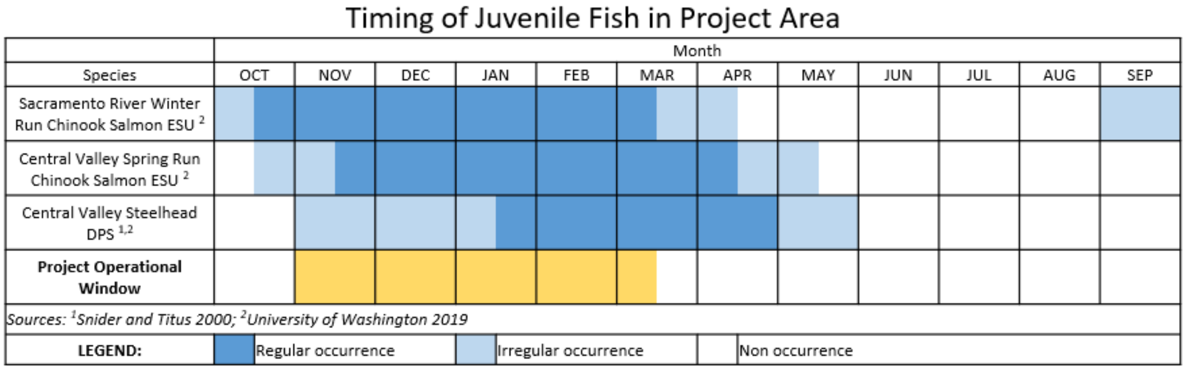


Figure 8-117. Timing of Juvenile Fish in Project Area

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