Appendix A List of Preparers

A.1 ICF

Name	Qualifications	Years of Experience	Project Role
Gregg Ellis	B.A. Geography	22	Project Management, Oversight and Review
Matilda Evoy-Mount	B.A. Environmental Studies	9	Project Management, Oversight and Review
Marin Greenwood	B.S. Aquatic Bioscience, M.S. Applied Fish Biology, Ph.D. The Fish Populations of the Lower Forth Estuary, Including the Environmental Impact of Cooling Water Extraction	20	Aquatics Author
Rick Wilder	B.S. Biology, Ph.D. Ecology, Evolution, and Marine Biology	15	Aquatics Author
Sophie Unger	B.A. Biology, Ph.D. Aquatic Ecology	34	Aquatics Author
Pat Crain	B.S. Wildlife, Fish, and Conservation Biology, Graduate Studies in Biological Conservation	23	Aquatics Author
Bill Mitchell	B.S. Biology, M.S. Fisheries Biology	32	Aquatics Author
Ellen Berryman	B.S. Zoology, M.S. Biology	32	Terrestrial Author
Amy Poopatanapong	B.S. Zoology, M.S. Zoology	17	Terrestrial Author
Torrey Edell	B.S. Ecology and Systematic Biology	15	Terrestrial Author
LeAnne Rojas	B.S. Biological Conservation, P.S.M. Water Resources Management	7	Terrestrial and Aquatics Author
Kasey Allen	B.A. Economics	15	Geographic Information Systems
David Ernst	B.A. Ethics and Politics, B.S. Urban Systems Engineering, M.C.R.P. Environmental Policy	39	Air Quality and GHG Author
Mikenna Wolff	B.S. Ecology & Biodiversity, Certificate Natural Resources Management, M.S. Environmental Policy & Management	4	Air Quality and GHG Author

Name	Qualifications	Years of Experience	Project Role
Jason Volk	B.S. (with honors) Mechanical Engineering	19	Noise Author
Lesa Erecius	B.S. Physiology, M.S. Pharmacology and Toxicology (Aquatic Toxicology emphasis)	13	Hazards and Hazardous Materials Author
Diana Roberts	B.S. Applied Psychology, M.A. Linguistics	22	Land Use and Agriculture Author
David Lemon	B.A. U.S. History, M.A. Public History, Ph.D. candidate Public History	17	Cultural Resources Author
Christiaan Havelaar	B.A. Anthropology (minor in History)	22	Cultural Resources Author (Architectural Historian)
Susan Lassell	B.S. Environmental Design, M.A. Historic Preservation Planning	25	Technical Review
Zetta Quick	B.A. Environmental Studies/Politics, Certificate Landscape Architecture	18	Visual Resources Author
Erin Gustafson	B.A. (cum laude) Urban Studies and Planning (minors in Environmental Studies and Economics)	7	Contributing Author
Teresa Chan	B.A. Political Science, J.D. with Certificate in Law and Business	15	Contributing Author, Technical Review
Stefanie Lyster	B.A. Journalism and Political Science, Master of Public Administration	18	Document Production, Oversight and Review
Sara Wilson	B.A. Classical Languages	21	Technical Editor
Mindy Farnsworth	B.A. English Language	14	Technical Editor
Tamar Grande	B.A. Creative Writing/English, M.A. Creative Writing	20	Technical Editor
Corrine Ortega	A.A. Communications	31	Document/Publications Specialist
Kristin Gunn	B.S. Business Administration, M.S. Library and Information Science	33	Administrative Record
Gregg Roy	B.S. Political Economy of Natural Resources,	30	Technical Review

A.2 CDM Smith

Name	Qualifications	Years of Experience	Project Role
Carrie Buckman, PE	B.S., Environmental Engineering, B.S., Environmental Policy, M.Eng, Environmental Engineering	20	Deputy Project Manager
Andria Loutsch, AICP	B.S. Economics	22	NEPA Task Lead
Gina Veronese	B.S. Agricultural Economics, M.S. Resource Economics	16	EIS Author
Christopher Park, AICP	B.S Natural Resources Planning, M.C.R.P. City and Regional Planning	13	Water Quality Author, Water Supply Author
Laura Lawson	B.S Environmental Studies: Natural Resource Management and Conservation	2	Water Quality Author
Donielle Grimsley	B.S. Biology	12	Water Quality Author
Abbie Woodruff, AICP	B.S. Geography, B.S. Environmental Studies, M.S. Urban and Environmental Planning	5	Water Supply Author
Brian Heywood, PE	B.S. Civil Engineering, M.S. Civil and Environmental Engineering	21	Groundwater Author
Anusha Kashyap	B.S. Civil Engineering, M.S. Environmental Engineering	10	Regional Economics Author
Dorothy Meyer	B.A. Geography, Minor Environmental Studies	32	Recreation Author, Environmental Justice Author
Megan Regel	B.A. Geology, M.S. Geosciences	9	Recreation Author
Emma Argiroff	B.A. Environmental Science, B.A. Art and Design, M.A. Urban Planning	3	Recreation Author
Tsui Li	B.S. Environmental Sciences, M.A. Urban and Regional Planning	3	Environmental Justice Author
Kate Stenberg, Ph.D.	Ph.D. Wildlife-Fisheries Science/Regional Planning, M. Admin. Environmental Administration; B.A. Environmental Studies/Biology	35	Technical Review
John Wondolleck	M.S Zoology, B.S. Biology	45	Technical Review
Robert Fitzgerald, PE	M.S. Civil Engineering, B.S. Civil Engineering	38	Technical Review
Traci Mordell	B.A. Hispanic Studies	20	Editorial Review
Melissa Vagi, CPTC	M.J., Journalism; B.A., Spanish	12	Editorial Review
Terry Crowell, ASQ CQA, CHMM	B.S. Biology	23	Editorial Review
Allison Fick	B.A. Journalism	4	Editorial Review
Rose Hanson	B.A. History	5	Editorial Review
Daisy Hesselberg			Word Processing

A.3 Cramer Fish Sciences

Name	Qualifications	Years of Experience	Project Role
Brad Cavallo	B.S. Fisheries Biology, M.S. Aquatic Ecology	23	Aquatics Author
Steven Zeug	B.S. Fisheries Biology, Ph.D. Wildlife and Fisheries Sciences	18	Aquatics Author
Travis Hinkelman	B.S. Fisheries and Wildlife, Ph.D. Biological Sciences	16	Aquatics Author
Annie Brodsky	B.S. Evolution, Ecology and Biodiversity	8	Aquatics Author

A.4 HDR

Name	Qualifications	Years of Experience	Project Role
Gabriel Kopp	B.S. Biology, 2 years Graduate study in Aquatic Ecology	18 years	General PM, Supporting Aquatics Author, Technical Review
Jelica Arsenijevic	B.S. Earth Systems, Science, and Policy with concentration in Marine and Coastal Ecology	16.5 years	Aquatics Contributing Author
John Spranza	M.S. Zoology	23 years	Aquatics Contributing Author
Jacob Venard	M.S. Fisheries	19 years	Aquatics Contributing Author
Fred Holzmer	M.A. Geology	30 years	Geology and Soils Author
Jeff Weaver	B.S. Civil Engineering, PE	21 years	Primary Power and Energy Author
Hayley Huerd	B.S. Environmental Engineering	0.5 years	Supporting Power and Energy Author

A.5 Jacobs

Name	Qualifications	Years of Experience	Project Role
Robert Leaf	B.S. Forest and Resource Management, B.S. Civil Engineering, M.S. Civil Engineering, California P.E., MBA Business Administration	24	Senior Lead for Water Resources Modeling
Christine Arenal	B.S. Biology. M.S Wildlife Biology	25	Selenium and Mercury Bioaccumulation Modeling and Assessment
Nate Brown	B.S. Geology, M.S. Hydrogeology, California P.G. and C.Hg.	24	Senior Groundwater Modeler
Craig Cooledge	B.S. Civil and Environmental Engineering, M.S. Civil and Environmental Engineering	4	Groundwater Modeler
Kevin Kasberg	B.A. Environmental Studies/Economics, M.S. Agricultural and Resource Economics	7	Urban and Agricultural Water Supply Economist
Peter Lawson	B.S. Geology. M.S. Hydrology, California P.G. and C.Hg.	30	Senior Lead for Groundwater Modeling
Steven Micko	B.S. Civil and Environmental Engineering, M.S. Civil and Environmental Engineering	4	Water Resources Modeler
Harry Ohlendorf	B.S. Wildlife Management (Fisheries Option), M.S. Wildlife Science, Ph.D. Wildlife Science	47	Senior Lead for Selenium Bioaccumulation Modeling and Assessment
Solmaz Rasoulzadeh	B.S. Soil and Water Engineering, M.S. Water Resources Engineering, Ph.D. Water Resources Engineering	4	Water Resources Modeler
Samaneh Saadat	B.S. Water Engineering, M.S. Hydrology and Water Resources Engineering, Ph.D. Environmental and Water Resources Engineering	4	Water Resources Modeler

Name	Qualifications	Years of Experience	Project Role
Chad Whittington	B.S. Civil and Environmental Engineering, M.S. Civil and Environmental Engineering	3.5	Water Resources Modeler
Fatuma Yusuf	B.S. Range Management, M.A. Agricultural Economics, M.S. Statistics, Ph.D. Agricultural Economics	23	Senior Economist

A.6 Stillwater Sciences

Name	Qualifications	Years of Experience	Project Role
Mike Davis	B.A. Biology, M.S. Fish and Wildlife Management	12	Project Management, Oversight, Aquatics Author, Review
Sapna Khandwala	B.A. Integrative Biology	22	Project Management, Oversight, Review
AJ Keith	B.S. Environmental, Population, and Organismal Biology, M.A. Ecology and Systematic Biology	27	Project Management, Oversight, Review
Ethan Bell	B.S. Ecology and Evolution, M.S Fisheries Biology	21	Aquatics Author and Review
Kim Gould	B.S. Fisheries Science	20	Aquatics Author and Review
Dirk Pedersen	B.S. Fisheries Science	27	Aquatics Author and Review
Abel Brumo	B.S. Biology, M.S., Fisheries Science	16	Aquatics Author
Russ Liebig	B.S. Wildlife, Fisheries, and Conservation Biology	20	Aquatics Author and Review
Heather Bowen Neff	M.S. Biological Sciences, B.S. Wildlife, Fisheries, and Conservation Biology	12	Aquatics Author and Review
Emily Applequist	B.S. Biological Sciences, B.A. Environmental Geology, B.A. Environmental Studies	5	Aquatics Author and Review
David DeKrey	B.S. Biology, M.S. Biology	18	Aquatics Author
Ken Jarrett	B.S. Fisheries Biology	14	Aquatics Author

Name	Qualifications	Years of Experience	Project Role
Sam Rizza	B.A. Environmental Studies, M.S. Fisheries Biology	13	Aquatics Author
Crystal Garcia	B.A. Environmental Studies	8	Aquatics Author
Eric Sommerauer	B.S. Wildlife, Fish, and Conservation Biology	11	Aquatics Author

A.7 RBI

Name	Qualifications	Years of Experience	Project Role
Michael Bryan	B.S. Fisheries Biology, M.S. Fisheries Biology and Biology, Ph.D. Environmental Toxicology and Fisheries Biology	33	Water Quality Author
Michelle Brown	B.S. Civil Engineering, M.S. Civil Engineering	23	Water Quality Author
Cameron Irvine	B.S. Biology, M.S. Environmental Science (Ecotoxicology)	24	Water Quality Author
Ellen Preece	B.S. Environmental and Resource Economics, M.S. Natural Resource Science, Ph.D. Environmental and Natural Resource Sciences, Limnology	15	Water Quality Author
Cyle Moon	B.S. Environmental Engineering, M.S. Engineering Science	7	Water Quality Modeling Support

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Appendix C Facility Descriptions and Operations

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

This appendix describes the surface water resources, water supplies, and facilities within the Central Valley Project (CVP) and State Water Project (SWP) in the project area. The facilities and current operations are described under the No Action Alternative. Operations of some facilities would change under the action alternatives, as described in the Alternatives Appendix. Some facilities that would not be affected by any of the alternatives analyzed in this document have been included as supplementary information. The appendix is intended to provide relevant background information about the facilities and their operations.

C.1 Introduction

This section provides an overview of the CVP and of the SWP facilities. The sections that follow provide an overview of hydrologic conditions and CVP and SWP facilities and operations in the Trinity River, Sacramento Valley, San Joaquin Valley, and the Delta and Suisun Marsh.

C.1.1 Overview of the Central Valley Project

The 1935 Rivers and Harbors Act authorized Reclamation to take over the CVP from the State of California and its initial features were authorized for construction. In 1937, the Rivers and Harbors Act reauthorized the CVP under Reclamation Law. The 1937 Act and subsequent authorizations completed CVP facilities, that include:

- Trinity and Lewiston dams on the Trinity River.
- Shasta and Keswick dams on the Sacramento River.
- Red Bluff Pumping Plant on the Sacramento River to deliver water into the Tehama-Colusa Canal and the Corning Canal.
- Folsom and Nimbus dams on the American River and the Folsom-South Canal.
- Delta Cross Channel in the Delta.
- Rock Slough Intake to deliver water into the Contra Costa Pumping Plant, Contra Costa Canal, and Contra Loma Reservoir.
- Friant Dam along the San Joaquin River to deliver water into the Friant-Kern and Madera.

- C.W. Jones Pumping Plant (Jones Pumping Plant) (previously known as the Tracy Pumping Plant) in the south Delta to deliver water into the Delta-Mendota Canal and Mendota Pool.
- Delta-Mendota Canal/California Aqueduct Intertie downstream of the CVP Jones Pumping Plant and the SWP Banks Pumping Plant.
- San Felipe Division, including San Luis Reservoir-related facilities, consisting of the O'Neill Forebay, Pumping Plant, and Canal; Coalinga Canal, Pleasant Valley Pumping Plant, and San Luis Drain. The O'Neill Forebay is operated in coordination with the SWP. The SWP facilities operated in coordination with the CVP include the B.F. Sisk San Luis Dam (the major dam that forms San Luis Reservoir), San Luis Canal, Los Banos and Little Panoche dams, and associated pumping plants.
- Pacheco Tunnel and Conduit to deliver water from the San Luis Reservoir into the San Justo Dam and Reservoir, Hollister Conduit, and Santa Clara Tunnel and Conduit.
- New Melones Dam along the Stanislaus River.

The CVP reservoirs are listed in Table C.1-1 and shown on Figures C.1-1 through C.1-5. Table C.1-1 also includes reservoirs of the Bureau of Reclamation Orland Project (which are not part of CVP) because these reservoirs also affect hydrology of Stony Creek, a tributary to the Sacramento River.

Table C.1-1. Major Central Valley Project and Orland Project Reservoirs

Project	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
CVP	Millerton Lake	Friant	San Joaquin River	1942	524,000
CVP	Shasta Lake	Shasta	Sacramento River	1945	4,552,000
CVP	Keswick Reservoir	Keswick	Sacramento River	1950	23,772
CVP	Trinity Lake	Trinity	Trinity River	1962	2,447,650
CVP	Lewiston Reservoir	Lewiston	Trinity River	1963	14,660
CVP	Spring Creek Reservoir	Spring Creek Debris Dam	Spring Creek (tributary of Sacramento River)	1963	5,874
CVP	Whiskeytown Lake	Whiskeytown	Clear Creek (tributary of Sacramento River)	1963	241,100
CVP	Folsom Lake	Folsom	American River	1956	967,000
CVP	Lake Natoma	Nimbus	American River	1955	9,000
CVP	Contra Loma Reservoir	Contra Loma	Off-Stream	1967	2,627
CVP	Martinez Reservoir	Martinez	Wildcat Creek	1938	268
CVP	San Luis Reservoir	B.F. Sisk	San Luis Creek	1967	2,041,000
CVP	O'Neill Forebay	O'Neill	San Luis Creek	1967	56,400
CVP	Los Banos Creek Reservoir	Los Banos Detention	Los Banos Creek	1965	34,600
CVP	Little Panoche Creek Reservoir	Little Panoche Detention	Little Panoche Creek	1966	5,580
CVP	San Justo Reservoir	San Justo	Offstream	1985	10,300
CVP	Funks Reservoir	Funks	Funks Creek	1976	2,460
CVP	New Melones Reservoir	New Melones	Stanislaus River	1979	2,400,000
CVP	Hensley Lake	Hidden	Fresno River	1975	90,000
CVP	H.V. Eastman Lake	Buchanan	Chowchilla River	1975	150,000
Orland	East Park Reservoir	East Park	Little Stony Creek (tributary of Sacramento River)	1910	51,000
Orland	Stony Gorge Reservoir	Stony Gorge	Stony Creek (tributary of Sacramento River)	1928	50,350

Sources: DWR 2014b; Reclamation 1994, 2014a, 2014b.
Note: CVP is Central Valley Project; Orland is Orland Project

Figure C.1-1. California Major Water Supply Facilities

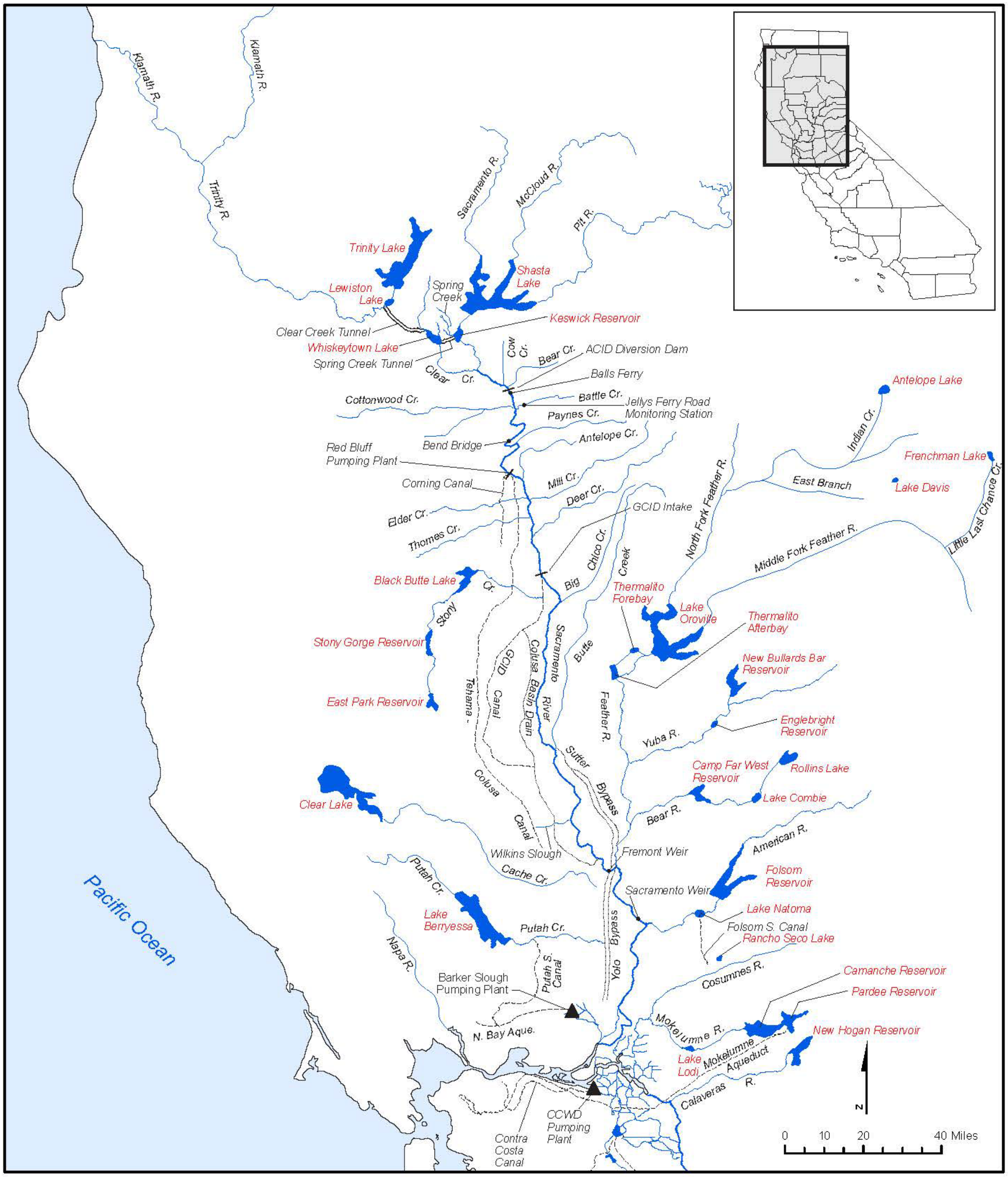

Figure C.1-2. Northern California Major Water Supply Facilities

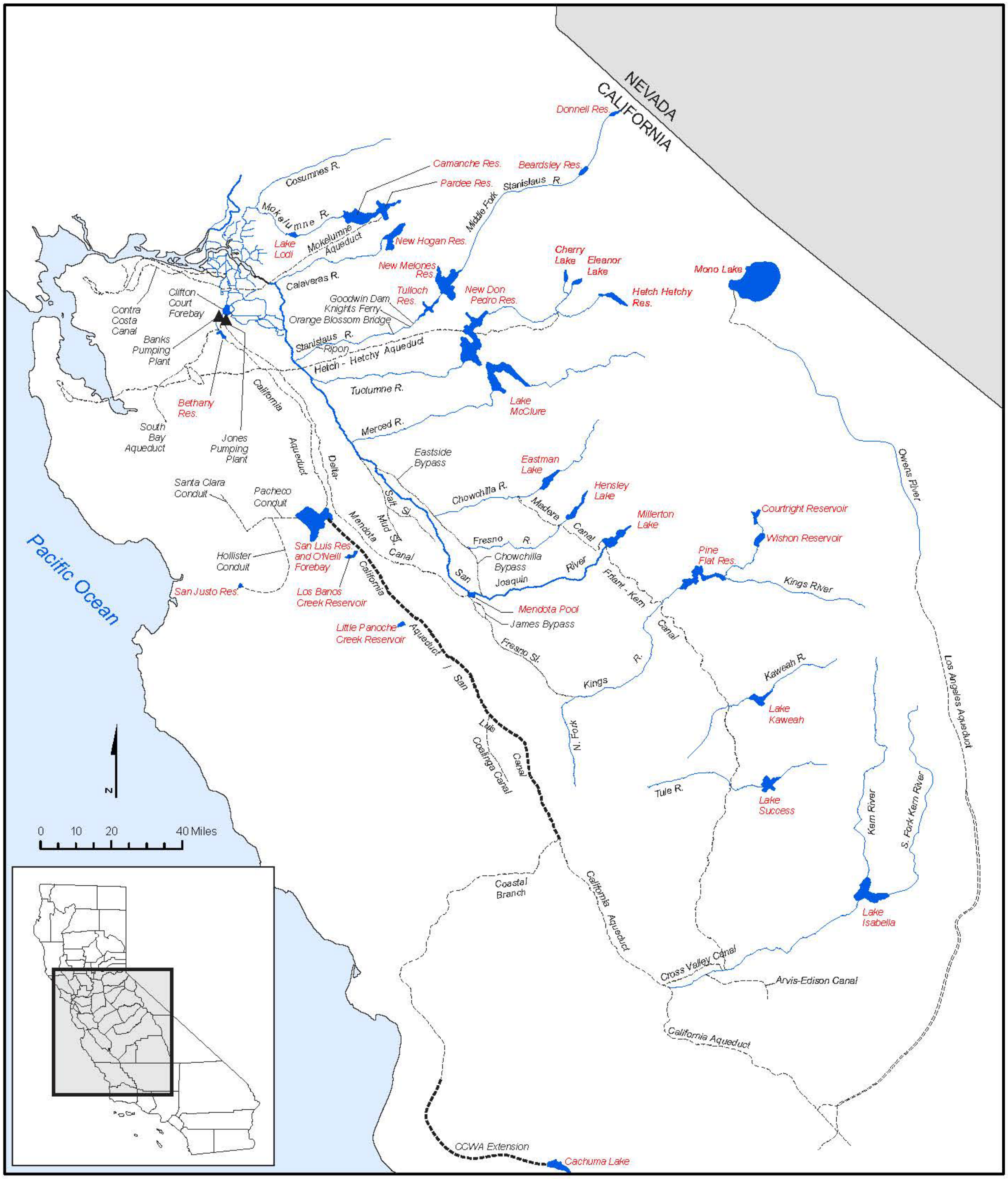

Figure C.1-3. San Joaquin Valley and Tulare Lake Major Water Supply Facilities

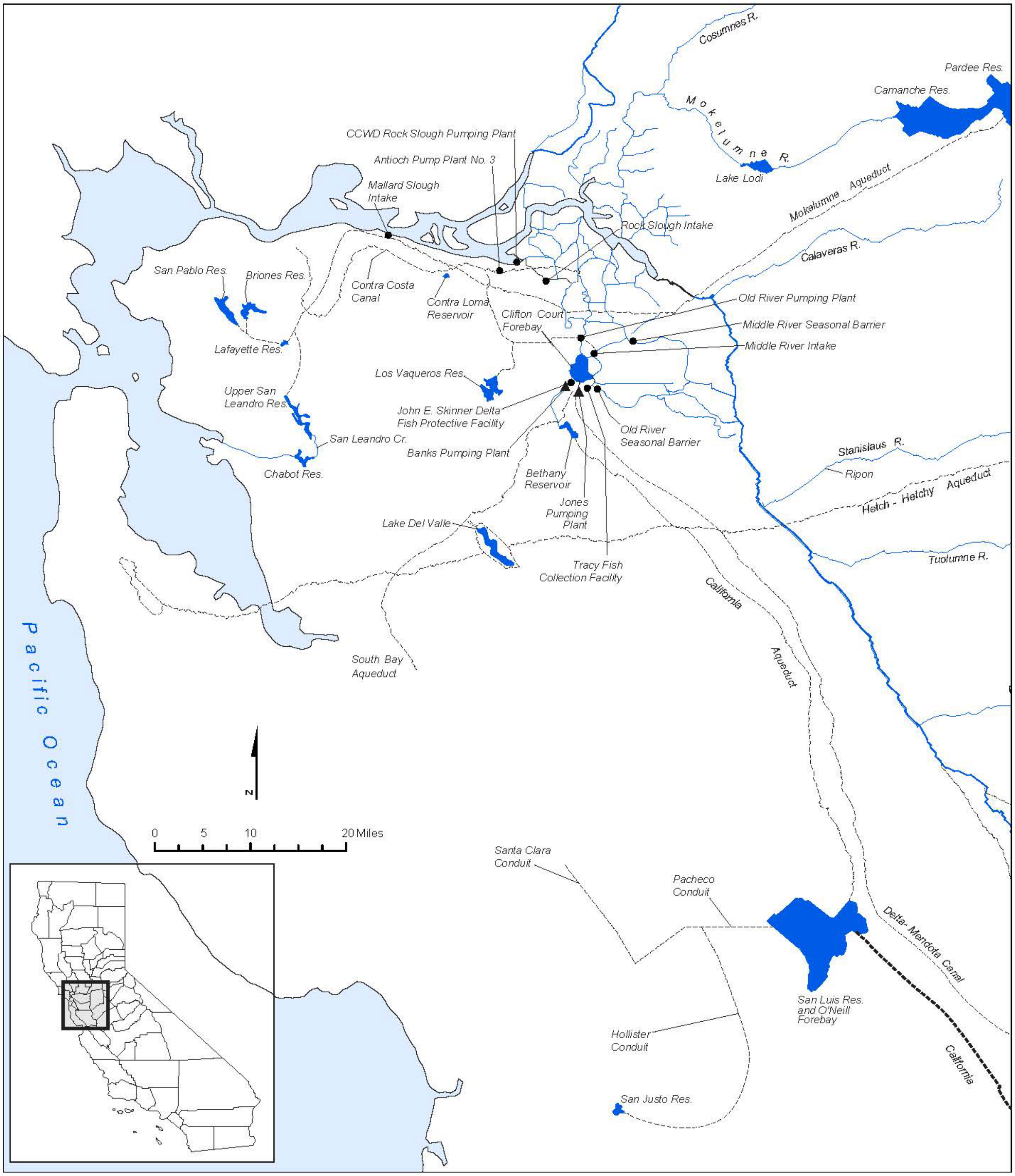

Figure C.1-4. San Francisco Bay Area Major Water Supply Facilities

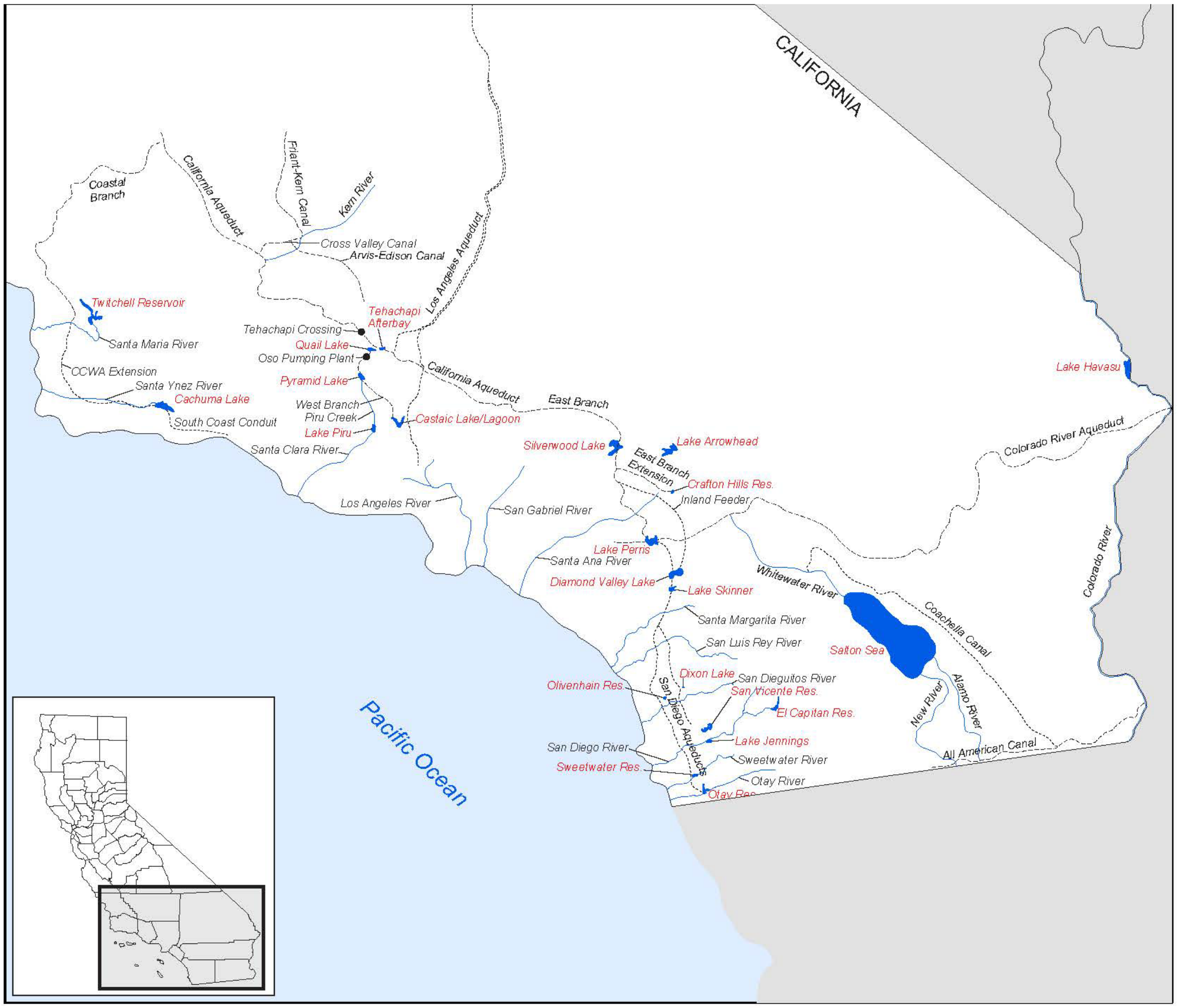

Figure C.1-5. Central Coast and Southern California Major Water Supply Facilities

C.1.2 Overview of the State Water Project

As the CVP facilities were being constructed after World War II, the state began investigations to meet additional water needs through development of the California Water Plan. In 1957, DWR published Bulletin Number 3 that identified new facilities to provide flood control in northern California and water supplies to the San Francisco Bay Area, San Joaquin Valley, San Luis Obispo and Santa Barbara counties in the Central Coast Region, and southern California (DWR 1957, 2012; Reclamation 2011a). The study identified a seasonal deficiency of 2.675 MAF/year in 1950 that resulted in groundwater overdraft throughout many portions of California. The report described facilities to meet the water demands and reduce groundwater overdraft, including facilities that would become part of the SWP.

In 1960, California voters authorized the Burns-Porter Act to construct the initial SWP facilities. The SWP facilities, as shown on Figures C.1-1 through C.1-5, include:

- Antelope Lake, Lake Davis, and Frenchman Lake on the upper Feather River upstream of Oroville Dam.
- Oroville Dam and Thermalito Diversion Dam on the Feather River.
- Barker Slough Pumping Plant in the north Delta which delivers water to the North Bay Aqueduct (NBA).
- Clifton Court Forebay and Harvey O. Banks Pumping Plant (Banks Pumping Plant) in the south Delta, which delivers water into the Bethany Forebay and California Aqueduct.
- South Bay Pumping Plant to deliver water from Bethany Forebay to the South Bay Aqueduct (SBA) and Lake Del Valle.
- San Luis Reservoir-related facilities, including the SWP facilities B.F. Sisk San Luis Dam (the major dam that forms San Luis Reservoir), San Luis Canal, Los Banos and Little Panoche dams, and associated pumping plants, and the CVP O'Neill Forebay. These facilities are operated in coordination between the SWP and CVP.
- California Aqueduct to deliver water to the San Joaquin Valley, Central Coast, and southern California. The California Aqueduct extends from the Banks Pumping Plant to San Luis Reservoir and continues to Lake Perris in Riverside County. The California Aqueduct reach in southern California also includes Quail Lake, Pyramid Lake, Castaic Lake, Silverwood Lake, Crafton Hills Reservoir, and Lake Perris.
- The Coastal Branch of the California Aqueduct to deliver water from the California Aqueduct to San Luis Obispo and Santa Barbara counties.

Major SWP reservoirs are listed in Table C.1-2.

Table C.1-2. State Water Project Reservoirs

Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
Frenchman Lake	Frenchman	Little Last Chance Creek (tributary of Feather River)	1961	55,477
Antelope Lake	Antelope	Indian Creek (tributary of Feather River)	1964	22,566
Lake Davis	Grizzly Valley	Big Grizzly Creek (tributary of Feather River)	1966	83,000
Oroville Reservoir	Oroville	Feather River	1968	3,537,577
Thermalito Pool	Thermalito Diversion	Feather River	1967	13,328
Thermalito Forebay	Thermalito Forebay	Cottonwood Creek (tributary of Feather River)	1967	11,768
Thermalito Afterbay	Thermalito Afterbay	Feather River	1967	57,041
Clifton Court Forebay	Clifton Court Forebay	Old River	1970	29,000
Bethany Forebay	Bethany Forebay	Italian Slough	1961	5,250
Patterson Reservoir	Patterson	Offstream	1962	98
Lake Del Valley	Del Valle	Arroyo Valle	1968	77,100
Quail Lake	No dam	Offstream	Historic	5,654

Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
Pyramid Lake	Pyramid	Piru Creek	1973	180,000
Castaic Lake	Castaic	Castaic Creek	1973	323,700
Silverwood Lake	Cedar Springs	Mojave River (West Fork)	1971	78,000
Crafton Hills Reservoir	Crafton Hills	Yucaipa Creek	2001	130
Lake Perris	Perris	Bernasconi Pass	1973	131,452

Sources: DWR 2014b, 2014c.

C.1.3 Other Major Water Supply and Flood Management Reservoirs

During the past 100 years, numerous water supply, flood management, and hydroelectric generation reservoirs were constructed throughout California. Many of these projects were constructed on tributaries to the Sacramento and San Joaquin rivers and tributaries to the Tulare Lake Basin. Operations of these non-CVP and non-SWP reservoirs affect flow patterns into the Sacramento and San Joaquin rivers and the Delta.

Major non-CVP and non-SWP reservoirs in the Sacramento Valley and San Joaquin Valley watersheds, generally with storage capacities greater than 100,000 acre-feet, which could affect operations of CVP or SWP reservoirs or Delta facilities or could be affected by operations of the CVP or SWP, are listed in Tables C.1-3 and C.1-4.

Table C.1-3. Major Non-Central Valley Project and Non-State Water Project Reservoirs in the Sacramento Valley Watershed Considered

Owner	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
U.S. Army Corps of Engineers	Black Butte Reservoir	Black Butte	Stony Creek (tributary of Sacramento River)	1963	143,700
Yuba County Water Agency	Bullards Bar Reservoir	New Bullards Bar	Yuba River (North Fork)	1970	969,600
U.S. Army Corps of Engineers	Englebright Reservoir	Englebright	Yuba River	1941	70,000
South Sutter Water District	Camp Far West Reservoir	Camp Far West	Bear River	1963	104,500
Pacific Gas & Electric Company	Bucks Lake	Bucks Storage	Bucks Creek (tributary of Feather River)	1928	103,000
Pacific Gas & Electric Company	Lake Almanor	Lake Almanor	Feather River (North Fork)	1927	1,308,000
South Feather Water And Power Agency	Little Grass Valley Reservoir	Little Grass Valley	Feather River (South Fork)	1961	93,010
Pacific Gas & Electric Company	Salt Springs Reservoir	Salt Springs	Mokelumne River (North Fork)	1931	141,900
East Bay Municipal Utility District	Pardee Lake	Pardee	Mokelumne River	1929	209,950
East Bay Municipal Utility District	Camanche Lake	Camanche	Mokelumne River	1963	417,120
Sacramento Municipal Utility District	Union Valley Reservoir	Union Valley	Silver Creek (tributary of American River)	1963	230,000

Owner	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
Placer County Water Agency	French Meadows Reservoir	L. L. Anderson	American River (Middle Fork)	1965	136,400
Placer County Water Agency	Hell Hole Reservoir	Lower Hell Hole	Rubicon River (tributary of American River)	1966	208,400

Sources: DWR 2014b, 2014c.

Table C.1-4. Major Non-Central Valley Project and Non-State Water Project Reservoirs in the San Joaquin Valley Watersheds Considered

Owner	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
Southern California Edison Company	Lake Thomas A. Edison	Vermilion Valley	Mono Creek (tributary of San Joaquin River)	1954	125,000
Southern California Edison Company	Shaver Lake	Shaver Lake	Stevenson Creek (tributary of San Joaquin River)	1927	135,283
Merced Irrigation District	Lake McClure	New Exchequer	Merced River	1967	1,032,000
San Francisco Public Utilities Commission	Cherry Lake	Cherry Valley	Cherry Creek (tributary of Tuolumne River)	1956	273,500
San Francisco Public Utilities Commission	Hetch Hetchy Reservoir	O' Shaughnessy	Tuolumne River	1923	360,000
Turlock Irrigation District	New Don Pedro Reservoir	New Don Pedro	Tuolumne River	1971	2,030,000
Calaveras County Water District	New Spicer Meadow Reservoir	New Spicer Meadow	Highland Creek (tributary of Stanislaus River)	1989	190,000
Tri-Dam Project	Donnells Reservoir	Donnells	Stanislaus River (Middle Fork)	1958	56,893
Tri-Dam Project	Beardsley Reservoir	Beardsley	Stanislaus River (Middle Fork)	1957	77,600
Tri-Dam Project	Tulloch Reservoir	Tulloch	Stanislaus River	1958	68,400
Oakdale Irrigation District and South San Joaquin Irrigation District	Goodwin Diversion	Goodwin	Stanislaus River	1912	500
South San Joaquin Irrigation District	Woodward Reservoir	Woodward	Simmons Creek (tributary of Stanislaus River)	1918	35,000
U.S. Army Corps of Engineers	New Hogan Lake	New Hogan	Calaveras River	1963	317,000

Sources: DWR 2014b, 2014c.

Major reservoirs used to store CVP and SWP water supplies in the San Francisco Bay Area, Central Coast and Southern California regions are shown on Figures C.1-4 and C.1-5 and listed in Tables C.1-5, C.1-6, and C.1-7.

Table C.1-5. Major Non-Central Valley Project and Non-State Water Project Reservoirs in the San Francisco Bay Area Region Used to Store Central Valley Project and/or State Water Project Water

Owner	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
Contra Costa Water District	Los Vaqueros Reservoir	Los Vaqueros	Kellogg Creek	1997	160,000
East Bay Municipal Utility District	Briones Reservoir	Briones	Bear Creek	1964	67,520
East Bay Municipal Utility District	San Pablo Reservoir	San Pablo	Bear Creek	1964	38,600
East Bay Municipal Utility District	Lafayette Reservoir	Lafayette	Marsh Creek	1963	4,250
East Bay Municipal Utility District	Upper San Leandro Reservoir	Upper San Leandro	San Leandro Creek	1977	37,960
East Bay Municipal Utility District	Chabot Reservoir	Chabot	San Leandro Creek	1892	10,281

Sources: DWR 2014b, 2014c; East Bay Municipal Utility District (EBMUD) 2011; City and County of San Francisco (CCSF) 2009; Santa Clara Valley Water District (SCVWD) 2016.
Note:
[a] Anderson Reservoir capacity is restricted due to California Department of Safety and Dams (SCVWD 2016).

Table C.1-6. Major Non-Central Valley Project and Non-State Water Project Reservoirs in the Central Coast Region Used to Store State Water Project Water

Owner	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
Bureau of Reclamation	Cachuma Lake	Bradbury	Santa Ynez River	1953	205,000

Sources: DWR 2014b; Reclamation 2014c.

Table C.1-7. Major Non-Central Valley Project and Non-State Water Project Reservoirs in the Southern California Region Used to Store State Water Project Water

Owner	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
United Water Conservation District	Lake Piru	Santa Felicia	Piru Creek	1955	100,000
Metropolitan Water District Of Southern California	Diamond Valley Lake	Diamond Valley Lake	Domenigoni Valley Creek	2000	800,000
Metropolitan Water District Of Southern California	Lake Skinner	Robert A Skinner	Tucalota Creek	1973	43,800
Rancho California Water District	Vail Lake	Vail	Temecula Creek	1949	51,000
City of Escondido	Dixon Lake	Dixon	Escondido Creek	1970	2,500
San Diego County Water Authority	Olivenhain Reservoir	Olivenhain	Escondido Creek	2003	24,900
City of San Diego	Lake Hodges	Lake Hodges	San Dieguito River	1918	37,700

Owner	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
City of San Diego	San Vicente Reservoir	San Vicente	San Vicente Creek	1943	249,358
City of San Diego	El Capitan Reservoir	El Capitan	San Diego River	1934	112,800
Helix Water District	Lake Jennings	Chet Harritt	Quail Canyon Creek	1962	9,790
Sweetwater Authority	Sweetwater Reservoir	Sweetwater	Sweetwater River	1888	27,700
City of San Diego	Murray Reservoir	Murray	Off-stream	1918	4,818
City of San Diego	Morena Reservoir	Morena	Cottonwood Creek	1912	50,694
City of San Diego	Lower Otay Reservoir	Savage	Otay River	1919	47,061

Sources: DWR 2014b, 2014c; City of San Diego 2019a, 2019b, 2019c, 2019d; San Diego County Water Authority 2019; SDCWA and USACE 2008.

Major reservoirs used to store CVP and SWP water supplies in the San Francisco Bay Area, Central Coast, and Southern California regions are shown on Figures C.1-4 and C.1-5 and listed in Tables C.1-5, C.1-6, and C.1-7.

C.2 Trinity River Region

The Trinity River Region includes the area along the Trinity River from Trinity Lake to the confluence with the Klamath River; and along the lower Klamath River from the confluence with the Trinity River to the Pacific Ocean. The Trinity River Region includes Trinity Lake, Lewiston Reservoir, the Trinity River between Lewiston Reservoir and the confluence with the Klamath River, and along the lower Klamath River.

C.2.1 Trinity River Watershed

The Trinity River watershed extends over approximately 1,897,600 acres and ranges in elevation from over 9,000 feet above sea level in the headwaters area to less than 300 feet at the confluence of the Trinity River with the Klamath River (California North Coast Regional Water Quality Control Board [NCRWQCB] et al. 2009; U.S. Fish and Wildlife Service [USFWS] et al. 1999). Average precipitation in the Trinity River watershed ranges from 30 to 70 inches per year, with a long-term average of approximately 62 inches per year. Over 90 percent of the precipitation has historically occurred between October and April. Precipitation ranges from mostly snow at higher elevations to mostly rain near the confluence with the Klamath River.

The Trinity River includes the mainstem, North Fork Trinity River, South Fork Trinity River, New River, and numerous smaller streams (NCRWQCB et al. 2009; USFWS et al. 1999). The mainstem of the Trinity River flows 170 miles to the west from the headwaters to the confluence with the Klamath River. The CVP Trinity and Lewiston dams are located at approximately River Miles 105 and 112, respectively; and upstream from the confluences of the Trinity River and the North Fork, South Fork, and New River. Flows on the North Fork, South Fork, and New River are not affected by CVP facilities. The Trinity River flows approximately 112 miles from Lewiston Dam to the Klamath River through Trinity and Humboldt counties and the Hoopa Indian Reservation within Trinity and Humboldt counties.

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

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

A large portion of the Trinity River flows upstream of Trinity Lake and Lewiston Dam is exported to the Sacramento River watershed through CVP facilities. The reduction in flows in the Trinity River initially caused substantial reductions in the Trinity River fish populations (Department of the Interior [DOI] 2000). In response to the reductions in fish populations, Congress enacted legislation and directed that restoration actions be evaluated for the Trinity River. In December 2000, the U.S. Department of the Interior (DOI) adopted the Trinity River Mainstem Fishery Restoration Record of Decision (Trinity River ROD) which restored Trinity River flow and habitat to produce a healthy, functioning alluvial river system. The Trinity River ROD included physical channel rehabilitation; sediment management; watershed restoration; and variable annual instream flow releases from Lewiston Dam based on forecasted hydrology for the Trinity River Basin as of April 1st each year that range from 368,600 acre-feet/year in critically dry years to 815,000 acre-feet/year in extremely wet years.

Additional water releases periodically occur into the Trinity River as part of flood control operations and to provide other flow releases (NCRWQCB et al. 2009; Reclamation 2011a). Although flood control is not an authorized purpose of the Trinity River Division, flood control benefits are provided through normal operations. The Reclamation Safety of Dams release criteria generally provide for maximum storage in Trinity Lake of 2.1 between November and March. Initial flood releases are discharged from Trinity Lake into Lewiston Reservoir, and then, through the powerplant and into Whiskeytown Lake in the Clear Creek watershed. To reduce the potential for flooding on the Trinity River, releases into Trinity River generally are less than 11,000 cfs from Lewiston Dam (under Safety of Dams criteria) due to local high-water concerns in the floodplain and local bridge flow capacities. Reclamation has periodically released water from Lewiston Dam into the Trinity River to improve late summer flow conditions to avoid fish die-offs in the lower Klamath River or for tribal requirements along the Trinity River (DOI 2014; Trinity River Restoration Program [TRPP] 2019).

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

Water storage volumes and water storage elevations for Trinity Lake for Water Years 2001 through 2018 are presented on Figures C.2-1 and C.2-2 (DWR 2018a, 2018b). Trinity Lake storage varies in accordance with upstream hydrology and downstream water demands and instream flow requirements. Reclamation maintains at least 600 TAF in Trinity Reservoir, except during the 10 to 15 percent of the years when Shasta Lake is also drawn down.

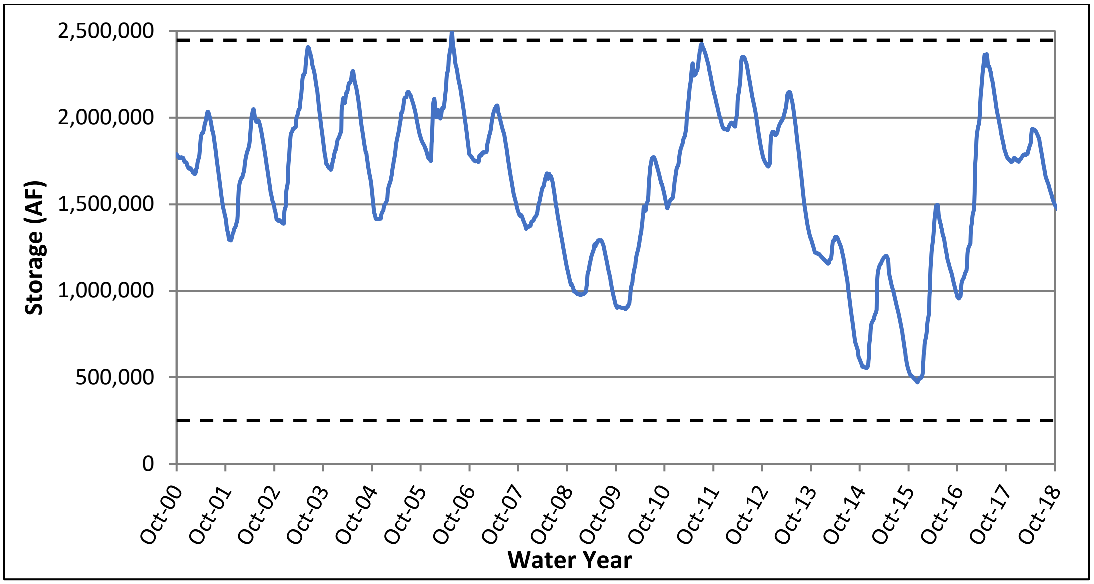

Figure C.2-1. Trinity Lake Storage

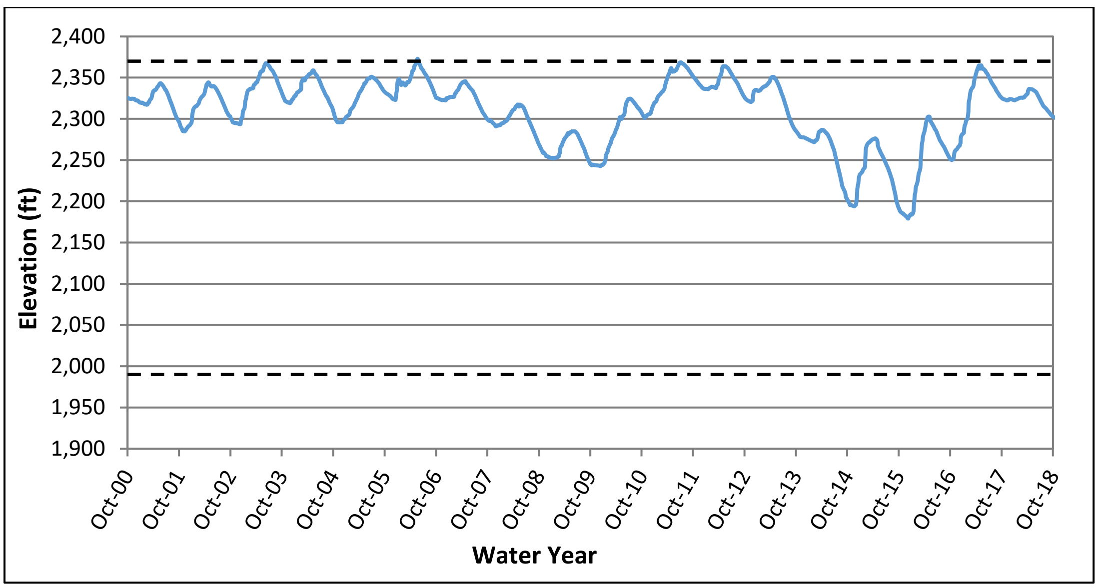

Figure C.2-2. Trinity Lake Elevation

Historical water storage volumes and water storage elevations in Lewiston Reservoir for Water Years 2001 through 2018 are presented on Figures C.2-3 and C.2-4 (DWR 2018c, 2018d). The Lewiston Reservoir water storage volume is more consistent throughout the year because this reservoir is used to regulate flow releases to the powerplant and other downstream uses; and not to provide long-term water storage.

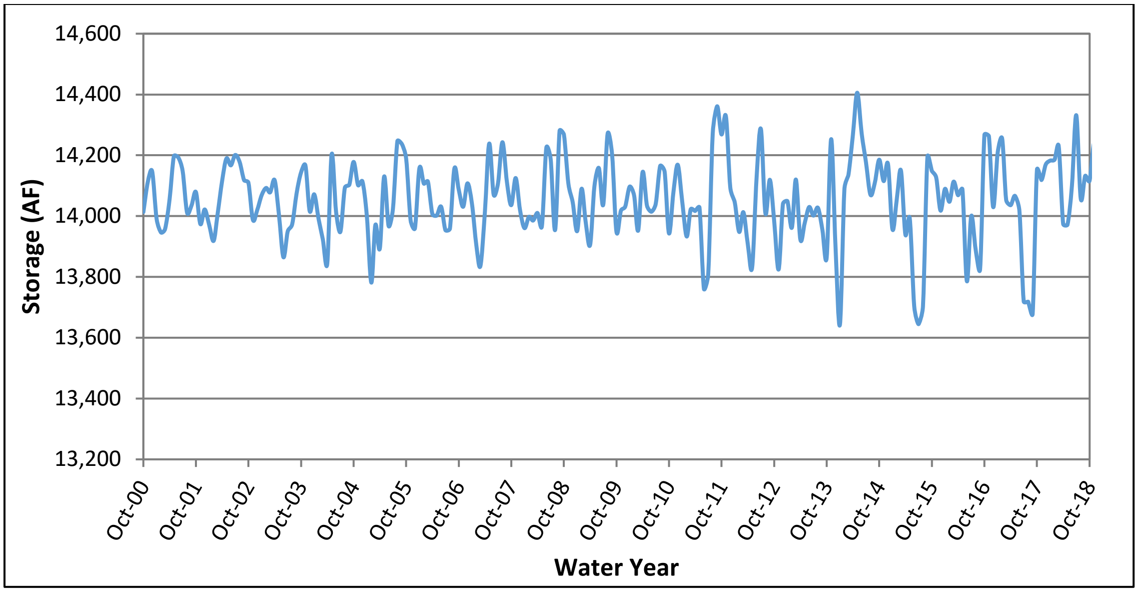

Figure C.2-3. Lewiston Reservoir Storage

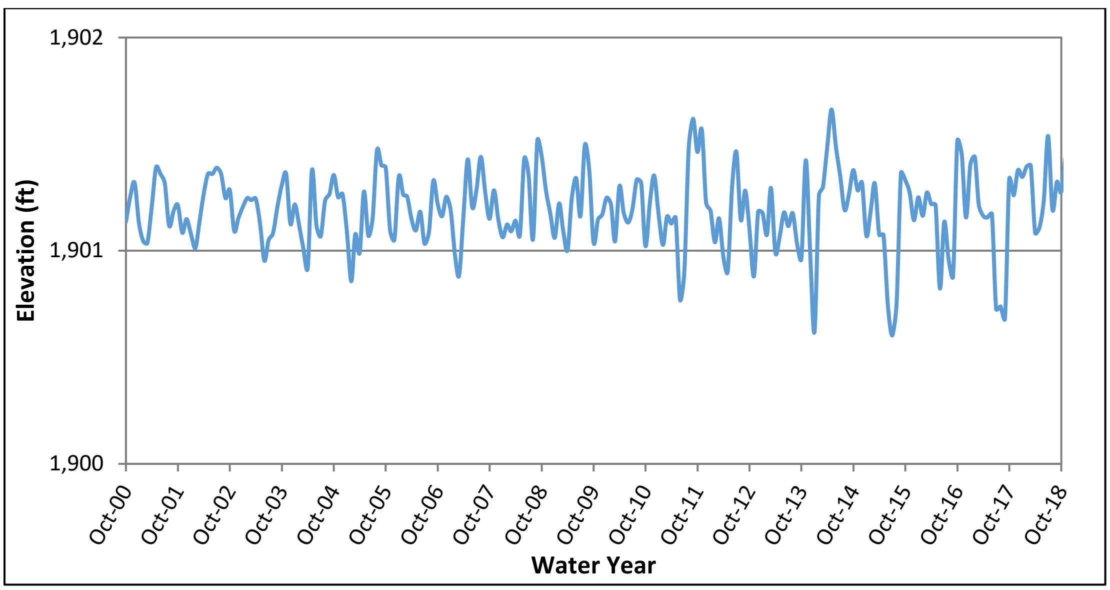

Figure C.2-4. Lewiston Reservoir Elevation

Trinity River flows downstream of Lewiston Reservoir at Douglas City are presented on Figure C.2-5 (DWR 2018e). The flow record is limited at the Douglas City gauge to 2003 through 2018. The mean monthly flows reflect the wet year pattern in 2006 and the drier year patterns in 2008 and 2009.

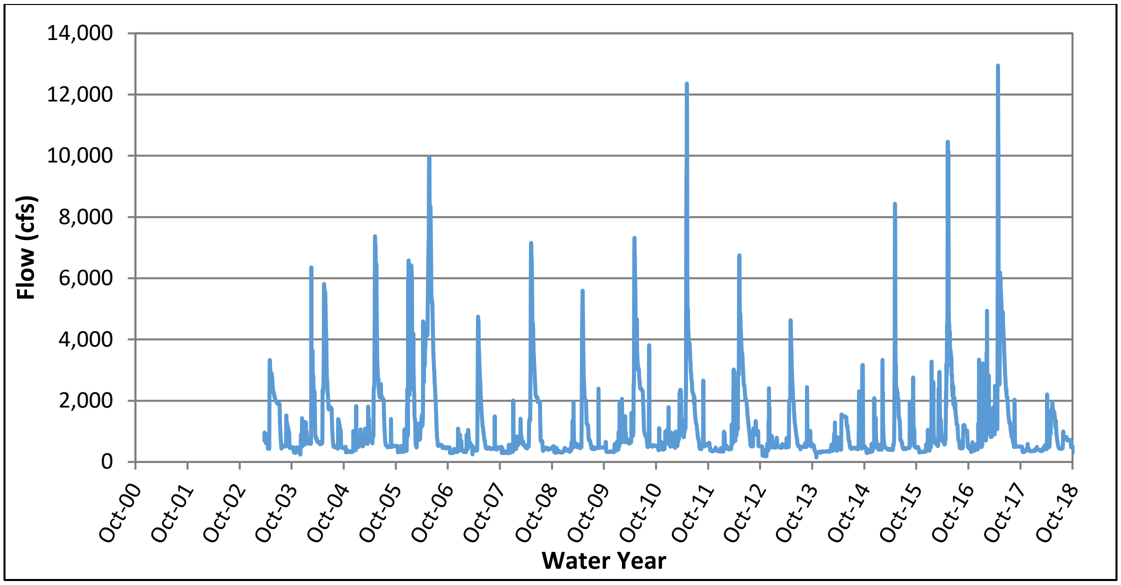

Figure C.2-5. Trinity River Near Douglas City

C.2.2 Trinity River Division Operations

Natural flows began to be stored along the Trinity River in November 1960, affecting river hydraulic function. The Trinity River Division, completed in 1964, includes facilities to store and regulate water in the Trinity River, as well as facilities to divert water to the Sacramento River Basin. The Trinity River Division includes the Trinity River and Dam, Lewiston Dam, Whiskeytown Reservoir and Dam, Clear Creek, and Spring Creek and Debris Dam. Trinity Dam is located on the Trinity River and regulates the flow from a drainage area of approximately 720 square miles. The dam was completed in 1962, forming Trinity Lake, which has a maximum storage capacity of approximately 2.4 MAF.

Water is diverted from the Trinity River at Lewiston Dam via the Clear Creek Tunnel and passes through the Judge Francis Carr Powerhouse as it is discharged into Whiskeytown Lake on Clear Creek. From Whiskeytown Lake, water is released through the Spring Creek Power Conduit to the Spring Creek Power Plant and into Keswick Reservoir. Water diverted from the Trinity River, plus a portion of Clear Creek flows, is diverted through the Spring Creek Power Conduit into Keswick Reservoir and Whiskeytown Dam providing flow to Clear Creek below.

Spring Creek also flows into the Sacramento River and enters at Keswick Reservoir. Flows on Spring Creek are partially regulated by the Spring Creek Debris Dam. Historically (1964–1992), an average annual quantity of 1,269 TAF of water has been diverted from Whiskeytown Lake to Keswick Reservoir. This annual quantity is approximately 17 percent of the flow measured in the Sacramento River at Keswick.

The mean annual inflow to Trinity Lake is 1.26 MAF per year (water years 2001-2017). From water year 1965 through 1980, an average of 80% of inflow was diverted. Under a secretarial decision, an average of 61% of inflow was diverted for water years 1981 through 2000. Under a second secretarial decision, an average of 51% of inflows has since been diverted (water years 2001 - 2017).

C.2.2.1 *Safety of Dams at Trinity Reservoir*

Periodically, increased water releases are made from Trinity Dam consistent with Reclamation Safety of Dams criteria intended to prevent overtopping of Trinity Dam. Although flood control is not an authorized purpose of the Trinity River Division, flood control benefits are provided through normal operations.

The Safety of Dams release criteria specify that Carr power plant capacity be used as a first preference destination for Safety of Dams releases made at Trinity Dam. Trinity River releases are made as a second preference destination. During significant Northern California high-water flood events, the Sacramento River water stages are also often at concern levels. Under such high-water conditions, the water that would otherwise move through the Carr power plant is routed to the Trinity River so as to avoid exacerbating any flooding concerns on the Sacramento River side. Total river releases are capped at 11,000 cfs from Lewiston Dam (under Safety of Dams criteria) due to local high-water concerns in the floodplain and local bridge flow capacities. The Safety of Dams criteria provide seasonal storage targets and recommended releases November 1 to March 31.

C.2.2.2 *Fish and Wildlife Requirements on Trinity River*

Based on the Trinity River ROD, 368.6 TAF to 815 TAF is allocated annually for Trinity River flows, depending on water year type. This amount is scheduled in coordination with USFWS and other in-basin partners to best meet habitat, temperature, and sediment transport objectives in the Trinity Basin.

Water temperature objectives for the Trinity River are set forth in SWRCB Water Rights Order 90-5, as summarized in Table C.2-1. These objectives vary by reach and by season. Between Lewiston Dam and Douglas City Bridge, the daily average temperature should not exceed 60 degrees Fahrenheit (°F) from July 1 to September 14, and 56°F from September 15 to September 30. From October 1 to December 31, the daily average temperature should not exceed 56°F between Lewiston Dam and the confluence of the North Fork Trinity River.

Table C.2-1. Water Temperature Objectives for the Trinity River during the Summer, Fall, and Winter as Established by the California Regional Water Quality Control Board North Coast Region

Date	Temperature Objective (°F)	
	Douglas City (RM 93.8)	North Fork Trinity River (RM 72.4)
July 1 through September 14	60	–
September 15 through September 30	56	–
October 1 through December 31	–	56

The Long-Term Plan to Protect Adult Salmon on the Lower Klamath River ROD, dated April 20, 2017, includes supplemental flows from Lewiston Dam to prevent a disease outbreak (*Ichthyophthirius multifiliis*) in the lower Klamath River in years when the flow in the lower Klamath River is projected to be less than 2,800 cfs. The water for these supplemental flows would come from water stored in Trinity Reservoir, with releases of not less than 50 TAF. The three flow augmentation components include:

1. a preventive base-flow release that targets increasing the base flow of the lower Klamath River to 2,800 cfs from mid-August to late September to improve environmental conditions;
2. a one-day preventive pulse flow (targeting 5,000 cfs in the lower Klamath River) to be used as a secondary measure to alleviate continued poor environmental conditions and signs of *Ichthyophthirius multifiliis* infection in the lower Klamath River; and

3. a five-day emergency pulse flow (targeting 5,000 cfs in the lower Klamath River) to be used on an emergency basis as a tertiary treatment, to avoid a significant die-off of adult salmon when the first two components are not successful at meeting intended objectives.

C.2.2.3 *Transbasin Diversions*

Diversion of Trinity water to the Sacramento Basin provides water supply and major hydroelectric power generation for the CVP and plays a key role in water temperature control in the Trinity River and upper Sacramento River.

The seasonal timing of Trinity exports, detailed in Table C.2-2, is a result of determining how to make best use of a limited volume of Trinity export (in concert with releases from Shasta Lake) to help conserve cold water pools and meet temperature objectives on the upper Sacramento and Trinity Rivers, as well as power production economics. A key consideration in the export timing determination is the thermal degradation that occurs in Whiskeytown Lake due to the long residence time of transbasin exports in the lake.

Table C.2-2. Average Trinity Lake inflow, release, and export for water years 2001-2017

Month	Average Trinity Lake Inflow (AF)	Average Release to Trinity River (AF)	Average Export to CVP (AF)
January	128,945	30,591	15,349
February	147,763	21,423	19,385
March	194,151	21,209	27,709
April	200,039	41,497	36,030
May	237,307	218,873	44,001
June	128,484	110,756	84,820
July	38,753	51,835	114,410
August	11,294	37,399	108,121
September	6,659	38,170	84,144
October	17,921	23,416	61,594
November	34,837	18,777	28,253
December	116,490	19,486	19,282

To minimize the thermal degradation effects, transbasin export patterns are typically scheduled to provide an approximate 120 TAF volume to occur in late spring to create a thermal connection to the Spring Creek Powerhouse before larger transbasin volumes are scheduled to occur during the hot summer months. Typically, the water flowing from the Trinity Basin through Whiskeytown Lake must be sustained at fairly high rates to avoid warming and to function most efficiently for temperature control. The time period for which effective temperature control releases can be made from Whiskeytown Lake may be compressed when the total volume of Trinity water available for export is limited.

Export volumes from Trinity are made in coordination with the operation of Shasta Lake. Other considerations affecting the timing and magnitude of Trinity exports are power generation demand, and the maintenance schedule of the diversion works and generation facilities.

Maximum storage levels generally occur in April or May. Reclamation maintains at least 600 TAF in Trinity Reservoir, except during the 10 to 15 percent of the years when Shasta Lake is also drawn down. Reclamation addresses end-of-water-year carryover on a case-by-case basis in dry and critically dry water year types with considerations provided by the USFWS and NMFS through the Water Operations Management Team.

C.2.3 Lower Klamath River from Trinity River Confluence to the Pacific Ocean

The Klamath River watershed extends over 15,600 square miles from southern Oregon to northern California, and ranges in elevation from over 9,500 feet above sea level near the headwaters to sea level at the Pacific Ocean (USFWS et al. 1999). The Klamath River watershed is generally divided into two or three subbasins. For the purpose of this study, the upper Klamath River basin extends over 60 miles from the headwaters to Iron Gate Dam (DOI and DFG 2012).

The lower Klamath River basin extends 190 miles from Iron Gate Dam to the Pacific Ocean. Four major tributaries flow into the lower Klamath River, including Shasta, Scott, Salmon, and Trinity rivers. The lower Klamath River flows 43.5 miles from the confluence with the Trinity River to the Pacific Ocean (USFWS et al. 1999). Downstream of the Trinity River confluence, the Klamath River flows through Humboldt and Del Norte counties and through the Hoopa Indian Reservation, Yurok Indian Reservation, and Resighini Indian Reservation within Humboldt and Del Norte counties (DOI and Department of Fish and Game [now known as Department of Fish and Wildlife] DFG 2012).

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

The Klamath River estuary extends from approximately 5 miles upstream of the Pacific Ocean (DOI and DFG 2012). This area is generally under tidal effects and salt water can occur up to 4 miles from the coastline during high tides in summer and fall when Klamath River flows are low. Klamath River flows at Klamath within the Klamath River estuary are affected by tidal influence within the estuary, as presented on Figure C.2-6 (DWR 2018f).

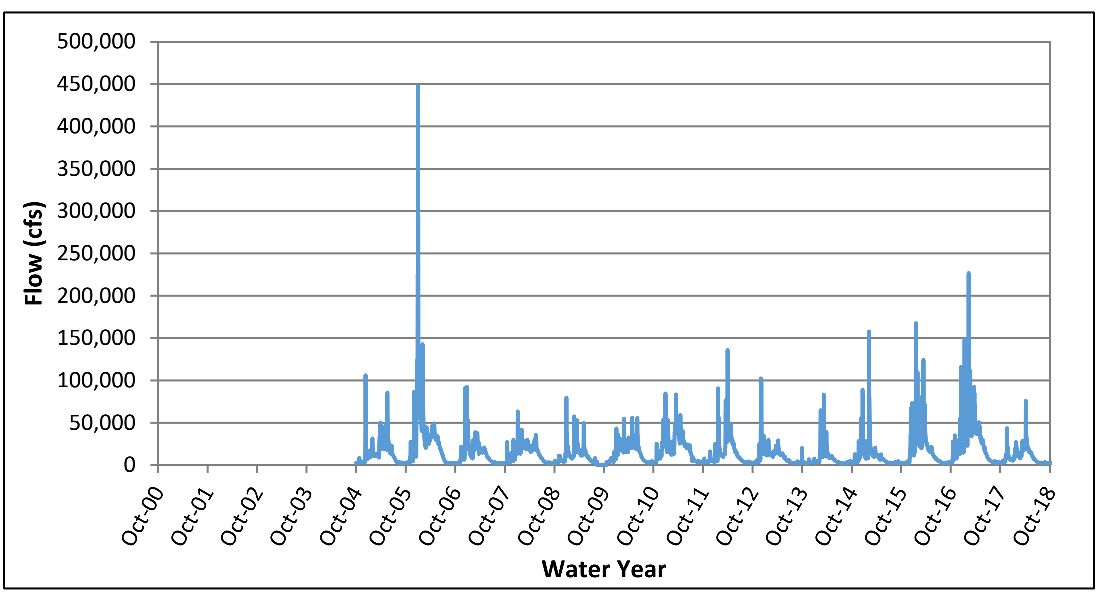

Figure C.2-6. Klamath River Near Klamath

C.3 Sacramento Valley

Rivers in the Sacramento Valley that could be affected by changes in CVP and SWP operations include the following:

- Clear Creek from Whiskeytown Reservoirs to the confluence with the Sacramento River
- Sacramento River from Shasta Lake to the confluence with the San Joaquin River in the Delta
- Feather River from upstream of Oroville Reservoir to the confluence with the Sacramento River
- Yuba River from New Bullards Bar Reservoir to the confluence with the Feather River
- Bear River from Camp Far West Reservoir to the confluence with the Feather River
- American River from Folsom Lake to the confluence with the Sacramento River

Flows from smaller tributaries to the Sacramento River and the Cosumnes and Mokelumne rivers in the Sacramento Valley contribute substantial flows into the Sacramento River and affect CVP and SWP operations; however, flows in these rivers would not be affected by changes in CVP and SWP operations. Therefore, hydrologic conditions on these water bodies are not described.

The Sacramento River watershed encompasses an area over 15,360,000 acres in the northern portion of the Central Valley; extends from the foothills of the Coast Ranges and Klamath Mountains on the west; extends from the foothills of the Sierra Nevada and Cascade Range on the east; and extends through the Delta on the south (Reclamation 2015).

Ground surface elevations in the northern portion of the Sacramento River watershed range from approximately 14,000 feet above mean sea level in the headwaters of the Sacramento River to approximately 1,070 feet at Shasta Lake (Reclamation 2015). In the mountains surrounding the valley, annual average precipitation generally ranges between 60 and 70 inches up to 90 inches, with snow prevalent at higher elevations. The floor of the Sacramento Valley is relatively flat, with elevations ranging from approximately 60 to 300 feet above mean sea level. This area is characterized by hot dry summers and mild winters. Average precipitation ranges from 15 to 20 inches per year, falling mostly as rain.

The Sacramento River flows approximately 351 miles from the north near Mount Shasta to the confluence with the San Joaquin River at Collinsville in the western Delta (Reclamation 2015). The Sacramento River receives contributing flows from numerous major and minor streams and rivers that drain the east and west sides of the basin. The Sacramento River also receives imported flows from the Trinity River watershed, as discussed above. The volume of flow increases as the river progresses southward and is increased considerably by the contribution of flows from the Feather River and the American River.

C.3.1 Upper Sacramento River Watershed Hydrology

The portion of the watershed upstream of Keswick Dam includes the McCloud River, Pit River, Squaw Creek, headwaters of the Sacramento River, and Goose Lake basins. The Goose Lake basin is located within the Pit River watershed; however, water rarely spills from Goose Lake into the Pit River. The last recorded spill occurred in 1880 (Reclamation 2015). Long-term average annual inflows into Shasta Lake are approximately 4.875 MAF between the mid-1940s and 2010.

The McCloud River watershed extends over approximately 402,000 acres (Reclamation 2015). The McCloud River flows approximately 59 miles from the headwaters in Moosehead Creek located southeast of Mount Shasta, through McCloud Reservoir, and into Shasta Lake. McCloud Reservoir is operated primarily to generate hydroelectric power. The Pit River watershed extends over approximately 3,008,000 acres along the north and south forks of the Pit River basins and includes 21 named tributaries and numerous smaller tributaries (Reclamation 2015). Pacific Gas and Electric Company operate several hydropower diversions and reservoirs within the Pit River watershed.

The Squaw Creek watershed extends over approximately 66,000 acres located to the east of Shasta Lake (Reclamation 2015).

The Sacramento River extends approximately 40 miles from the headwaters to Shasta Lake downstream of the town of Delta (Reclamation 2015). The basin extends into portions of Mount Shasta and the Trinity and Klamath mountains.

C.3.2 Clear Creek Watershed

The Clear Creek watershed is 238 square miles, extending from the Trinity Mountains to the confluence with the Sacramento River downstream of the City of Redding (DWR 1986 and Western Shasta Resource Conservation District [WSRCD] 2004). Hydrology in the watershed is divided into the upper 238-square mile watershed upstream of Whiskeytown Dam at River Mile 18.1, and the lower 49 square miles watershed downstream of the dam. Clear Creek flows approximately 17 miles from the Trinity Mountains into Whiskeytown Lake. Clear Creek continues for 18.1 miles downstream of Whiskeytown Lake into the Sacramento River downstream of the CVP Keswick Dam and south of the City of Redding.

C.3.2.1 *Whiskeytown Lake*

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

Water from Whiskeytown Lake is released to the Sacramento River through the Spring Creek Tunnel which conveys water to the Spring Creek Conduit, and then to Keswick Reservoir. Water from Whiskeytown Lake also is released into Clear Creek directly from Whiskeytown Lake; or during high flow conditions (e.g., flood flows), from a Glory Hole within Whiskeytown Lake through a conduit into Clear Creek. Most of the flows are released through the Spring Creek Tunnel and Powerplant to Keswick Reservoir. These flows into Keswick Reservoir provide cold water flows that reduce temperatures in the upper Sacramento River, especially during the fall months. Water also is discharged from Whiskeytown Lake to Clear Creek to provide for instream flows and water for users located in the CVP Clear Creek South Unit within, or adjacent to, the Clear Creek watershed.

The capacity of the outlet from Whiskeytown Dam that conveys water to Clear Creek is 1,240 cfs when the water elevation in Whiskeytown Lake is at 1,220.5 feet. To provide flows into Clear Creek in excess of 1,240 cfs, the Whiskeytown Reservoir water elevations need to be raised higher than 1,220 feet to allow water to flow through the Glory Hole spillway, as described below (CALFED 2004; Reclamation 2009a).

Water storage volume and water storage elevations related to Whiskeytown Lake for Water Years 2001 through 2018 are presented on Figures C.3-1 and C.3-2 (DWR 2018g, 2018h). Whiskeytown Lake storage is relatively constant due to agreements between Reclamation and the National Park Service to maintain certain winter and summer lake elevations for recreation. Whiskeytown Lake outflow variations were greater prior to 2006 when Trinity River restoration flows were implemented which reduced the amount of water available for conveyance to CVP water users. In addition, hydrologic conditions in the years following 2006 were drier than the water years between 2001 and 2006.

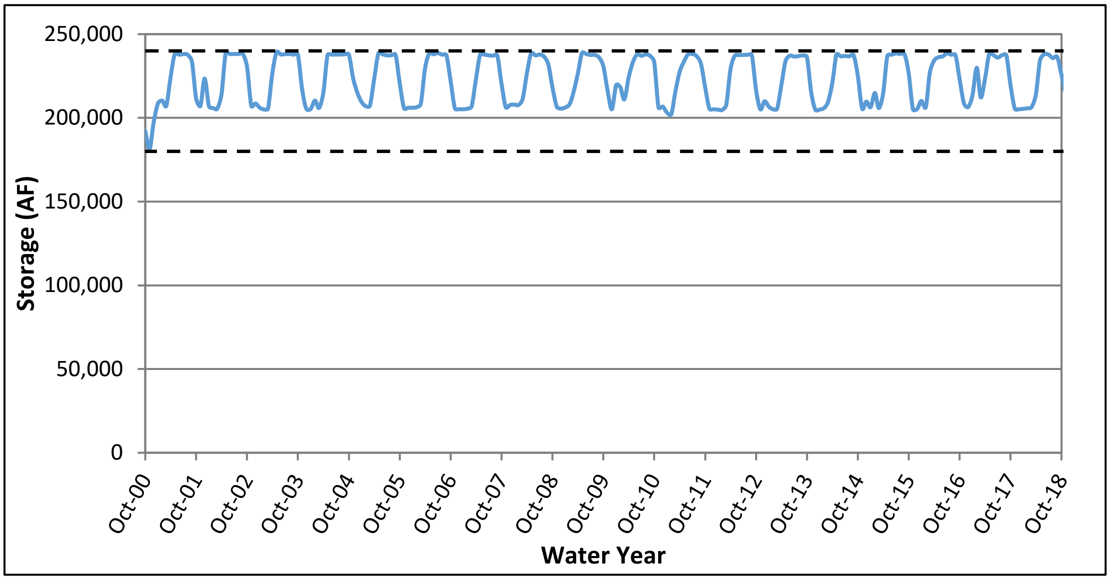

Figure C.3-1. Whiskeytown Lake Storage

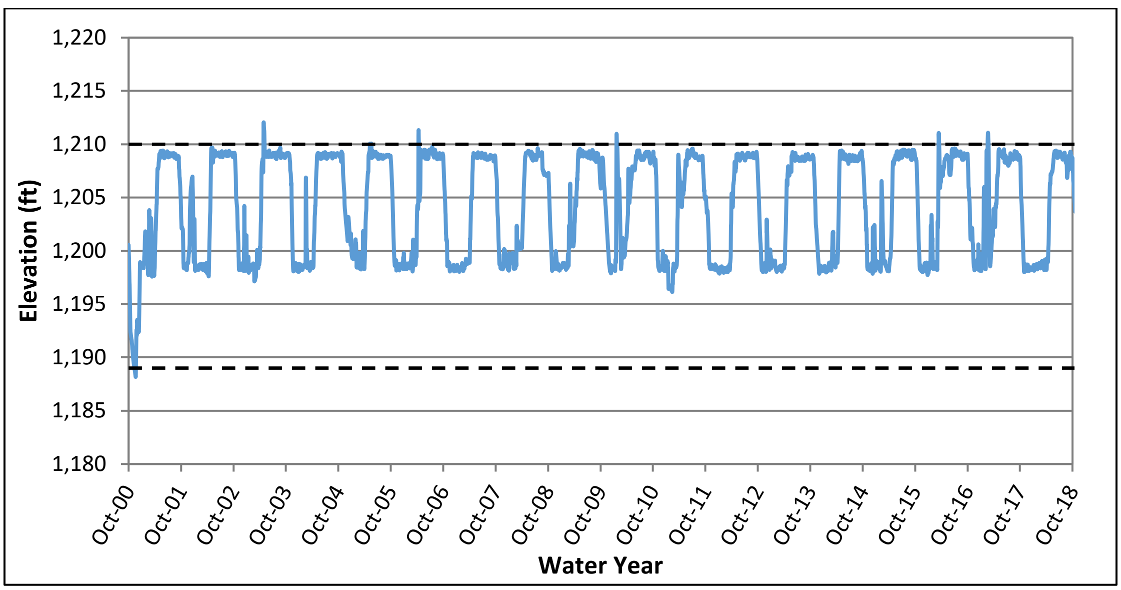

Figure C.3-2. Whiskeytown Lake Elevation

C.3.2.1.1 Whiskeytown Reservoir Operations

Whiskeytown Reservoir is normally operated to (1) regulate inflows for power generation and recreation; (2) support upper Sacramento River temperature objectives; and (3) provide for releases to Clear Creek. Although it stores up to 241 TAF, this storage is held fairly constant from May through October in most years. Two fully functional water temperature curtains exist in Whiskeytown Reservoir. These curtains have been subject to repairs since their initial installation in 1993. The purpose of these curtains is to improve passage of cold source water through the reservoir during the warm months of the year for downstream cold-water needs (i.e., threatened and endangered fish). The Oak Bottom Temperature Control Curtain or OBTCC is located in the upstream portion of the reservoir and the Spring Creek curtain is located in front of the Spring Creek tunnel at the eastern end of Whiskeytown Reservoir.

C.3.2.1.2 Historic Spillway Flows below Whiskeytown Lake

Whiskeytown Lake storage is annually drawn down by approximately 35 TAF during the wet season (November through April) to assist in regulating excessive winter storm runoff. Heavy rainfall events occasionally result in glory hole discharges to Clear Creek, as shown in Table C.3-1 below.

Table C.3-1. Days of Spilling below Whiskeytown and 40-30-30 Index from Water Year 1978 to 2012

Water Year	Days of Spilling	40-30-30 Index
1978	5	AN
1979	0	BN
1980	0	AN
1981	0	D
1982	63	W
1983	81	W
1984	0	W
1985	0	D
1986	17	W
1987	0	D
1988	0	C
1989	0	D
1990	8	C
1991	0	C
1992	0	C
1993	10	AN
1994	0	C
1995	14	W
1996	0	W
1997	5	W
1998	8	W
1999	0	W
2000	0	AN
2001	0	D
2002	0	D
2003	8	AN
2004	0	BN
2005	0	AN
2006	4	W
2007	0	D
2008	0	C

Water Year	Days of Spilling	40-30-30 Index
2009	0	D
2010	6	BN
2011	0	W
2012	0	BN

Notes: W = Wet Year Water Year Type; AN = Above Normal Water Year Type; BN = Below Normal Water Year Type; D = Dry Water Year Type; and C = Critical Dry Water Year Type.

Operations at Whiskeytown Lake during flood conditions are complicated by its operational relationship with the Trinity River, Sacramento River, and Clear Creek. On occasion, imports of Trinity River water to Whiskeytown Reservoir may be suspended to avoid aggravating high flow conditions in the Sacramento Basin.

C.3.2.2 *Clear Creek*

Substantial modifications of the Clear Creek stream channel occurred due to placer mining activities from the mid-1800s through the early 1900s. In addition, several irrigation diversions were constructed along the lower Clear Creek reach during the late 1800s and early 1900s. One of the largest diversions was the 15-foot-high, 200-foot-wide McCormick-Saeltzer Dam constructed in 1903 at River Mile 6.5 (approximately 12 miles downstream of Whiskeytown Dam). The downstream of Whiskeytown Dam was constructed upstream of a steep gorge along Clear Creek and removed in 2001. More recent channel modifications occurred in the lower Clear Creek due to gravel extraction activities from the 1950s to 1970s.

Construction of Whiskeytown Dam modified the hydraulics, gravel loading, and sediment transport in the lower Clear Creek. The overall average annual flow in the lower Clear Creek was reduced by 87 percent following construction of the dam (DWR 1984, 1986). The dam also reduced gravel loading into the lower Clear Creek and the frequency of high flow events that move the gravel and remove fine sediments from riffles. This change in hydrology and loss of gravel loading adversely affected the salmonid habitat downstream of Whiskeytown Dam, including compaction of riffles with sand. Recently, minimum flow releases from Whiskeytown Lake into Clear Creek occur in accordance with Federal and state requirements (DWR 1984). Historical flow data has been collected since 1941 at the Igo Gage at River Mile 10.9 (approximately 7.2 miles downstream of Whiskeytown Dam) (DWR 1986 and WSRCD 2004).

Since the early 1980s, numerous studies were conducted to evaluate methods to rehabilitate and/or restore habitat along lower Clear Creek. In the 1990s, additional studies were conducted following the adoption of the 1992 Central Valley Project Improvement Act (CVPIA). In 1998, a watershed management plan prepared by the WSRCD evaluated methods to achieve healthy fish populations, diverse biological habitats, recreational opportunities, clean and safe conditions for visitors, and protection of property rights developed by the Lower Clear Creek Coordinated Resource Management and Planning Group of local landowners, stakeholders, and agencies (WSRCD 1998). The recommendations included the following:

- Removal of the McCormick-Saeltzer Dam.
- Inject gravel downstream of Whiskeytown Dam and reconstruct gravel channels below McCormick-Saeltzer Dam to reduce stranding.
- Modify water release patterns from Whiskeytown Dam.
- Reduce exotic vegetation along Clear Creek.
- Reduce sands in Clear Creek through erosion control programs in the lower watershed.

This and other studies led to the formation of the Lower Clear Creek Floodway Rehabilitation Project that was implemented under CVPIA (CALFED 2004, WSRCD 2003, DWR 2003). Initial actions under this program included gravel augmentation initiated in 1996, increase in Whiskeytown Dam releases initiated in 2001, removal of the McCormick-Saeltzer Dam in 2001, reconstruction and revegetation of the floodway, and reduction of watershed erosion.

Following the removal of the McCormick-Saeltzer Dam, extensive geomorphological studies have been conducted to recommend approaches for restoration of the channel and adjacent floodplain downstream of the McCormick-Saeltzer Dam site. Based upon hydrological data collected at the Igo gage, one of the studies discussed that peak flow events in lower Clear Creek following completion of Whiskeytown Dam occur about once every 3 years; although, the pre-dam frequency was approximately once every 2 years. Clear Creek flows at Igo between 2001 and 2018 are presented on Figure C.3-3 14 (DWR 2018i). High flow events: 1) naturally moved gravel placed downstream of Whiskeytown Dam and along Clear Creek; 2) developed and maintained Clear Creek channel and adjacent floodplain habitat for spring-run and fall-run Chinook Salmon and steelhead; 3) created and maintained deep pools in the channel to support spawning of spring-run Chinook Salmon and steelhead, and create appropriate salmonid habitat within and along Clear Creek; and 4) established and maintained nesting and foraging habitat for neotropical migrant birds, native resident birds, and amphibians.

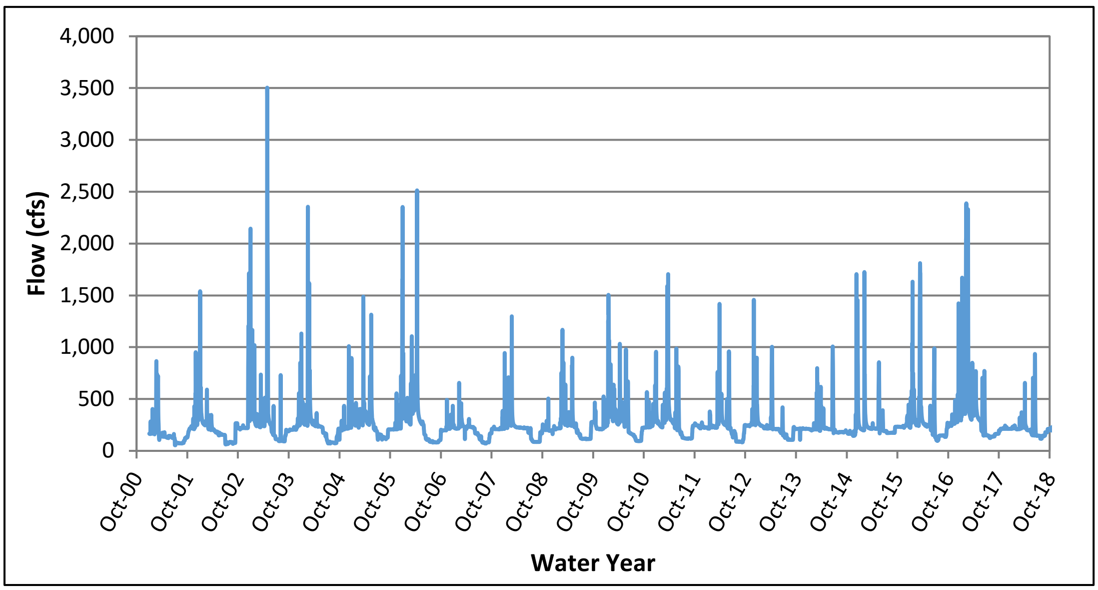

Figure C.3-3. Clear Creek Near Igo

Following removal of McCormick-Saeltzer Dam, the Clear Creek channel and adjacent floodplain geomorphology changed. The Clear Creek channel capacity is generally about 3,000 cfs. The 2004 studies indicated that flows in excess of 3,000 cfs are required to overflow from the Clear Creek channel onto the adjacent floodplains. The study discussed that during pre- and post-Whiskeytown periods, the 5-year flood event at Igo decreased from 9,000 to 3,400 cfs and the 2.5-year flood event decreased from 6,200 to 1,800 cfs. Therefore, the study discussed that flows in excess of 5,000 cfs did not occur more frequently than 3 times in 10 years (CALFED 2004).

C.3.2.2.1 Fish and Wildlife Requirements on Clear Creek

CVPIA (b)(2) operations and water rights permits issued by the SWRCB for diversions from Trinity River and Clear Creek specify minimum downstream releases from Lewiston and Whiskeytown Dams, respectively. The following agreements govern releases from Whiskeytown Lake:

- A 1960 Memorandum of Agreement (MOA) with CDFW established minimum flows to be released to Clear Creek at Whiskeytown Dam, as summarized in Table C.3-2.
    - A 1963 release schedule for Whiskeytown Dam was developed with USFWS and implemented, but never finalized. Although this release schedule was never formalized, Reclamation has used this flow schedule for minimum flows since May 1963.
    - Water rights permit modification in 2002 that allowed release of water from Whiskeytown Lake into Clear Creek for the purposes of maintenance of fish and wildlife resources as provided for in Provision 2.1 of Instream Flow Preservation Agreement by and among Reclamation, USFWS, and DFW, dated August 11, 2000.
    - Dedication of (b)(2) water on Clear Creek provides instream flows below Whiskeytown Dam greater than the minimum flows (that would have occurred under pre-CVPIA conditions). Instream flow objectives are usually taken from the AFRP plan, in consideration of spawning and incubation of fall-run Chinook Salmon. Augmentation in the summer months is usually in consideration of water temperature objectives for steelhead and in late summer for spring-run Chinook Salmon.

The 2009 NMFS BO RPA requires Reclamation to release spring attraction flows for adult spring-run Chinook Salmon (Action I.1.1) and channel maintenance flows in Clear Creek (Action I.1.2); and to continue gravel augmentation programs initiated under CVPIA. The spring attraction flows are to be released from Whiskeytown Lake into Clear Creek in at least two pulse flows of at least 600 cfs, each lasting at least 3 days, in May and June.

Under the 2009 NMFS BO RPA, the channel maintenance flows are to be released at a minimum flow of 3,250 cfs for 24 hours, which exceeds the 1,240 cfs capacity of the Whiskeytown Dam outlet to Clear Creek. This action is to occur seven times in a ten-year period. Therefore, to provide channel maintenance flows, the Whiskeytown Lake water elevation must be increased to provide flow of water over the Glory Hole inlet. The Glory Hole is designed to operate with the higher water elevations expected during flood events. However, during non- flood periods, raising the water elevations and operating the Glory Hole inlet can cause safety concerns for recreationists along the Whiskeytown Lake shoreline.

Table C.3-2. Minimum Flows at Whiskeytown Dam

Period	Minimum flow (cfs)
1960 MOA with CDFW	
January 1–February 28(29)	50
March 1–May 31	30
June 1–September 30	0
October 1–October 15	10
October 16–October 31	30
November 1–December 31	100
1963 USFWS Proposed Normal year flow	
January 1–October 31	50
November 1–December 31	100

Period	Minimum flow (cfs)
1963 USFWS Proposed Critical year flow	
January 1–October 31	30
November 1–December 31	70
2002 Water Right Modification for Critical year flow	
January 1–October 31	50
November 1–December 31	70

C.3.2.2.2 Spring Creek Debris Dam Operations

The Spring Creek Debris Dam (SCDD) is a feature of the Trinity Division of the CVP. It was constructed to regulate runoff containing debris and acid mine drainage from Spring Creek, a tributary to the Sacramento River that enters Keswick Reservoir. The SCDD can store approximately 5.8 TAF of water. Operation of SCDD and Shasta Dam has allowed some dilution. In January 1980, Reclamation, CDFW, and SWRCB executed a Memorandum of Understanding (MOU) to implement actions that protect the Sacramento River system from heavy metal pollution from Spring Creek and adjacent watersheds.

The MOU states that Reclamation agrees to operate to dilute releases from SCDD (according to the criteria and schedules provided), provided that such operation would not cause flood control parameters on the Sacramento River to be exceeded and would not unreasonably interfere with other Project requirements as determined by Reclamation. The MOU also specifies a minimum schedule for monitoring copper and zinc concentrations at SCDD and in the Sacramento River below Keswick Dam. Reclamation has primary responsibility for the monitoring; however, CDFW and RWQCB also collect and analyze samples on an as-needed basis. Due to more extensive monitoring, improved sampling and analysis techniques, and continuing cleanup efforts in the Spring Creek drainage basin, Reclamation now operates SCDD to target the more stringent Central Valley Region Water Quality Control Board Plan (CVRWQCB Basin Plan) criteria in addition to the MOU goals. Instead of the total copper and total zinc criteria contained in the MOU, Reclamation operates SCDD releases and Keswick dilution flows to not exceed the CVRWQCB Basin Plan standards of 0.0056 milligrams per liter (mg/L) dissolved copper and 0.016 mg/L dissolved zinc. Release rates are estimated from a mass balance calculation of the copper and zinc in the debris dam release and in the river.

In order to minimize the build-up of metal concentrations in the Spring Creek arm of Keswick Reservoir, releases from the debris dam are coordinated with releases from the Spring Creek Power Plant to keep the Spring Creek arm of Keswick Reservoir in circulation with the main water body of Keswick Lake.

The operation of SCDD is complicated during major heavy rainfall events. SCDD reservoir can fill to uncontrolled spill elevations in a relatively short time period, anywhere from days to weeks. Uncontrolled spills at SCDD can occur during major flood events on the upper Sacramento River and also during localized rainfall events in the Spring Creek watershed. During flood control events, Keswick releases may be reduced to meet flood control objectives at Bend Bridge when storage and inflow at Spring Creek Reservoir are high.

Because SCDD releases are maintained as a dilution ratio of Keswick releases to maintain the required dilution of copper and zinc, uncontrolled spills can and have occurred from SCDD. In this operational situation, high metal concentration loads during heavy rainfall are usually limited to areas immediately downstream of Keswick Dam because of the high runoff entering the Sacramento River, adding dilution flow. In the operational situation when Keswick releases are increased for flood control purposes, SCDD releases are also increased to reduce spill potential.

In the operational situation when heavy rainfall events would fill SCDD and Shasta Lake would not reach flood control conditions, increased releases from CVP storage may be required to maintain desired dilution ratios for metal concentrations. Reclamation has voluntarily released additional water from CVP storage to maintain release ratios for toxic metals below Keswick Dam. Reclamation has typically attempted to meet the CVRWQCB Basin Plan standards, but these releases have no established criteria and are dealt with on a case-by-case basis. Since water released for dilution of toxic spills is likely to be in excess of other CVP requirements, such releases increase the risk of a loss of water for other beneficial purposes.

C.3.3 Shasta and Sacramento River Divisions

C.3.3.1 *Facilities*

C.3.3.1.1 CVP Shasta Division

The Shasta Division includes Shasta Dam, Lake, and Power Plant; Keswick Dam, Reservoir, and Power Plant, and the Shasta Temperature Control Device. The CVP's Shasta Division includes facilities that conserve water in the Sacramento River for:

- Flood control
- Navigation maintenance
- Agricultural water supplies
- M&I water supplies
- Hydroelectric power generation
- Conservation of fish in the Sacramento River
- Protection of the Delta from intrusion of saline ocean water.

The CVP Shasta and Keswick dams are located at approximately Sacramento River Miles 308 and 299, respectively. Shasta Lake, a CVP facility on the Sacramento River formed by Shasta Dam, is located near Redding. Shasta Dam is located on the Sacramento River just below the confluence of the Sacramento, McCloud, and Pit Rivers. The dam regulates the flow from a drainage area of approximately 6,649 square miles. Shasta Dam was completed in 1945, forming Shasta Lake, which has a maximum storage capacity of 4.552 MAF. Water in Shasta Lake is released through or around the Shasta Power Plant to the Sacramento River, where it is re-regulated downstream by Keswick Dam. A small amount of water is diverted directly from Shasta Lake for M&I uses by local communities.

Historical water storage volumes and water storage elevations for Shasta Lake for Water Years 2001 through 2018 are presented on Figures C.3-4 and C.3-5 (DWR 2018j, 2018k). Shasta Lake storage varies in accordance with upstream hydrology and downstream water demands and instream flow requirements. For example, storage declined during the drier years in 2008 and 2009.

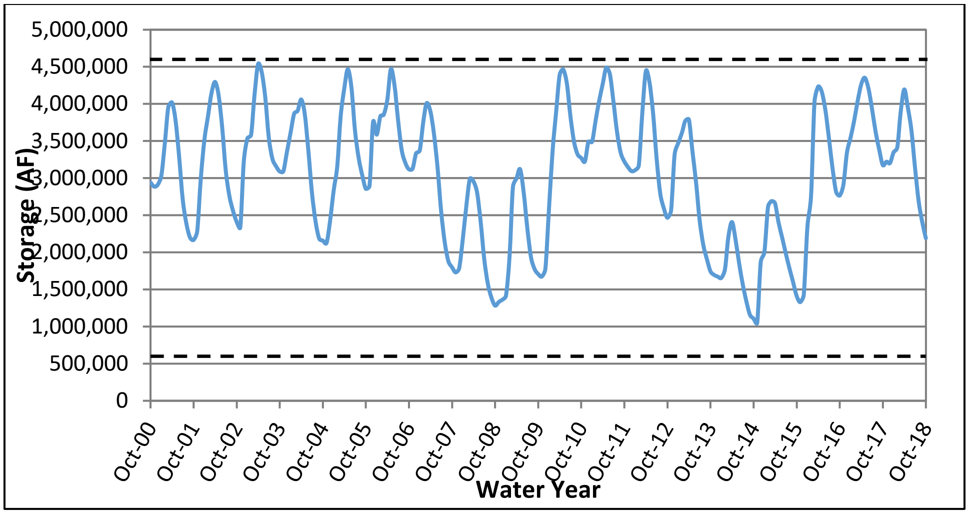

Figure C.3-4. Shasta Storage

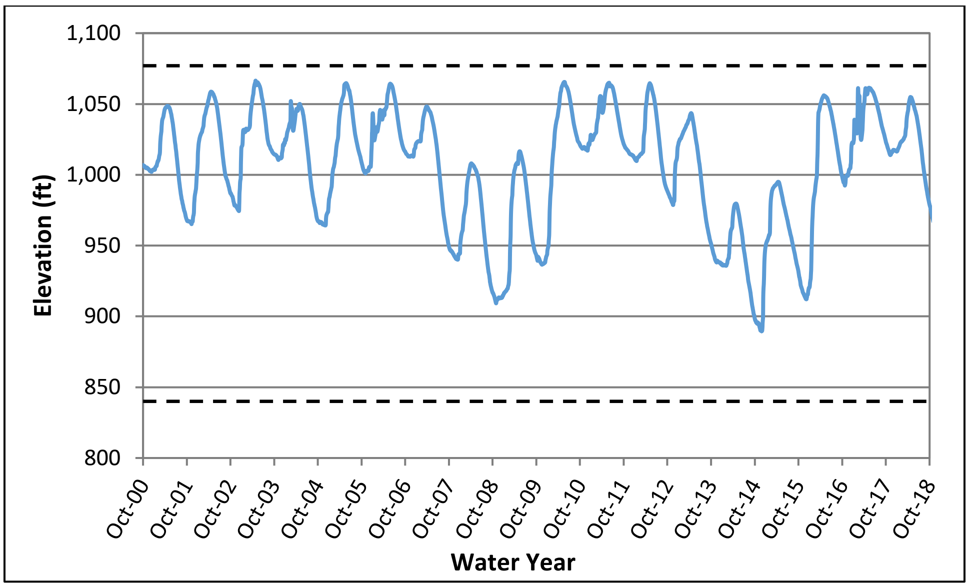

Figure C.3-5. Shasta Elevation

Keswick Reservoir was formed by the completion of Keswick Dam in 1950. It has a capacity of approximately 23.8 TAF and serves as an afterbay for releases from Shasta Dam and for discharges from the Spring Creek Power Plant. A temperature control device at Shasta Dam was constructed between 1996 and 1998 to provide cold water without power bypass to the Sacramento River downstream of Keswick Reservoir. All releases from Keswick Reservoir are made to the Sacramento River from Keswick Dam. The dam has a fish trapping facility that operates in conjunction with the Coleman National Fish Hatchery on Battle Creek.

The Keswick Reservoir water storage volume is more consistent throughout the year because this reservoir is used to regulate flow releases to the powerplant and other downstream uses and not to provide long-term water storage, as shown on Figures C.3-6 and C.3-7 (DWR 2018l, 2018m).

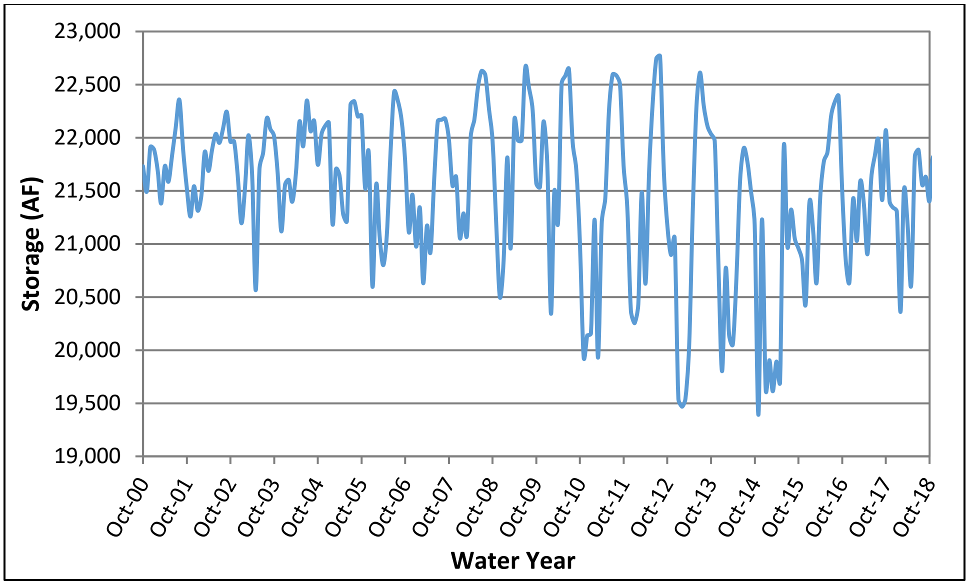

Figure C.3-6. Keswick Reservoir Storage

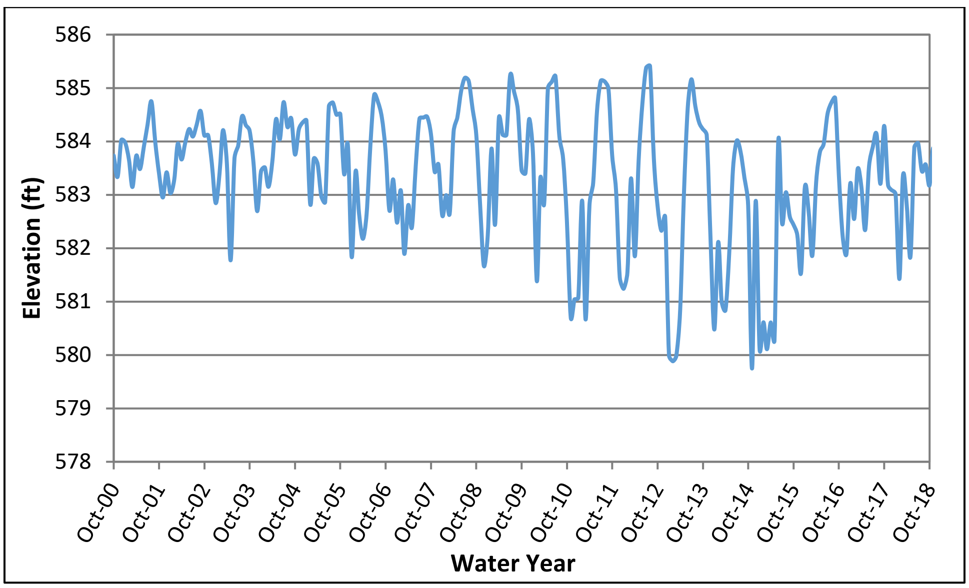

Figure C.3-7. Keswick Reservoir Elevation

C.3.3.1.2 CVP Sacramento River Division

The Sacramento River Division was authorized after completion of the Shasta Division. The Sacramento River Division includes facilities for the diversion and conveyance of water to CVP contractors on the west side of the Sacramento River. The division includes the Sacramento Canals Unit, which was authorized in 1950 and consists of the Red Bluff Pumping Plant, the Corning Pumping Plant, and the Corning and Tehama-Colusa Canals. Total authorized diversions for the Sacramento River Division are approximately 2.8 MAF. Historically the total diversion has varied from 1.8 MAF in a critically dry year to the full 2.8 MAF in a wet year, including diversions by Sacramento River Settlement contractors and CVP water service contractors. Sacramento River Settlement contractors divert water under their own water rights and through their own facilities.

The Sacramento Canals Unit was authorized to supply irrigation water to over 200,000 acres of land in the Sacramento Valley, principally in Tehama, Glenn, Colusa, and Yolo counties. Black Butte Dam, which is operated by the U.S. Army Corps of Engineers (USACE), also provides supplemental water to the Tehama-Colusa Canals as it crosses Stony Creek. The operations of the Shasta and Sacramento River divisions are presented together because of their operational inter-relationships.

Sacramento River from Keswick Dam to the Delta

Water released from Shasta Dam travels approximately 245 miles over three to four days to the northern Delta boundary near Freeport (Reclamation 2015). The upper reach of the Sacramento River flows for approximately 60 miles from Keswick Dam to Red Bluff; and the middle reach of the Sacramento River flows approximately 160 miles from Red Bluff to the confluence with the Feather River. The lower reach of the Sacramento River flows for approximately 20 river miles between the confluence with the Feather River and Freeport, immediately downstream of the confluence with the American River.

Moderately high releases (greater than 10,000 cfs) are typically sustained during the major irrigation season of June through September. Flows are released in the fall months from CVP and SWP reservoirs to meet water temperature criteria for winter-run Chinook Salmon spawning and incubation, to provide suitable habitat for spring-run and early returning fall-run Chinook Salmon, provide water supplies to rice farms for rice stubble decomposition, and to provide water for wildlife refuges.

Sacramento River from Keswick Dam to Red Bluff

The Sacramento River between Keswick Dam and the City of Red Bluff flows through the northern foothills of the Sacramento Valley. Flows are influenced by outflow from Keswick Reservoir and inflows from Clear Creek (described above); and Cow Creek, Bear Creek, Cottonwood Creek, Battle Creek, and Paynes Creek which provide 15 to 20 percent of the flows in this reach as measured at Bend Bridge. There are several moderate major diversions along the Sacramento River upstream of Red Bluff, including the CVP Wintu Pumping Plant to provide water for the Bella Vista Water District, and the Anderson-Cottonwood Irrigation District Diversion. Both of these diversions near Redding provide water to agricultural, municipal, and industrial water users (Reclamation 1997). No major storage or diversion structures have been constructed in the tributary watersheds in this reach of the Sacramento River, although several small diversions for irrigation, domestic use, and hydroelectric power generation are present (Reclamation 1997). Flow patterns on one major tributary in this reach, Battle Creek, are undergoing changes as the Battle Creek Salmon and Steelhead Restoration Project is implemented to restore ecological processes along 42 miles of Battle Creek and 6 miles of tributaries while minimizing reductions to hydroelectric power generation through the decommissioning of five powerplants.

Reclamation operates the Shasta, Sacramento River, and Trinity River divisions of the CVP to meet (to the extent possible) the provisions of SWRCB Order 90-05. An April 5, 1960 Memorandum of Agreement between Reclamation and California Department of Fish and Wildlife (CDFW) originally established flow objectives in the Sacramento River for the protection and preservation of fish and wildlife resources. The agreement provided for minimum releases into the natural channel of the Sacramento River at Keswick Dam for normal and critically dry years. Since October 1981, Keswick Dam has operated based on a minimum release of 3,250 cfs for normal years from September 1 through the end of February, in accordance with an agreement between Reclamation and CDFW. This release schedule was included in SWRCB Order 90-05, which maintains a minimum release of 3,250 cfs at Keswick Dam and Red Bluff Pumping Plant from September through the end of February in all water years except critically dry years.

Generally, releases from Keswick Reservoir are implemented to comply with the minimum fishery requirement by October 15 each year and to minimize changes in Keswick releases between October 15 and December 31. Releases may be increased during this period to meet downstream needs such as higher outflows in the Delta to meet water quality requirements, or to meet flood control requirements. Releases from Keswick Dam may be reduced when downstream tributary inflows increase to a level that will meet flow needs. Reclamation attempts to establish a base flow that minimizes release fluctuations to reduce impacts to fisheries and bank erosion from October through December.

Sacramento River from Red Bluff to the Delta

Between Red Bluff and Colusa, the Sacramento River is a meandering stream, migrating through alluvial deposits between widely spaced levees. From Colusa to the northern boundary of the Delta near Freeport, flows increase due to the addition of the Feather and American rivers flows.

Major streams entering the Sacramento River between Red Bluff and the Feather River include Antelope, Elder, Mill, Thomes, Deer, Stony, Big Chico, and Butte creeks. No major storage or diversion structures have been constructed on Antelope, Elder, Mill, and Thomes creeks, although several small seasonal diversions for irrigation, domestic use, and hydroelectric power generation are present (Reclamation 1997). Non-CVP and non-SWP diversion dams are located on Deer, Big Chico, and Butte creeks.

Stony Creek flows are controlled by East Park Dam, Stony Gorge Dam, and Black Butte Dam (Reclamation 1997). East Park and Stony Gorge reservoirs store surplus water for irrigation deliveries and are operated by Reclamation as part of the Orland Project which is independent of the CVP. Black Butte Dam is operated by the USACE for flood control and irrigation supply. Black Butte Dam operations are coordinated with the CVP. The GCID canal, which crosses Stony Creek downstream of Black Butte Dam, includes a seasonal gravel dam constructed across the creek on the downstream side of the canal.

The Sacramento River between Red Bluff and Chico Landing, the Sacramento River Flood Control Project has provided bank protection and incidental channel modification since 1958 (DWR 2013b). Between Chico Landing and Colusa, the flood management facilities consist of levees and overflow areas. Black Butte Reservoir regulates Stony Creek flood flows, which enter the Sacramento River downstream of Hamilton City. Right bank levees from Ord Ferry through Colusa prevent Sacramento River flood water from entering the Colusa Basin, except when flows exceed 300,000 cfs near Ord Ferry (DWR 2013b). Three flood relief weirs along the right bank, downstream of Chico Landing, allow flood flows to spill into the Butte Basin Overflow Area. The left bank levee begins midway between Ord Ferry and Butte City and extends south through Verona and includes the Moulton and Colusa weirs that allow flood flows to spill into the Butte Basin Overflow Area. The natural Sutter Basin overflow (Sutter Bypass) to the east of the Sacramento River and downstream of the Sutter Buttes was included in the Sacramento River Flood Control Project. The Sutter Bypass conveys floodwaters from the Butte Basin Overflow

Area, Butte Creek, Wadsworth Canal, and Reclamation Districts 1660 and 1500 drainage plants, state drainage plants, and Tisdale Weir to the confluence of the Sacramento and Feather rivers. Downstream of Colusa, Reclamation Districts 70, 108, and 787 pump flood waters from adjacent closed basin lands into the river.

The Colusa Basin Drain provides drainage for a large portion of the irrigated lands on the western side of the Sacramento Valley in Glenn, Colusa, and Yolo counties; and supplies irrigation water to lands in this area. Water from the drain is discharged to the Sacramento River through the Knights Landing Outfall, a gravity flow structure and prevents the Sacramento River from flowing into the Colusa Basin.

Recent mean daily flows in the Sacramento River at Bend Bridge (near Red Bluff), Vina Bridge (near Tehama), Hamilton City, Wilkins Slough (upstream of the Feather River confluence), Verona (downstream of the Feather River confluence), and Freeport (downstream of the American River Confluence and near the northern boundary of the Delta), are presented on Figures C.3-8 through C.3-13 (DWR 2018n, 2018o, 2018p, 2018q, 2018r, 2018s).

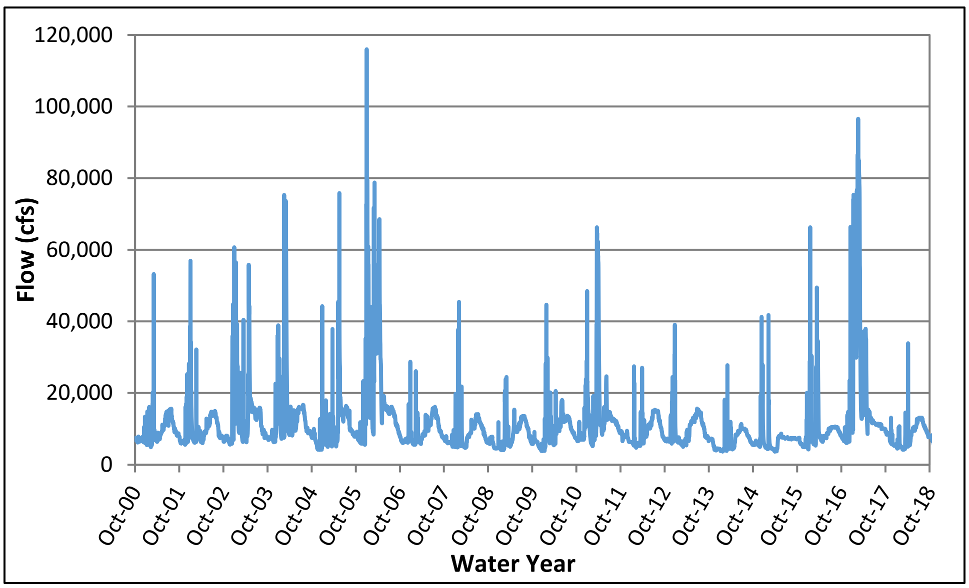

Figure C.3-8. Sacramento River at Bend Bridge

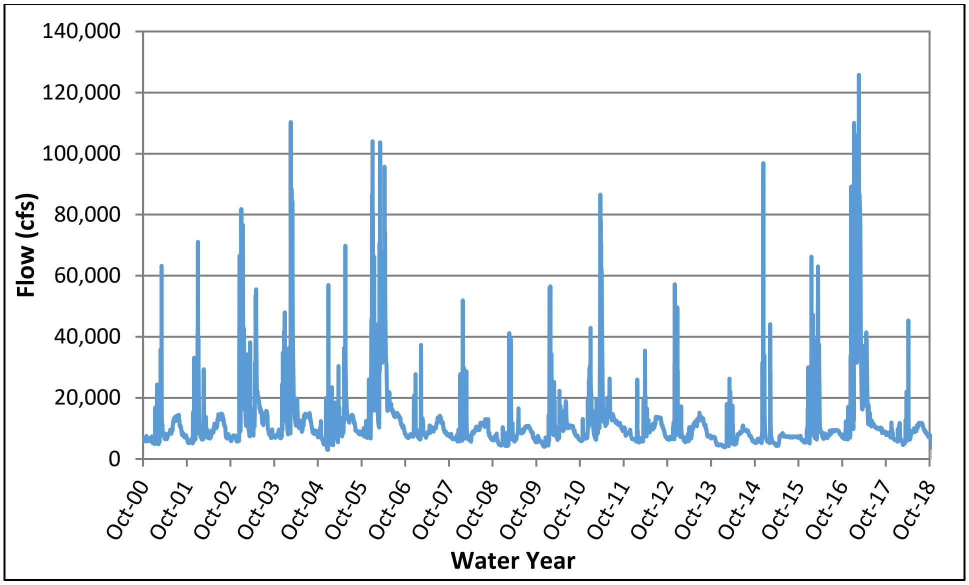

Figure C.3-9. Sacramento River at Vina Bridge

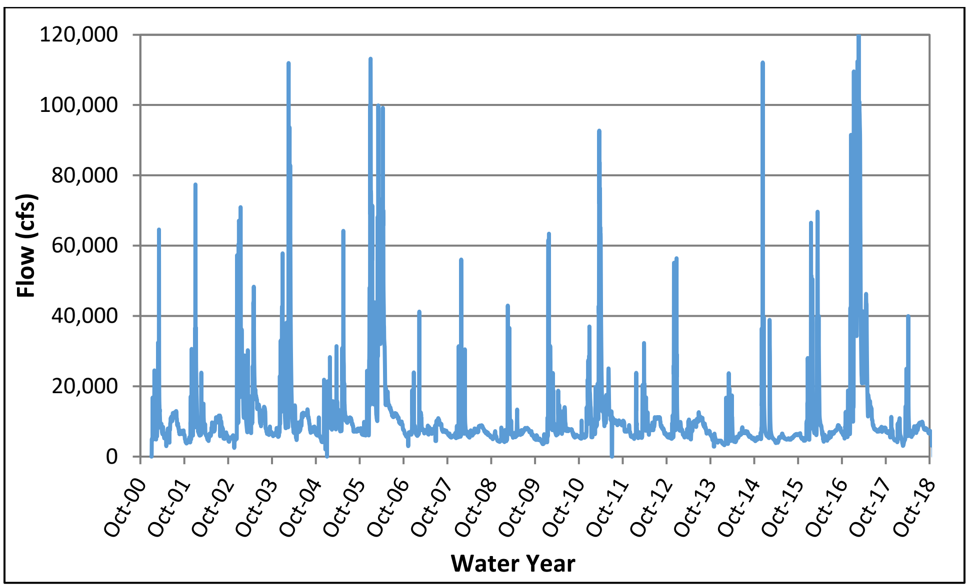

Figure C.3-10. Sacramento River at Hamilton City

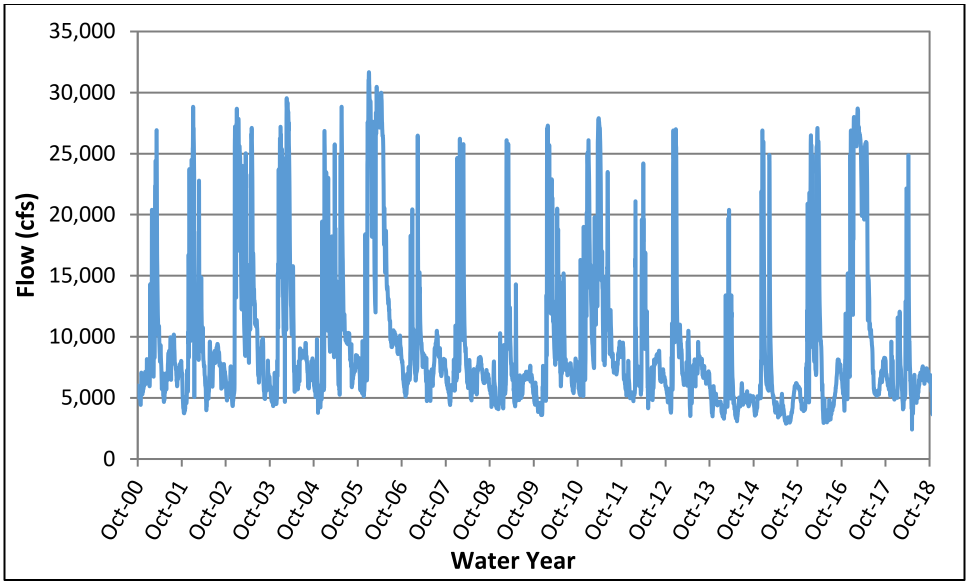

Figure C.3-11. Sacramento River at Wilkins Slough

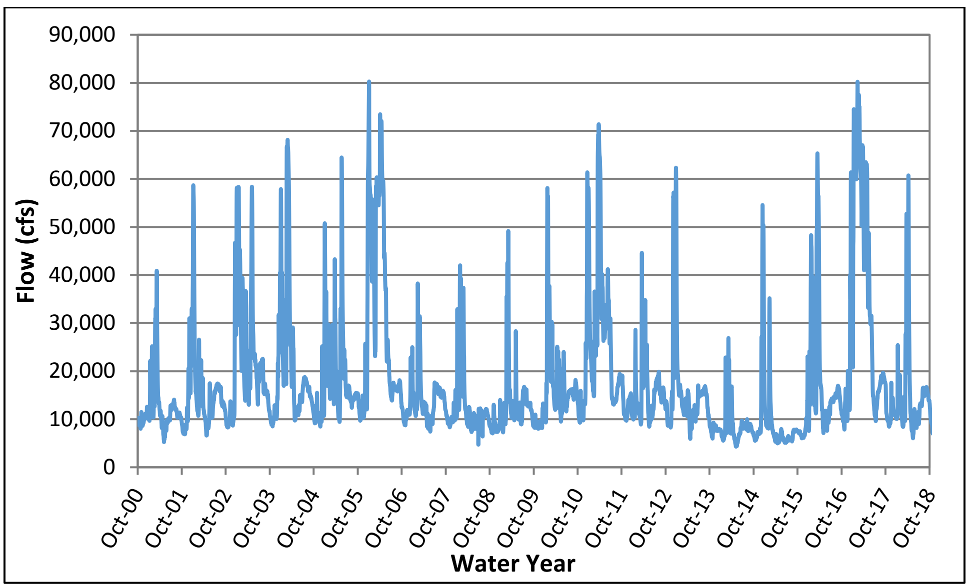

Figure C.3-12. Sacramento River at Verona

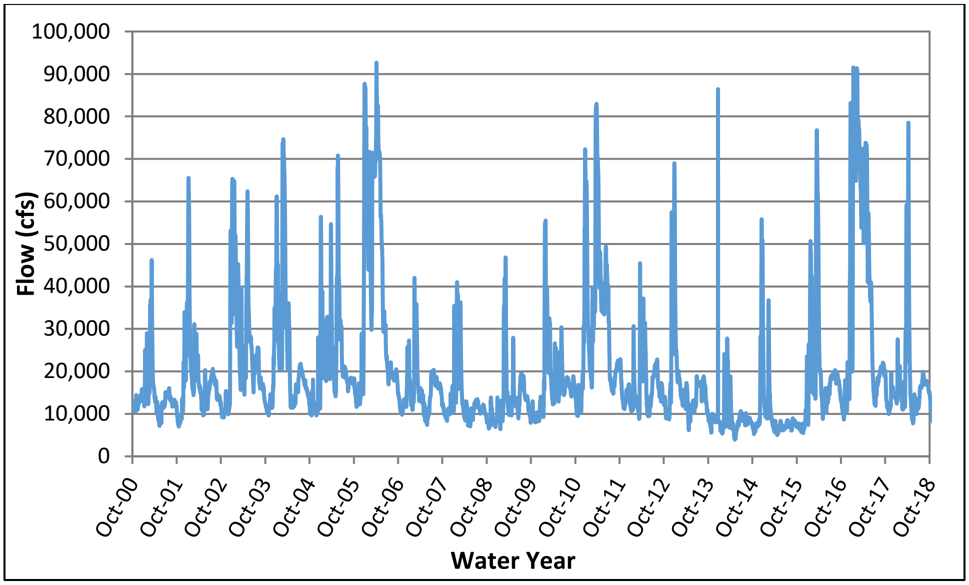

Figure C.3-13. Sacramento River at Freeport

Flows in the Sacramento River generally peak during winter and spring storm events. Upstream of Hamilton City, sharp increases in flow occur during rainfall events, such as events in February 2004, December 2005/January 2006, and January 2010. Downstream of Hamilton City, the high flow events occur over a longer period of time as water flows into the river from the tributaries.

Major Diversions

Major diversions in this reach of the Sacramento River include the CVP Red Bluff Pumping Plant, Glenn-Colusa Irrigation District (GCID) intake, and individual diversions for the CVP Sacramento River Settlement Contractors.

The Red Bluff Pumping Plant was completed in August 2012 to improve fish passage conditions on the Sacramento River by removing the Red Bluff Diversion Dam, and to continue to divert water from the Sacramento River into the Tehama-Colusa and Corning canals. The facility includes a 1,118-foot-long flat-plate fish screen, intake channel, 2,500 cfs capacity pumping plant and discharge conduit to divert water from the Sacramento River into the Tehama-Colusa and Corning canals. In 2011, the dam gates were permanently placed in the open position for free migration of fish while ensuring continued water deliveries by way of the Red Bluff Pumping Plant.

The GCID Main Pump Station is located near Hamilton City to divert water into the GCID Canal that conveys water to over 130,000 acres, including the USFWS Sacramento National Wildlife Refuge; and terminates at the Colusa Basin Drain near Williams. In 2001, the GCID Fish Screen was completed in addition to several canal improvements to allow year-round water deliveries.

C.3.3.2 *CVP Shasta and Sacramento River Divisions Operations*

C.3.3.2.1 Flood Control

Flood control objectives for Shasta Lake require that releases be restricted to quantities that would not cause downstream flows or stages to exceed specified levels. These include a flow of 79,000 cfs at the tailwater of Keswick Dam, and a stage of 39.2 feet in the Sacramento River at Bend Bridge gauging station, which corresponds to a flow of approximately 100,000 cfs.

Flood control operations are based on regulating criteria developed by the USACE pursuant to the provisions of the Flood Control Act of 1944. Maximum flood space reservation is 1.3 MAF, with variable storage space requirements based on an inflow parameter. Flood control operation at Shasta Lake requires forecasting runoff conditions into Shasta Lake and runoff conditions of unregulated creek systems downstream from Keswick Dam as far in advance as possible. A critical element of upper Sacramento River flood operations is the local runoff entering the Sacramento River between Keswick Dam and Bend Bridge.

The unregulated creeks (major creek systems are Cottonwood Creek, Cow Creek, and Battle Creek) in this reach of the Sacramento River can be very sensitive to a large rainfall event and produce high rates of runoff into the Sacramento River in short time periods. During large rainfall and flooding events, the local runoff between Keswick Dam and Bend Bridge can exceed 100,000 cfs.

The travel time required for release changes at Keswick Dam to affect Bend Bridge flows is approximately 8 to 10 hours. If the total flow at Bend Bridge is projected to exceed 100,000 cfs, the release from Keswick Dam is decreased to maintain Bend Bridge flow below 100,000 cfs. As the flow at Bend Bridge is projected to recede, the Keswick Dam release is increased to evacuate water stored in the flood control space at Shasta Lake. Changes to Keswick Dam releases are scheduled to minimize rapid fluctuations in the flow at Bend Bridge.

The flood control criteria for Keswick releases specify that releases should not be increased more than 15,000 cfs or decreased more than 4,000 cfs in any 2-hour period. The restriction on the rate of decrease is intended to prevent sloughing of saturated downstream channel embankments caused by rapid reductions in river stage. In rare instances, the rate of decrease may have to be accelerated to avoid exceeding critical flood stages downstream.

C.3.3.2.2 Fish and Wildlife Requirements in the Sacramento River

Historical Perspective

Reclamation operates the Shasta, Sacramento River, and Trinity River divisions of the CVP to meet (to the extent possible) the provisions of SWRCB Order 90-5. An April 5, 1960, MOA between Reclamation and CDFW originally established flow objectives in the Sacramento River for the protection and preservation of fish and wildlife resources.

The agreement provided for minimum releases into the natural channel of the Sacramento River at Keswick Dam for normal and critically dry years (Table C.3-3). Since October 1981, Keswick Dam has operated based on a minimum release of 3,250 cfs for normal years from September 1 through the end of February, in accordance with an agreement between Reclamation and CDFW. This release schedule was included in SWRCB Order 90-05, which maintains a minimum release of 3,250 cfs at Keswick Dam and Red Bluff Pumping Plant from September through the end of February in all water years except critically dry years.

Dedication of (b)(2) water on the Sacramento River provided instream flows below Keswick Dam greater than those that would have occurred under pre-CVPIA conditions, e.g. the fish and wildlife requirements specified in SWRCB Order 90-5 and the temperature criteria formalized in the 1993 NMFS winter-run Chinook Salmon BO as the base. Instream flow objectives from October 1 to April 15 (typically April 15 is when water temperature objectives for winter-run Chinook Salmon become the determining factor) were usually selected to minimize dewatering of redds and provide suitable habitat for salmon spawning, incubation, rearing, and migration.

Table C.3-3. Minimum Flow Requirements and Objectives (cfs) on the Sacramento River below Keswick Dam

Period	MOA	Water Rights 90-5	MOA and Water Rights 90-5
Water Year Type	Normal	Normal	Critically Dry
January 1–February 28(29)	2,600	3,250	2,000
March 1–March 31	2,300	2,300	2,300
April 1–April 30	2,300	2,300	2,300
May 1–August 31	2,300	2,300	2,300
September 1–September 30	3,900	3,250	2,800
October 1–November 30	3,900	3,250	2,800
December 1–December 31	2,600	3,250	2,000

The 1960 MOA between Reclamation and CDFW provides that releases from Keswick Dam (from September 1 through December 31) are made with minimum water level fluctuation or change to protect salmon to the extent compatible with other operations requirements.

Reclamation usually attempts to reduce releases from Keswick Dam to the minimum fishery requirement by October 15 each year and to minimize changes in Keswick releases between October 15 and December 31. Releases may be increased during this period to meet downstream needs such as higher outflows in the Delta to meet water quality requirements, or to meet flood control requirements. Releases from Keswick Dam may be reduced when downstream tributary inflows increase to a level that would meet flow needs. Reclamation attempts to establish a base flow that minimizes release fluctuations to reduce impacts to fisheries and bank erosion from October through December.

The Connelly-Areias-Chandler Rice Straw Burning Reduction Act of 1991 changed agricultural water diversion practices along the Sacramento River and has affected Keswick Dam release rates in the fall. This program is generally known as the Rice Straw Decomposition and Waterfowl Habitat Program. Prior to this change, the preferred method of clearing fields of rice stubble was to systematically burn it. Today, rice field burning has been phased out due to air quality concerns and has been replaced in some areas by a program of rice field flooding that decomposes rice stubble and provides additional waterfowl habitat. The result has been an increase in water demand to flood rice fields in October and November, which has increased the need for higher Keswick releases in all but the wettest of fall months.

C.3.3.2.3 Minimum Flow for Navigation as Measured at Wilkins Slough

Historical commerce on the Sacramento River resulted in a CVP authorization to maintain minimum flows of 5,000 cfs at Chico Landing to support navigation in accordance with references to Sacramento River Division operations in the River and Harbors Act of 1935 and the Rivers and Harbors Act of 1937. Currently, there is no commercial traffic between Sacramento and Chico Landing, and USACE has not dredged this reach to preserve channel depths since 1972. However, long-time water users diverting from the river have set their pump intakes just below this level and cannot easily divert when lower river elevations occur with lower flows. Therefore, the CVP is operated to meet the navigation flow requirement of 5,000 cfs to Wilkins Slough, (gauging station on the Sacramento River), under all but the most critical water supply conditions, to facilitate pumping and use of screened diversions.

At flows below 5,000 cfs at Wilkins Slough, diverters have reported increased pump cavitation as well as greater pumping head requirements. Diverters are able to operate for extended periods at flows as low as 4,000 cfs at Wilkins Slough, but pumping operations become severely affected and some pumps become inoperable at flows lower than this. Flows may drop as low as 3,500 cfs for short periods while changes are made in Keswick releases to reach target levels at Wilkins Slough.

C.3.3.2.4 Water Temperature Operations in the Upper Sacramento River

Water temperature on the Sacramento River system is influenced by several factors, including the relative water temperatures and ratios of releases from Shasta Dam and from the Spring Creek Power Plant. The temperature of water released from Shasta Dam and the Spring Creek Power Plant is a function of the reservoir temperature profiles at the discharge points at Shasta and Whiskeytown, the depths from which releases are made, the seasonal management of the deep cold water reserves, ambient seasonal air temperatures and other climatic conditions, tributary accretions and water temperatures, and residence time in Keswick, Whiskeytown and Lewiston Reservoirs, and in the Sacramento River. Water temperature in the upper Sacramento River is governed by current water rights permit requirements.

In 1990 and 1991, SWRCB issued Water Rights Orders 90-05 and 91-01 modifying Reclamation's water rights for the Sacramento River. The orders stated that Reclamation shall operate Keswick and Shasta Dams and the Spring Creek Power Plant to meet a daily average water temperature of 56°F as far downstream in the Sacramento River as practicable during periods when higher temperature would be harmful to fisheries. The optimal control point is the Red Bluff Pumping Plant.

Under the orders, the water temperature compliance point may be modified when the objective cannot be met at Red Bluff Pumping Plant. In addition, SWRCB Order 90-05 modified the minimum flow requirements initially established in the 1960 MOA for the Sacramento River below Keswick Dam. The water right orders also recommended the construction of a Shasta Temperature Control Device (TCD) to improve the management of the limited cold-water resources.

Pursuant to SWRCB Orders 90-05 and 91-01, Reclamation configured and implemented the Sacramento-Trinity Water Quality Monitoring Network to monitor temperature and other parameters at key locations in the Sacramento and Trinity Rivers. SWRCB orders also required Reclamation to establish the SRTTG to formulate, monitor, and coordinate temperature control plans for the upper Sacramento and Trinity Rivers. This group consists of representatives from Reclamation, SWRCB, NMFS, USFWS, CDFW, Western, DWR, and the Hoopa Valley Indian Tribe.

Each year, with finite cold-water resources and competing demands usually an issue, the SRTTG devise operation plans with the flexibility to provide the best protection consistent with the CVP's temperature control capabilities and considering the annual needs and seasonal spawning distribution monitoring information for winter-run and fall-run Chinook Salmon. In every year since SWRCB issued the orders, those plans have included modifying the Red Bluff Pumping Plant compliance point to make best use of the cold-water resources based on the location of spawning Chinook Salmon. These modifications occurred in 2012. Reports are submitted periodically to SWRCB over the temperature control season defining our temperature operation plans. SWRCB has overall authority to determine if the plan is sufficient to meet water right permit requirements.

C.3.3.2.5 Fish and Wildlife Requirements

The 2009 NMFS BO RPA Action I.2.1 requires Reclamation to achieve the following carryover storage performance measures for Shasta Lake to maintain the cold-water volume needed to meet downstream temperature requirements:

- 87 percent of the years: 2,200 TAF end-of-September storage

- 82 percent of the years: 2,200 TAF end-of-September storage and 3,800 TAF end-of-April storage in following year
- 40 percent of the years: 3,200 TAF end-of-September storage

The 2009 NMFS BO RPA requires Reclamation to achieve the following temperature requirements over a ten-year running average.

- 95 percent of the years: Clear Creek temperature compliance
- 85 percent of the years: Ball's Ferry temperature compliance
- 40 percent of the years: Jelly's Ferry temperature compliance
- 15 percent of the years: Bend Bridge temperature compliance

From November through February, if the end-of-September storage in Shasta Lake is equal to or greater than 2,400 TAF by October 15, Reclamation is required to work with NMFS, and CDFW to develop a release schedule that would consider the need to maintain flood control space in Shasta Lake (which results in a maximum storage of 3,250 TAF at the end-of-November), and the need to provide stable Sacramento River flows and elevations during this period. If the end-of-September storage in Shasta Lake is between 1,900 and 2,400 TAF, a monthly release schedule for this period must be developed to consider maintaining Keswick Reservoir releases between 3,250 and 7,000 cfs; flows to support fall-run Chinook Salmon in accordance with the CVPIA AFRP guidelines; and provide for conservative Keswick Reservoir releases in drier years. If end-of-September storage in Shasta Lake is less than 1,900 TAF, Keswick Reservoir releases are reduced to 3,250 cfs in early October unless the flows are needed for temperature compliance, and if needed, reduce discretionary deliveries; and develop projected monthly deliveries for the period to maintain releases of 3,250 cfs, and if needed, reduce CVP and SWP Delta exports to meet Delta outflow and other legal requirements.

From April 15 through May 15, water temperatures are to be maintained at 56° F between Ball's Ferry and Bend Bridge. In addition, in March, Reclamation uses projections of CVP water availability, based upon a 90 percent forecast, to project the ability to meet temperature compliance at Ball's Ferry and achieve an end-of September storage in Shasta Lake of 2,200 TAF. If the projections indicate that only one of the objectives can be met, releases from Keswick Reservoir would be reduced to 3,250 cfs unless another release pattern is agreed upon with NMFS. The release pattern would consider actions to maintain monthly average flows for Reclamation's non-discretionary delivery obligations; provide flows for the biological needs of spring life stages of species addressed in the 2009 NMFS BO; and approaches, including reductions in Delta exports, to meet Delta outflow and other legal requirements while not reducing Keswick Reservoir releases. If the projections indicate that the Clear Creek temperature compliance point or the 1,900 TAF end-of-September Shasta Lake storage cannot be met, Reclamation would develop a plan to manage the cold-water pool in Whiskeytown Reservoir and Shasta Lake through several operational changes, including a reduction in the Wilkins Slough flow criteria (discussed above) to 4,000 cfs.

For operations from May 15 through October, Reclamation would develop a Temperature Management Plan to achieve temperatures of 56° F or less at compliance locations between Ball's Ferry and Bend Bridge.

C.3.3.2.6 <u>Shasta Temperature Control Device</u>

Construction of the TCD at Shasta Dam was completed in 1997. This device is designed for greater flexibility in managing the cold-water reserves in Shasta Lake while enabling hydroelectric power generation to occur and to improve salmon habitat conditions in the upper Sacramento River. The TCD is also designed to enable selective release of water from varying lake levels through the power plant in order to manage and maintain adequate water temperatures in the Sacramento River downstream of Keswick Dam.

Prior to construction of the Shasta TCD, Reclamation released water from Shasta Dam's low-level river outlets to alleviate high water temperatures during critical periods of the spawning and incubation life stages of the winter-run Chinook Salmon stock. The release of water through the low-level river outlets was a major facet of Reclamation's efforts to control upper Sacramento River temperatures from 1987 through 1996. Releases through the low-level outlets bypass the power plant and result in a loss of hydroelectric generation at the Shasta Power Plant.

The seasonal operation of the TCD is generally as follows: during mid-winter and early spring the highest possible elevation gates are utilized to draw from the upper portions of the lake to conserve deeper colder resources. During late spring and summer, the operators begin the seasonal progression of opening deeper gates as Shasta Lake elevation decreases and cold-water resources are utilized. In late summer and fall, the TCD side gates are opened to utilize the remaining cold-water resource below the Shasta Power Plant elevation in Shasta Lake. Table C.3-4 shows TCD gates with associated elevations and storages.

Table C.3-4. Shasta Temperature Control Device Gates with Elevation and Storage

TCD Gates	Shasta Elevation with 35 feet of Submergence (feet)	Shasta Storage (MAF)
Upper Gates	1,035	~3.65
Middle Gates	935	~2.50
Pressure Relief Gates	840	~0.67
Side Gates	720*	~0.01

*Low level intake bottom

The seasonal progression of the Shasta TCD operation is designed to maximize the conservation of cold-water resources deep in Shasta Lake, until the time the resource is of greatest management value for fishery management purposes. Recent operational experience with the Shasta TCD has demonstrated significant operational flexibility improvement for cold water conservation and upper Sacramento River water temperature and fishery habitat management purposes. Recent operational experience has also demonstrated the Shasta TCD has significant leaks that are inherent to TCD design. Also, operational uncertainties cumulatively impair the seasonal performance of the Shasta TCD to a greater degree than was anticipated in previous analysis and modeling used to describe long-term Shasta TCD benefits.

C.3.3.2.7 CVPIA 3406 (b)(2) on the Upper Sacramento River

Dedication of (b)(2) water on the Sacramento River provides instream flows below Keswick Dam greater than those that would have occurred under pre-CVPIA conditions, e.g., the fish and wildlife requirements specified in SWRCB Order 90-5 and the temperature criteria formalized in the 1993 NMFS winter-run Chinook Salmon BO as the base. Instream flow objectives from October 1 to April 15 (typically April 15 is when water temperature objectives for winter-run Chinook Salmon become the determining factor) are usually selected to minimize dewatering of redds and provide suitable habitat for salmonid spawning, incubation, rearing, and migration.

C.3.3.3 *Anderson-Cottonwood Irrigation District Diversion Dam*

Anderson Cottonwood Irrigation District (ACID) holds senior water rights and has diverted into the ACID Canal for irrigation along the west side of the Sacramento River between Redding and Cottonwood since 1916. The United States and ACID signed a contract providing for Project water service and agreement on diversion of water. ACID diverts to its main canal (on the right bank of the river) from a diversion dam located in Redding about 5 miles downstream from Keswick Dam.

Close coordination between Reclamation and ACID is required for regulation of river flows to ensure safe operation of ACID's diversion dam during the irrigation season. The irrigation season for ACID runs from April through October. Keswick release rate decreases required for the ACID operations are limited to 15 percent in a 24-hour period and 2.5 percent in any one hour. Therefore, advance notification is important when scheduling decreases to allow for the installation or removal of the ACID diversion dam.

C.3.3.4 *Tehama-Colusa Canal Authority Operations*

The intake for the Tehama-Colusa Canal and the Corning Canal is located on the Sacramento River approximately 2 miles southeast of Red Bluff. Water is diverted through fish passage facilities along the Sacramento River and lifted by a 2,500 cfs pumping plant into a settling basin for continued conveyance in the Tehama-Colusa Canal and the Corning Canal. Reclamation operates the pumping plant in accordance with BOs issued by USFWS and NMFS specifically for the Red Bluff Pumping Plant.

The Tehama-Colusa Canal is a lined canal extending from the settling basin 111 miles south from the Red Bluff Pumping Plant and provides irrigation service on the west side of the Sacramento Valley in Tehama, Glenn, Colusa, and northern Yolo counties. Construction of the Tehama-Colusa Canal began in 1965, and it was completed in 1980.

The Corning Pumping Plant lifts water approximately 56 feet from the screened portion of the settling basin into the unlined, 21-mile-long Corning Canal. The Corning Canal was completed in 1959, to provide water to the CVP contractors in Tehama County that could not be served by gravity from the Tehama-Colusa Canal. The Tehama-Colusa Canal Authority (TCCA) operates both the Tehama-Colusa and Corning canals.

C.3.4 Feather River Watershed

The Feather River, with a drainage area of 3,607 square miles on the east side of the Sacramento Valley, is the largest tributary to the Sacramento River below Shasta Dam (Reclamation 1997, DWR 2007a). The Feather River enters the Sacramento River from the east at Verona. The total flow is provided by the Feather River and tributaries, which include the Yuba and Bear rivers.

C.3.4.1 *Lower Yuba River*

The Yuba River watershed extends over 1,339 square miles in the Sierra Nevada. The Yuba River is a major tributary to the Feather River, and historically has contributed over 40 percent of the lower Feather River flows (Reclamation 1997). The major reservoir in the watershed is the 970-TAF New Bullards Bar Reservoir that is owned and operated by the Yuba County Water Agency to provide flood control, water storage, and hydroelectric generation (Yuba County Water Agency [YCWA] 2012). The Yuba River watershed also includes over 400 TAF additional storage in reservoirs located upstream of New Bullards Bar Reservoir.

Water is diverted from New Bullards Bar Reservoir through the Colgate Tunnel and Powerhouse and discharged into the Yuba River. The 70-TAF Englebright Lake is formed by the Harry L. Englebright Dam downstream of New Bullards Dam. Englebright Lake was constructed by the California Debris Commission to trap and store sediment from historical hydraulic mining sites in the upper watershed and provide recreation and hydroelectric generation opportunities (USACE 2013). Following decommissioning of the California Debris Commission in 1986, administration of Englebright Dam and Lake was assumed by the USACE (USACE 2012, 2013, 2019). Major water diversions from the Yuba River occur 12.5 miles downstream of Englebright Dam at Daguerre Point Dam. Water transfers have occurred between Yuba County Water Agency and other water agencies, including CVP and SWP water users, since 2008 under the Lower Yuba River Accord (Lower Yuba River Accord, River Management Team [LYRARMT] 2013).

C.3.4.2 *Oroville Complex*

DWR holds contracts with 29 public agencies in Northern, Central, and Southern California for water supplies from the SWP. Water stored in the Lake Oroville facilities, along with excess water available in the Delta, is captured in the Delta and conveyed through several facilities to SWP water contractors.

The SWP is operated to provide flood control, meet Delta requirements and provide water for agricultural, M&I, recreational, and environmental purposes. Water is stored in Lake Oroville and released to serve three Feather River area water contractors and two water contractors served from the NBA, and 24 SWP contractors in the SWP service areas in the south San Francisco Bay Area, San Joaquin Valley, and Southern California. In addition to exporting portions of water released from Lake Oroville, the Clifton Court/Banks Pumping Plant complex diverts natural surplus flow available in the Delta. Water exported at Banks PP is conveyed into storage at San Luis Reservoir or is delivered directly to SWP member agencies south of the Delta via the California Aqueduct and its associated facilities.

C.3.4.2.1 Facilities

Oroville Dam and its related facilities comprise a multipurpose complex. The reservoir stores winter and spring runoff, which is released into the Feather River to meet the Project's needs, Delta requirements, and fish and wildlife protection. The Oroville Complex also provides power generation (including pumpback operations) flood control storage, and recreation opportunities.

The Oroville Project creates a lake with a maximum surface area of 15,810 acres, has a total storage capacity of 3,538 TAF, and is fed by the North, Middle, and South forks of the Feather River. Average annual unimpaired runoff into the lake is about 4.5 MAF. Historical water storage volumes and water storage elevations for Lake Oroville for Water Years 2001 through 2018 are presented on Figures C.3-14 and C.3-15 (DWR 2018t, 2018u).

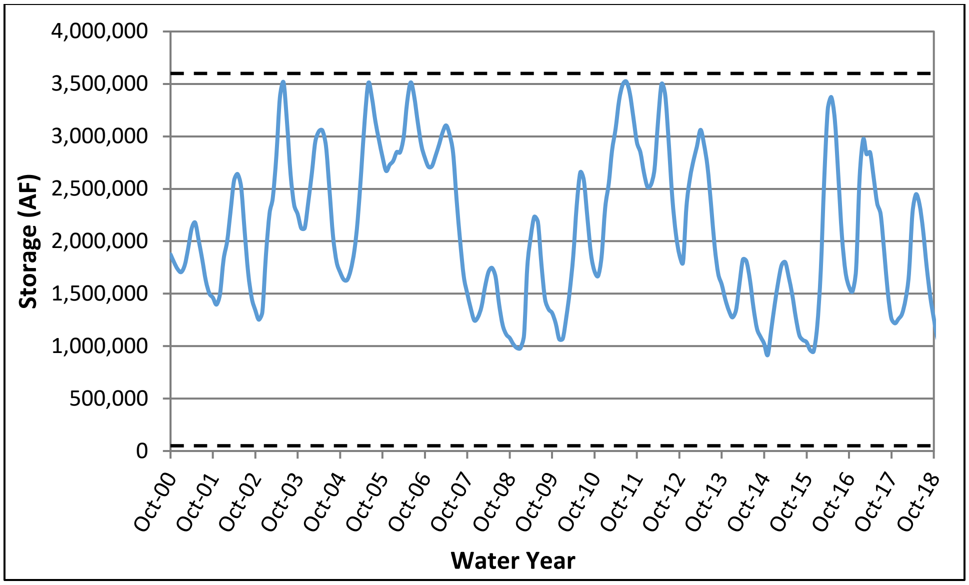

Figure C.3-14. Lake Oroville Storage

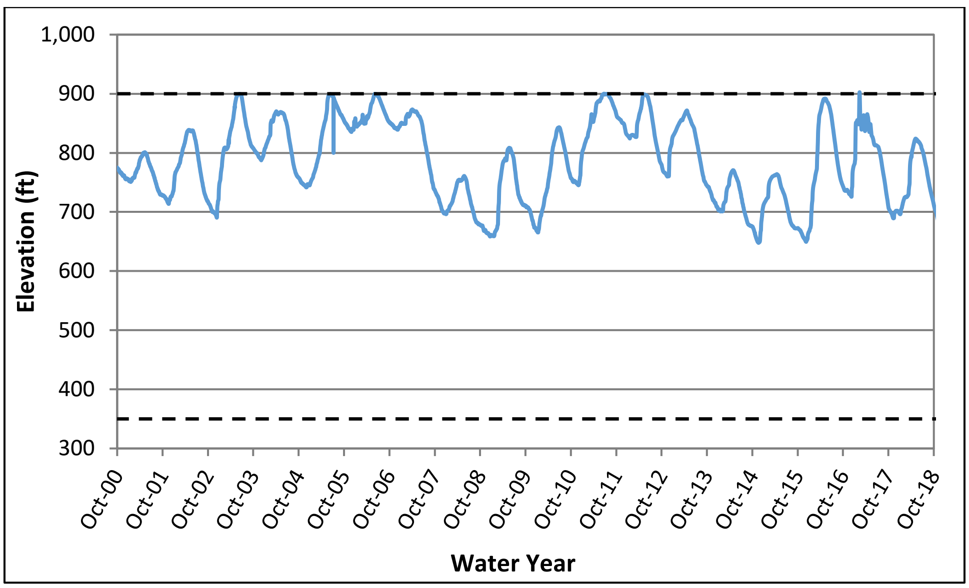

Figure C.3-15. Lake Oroville Elevation

A maximum of 16,950 cfs can be released through the Edward Hyatt Power Plant, located underground near the left abutment of Oroville Dam. Three of the six units are conventional generators driven by vertical-shaft, Francis-type turbines. The other three are motor-generators coupled to Francis-type, reversible pump turbines. The latter units allow pumped storage operations. The intake structure has an overflow type shutter system that determines the level from which water is drawn.

Approximately 4 miles downstream of Oroville Dam and Edward Hyatt Power Plant is the Thermalito Diversion Dam. Thermalito Diversion Dam consists of a 625-foot-long, concrete gravity section with a regulated ogee spillway that releases water to the low flow channel of the Feather River. On the right abutment is the Thermalito Power Canal regulating headwork structure. Water storage volumes and water storage elevations for Thermalito Reservoir for Water Years 2001 through 2018 are presented on Figures C.3-16 and C.3-17 (DWR 2018v, 2018w).

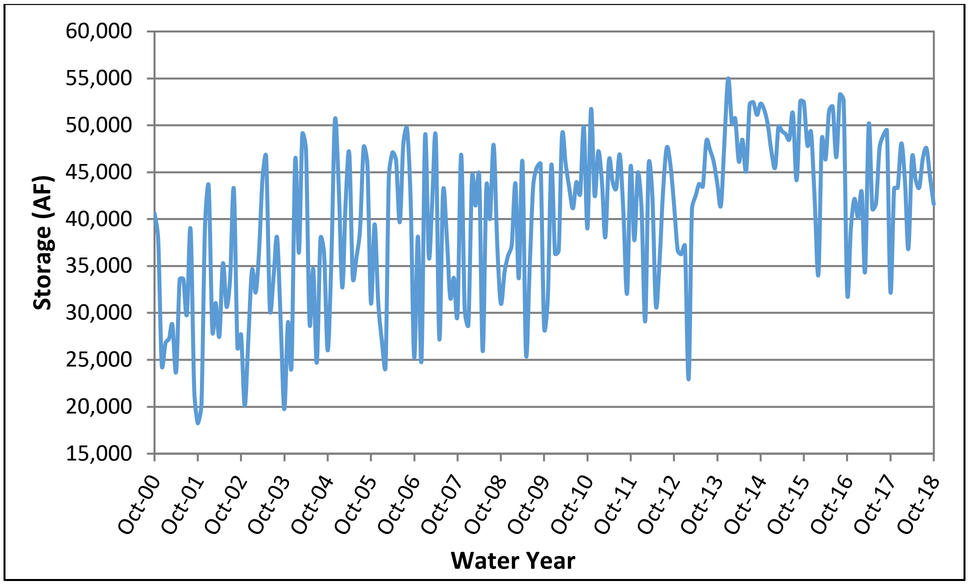

Figure C.3-16. Thermalito Reservoir Storage

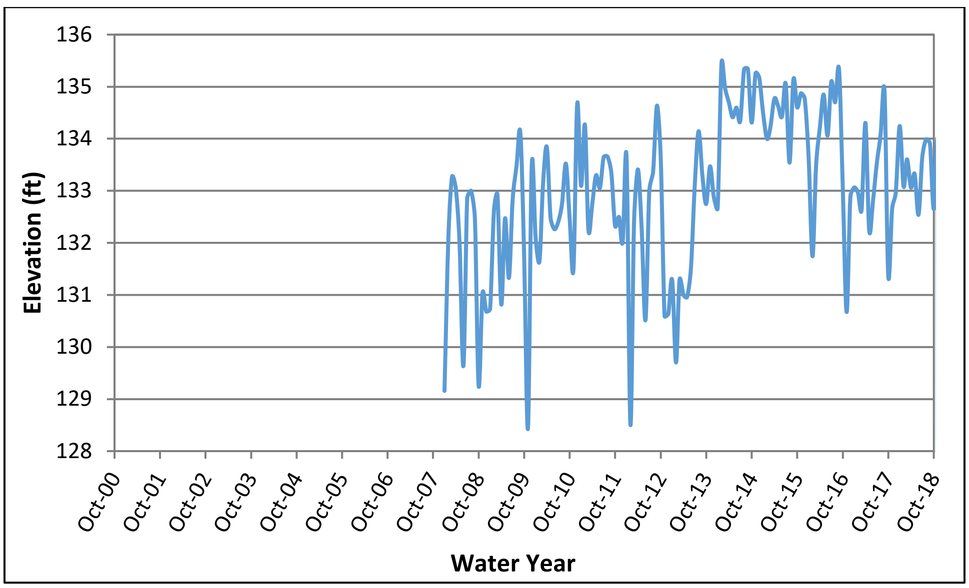

Figure C.3-17. Thermalito Reservoir Elevation

The purpose of the diversion dam is to divert water into the 2-mile long Thermalito Power Canal that conveys water in either direction and creates a tailwater pool (Thermalito Diversion Pool) for Edward Hyatt Power Plant. The Thermalito Diversion Pool acts as a forebay when Hyatt is pumping water back into Lake Oroville. On the left abutment is the Thermalito Diversion Dam Power Plant, with a capacity of 615 cfs that releases water to the low-flow section of the Feather River.

Thermalito Power Canal hydraulically links the Thermalito Diversion Pool to the Thermalito Forebay (11.768 TAF), which is the off-stream regulating reservoir for Thermalito Power Plant.

Thermalito Power Plant is a generating-pumping plant operated in tandem with the Edward Hyatt Power Plant. Energy prices and availability have historically been the two main factors that determine if pumpback operations are desirable for economic benefits. Pumpback operations typically occurred during off-peak hours when energy prices are lower. However, due to recent changes in the energy market (i.e. solar power contributions) and a desire to reduce operational stress on aging infrastructure, pumpback operations have been very infrequent in recent history. The Oroville Thermalito Complex has a capacity of approximately 17,000 cfs through the power plants. Water is returned to the Feather River via the Thermalito Afterbay river outlet.

Five agricultural districts divert water directly from the Thermalito Afterbay under the terms of water right settlement agreement with DWR. The diversion facilities replace the historic river diversion used by the local districts prior to the construction of the Thermalito Complex. The total capacity of afterbay diversions during peak demands is 4,050 cfs.

Feather River mean daily flows from Water Years 2001 through 2018 are presented in Figure C.3-18 (DWR 2018x).

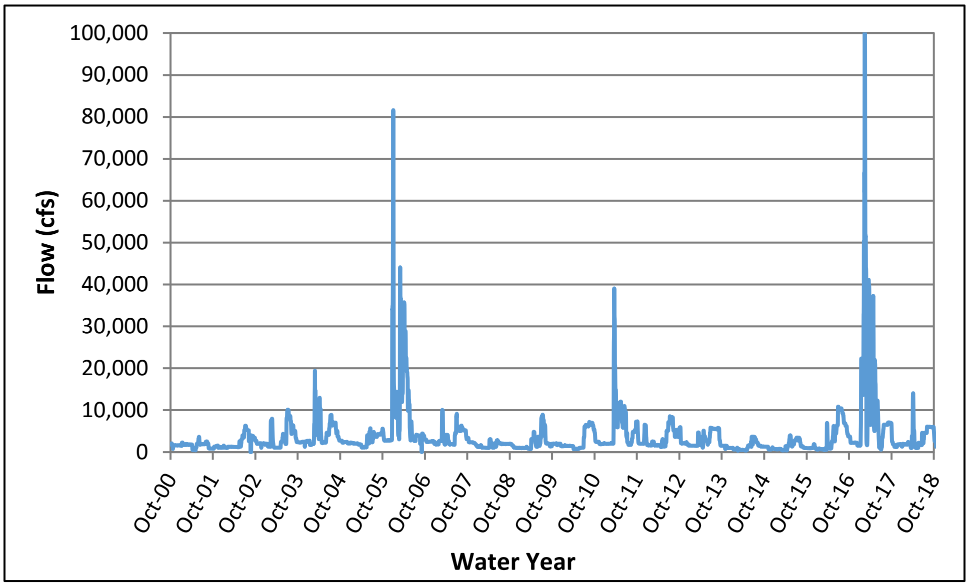

Figure C.3-18. Feather River Near Gridley

The Feather River Fish Hatchery (FRFH) provides mitigation for the construction of Oroville Dam, rears Chinook Salmon and steelhead and is operated by CDFW. Both indirect and direct take resulting from FRFH operations will be authorized through Section 4(d) of the Endangered Species Act through NMFS-approved Hatchery and Genetic Management Plans (HGMPs). DWR and CDFW are jointly preparing HGMPs for the spring and fall-run Chinook Salmon and steelhead production programs at the Feather River Fish Hatchery.

C.3.4.2.2 Flow Requirements

DWR maintains a minimum flow of 600 cfs within the Feather River LFC as required by the 1983 CDFW Agreement (except during flood events when minimum flows are governed by USACE's Water Control Manual and under certain other conditions as described in the 1984 FERC order). Downstream of the Thermalito Afterbay Outlet, in the high flow channel (HFC), per the license and the 1983 CDFW Agreement, minimum releases for flows in the Feather River are 1,000 cfs from April through September and 1,700 cfs from October through March, when the April-to-July unimpaired runoff in the Feather River is greater than 55 percent of normal. When the April-to-July unimpaired runoff is less than 55 percent of normal, the minimum flow requirements are 1,000 cfs from March to September and 1,200 cfs from October to February. The 1983 CDFW Agreement also states that if the April 1 runoff forecast in a given year indicates that the reservoir level would be drawn down to 733 feet, water releases for fish may be reduced, but not by more than 25 percent.

In addition, according to the 1983 Agreement, during the period of October 15 to November 30, if the average highest 1-hour flow of combined releases exceeds 2,500 cfs, then the minimum flow must be no lower than 500 cfs less than that flow through the following March 31 (with the exception of flood management, accidents, or maintenance.) In practice, flows are maintained below 2,500 cfs from October 15 to November 30 to prevent spawning in the overbank areas.

Flow Change Rates

Maximum allowable ramp-down release requirements are intended to prevent rapid reductions in water levels that could potentially cause dewatering and stranding of juvenile salmonids and other aquatic organisms. Ramp-down release requirements to the LFC during periods outside of flood management operations, and to the extent controllable during flood management operations, are shown in Table C.3-5.

Table C.3-5. Lower Feather River Ramping Rates

Releases to the Feather River Low Flow Channel (cfs)	Rate of Decrease (cfs)
5,000 to 3,501	1,000 per 24 hours
3,500 to 2,501	500 per 24 hours
2,500 to 600	300 per 24 hours

Source: National Marine Fisheries Service 2004.

C.3.4.2.3 Water Temperature Requirements

The temperature of the water released from Oroville Dam is in accordance with the temperature requirements for the FRFH, under the August 1983 CDFW Agreement titled Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish and Wildlife, and the 2004 NMFS Biological Opinion for Robinson Riffle, while also conserving the cold-water pool in Lake Oroville.

Water is withdrawn from Lake Oroville at depths that provide sufficiently cold water to meet the FRFH and Robinson Riffle temperature targets. The reservoir depth from which water is released initially determines the river temperatures, but atmospheric conditions, which fluctuate from day to day, influence downstream river temperatures. In order to conserve the cold-water pool during dry years, DWR strives to meet the Robinson Riffle temperatures by increasing releases to the low flow channel (LFC) rather than releasing colder water.

DWR has taken various other temperature management actions to achieve the water temperature requirements, including curtailing pumpback operations, removing shutters at the intakes of the Hyatt Pumping-Generating Plant, releasing flow through the river valves (for FRFH only), and increasing flows at the Thermalito Diversion Dam to the LFC (for Robinson Riffle only).

DWR plans to manage its cold-water storage and its intake shutters to avoid the need for flows through the river valve in order to meet its temperature obligations. Other than local diversions, outflow from the Oroville Project is released to the Feather River at the LFC and Thermalito Afterbay.

Temperature Requirements for Robinson Riffle

The 2004 NMFS Biological Opinion for Robinson Riffle requires DWR to provide water temperatures at Robinson Riffle (RR) at or lower than 65 degrees Fahrenheit (maximum allowable daily average) from June 1 through September 30. There is no RR requirement from October 1 through May 30.

Temperature Requirements for FRFH

The 1983 Agreement requires DWR to provide suitable Feather River water temperatures for salmon on a year-round basis. Current FRFH intake water temperatures, as required by the 1983 CDFW and DWR Agreement (DWR 1983) are shown in Table C.3-6.

Table C.3-6. Feather River Fish Hatchery Temperature Requirements

Period of Year	Temperature (°F)
April 1–May 15	51 (±4°F Allowed)
May 16–May 31	55 (±4°F Allowed)
June 1–June 15	56 (±4°F Allowed)
June 16–August 15	60 (±4°F Allowed)
August 16–August 31	58 (±4°F Allowed)
September 1–September 30	52 (±4°F Allowed)
October 1–November 30	51 (±4°F Allowed)
December 1–March 31	No greater than 55

C.3.4.2.4 Flood Control

Flood control operations at Oroville Dam are conducted in accordance with the requirements set forth by USACE. The Federal Government shared the expense of Oroville Dam, which provides up to 750 TAF of flood control space. For the 2018/2019 flood season, variable flood management storage based on dry and wet ground conditions will be used. Flood control storage ranges from 412,000 acre-feet (elevation 872.8 feet) to 920,000 acre-feet (elevation 835.5 feet) through February as dictated by the enhanced Flood Control Diagram (FCD) shown in Figure C.3-19. Elevations taper up to the 1970 WCM elevations at the end of March, and then the refill period starts.

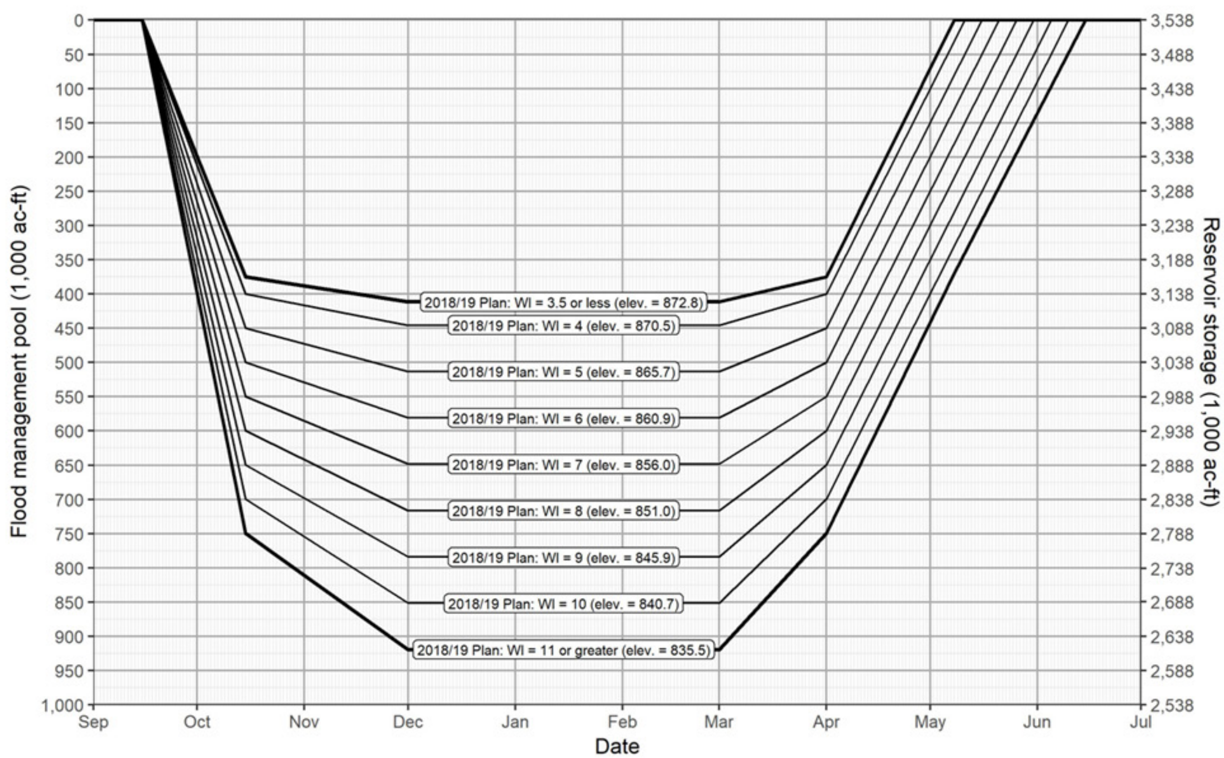

Figure C.3-19. Oroville Dam Flood Control Diagram

The spillway is located on the right abutment of the dam and has two separate elements: a controlled gated outlet and an emergency uncontrolled spillway. The gated control structure releases water to a concrete-lined chute that extends to the river. The uncontrolled emergency spill flows over a recently completed concrete apron.

C.3.4.2.5 Federal Energy Regulatory Commission Relicensing of the Oroville Project

The original FERC license to operate the Oroville Project expired in January 2007. Since 2007, annual license renewals have been issued, requiring DWR to operate to the original FERC license conditions. The new FERC license has not yet been adopted by the Commission. Until a new license for the Oroville Project is issued by FERC, DWR will continue to operate the Oroville facilities in accordance with the current (original) license conditions.

C.3.5 Yolo Bypass

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

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

Mean daily flows into the Yolo Bypass at Fremont Weir are presented on Figure C.3-20 (2018y). Between 2002 and 2018, flows have entered the Yolo Bypass at Fremont Weir during 19 periods, including:

- January 2002 – spill continued for 7 days with flows up to 30,000 cfs
    - January 2003 – spill continued for 6 days with flows up to 22,000 cfs
    - May 2003 – spill continued for 1 day with flows up to 100 cfs
    - January 2004 – spill continued for 3 days with flows up to 3,000 cfs
    - February 2004 – spill continued for 20 days with flows up to 79,000 cfs
    - May 2005 – spill continued for 4 days with flows up to 35,000 cfs
    - January/February 2006 (2 events) – spill continued for a total of 37 days with flows up to 205,000 cfs
    - March/April/May 2006 – spill continued for 65 days with flows up to 96,000 cfs
    - January 2010 – spill continued for 4 days with flows up to 5,000 cfs
    - December 2010 – spill continued for 4 days with flows up to 9,000 cfs
    - March/April 2011 – spill continued for 24 days with flows up to 85,000 cfs
    - December 2012 – spill continued for 5 days with flows up to 26,000 cfs
    - March 2016 – spill continued for 10 days, with flows up to 62,000 cfs
    - December 2016 – spill continued for 4 days, with flows up to 27,000 cfs
    - January 2017 – spill continued for 62 days, with flows up to 180,000 cfs
    - March 2017 – spill continued for 12 days, with flows up to 177,000 cfs
    - April/May 2017 – spill continued for 25 days, with flows up to 41,000 cfs
    - April 2018 – spill continued for 3 days with flows up to 16,000 cfs

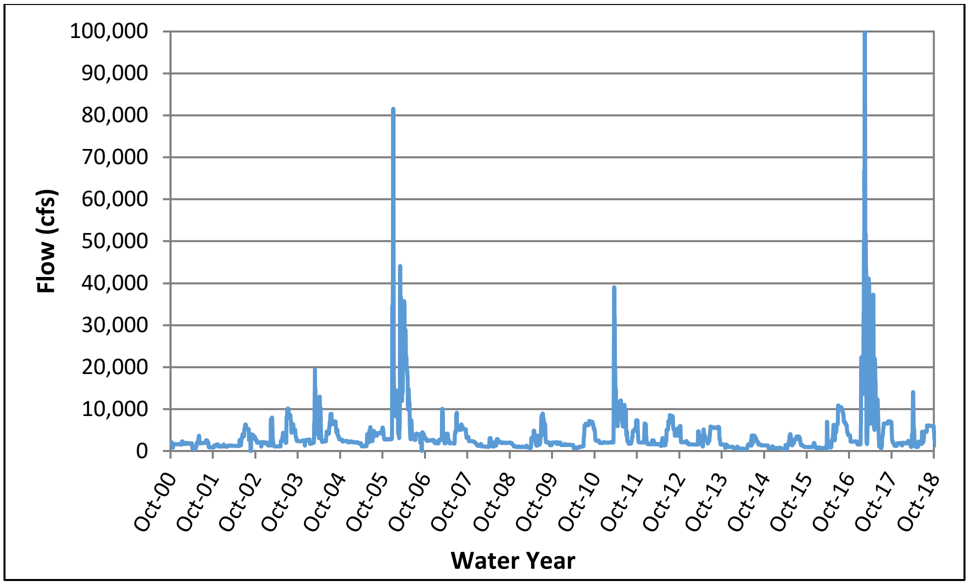

Figure C.3-20. Yolo Bypass over Fremont Weir

Reclamation is currently working on the Yolo Bypass Fish Passage Improvement Project.

C.3.6 American River from Folsom Lake to Sacramento River

The American River watershed extends over 1,895 square miles and contributes approximately 15 percent of the flow in the lower Sacramento River.

C.3.6.1 *Facilities*

The American River Division includes facilities that provide storage and conveyance of water on the American River for flood control, fish and wildlife protection, recreation, protection of the Delta from intrusion of saline ocean water, irrigation and M&I water supplies, and hydroelectric power generation. Initially authorized features of the American River Division included Folsom Dam, Lake, and Power Plant; Nimbus Dam and Power Plant, and Lake Natoma.

C.3.6.1.1 Upper American River Basin

Although Folsom Reservoir is the main storage and flood control reservoir on the American River, numerous other small non-federal reservoirs in the upper basin provide hydroelectric generation and water supply. None of the upstream reservoirs have any specific flood control responsibilities but PCWA and SMUFD reservoirs are considered to provide flood storage space when they have it. The total upstream reservoir storage above Folsom Reservoir is approximately 820 TAF. Ninety percent of this upstream storage is contained by five reservoirs: French Meadows (136 TAF); Hell Hole (208 TAF); Loon Lake (76 TAF); Union Valley (271 TAF); and Ice House (46 TAF). Reclamation has agreements with the operators of some of these reservoirs to coordinate operations for releases.

French Meadows and Hell Hole reservoirs, located on the Middle Fork of the American River, are owned and operated by the Placer County Water Agency (PCWA). The PCWA provides wholesale water to agricultural and urban areas within Placer County. For urban areas, PCWA operates water treatment plants and sells both wholesale raw water and treated water to municipalities that provide retail delivery to their customers. The cities of Rocklin and Lincoln receive water from PCWA, Loon Lake, and Union

Valley and Ice House reservoirs on the South Fork of the American River, are all operated by the Sacramento Municipal Utilities District (SMUD) for hydropower purposes.

C.3.6.1.2 Folsom Dam and Reservoir

Reclamation's Folsom Reservoir, the largest reservoir in the American River watershed, has a capacity of 967 TAF. Folsom Dam, located approximately 30 miles upstream from the confluence with the Sacramento River, is operated as a major component of the CVP. The facility serves water to M&I users in Placer and Sacramento counties.

Table C.3-7 provides Reclamation's annual water deliveries for the period 2000 through 2010 in the American River Division. The totals reveal an increasing trend in water deliveries over that period. For this EIS under the No Action Alternative, the American River Division water demands are modeled assuming that water users can utilize their full contract/agreement values with average annual deliveries of about 800 TAF per year. The American River contractors are not currently using this volume, but it is anticipated that due to fast growth and new water agreements, the actual usage (as projected by their Urban Water Management Plans) could increase to about 650 to 800 TAF/year over the next 10 years, depending upon growth rates and implementation of water demand reduction measures.

Table C.3-7. Annual Water Deliveries- American River Division

Year	Water Delivery (TAF)*
2000	174
2001	223
2002	221
2003	270
2004	266
2005	297
2006	280
2007	113
2008	233
2009	260
2010	125
2011	269
2012	279

Notes:
* Annual water delivery data has been enhanced and the annual totals include CVP contracts, water rights (including water rights for the City of Sacramento), and other deliveries (e.g. Folsom South Canal losses)
TAF = thousand acre-feet

C.3.6.1.3 Nimbus Dam and Lake Natoma

Nimbus Dam creates Lake Natoma, a forebay built to re-regulate flows of the American River and to direct water into the CVP Folsom South Canal. Releases from Nimbus Dam to the American River pass through the Nimbus Powerplant when releases are less than 5,000 cfs or the spillway gates for higher flows. The American River flows 23 miles between Nimbus Dam and the confluence with the Sacramento River. Water storage volumes and water storage elevations for Folsom Lake and Lake Natoma for Water Years 2001 through 2018 are presented on Figures C.3-21 through C.3-24 (DWR 2018z, 2018aa, 2018ab, 2018ac). Mean daily flows in American River at Fair Oaks, downstream of Nimbus Dam are presented in Figure C.3-25 (DWR 2018ad).

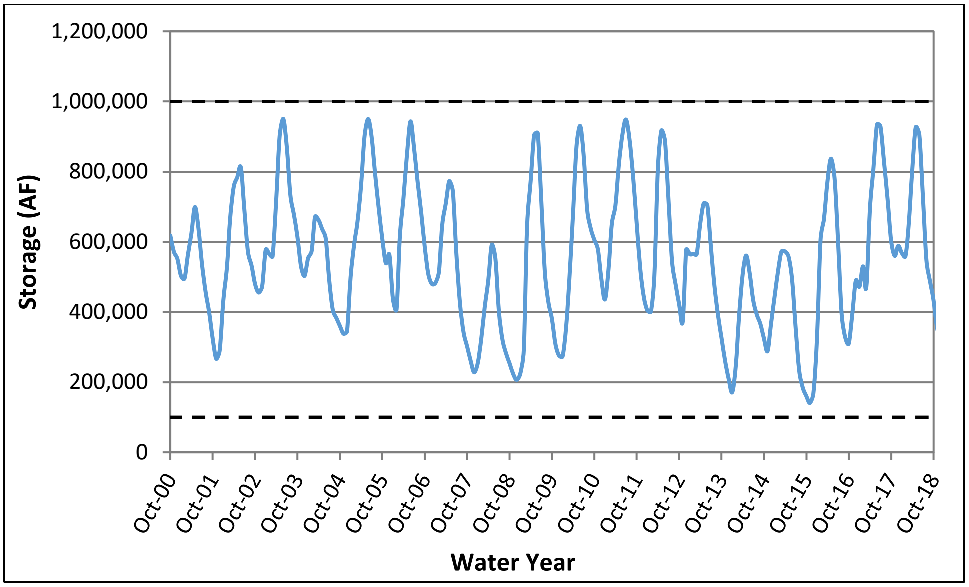

Figure C.3-21. Folsom Lake Storage

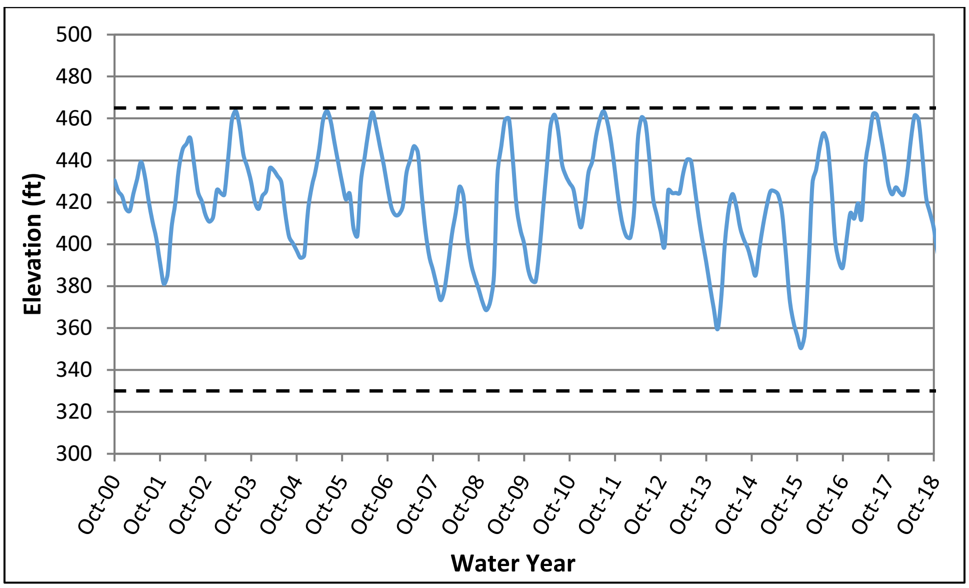

Figure C.3-22. Folsom Lake Elevation

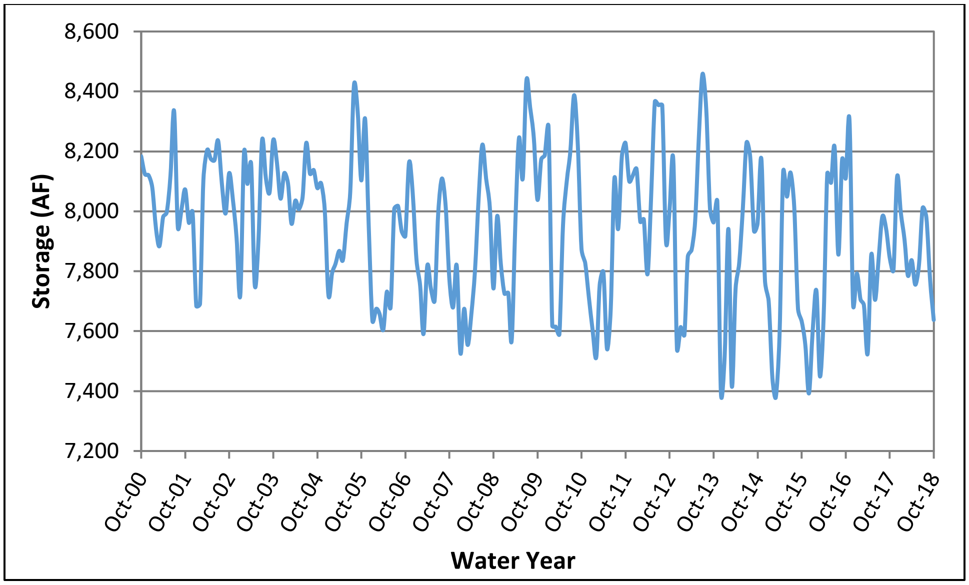

Figure C.3-23. Lake Natoma Storage

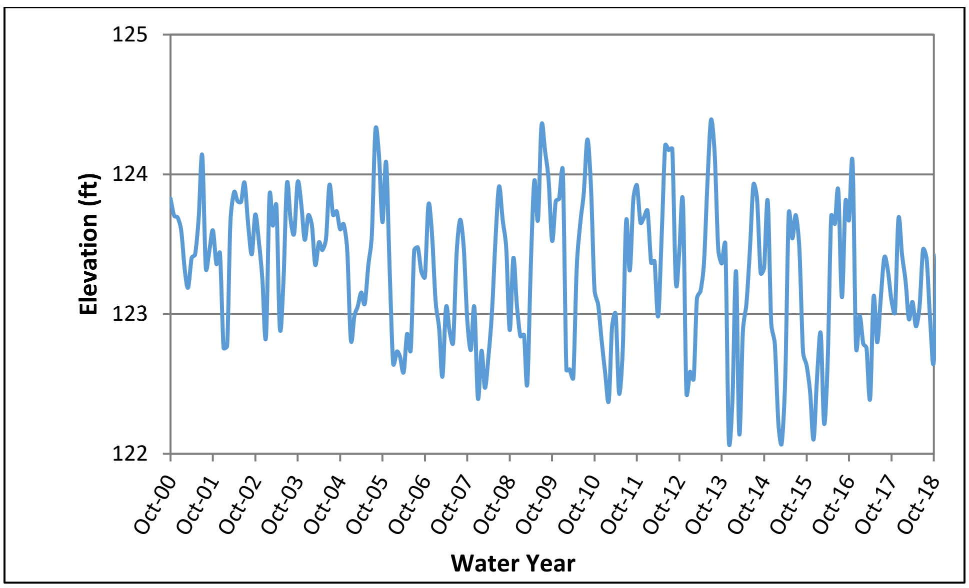

Figure C.3-24. Lake Natoma Elevation

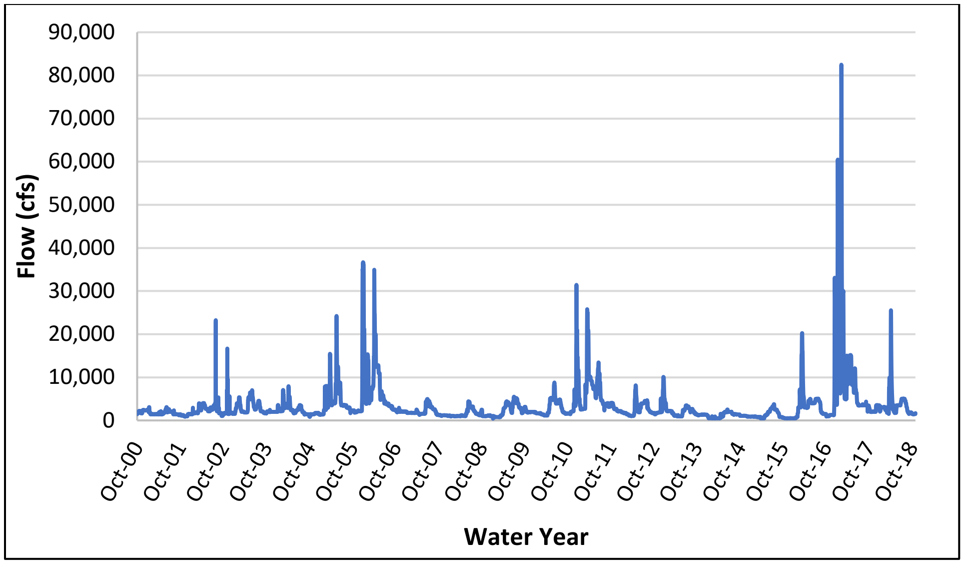

Figure C.3-25. American River at Fair Oaks

C.3.6.1.4 Diversion Management

The American River Operations Group (ARG) is a public forum consisting of Reclamation, fisheries agencies, and other interested parties. Since 1996 the group has provided input on a number of operational issues and has served as a discussion forum for topics such as adaptively managing releases, including flow fluctuation and stability, and managing water temperatures in the Lower American River to meet the needs of salmon and steelhead.

Water is diverted to municipal and industrial water users, including water rights holders, upstream of Folsom Dam, from the Folsom South Canal, and from the American River downstream of Folsom Dam. During recent critically dry years it was feared that water elevations in Folsom Lake would become too low for adequate operation of diversion facilities; as a precaution Reclamation provided temporary barges with intake and conveyance facilities to divert water from the lake to the adjacent water users. To date the barges have not been necessary to provide water conveyance.

C.3.6.2 *Operations in the Lower American River*

Releases to the lower American River are governed by multiple factors. Minimum releases are set based on the Flow Management Study (FMS) Minimum River Release (MRR). Releases above the MRR can be required for many reasons; instream temperature control, releases to help meet delta outflow or salinity requirements, flood control releases and export needs.

C.3.6.2.1 Flood Control

Historical Perspective

Flood control requirements and regulating criteria for October 1 through May 31 are specified by the USACE and described in the Folsom Dam and Lake, American River, California Water Control Manual (U.S. Army Corps of Engineers 1987). Flood control objectives for the Folsom unit require that the dam and lake be operated to:

- Protect the City of Sacramento and other areas within the Lower American River floodplain against reasonable probable rain floods.
- Control flows in the American River downstream from Folsom Dam to existing channel capacities, insofar as practicable, and reduce flooding along the lower Sacramento River and in the Delta in conjunction with other CVP Projects.
- Provide the maximum amount of water conservation storage without impairing the flood control functions of the reservoir.
- Provide the maximum amount of power practicable and be consistent with required flood control operations and the conservation functions of the reservoir.

From June 1 through September 30, no flood control storage restrictions exist. From October 1 through November 16 and from April 20 through May 31, reserving storage capacity for flood control is a function of the date only, with full flood reservation capacity required from November 17 through February 7. Beginning February 8 and continuing through April 20, flood reservation capacity is a function of both date and current hydrologic conditions in the basin.

If the inflow into Folsom Reservoir causes the water elevation to encroach into the capacity reserved for flood control, releases from Nimbus Dam are increased. Flood control regulations prescribe the following releases when water is stored within the flood control reservation space.

- Maximum inflow (after the storage entered into the flood control reservation space) of as much as 115,000 cfs, but not less than 20,000 cfs, when inflows are increasing.
- Releases would not be increased more than 15,000 cfs or decreased more than 10,000 cfs during any two-hour period.
- Flood control requirements override other operational considerations in the fall and winter period. Consequently, short-term changes in river releases may occur.

Since 1996, Reclamation has operated according to modified flood control criteria, which reserve 400 to 670 TAF of flood control space in Folsom Reservoir in combination with empty reservoir space in Hell Hole, Union Valley, and French Meadows, to be treated as if it were available in Folsom Reservoir. This flood control plan, which provides additional protection for the Lower American River, is implemented through an agreement between Reclamation and SAFCA. The terms of the agreement allow some of the empty reservoir space in Hell Hole, Union Valley, and French Meadows to be treated as if it were available in Folsom Reservoir.

Following significant flood events in February 1986 and January 1997, the lower American River flooding issues were analyzed; and revised flood operations criteria were developed by the Sacramento Area Flood Control Agency (SAFCA). The SAFCA release criteria are generally equivalent to the USACE plan, except the SAFCA diagram may prescribe flood releases earlier than the USACE plan. The SAFCA diagram also relies on Folsom Dam outlet capacity to make the earlier flood releases. The outlet capacity at Folsom Dam is currently limited to 32,000 cfs based on lake elevation. However, in general the SAFCA plan diagram provides greater flood protection than the existing USACE plan for communities in the American River floodplain.

Required flood control space under the SAFCA diagram begins to decrease on March 1. Between March 1 and April 20, the rate of filling is a function of the date and available upstream space. As of April 21, the required flood reservation is about 225 TAF. From April 21 to June 1, the required flood reservation is a function of the date only, with Folsom Reservoir storage permitted to fill completely on June 1.

C.3.6.3 *Current Status*

Reclamation and USACE constructed an auxiliary spillway under the Joint Federal Project, at Folsom Dam in accordance with the recommendations of the Water Control Manual Update (Reoperation Study). The USACE is also implementing increased system capabilities provided by the authorized features of the Common Features Project to strengthen the American River levees to convey up to 160,000 cfs and completion of the authorized Folsom Dam Mini-Raise Project. The spillway work is complete, and the facility has been transferred to Reclamation for operation and maintenance. This spillway allows Reclamation to release higher flows for flood control purposes while the reservoir storage is lower than we were previously able to do. This should help reduce peak releases from moderate events by allowing us to release earlier in the event thus preventing reservoir storage from encroaching significantly into the flood control pool.

USACE and Reclamation, as the National Environmental Policy Act [NEPA] cooperating agency, have completed a Folsom Dam Reoperation Study to develop, evaluate, and recommend changes to the flood control operations of the Folsom Dam project that would further the goal of reduced flood risk for the Sacramento area. Operational changes may be necessary to fully realize the flood risk reduction benefits of the additional operational capabilities created by completion of the Joint Federal Project, and the increased system capabilities provided by the implemented and authorized features of the Common Features Project (a project being carried out by USACE and designed to strengthen the American River levees so they can safely pass a flow of 160,000 cfs); and those anticipated to be provided by completion of the authorized Folsom Dam MiniRaise Project. The Folsom Dam Reoperation Study considers improved forecasts from the National Weather Service. USACE, in cooperation with Reclamation (and DWR as the California Environmental Quality Act [CEQA] lead and SAFCA as the local partner), is consulting with USFWS and NMFS relative to any changes to American River and/or system-wide CVP operations that may result.

The new Water Control Manual (WCM) utilizes forecasted inflow as the criteria for determining flood control releases. There are criteria for total forecasted inflow on a 5 day out, 3 day out, 2 day out, and 1 day out basis. This is a first of its kind flood control diagram. Historically the flood control diagrams were based on current storage and current inflows to the reservoir, with a resulting action specified. Our new manual looks ahead five days and considers the forecasted inflow volume for the total of those five days. If that volume exceeds a threshold, a flood control release is specified. This is being termed a “blue sky release” because the release may occur before rainfall begins. The concept is to pre-emptively draw the reservoir down in anticipation of high inflows, thus providing space to store the rain event when it arrives. This will allow Reclamation to pass higher precipitation events with lower peak releases which relieves stress on the downstream levees and provides a higher level of flood protection to downstream areas.

The WCM is complete, the USFWS and NMFS are currently providing biological reviews of the WCM. At this time, Reclamation is operating to the new WCM under a temporary one year order from the USACE.

Additional information related to the flood control criteria for Folsom Dam operations is included by reference to documents prepared by the USACE and SAFCA.

C.3.6.3.1 American River Flows to Meet Delta Salinity Requirements

Folsom Reservoir is also operated by Reclamation to release water to help meet Delta salinity and flow objectives established to improve fisheries conditions. Weather conditions combined with tidal action and local accretions from runoff and return flows can quickly affect Delta salinity conditions and require increases in Delta inflow to maintain salinity standards, as described below. In accordance with Federal and state regulatory requirements, the CVP and SWP are frequently required to release water from upstream reservoirs to maintain Delta water quality. Because Folsom Lake is located closer to the Delta than Lake Oroville and Shasta Lake, if the need for salinity control is immediate, releases may be made first from Folsom Reservoir. As water from the other reservoirs arrives in the Delta, Folsom Reservoir releases can be reduced. In general, however, as the CVP is operated as an integrated project, releases to meet downstream needs are sourced from multiple locations, e.g. both Shasta Reservoir and Folsom Reservoir, and SWP contributions from Lake Oroville. Water released from Lake Oroville and Shasta Lake generally reaches the Delta in approximately three and five days, respectively. Travel time is taken into consideration when release decisions are made as part of operating as an integrated project.

C.3.6.3.2 Fish and Wildlife Requirements in the Lower American River

Flow Requirements

The minimum allowable flows in the Lower American River are defined by SWRCB Water Right Decision 893 (D-893), which states that, in the interest of fish conservation, releases should not ordinarily fall below 250 cfs between January 1 and September 15 or below 500 cfs at other times. D-893 minimum flows are rarely the controlling objective of CVP operations at Nimbus Dam. Nimbus Dam releases are nearly always controlled during significant portions of a water year by either flood control requirements or are coordinated with other CVP and SWP releases to meet downstream SWRCB WQCP requirements and CVP water supply objectives. Power regulation and management needs occasionally control Nimbus Dam releases. Nimbus Dam releases are expected to exceed the D-893 minimum flows in all but the driest of conditions.

In July 2006, Reclamation, the Sacramento Area Water Forum and other stakeholders completed a draft technical report establishing a flow and temperature regime intended to improve conditions for fish in the lower American River (i.e., the Lower American River Flow Management Standard [FMS]). Minimum flow requirements during October, November, and December are primarily intended to address fall-run Chinook Salmon spawning, and flow requirements during January and February address fall-run Chinook Salmon egg incubation and steelhead spawning. From March through May, minimum flow requirements are primarily intended to facilitate steelhead spawning and egg incubation, as well as juvenile rearing and downstream movement of fall-run Chinook Salmon and steelhead. The June through September flows are designed to address over-summer rearing by juvenile steelhead, although this period partially overlaps with adult fall-run Chinook Salmon immigration. Reclamation began operating to the FMS immediately thereafter.

Water Temperature Requirements

The current objectives for water temperatures in the Lower American River address the needs for steelhead incubation and rearing during the late spring and summer, and for fall–run Chinook Salmon spawning and incubation starting in late October or early November.

Water temperature control operations in the Lower American River are affected by many factors and operational tradeoffs. These include available cold-water resources, Nimbus release schedules, annual hydrology, Folsom power penstock shutter management flexibility, Folsom Dam Urban Water Supply TCD management, and Nimbus Hatchery considerations. Shutter and TCD management provide the majority of operational flexibility used to control downstream temperatures.

Selective withdrawal capability on the Folsom Dam Urban Water Supply Pipeline (also known as the M&I TCD) became operational in 2003. A telescoping control gate allows for selective withdrawal of water to provide additional flexibility to conserve cold water for downstream use. The TCD is operated during the summer months and delivers water that is slightly warmer than that which could be used to meet downstream requirements, but not so warm as to cause significant treatment issues.

During the late 1960s, Reclamation designed a modification to the trashrack structures to provide selective withdrawal capability at Folsom Dam through the Folsom Power Plant.

The steel trashracks are now equipped with three groups of shutters that allow operators to pull water from various elevations, which are different temperatures when the lake is stratified. The shutters can be different at different locations on each of the three penstocks, allowing operators to blend water at different temperatures to meet downstream requirements.

Only in wetter hydrologic conditions is the volume of cold water sufficient to meet the majority of the water temperature objectives. Therefore, significant operations tradeoffs and flexibilities are part of an annual planning process for coordinating an operation strategy that realistically manages the limited cold-water resources available.

Hatchery Concerns

Reclamation-owned Nimbus Fish Hatchery, located just downstream of Nimbus Dam, is a mitigation facility that produces Chinook Salmon and Steelhead. A fish diversion weir at the hatchery blocks Chinook Salmon from continuing upstream and guides them to the hatchery fish ladder entrance. Installing the weir requires flows to be lowered for less than a week in early to mid-September. The hatchery also has water temperature concerns, especially June through September. Reclamation considers the Nimbus Fish Hatchery needs when balancing the cold-water pool for fish spawning in the river during fall.

Delta Needs

Folsom Reservoir can be operated to release water to meet Delta water quality and flow objectives to improve fisheries conditions, including releases for salinity objectives. When Delta needs require an increase upstream reservoir releases, then Folsom Reservoir often releases first because the released water would reach the Delta (in about one day) before flows released from other CVP and SWP reservoirs would get there. Lake Oroville water releases require about 3 days to reach the Delta, while water released from Shasta Lake requires 5 days to travel from Keswick Reservoir to the Delta. As water from the other reservoirs arrives in the Delta, Folsom Reservoir releases can be adjusted downward. It should be noted that Folsom Reservoir does not always release first for anticipated Delta needs. The CVP is operated as in integrated project, and releases from Shasta and Folsom are coordinated with releases from Oroville for the SWP contribution to meeting Delta standards. Many factors are considered when making a determination of which reservoir to release from first. Current storage, current releases, temperature control objectives, cold water pool volume in all reservoirs, COA balance, and anticipated future demands are all considered when determining which reservoir(s) to release from, and how much to release from each reservoir.

The real-time implementation of flow objectives and meeting SWRCB D-1641 Delta standards with the limited water resources of the Lower American River requires a significant coordination effort to manage the cold-water resources at Folsom Dam and Reservoir. Reclamation consults with USFWS, NMFS, and CDFW through ARG when these types of difficult decisions are needed.

Water Delivery Requirements

American River allocations to contractors and water settlement contractors is a function of storage in Folsom Reservoir and projected inflow for the water year. Default allocation is 100 percent, unless forecasted end of September storage is so low that the system would not be support that allocation. During the recent drought period, many M & I contractors on the American River were allocated what is referred to as Health and Safety allocations, this is a minimal amount that will maintain all essential functions, with rationing imposed.

C.4 San Joaquin Valley

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

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

Flows from Fresno, Chowchilla, Tuolumne, Merced, Calaveras, Kings, Kaweah, Tule, and Kern rivers also contribute substantial flows into the San Joaquin Valley and affect operations of CVP and SWP water users and operations.

C.4.1 San Joaquin River

The San Joaquin River flows 100 miles from Friant Dam to the Delta. Flows in the upper San Joaquin River are regulated by the CVP Friant Dam which forms Millerton Lake. Flows downstream of Friant Dam are influenced by flows from tributary rivers and streams, as described below; including CVP operations of New Melones Reservoir on the Stanislaus River.

C.4.1.1 *Millerton Lake*

Friant Dam is a concrete gravity structure located on the San Joaquin River, 25 miles northeast of Fresno where the San Joaquin River exits the Sierra foothills and enters the valley. Several reservoirs in the upper portion of the San Joaquin River watershed, including Mammoth Pool and Shaver Lake, affect the inflow to Millerton Lake. Millerton Lake provides flood control capacity on the San Joaquin River, provides downstream releases to meet senior water rights requirements above Mendota Pool, and provides conservation storage as well as diversion into Madera and Friant-Kern Canals.

Millerton Lake has a volume of 524 TAF, a surface area of 4,905 acres, and an elevation of 580.6 feet above msl (NAVD 1988) (elevation 580.6) at top of active storage (Reclamation 2008). The flood pool elevation is 587.6 while the maximum observed water surface elevation was 583, experienced during the January 1997 flood. Recent water storage volumes and elevations for Water Years 2001 through 2018 in Millerton Lake are presented on Figures C.4-1 through C.4-2 (DWR 2018ae, 2018af). Outflow from Millerton Lake for these Water Years is presented in Figure C.4-3 (DWR 2018ag).

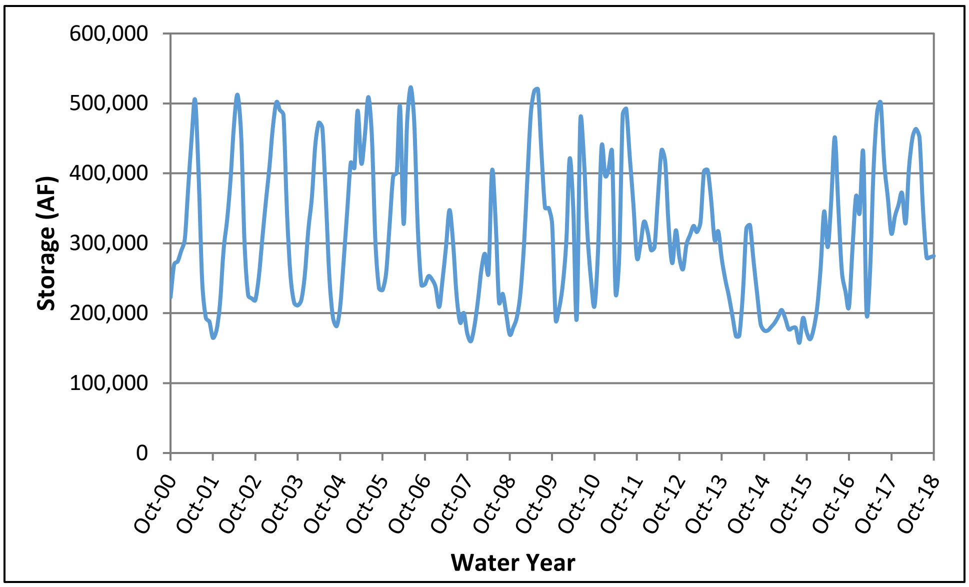

Figure C.4-1. Millerton Lake Storage

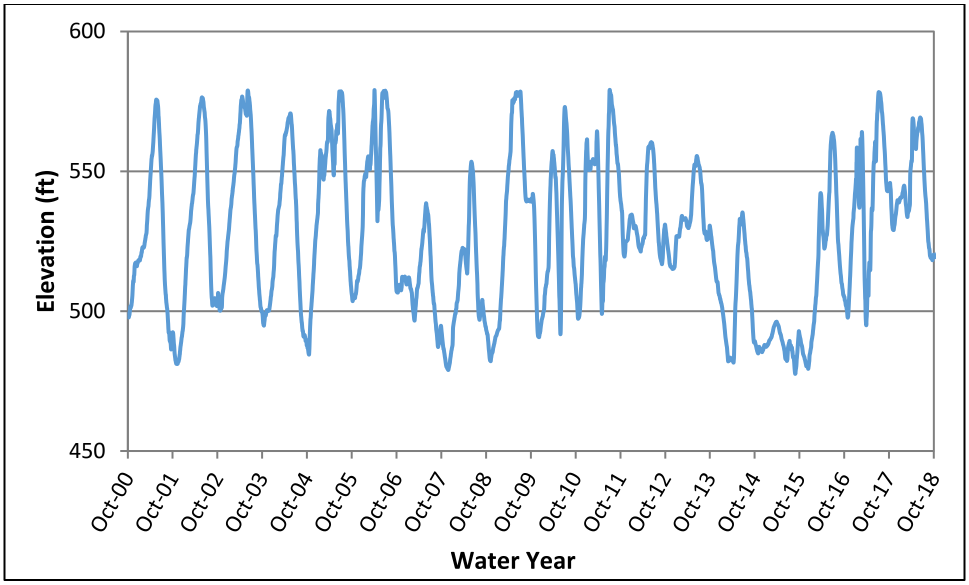

Figure C.4-2. Millerton Lake Elevation

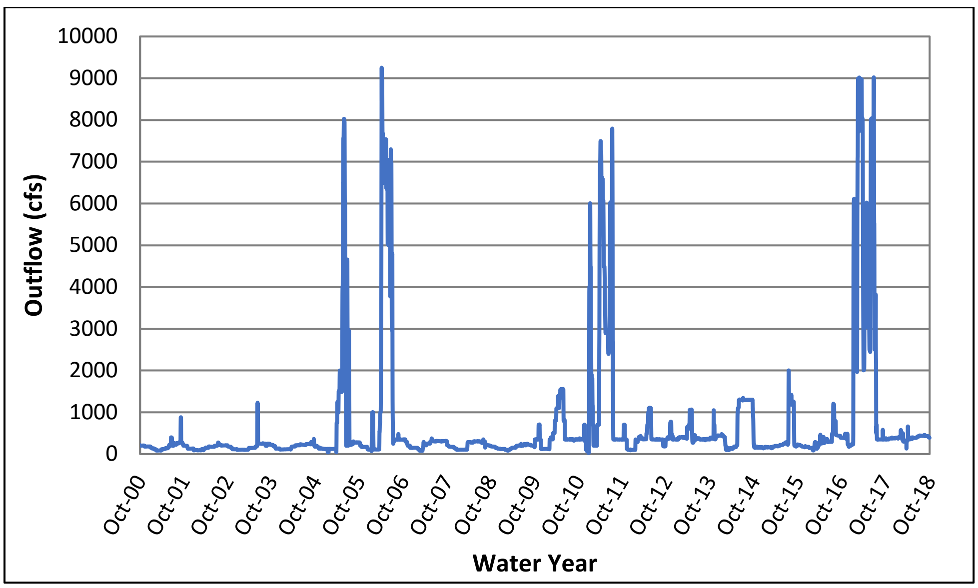

Figure C.4-3. Millerton Lake Outflow

The minimum operating storage of Millerton Lake is 130 TAF, resulting in active available conservation storage of about 390 TAF (SJRRP 2012). The minimum operating storage allows for diversion from dam outlets to the Friant-Kern canal (elevation 466.6), Madera canal (elevation 448.6), and the San Joaquin River (elevation 382.6). The reservoir has three small dikes to close low areas along the reservoir rim, one of which is located in the Millerton Lake SRA. Millerton Road, a two-lane paved secondary highway, passes over these dikes.

Friant Dam is the principal flood damage reduction facility on the San Joaquin River and is operated to maintain combined releases to the San Joaquin River at or below a flow objective of 8,000 cfs. Several flood events in the past few decades have resulted in flows greater than 8,000 cfs downstream from Friant Dam and, in some cases, flood damages resulted. Flood control storage space in Millerton Lake is based on a complex formula, which considers storage in upstream reservoirs, forecasted snowmelt, and time of year. Flood management releases occur approximately once every 3 years and are managed based on downstream channel design capacity to the extent possible.

C.4.1.2 *San Joaquin River Restoration Program: Friant Dam to Confluence of Merced River*

In 2006, parties to NRDC, et al., v. Rodgers, et al., executed a stipulation of settlement that called for a comprehensive long-term effort to restore flows to the San Joaquin River from Friant Dam to the confluence of the Merced River and a self-sustaining Chinook Salmon fishery while reducing or avoiding adverse water supply impacts. The SJRRP implements the settlement consistent with the San Joaquin River Restoration Settlement Act in Public Law 111-11. The USFWS issued a Programmatic BO for the implementation of the SJRRP on August 21, 2012 and NMFS issued a Programmatic BO on September 18, 2012 for SJRRP flow releases of up to 1,660 cfs from Millerton Lake into the San Joaquin River. The settlement-required flow targets for releases from Millerton Lake include six water year types for releases depending upon available water supply as measures of inflow to Millerton Lake. The Millerton Lake releases include the flexibility to reshape and retime releases forwards or backwards by 4 weeks during the spring and fall pulse periods. Flood flows may potentially occur and meet or exceed the Settlement flow targets. If flood flows meet the settlement flow targets, then Reclamation would not release additional water from Millerton Lake. The San Joaquin River channel downstream of Friant Dam currently lacks the capacity to convey flows to the Merced River and releases are limited accordingly.

The San Joaquin River Restoration Program Restoration Area includes five distinct reaches of the San Joaquin River and portions of the flood management system (Figure C.4-4): Reach 1: Friant Dam to Gravelly Ford, Reach 2: Gravelly Ford to Mendota Dam, Reach 3: Mendota Dam to Sack Dam, Reach 4: Sack Dam to Eastside Bypass Confluence, Reach 5: Eastside Bypass Confluence to Merced River, and Chowchilla, Eastside, and Mariposa Flood Bypasses. San Joaquin River flows from Water Years 2001 through 2018 at Gravelly Ford, near Dos Palos, near Washington Road, at Bifurcation Structure, at Freemont Ford Bridge are presented in Figures C.4-5 through C.4-10 (DWR 2018ah, 2018ai, 2018aj; Reclamation 2018a, 2018b, 2018c).

Figure C.4-4. San Joaquin River Restoration Area River Reaches

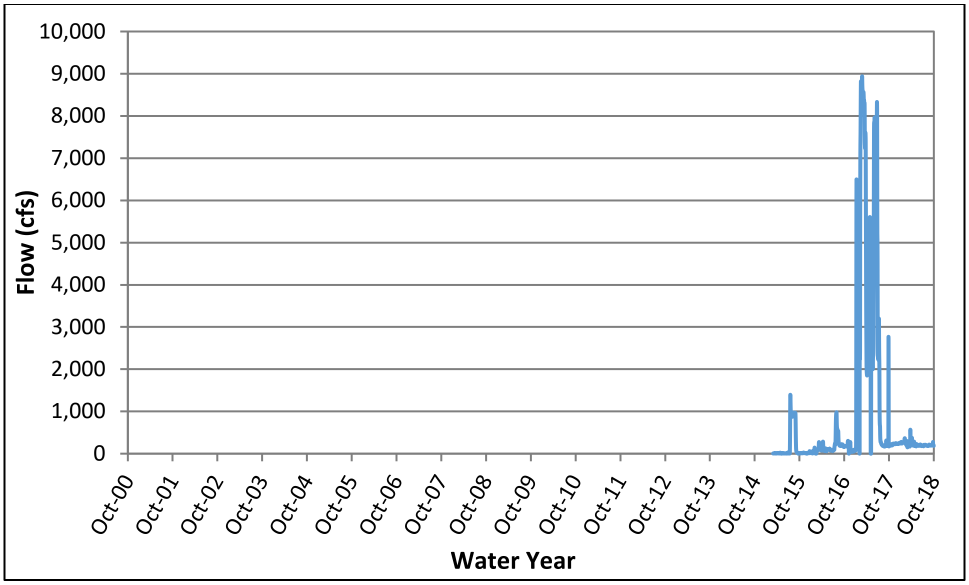

Figure C.4-5. San Joaquin River at Gravelly Ford

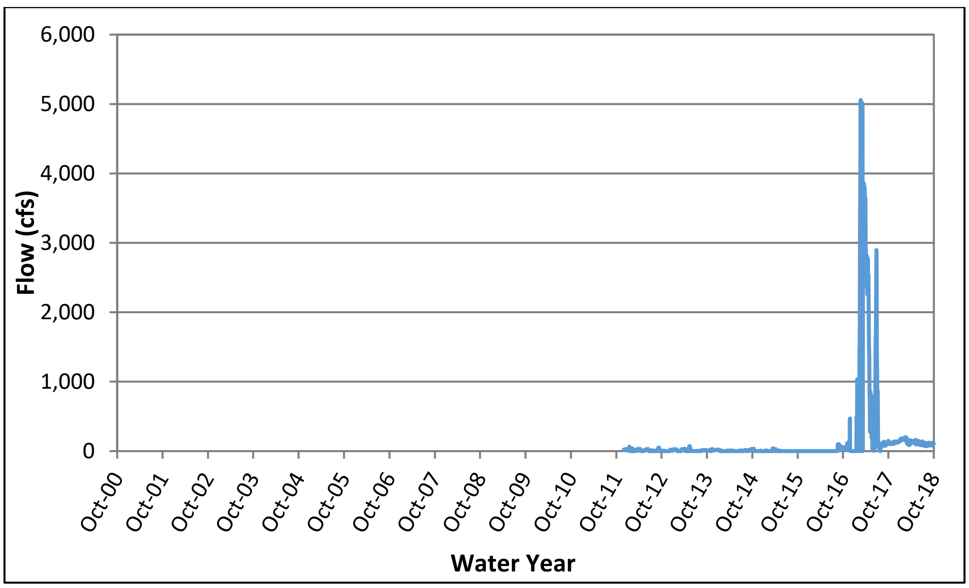

Figure C.4-6. San Joaquin River Near Dos Palos

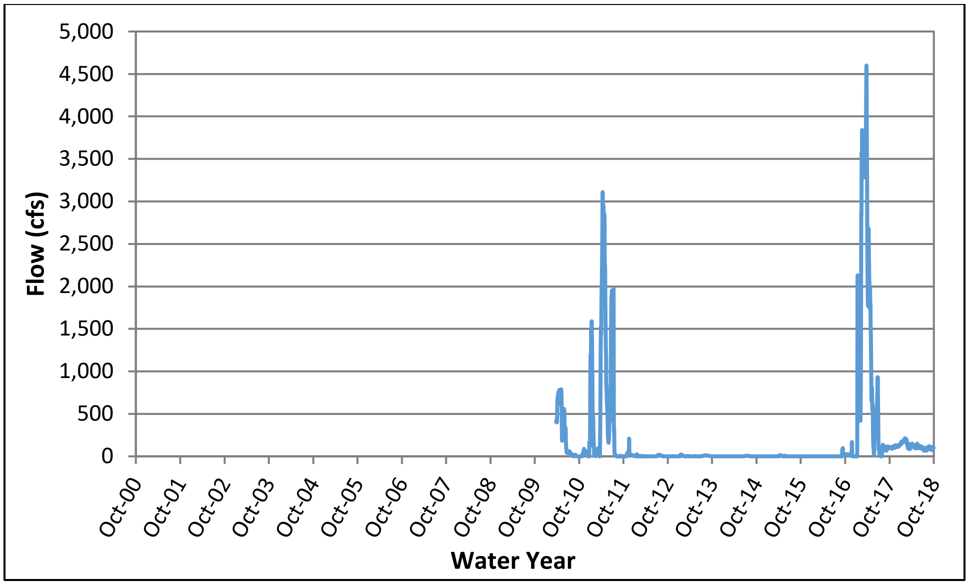

Figure C.4-7. San Joaquin River near Washington Rd

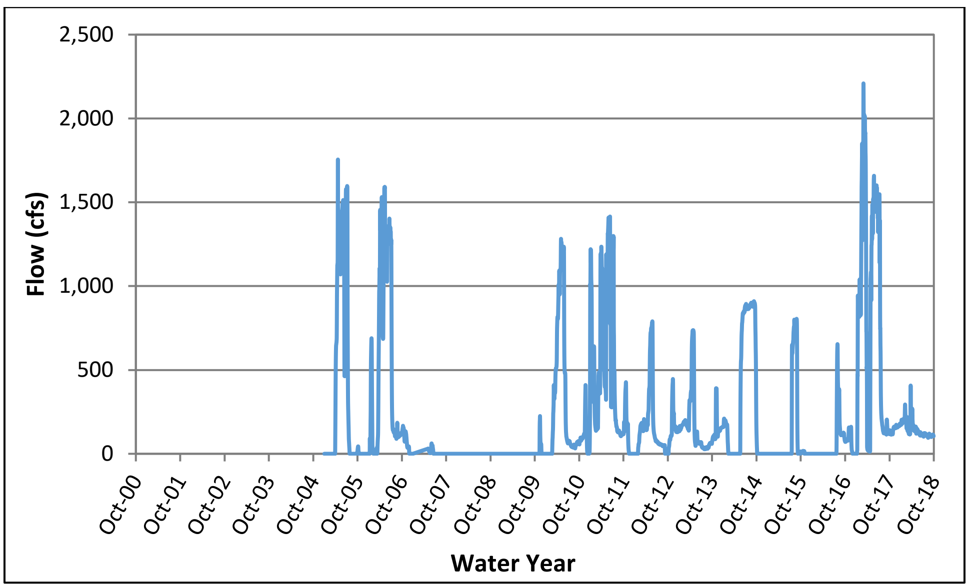

Figure C.4-8. San Joaquin River at Bifurcation Structure

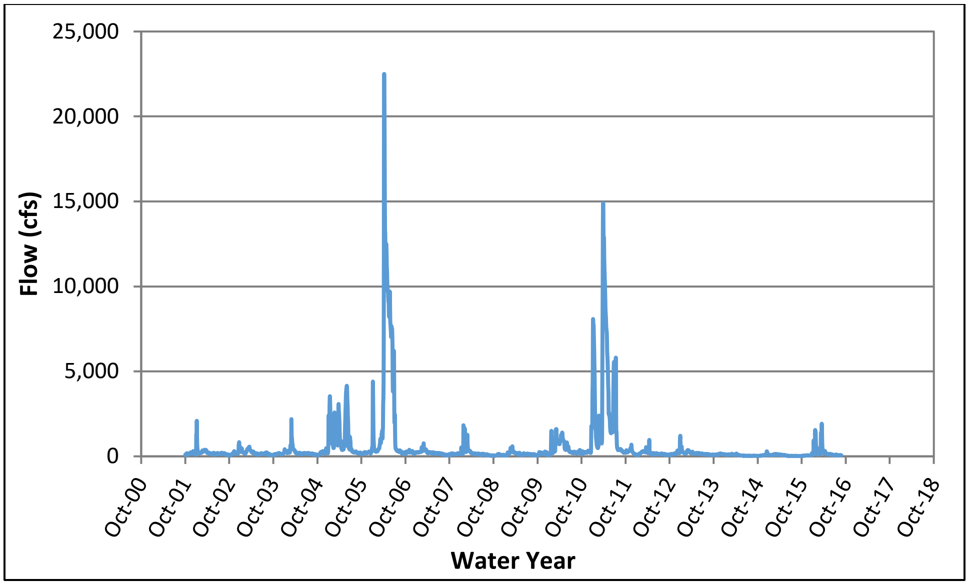

Figure C.4-9. San Joaquin River at Freemont Ford Bridge

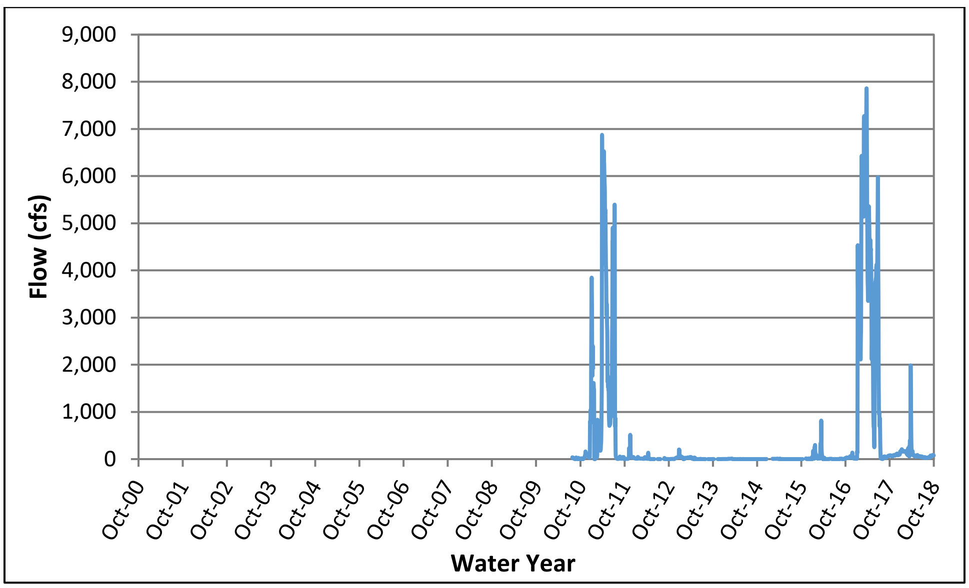

Figure C.4-10. Eastside Bypass Below Mariposa Bypass

C.4.1.2.1 Reach 1 – Friant Dam to Gravelly Ford

Reach 1 conveys continuous flows approximately 39 miles through an incised, gravel-bedded channel to Gravelly Ford, forming part of the boundary between Fresno and Madera counties. Releases are made at Friant Dam to comply with Holding Contract requirements along Reach 1. Streamflow of at least 5 cfs is maintained past the last diversion near Gravelly Ford, with no requirements for streamflow into Reach 2. Reach 1 is the only reach in the Restoration Area with exposed gravel and a river gradient suitable for Chinook salmon spawning. Extensive gravel mining in Reach 1A and the upper portion of Reach 1B has left many pits, some connected to the river, within the historical floodplain. An average of 117,000 acre-feet of water per year is released from Friant Dam into Reach 1 for riparian water users. Reach 1 is subdivided into two subreaches, 1A and 1B, at SR 99.

The objective release from Friant Dam into Reach 1 is 8,000 cfs. Reach 1 of the San Joaquin River is hydraulically connected to 190 acres of sand and aggregate mining pits, with an additional 1,170 acres of pits in the surrounding floodplain (McBain and Trush 2002). These pits can attenuate flow and increase evaporation through ponding. There are no storage facilities in Reach 1. Ten major road crossings in this reach can affect flow stage (McBain and Trush 2002). Agricultural return flows in Reach 1 are minor but have reached up to 300 cfs on occasion (EPA 2007). Stormwater runoff from the Fresno Metropolitan Area is managed by the Fresno Metropolitan Flood Control District. All but five of the District's 161 drainage basins route stormwater to retention and detention facilities, limiting the urban surface runoff into Reach 1.

Reach 1A. Flows within Reach 1A are predominantly influenced by releases from Friant Dam, along with diversions and seepage losses. Mining pits in Reach 1 are primarily located in Reach 1A. Eighty-four water diversions are located along this reach, not all of which are active on a regular basis. Cottonwood Creek and Little Dry Creek, two intermittent streams, join the San Joaquin River in Reach 1A. Cottonwood Creek, draining 35.6 square miles, flows in from the north near the base of Friant Dam. Little Dry Creek, draining 57.9 square miles, joins the San Joaquin River from the south approximately 8 miles downstream from Friant Dam. Flows in Little Dry Creek can be augmented from the Big Dry Creek flood control reservoir (McBain and Trush 2002). Flows from these two creeks must be included in the 8,000 cfs Reach 1A capacity limits when determining releases from Friant Dam.

Since 1949, Reclamation has made average annual releases of approximately 117 TAF from Friant Dam to the San Joaquin River to comply with Holding Contract requirements upstream from Gravelly Ford. Additional river flows occur during years when releases are made to the San Joaquin River for flood management purposes or for the San Joaquin River Restoration Program.

Reach 1B. Flows within Reach 1B are predominantly influenced by inflow from Reach 1A, diversions and seepage losses. Fifteen water diversions are located along this reach, not all of which are active on a regular basis.

C.4.1.2.2 Reach 2 – Gravelly Ford to Mendota Dam

Reach 2 marks the end of the incised channel and is a meandering channel of low gradient. Reach 2 meanders approximately 24 miles across the sandy alluvial fan of the San Joaquin River between Gravelly Ford and Mendota Dam and is subdivided into two subreaches, 2A and 2B, at the Chowchilla Bypass Bifurcation Structure. Reach 2 is typically dry; flows reach the Mendota Pool from Reach 2B or from the Fresno Slough only during periods of flood management releases. Flood flows in the San Joaquin and/or Kings rivers occurred at the Mendota Pool in 1997, 2001, 2005, 2006, 2011, and 2017. Additionally, flows released by the San Joaquin River Restoration Program have at times been recaptured in Mendota Pool due to downstream capacity constraints. At all other times, the DMC is the primary source of water to the Mendota Pool. The Mendota Pool provides no long-term storage for water supply operations or flood management. Reach 2 ends at Mendota Dam, and the Mendota Pool backwater extends up a portion of this subreach. The Mendota Pool delivers water to the San Joaquin River Exchange Contractors Water Authority, other CVP contractors, wildlife refuges and management areas, and State water authorities.

Reach 2A. Reach 2A is typified by the accumulation of sand caused in part by backwater effects of the Chowchilla Bypass Bifurcation Structure and by a lower gradient relative to Reach 1. Reach 2A has a design channel capacity of 8,000 cfs to accommodate controlled releases from Friant Dam. Under steady-state conditions (i.e., losses are calculated under extended periods of steady flow), flow does not reach the Chowchilla Bypass Bifurcation Structure when discharge at Gravelly Ford is less than 75 cfs (McBain and Trush 2002). Agricultural return flows within this reach are minor. Ten water diversions are located along this reach. Reach 2A has also been subject to local sand mining, although this has not caused the extensive channel degradation seen in Reach 1.

Reach 2B. Reach 2B is a sandy channel extending into the Mendota Pool. The design conveyance capacity of this reach is 2,500 cfs, but significant seepage has been observed at flows above 1,300 cfs (RMC 2007). The Mendota Pool Bypass and Reach 2B Project will expand the channel capacity of this reach. Agricultural return flows within this reach are minor. Reach 2B ends at Mendota Dam, and Mendota Pool backwater extends up a portion of this reach. Twenty-nine water diversions are located along this reach. One major road crossing in this reach can affect flow stage. The DMC typically conveys 2,500 to 3,000 cfs to the Mendota Pool during the irrigation season.

Mendota Dam. Mendota Dam, built in 1917, is owned and operated by the Central California ID. Mendota Dam is a flashboard and buttress dam 23 feet high and 485 feet long; the crest elevation is 168.5 17 feet. The Dam is located at the confluence of the San Joaquin River and Fresno Slough, serves as a forebay for diversions to the Main and Outside canals, and is the termination of the Delta-Mendota Canal, which conveys CVP water from the Delta. Fresno Slough connects the Kings River to the San Joaquin River and delivers water to the south from Mendota Pool during irrigation season and delivers water to the Mendota Pool and San Joaquin River from the Kings River when the Kings River is flooding. The 50-TAF Mendota Pool is a small reservoir, with approximately 8,500 acre-feet of storage, created by the 23-foot-high Mendota Dam (Reclamation 2004). The Mendota Pool does not provide any appreciable flood storage. The water surface elevation in the pool is maintained by a set of gates and flashboards that are manually opened/removed in advance of high-flow conditions. This process lowers the water level in the pool for passing high flows to reduce seepage impacts to adjacent lands but prevents diversions on Fresno Slough from the Delta-Mendota Canal and San Joaquin River flows. A fish ladder exists at Mendota Dam, but has been inoperable for the last several decades. The Mendota Pool Bypass and Reach 2B Project will provide fish passage around Mendota Pool.

Cyclically, the Mendota Pool fills with sediment during infrequent high-flow releases from Friant Dam. During times of high flows, some unknown portion of this sediment is able to flush and route downstream when flashboards have been pulled, restoring much of the Mendota Pool storage capacity. If the flashboards are not pulled before a high-flow event from either the San Joaquin River or Fresno Slough, the increased water surface elevations cause seepage problems on upstream and adjacent properties. Recent mean daily flows in the San Joaquin River at Mendota are presented on Figure C.4-11 (DWR 2018al).

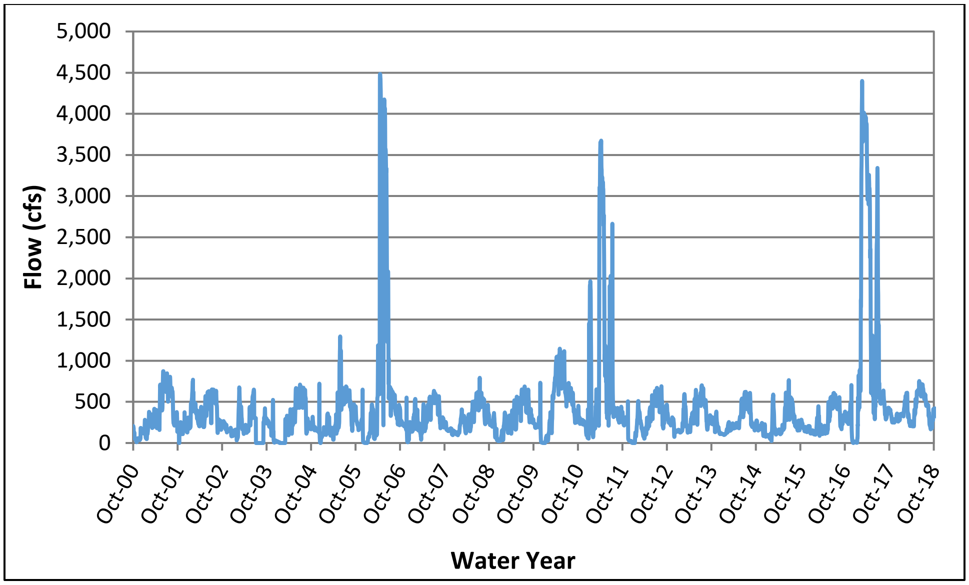

Figure C.4-11. San Joaquin River Near Mendota

C.4.1.2.3 Reach 3 – Mendota Dam to Sack Dam

Reach 3 begins at Mendota Dam and extends approximately 23 miles downstream to Sack Dam. Reach 3 conveys flows of up to 800 cfs from the Mendota Pool for diversion to the Arroyo Canal at Sack Dam, maintaining flow year-round in a meandering channel with a sandy bed. The Fresno Slough and Mendota Pool convey flood flows from the Kings River to this reach. Irrigation canals bound this reach for most of its length. In some portions, lands within the floodway are actively used for agricultural production and are protected by local or interior levees.

Reach 3 flows 23 miles along a sandy channel from Mendota Dam to Sack Dam. The design capacity of Reach 3 is 4,500 cfs; however, anecdotal evidence suggests that seepage and associated flooding may begin at sustained flows above 800 cfs (RMC 2007). The San Joaquin River Restoration Program is actively pursuing seepage easements and projects in this reach. Significant bed lowering has been measured within Reach 3; however, the extent of this lowering that is due to subsidence from groundwater overdraft, or to human-induced sediment and hydrology modification within the channel, is unknown (McBain and Trush 2002). Flows within this reach predominantly consist of water conveyed from the Delta by the DMC and released from the Mendota Pool for diversion.

Sack Dam is a 5-foot-high concrete and wood diversion structure delivering water to the Arroyo Canal on the west side of the river (RMC, 2003). No operational storage for water supply exists within this reach. The Arroyo Canal and Sack Dam Fish Passage Project of the San Joaquin River Restoration Program will screen Arroyo Canal and provide for fish passage over the site of Sack Dam. Flows of 500 to 600 cfs are typically released from the Mendota Pool for downstream diversions at Sack Dam. Flows greater than required for diversions (such as during flood events) spill over Sack Dam into the San Joaquin River downstream into Reach 4A. Seven water diversions are located in this reach. One major road crossing in this reach can affect flow stage.

C.4.1.2.4 Reach 4 – Sack Dam to Eastside Bypass Confluence

Reach 4 runs approximately 46 miles from Sack Dam to the confluence of the Eastside Bypass. Historically, flows within much of this reach were predominantly agricultural return flows, and large sections of this reach were dry. Since 2016, Restoration Flows have re-wet Reach 4A and Restoration Flows are maintained at low levels year-round.

Reach 4 is subdivided into three subreaches: 4A, 4B1, and 4B2. 4A begins at Sack Dam and extends to the Sand Slough Control Structure; 4B1 extends from the Sand Slough Control Structure to the Mariposa Bypass confluence; and 4B2 begins at the confluence of the Mariposa Bypass and extends to the confluence of the Eastside Bypass. The Sand Slough Control Structure controls the flow split between the mainstem San Joaquin River and Eastside Bypass. A headgate is also present at the entrance to Reach 4B1 of the San Joaquin River. Reach 4 subreaches have different characteristics and design capacities, as discussed below.

Reach 4A. The design channel capacity in this reach is approximately 4,500, beginning at Sack Dam and extending to the Sand Slough Control Structure. The channel below Sack Dam has flow during the agricultural season (agricultural return flows) and during upstream flood releases, in addition to Restoration Flows. Four water diversions are located along this reach. This subreach has experienced bed lowering similar to that discussed for Reach 3.

Reach 4B1. This reach has a design capacity of 1,500 cfs, and the Sand Slough Control Structure is designed to maintain this design discharge; although current operations recommend discharge past the control structure to be 300 to 400 cfs because of reduced capacity in the channel. Thus, actual operations keep the gates of the San Joaquin River headgates closed, diverting all flow from Reach 4B1 to the Eastside Bypass (McBain and Trush 2002). Reach 4B1, therefore, is dry until downstream agricultural return flows contribute to its baseflow, although this flow is often pumped and reused for irrigation.

Reach 4B2. The design channel capacity of Reach 4B2 is 10,000 cfs. The channel carries tributary and flood flows from the Mariposa Bypass. No operational storage for water supply exists within this reach. Two water diversions are located along this reach.

C.4.1.2.5 Reach 5 – Eastside Bypass Confluence to Merced River

Reach 5 of the San Joaquin River extends approximately 18 miles from the confluence of the Eastside Bypass downstream to the Merced River confluence. The design capacity of Reach 5 is 26,000 cfs; no significant capacity constraints have been identified in this reach. Reach 5 receives flow from Reach 4B2 and the Eastside Bypass. Agricultural and wildlife management area return flows also enter Reach 5 via Mud and Salt sloughs, which drain the west side of the San Joaquin Valley. Three major road crossings within this reach can affect flow stage. San Joaquin River Flood Control Project levees confine Reach 5. West bank levees end at Salt Slough while the east bank levees continue to the Merced River confluence. There are four water diversions in this reach.

C.4.1.2.6 Flood Bypasses – Chowchilla, Eastside, and Mariposa

The State constructed the San Joaquin River Flood Control Project which includes flood damage reduction structures and facilities within the Restoration Area. Construction of the original State system was initiated in 1959 and completed in 1966. These improvements were coordinated with the Federal Government to ensure the effectiveness of the Federal portion of the project. The bypass system consists primarily of man-made channels (Eastside, Chowchilla, and Mariposa bypasses), which divert and carry flood flows from the San Joaquin River at Gravelly Ford, along with inflows from the Kings River and other tributaries, downstream to the mainstem just above Merced River. The system consists of about 193 miles of levees, several control structures, and other appurtenant facilities, and about 80 miles of surfacing on existing levees. Operations and maintenance (O&M) of the completed State upstream bypass features of the project are accomplished by the LSJLD. The flood damage reduction structures and facilities within the Restoration Area are described below.

The Chowchilla, Eastside, and Mariposa bypasses convey flood flows from the San Joaquin and Kings rivers. Tributaries to the Chowchilla Bypass include the Fresno River and Berenda Slough. The Chowchilla Bypass extends to the confluence of Ash Slough, which marks the beginning of the Eastside Bypass. Eastside Bypass Reach 1 extends from Ash Slough to the Sand Slough Bypass confluence and receives flows from the Chowchilla River. Eastside Bypass Reach 2 extends from the Sand Slough Bypass confluence to the head of the Mariposa Bypass. Eastside Bypass Reach 3 extends from the head of the Mariposa Bypass to the head of Reach 5 and receives flows from Deadman, Owens, and Bear creeks. The Mariposa Bypass extends from the Mariposa Bypass Bifurcation Structure to the head of Reach 4B2. A drop structure is located near the downstream end of the Mariposa Bypass that dissipates energy from flows before flows enter the mainstem San Joaquin River.

Chowchilla Bypass and Bypass Bifurcation Structure. As a component of the Lower San Joaquin River and Tributaries Project, the Chowchilla Bypass begins at the Chowchilla Bypass Bifurcation Structure in the San Joaquin River and runs northwest, parallel to the San Joaquin River, to the confluence of the Fresno River, where the Chowchilla Bypass ends and becomes the Eastside Bypass. The design channel capacity of the Chowchilla Bypass is 5,500 cfs. The bypass is constructed in highly permeable soils, and much of the initial flood flows infiltrate and recharge groundwater. The Chowchilla Bypass Bifurcation Structure is a gated structure that controls the proportion of flood flows between the Chowchilla Bypass and Reach 2B of the San Joaquin River. The Chowchilla Bypass Bifurcation Structure is operated to keep flows in Reach 2B at a level less than 2,500 cfs because of channel capacity limitations, though significant seepage has been observed at flows above 1,300 cfs (RMC 2007), and the Mendota Pool Bypass and Reach 2B Project will increase the capacity of Reach 2B. Historically, releases from the Chowchilla Bypass Bifurcation Structure to Reach 2B were limited to the 1,300 cfs capacity of Reach 2B, or to flows that would not exceed the capacity of Reaches 3 and 4A when combined with Kings River flood flows and irrigation delivery flows from Mendota Pool.

Eastside Bypass and Control Structure. The Eastside Bypass extends from the confluence of the Fresno River and the Chowchilla Bypass to its confluence with the San Joaquin River at the head of Reach 5. The Eastside Bypass is subdivided into three reaches. Eastside Bypass Reach 1 gradually increases in design channel capacity from 10,000 cfs to 17,000 cfs as it receives flows from the Fresno River, Berenda Slough, and Ash Slough, and ends at the downstream end of the Sand Slough Bypass, where it intercepts flows from the Chowchilla River. Eastside Bypass Reach 2, with a design channel capacity of 16,500 cfs, extends from the Sand Slough Bypass confluence to the Mariposa Bypass Bifurcation Structure at the head of the Mariposa Bypass and the Eastside Bypass Control Structure. Eastside Bypass Reach 3, with a design channel capacity of 13,500 cfs at the Eastside Bypass Control Structure, and a design channel capacity of 18,500 cfs at its confluence with Bear Creek, extends from the Eastside Bypass Control Structure to the head of Reach 5 of the San Joaquin River, and receives flows from Deadman, Owens, and Bear creeks. The gated Eastside Bypass Control Structure works in coordination with the Mariposa Bypass Bifurcation Structure to direct flows to either Eastside Bypass Reach 3 or to the Mariposa Bypass. The channel capacities described above are design capacities; current capacities may be reduced due to subsidence of Eastside Bypass levees. Eastside Bypass Reach 3 ultimately joins with Bear Creek to return flows to the San Joaquin River.

Sand Slough Control Structure/San Joaquin River Headgates. The Sand Slough Control Structure, located in the short connection between the San Joaquin River at mile post 168.5 and the Eastside Bypass between Eastside Bypass Reaches 1 and 2, is an uncontrolled weir working on coordination with the San Joaquin River Headgates to control the flow split between the mainstem San Joaquin River and the Eastside Bypass. The Sand Slough Control Structure diverts flows from the San Joaquin River to the Eastside Bypass, and the San Joaquin River Headgates control the timing and quantity of flows entering Reach 4A of the San Joaquin River into Reach 4B1. The operating rule for the control structure and headgates is to divert the first 50 cfs of San Joaquin River flow to Sand Slough, and then equally divide flow in excess of 50 cfs to Sand Slough and Reach 4B1. Historical operations have kept the headgates closed for many years, diverting all flood flows to Sand Slough (RMC 2007).

Mariposa Bypass and Bypass Bifurcation Structure. The Mariposa Bypass Bifurcation Structure controls the proportion of flood and Restoration flows that continue down the Eastside Bypass or return the San Joaquin River through the Mariposa Bypass to Reach 4B2. The Mariposa Bypass delivers flow back into the San Joaquin River from the Eastside Bypass at the head of Reach 4B2. Of 14 bays on the Mariposa Bypass Bifurcation Structure, eight are gated. The operating rule for the Mariposa Bypass is to divert all flows to the San Joaquin River when flows in the Eastside Bypass above the Mariposa Bypass are less than 8,500 cfs, with flows greater than 8,500 cfs remaining in the Eastside Bypass, eventually discharging back into the San Joaquin River at the Bear Creek Confluence at the end of Reach 4B2 of the San Joaquin River. Eastside Bypass below Mariposa Bypass flows are presented in Figure C.4-10 (DWR 2018ak).

However, actual operations have deviated from this rule, flows of up to 2,000 cfs to 3,000 cfs have historically remained in the Eastside Bypass, and approximately one-quarter to one-third of the additional flows are released to the Mariposa Bypass (McBain and Trush 2002). Flood flows not diverted to the San Joaquin River via the Mariposa Bypass continue down the Eastside Bypass and are returned to the San Joaquin River via Bravel Slough and Bear Creek. Restoration Flows continue down the Eastside Bypass. Bravel Slough reenters the San Joaquin River at mile post 136 and is the ending point of the bypass system.

C.4.1.3 *San Joaquin River from Merced River to the Delta*

Flows in the San Joaquin River below the Merced River confluence to the Delta are controlled in large part by releases from reservoirs, located on the tributary systems, to satisfy contract deliveries and instream flow requirements, as well as operational agreements such as D-1641. Recent mean daily flows in the San Joaquin River at Vernalis (located at the southeastern boundary of the Delta) are presented on Figure C.4-12 (DWR 2018am).

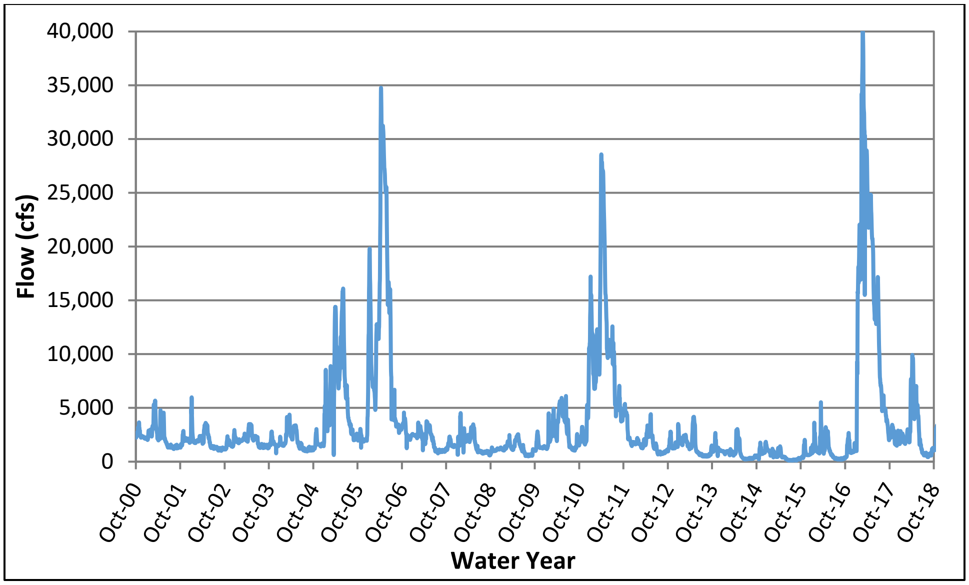

Figure C.4-12. San Joaquin River at Vernalis

C.4.1.3.1 Merced River

The Merced River flows west out of the Sierra Nevada to its confluence with the San Joaquin River at the end of Reach 5. Merced River stream flows are regulated primarily by New Exchequer and McSwain dams, which form Lake McClure and Lake McSwain, respectively. The Crocker-Hoffman Diversion Dam is located downstream from New Exchequer and McSwain dams. Lake McClure is a water supply, hydropower, and flood control reservoir and Lake McSwain is a regulating reservoir approximately 6 miles downstream from Lake McClure. Both reservoirs are owned and operated by the Merced ID. Minimum flow standards were established in 1964 (Project No. 2179) by a FERC license and, in addition, the Davis-Grunsky Contract No. D-GGR17 between Merced ID and DWR. During high-flow events, a portion of Merced River flows are conveyed to the San Joaquin River through Merced Slough.

C.4.1.3.2 Tuolumne River

The Tuolumne River enters the San Joaquin River downstream from the Merced River. The largest reservoir on the Tuolumne River is New Don Pedro Lake, owned and operated by the Turlock Irrigation District and Modesto Irrigation District for water supply, hydropower, and flood control purposes. La Grange Reservoir below New Don Pedro Lake is also jointly owned by the two irrigation districts and is operated as a diversion dam. The 1995 New Don Pedro Settlement Agreement contains instream flow requirements on the Tuolumne River for the anadromous fishery downstream from the project (FERC 2009).

The Stanislaus River and associated facilities and operations are described below.

C.4.2 Stanislaus River and the East Side Division

The East Side Division encompasses portions of the Stanislaus and San Joaquin River Systems and includes New Melones Dam, Tulloch Dam, Goodwin Dam, and smaller Diversion Dams and associated Reservoirs.

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

C.4.2.1 *Early Water Development*

Agricultural water supply development in the Stanislaus River watershed began in the 1850s and has significantly altered the basin's hydrologic conditions. Prior to 1856, the San Joaquin Water Company constructed a diversion dam on the Stanislaus River immediately downstream of the present-day location of Tulloch Dam and used the diversion dam to distribute water for irrigation and other uses in the Knights Ferry Area. Beginning in 1856, a series of water and power companies constructed several water supply and power facilities in the Stanislaus River watershed.

The San Joaquin Water Company was sold to the Tulloch family in the late 1800s, and in 1910, Oakdale Irrigation District (OID) and South San Joaquin Irrigation District (SSJID) bought the Tulloch water rights and physical distribution system. In 1913, OID and SSJID jointly constructed Goodwin Diversion Dam, an 80-foot tall double concrete arch dam, to divert Stanislaus River water (up to 1,816.6 cfs daily) into their respective canals for distribution into their respective service areas for irrigation. Despite its height, Goodwin Diversion Dam is a re-operating reservoir, not a storage reservoir, because a full reservoir is needed to allow diversion to these canals.

To address their lack of storage, OID and SSJID joined with The Pacific Gas and Electric Company (PG&E) in 1925 to construct the Melones Dam and Powerhouse (110 TAF capacity) approximately 12.3 river miles upstream of the Goodwin Diversion Dam. Water released from Melones was diverted at Goodwin Diversion Dam for delivery into OID and SSJID's distribution systems.

In 1955, OID and SSJID agreed to construct three new facilities, including the Donnells Dam and Reservoir (64,500 TAF capacity) and Beardsley Dam and Reservoir (97.5 TAF capacity) upstream of Melones Dam, and the Tulloch Dam and Reservoir (54.663 TAF capacity), downstream of Melones Dam. Construction of the three facilities, collectively referred to as the Tri-Dam Project, was completed in 1957 and the facilities became operational in 1958. As part of the construction of the Tri-Dam project, Goodwin Diversion Dam was raised to create an afterbay to regulate discharge from Tulloch. From 1985–1990, the Calaveras County Water District constructed the North Fork Stanislaus Hydroelectric Project, which included the construction of New Spicer Reservoir (189 TAF capacity) in 1989. This was a joint development project by Northern California Power Agency (NCPA) and Calaveras County Water District. Calaveras County Water District is the licensee and NCPA is the project operator.

Twenty ungauged tributaries contribute flow to the lower portion of the Stanislaus River below Goodwin Dam. These streams provide intermittent flows, occurring primarily during the months of November through April. Agricultural return flows, as well as operational spills from irrigation canals receiving water from both the Stanislaus and Tuolumne Rivers, enter the lower portion of the Stanislaus River. In addition, a portion of the flow in the lower reach of the Stanislaus River originates from groundwater accretions. There are also approximately 48 TAF of annual riparian water rights in the Stanislaus River downstream of Goodwin Dam.

C.4.2.2 *Federal Water Development*

In the Flood Control Act of December 1944, Congress authorized construction of a dam to replace Melones Dam to help alleviate serious flooding problems along the Stanislaus and Lower San Joaquin Rivers. In the Flood Control Act of October 1962, Congress reauthorized the project, and expanded it to be a multipurpose facility to be built by USACE and operated by the Secretary of the Interior as the New Melones Unit of the Eastside Division of the CVP. Dam and reservoir construction began in 1966 and, after being halted from 1972 to 1974, was completed by USACE in 1978, with a storage capacity of 2.4 MAF.

In 1972, Reclamation applied for the assignment of two state-filed water rights and two new water rights for the New Melones Project. These applications were protested by several parties and mostly resolved through protest settlement agreements. In 1973, SWRCB Decision 1422 (D-1422) initially approved less than 600 TAF in storage for power, senior water rights, water quality, and fish and wildlife protection and enhancement, citing a lack of demonstrated demand and protection of upstream recreation as a reason not to grant consumptive use rights for new demands without further demonstration of a demand for this water.

To demonstrate the consumptive use demands, in 1980 Reclamation produced a Stanislaus River Water Allocation and an EIS for the proposed water allocation of the New Melones Unit. The documents describe preferred and alternative boundaries of the Stanislaus River Basin, the anticipated project yield for 2020 conditions, the current and anticipated future needs of such basin, the determination of an available "interim" supply until the full buildup of in-basin needs, and an anticipated "firm yield" once full in-basin demand was established. The ROD described that New Melones Reservoir would generate a water supply yield of 230 TAF in 2000, and 180 TAF in 2020; assuming maximum annual releases of 70 TAF for water quality and 98 TAF for downstream fishery. For the interim supply, 85 TAF would be available in the year 2000, diminishing to zero at full in-basin demand. For the firm supply, the Secretary determined that there would be 49 TAF available in 2020 after in-basin demands were met. In 1983, Reclamation entered into a long-term water service contract with Central San Joaquin Water Conservation District for 49 TAF of firm supply and an interim supply of 31 TAF, and a long-term water service contract totaling 75 TAF of interim water with Stockton East Water District (SEWD). Reclamation then successfully applied to have D-1422 amended to allow up to full storage for demonstrated power and consumptive use demands in the same year, and New Melones briefly filled to its capacity of 2.4 MAF for the first time.

In 1984, Reclamation applied for the assignment of the direct diversion portion of one of the state water right filings, to be able to serve contracts water at times when New Melones is filling. The application was again protested, with protests largely settled through protest settlement agreements. The direct diversion right was granted in D-1616 in 1988. D-1616 continued water quality requirements and included a new fish and wildlife protest settlement agreement. A later revision added a requirement to study downstream steelhead/trout needs.

In 1995 and in 2000, water rights decisions related to updates of the San Francisco Bay/Sacramento–San Joaquin River Delta Water Quality Control Plan (WQCP) added flow requirements at Vernalis and partial responsibility for interior Delta water quality to CVP water rights.

C.4.2.3 *Reservoir Operations*

The operating criteria for New Melones Reservoir are constrained by water rights requirements, flood control operations, contractual obligations, and federal requirements under the Federal Endangered Species Act (ESA) and CVPIA. Reclamation must operate New Melones Reservoir to meet senior water rights and in-basin demands. Senior water rights are defined for both current and future upstream water right holders in accordance with the SWRCB Decision 1422 (D-1422) and Decision 1616 (D-1616); through protest settlement agreements with Tuolumne and Calaveras Counties; and for current downstream water right holders and riparian rights whose priorities are either senior to Reclamation or senior to appropriative rights in general, respectively. Reclamation also is required to make full contract amounts available to Stockton East Water District and Central San Joaquin Water Conservation District except for when contractual shortage provisions apply.

Tulloch Reservoir is owned and operated by the Tri-Dams Project for recreation, power, and flow re-regulation of New Melones Reservoir releases. Water released by Tulloch Reservoir and Powerplant flows downstream to Goodwin Reservoir where water is either diverted to canals to serve, Oakdale Irrigation District, South San Joaquin Irrigation District, and Stockton East Water District; or released from Goodwin Reservoir to the lower Stanislaus River (SWRCB 2012).

Below Goodwin Dam, the lower Stanislaus River flows approximately 40 miles to the confluence with the San Joaquin River. Agricultural return flows and operational spills from irrigation canals also enter the lower Stanislaus River.

Reservoir storage varies in accordance with upstream hydrology and downstream water demands and instream flow requirements. Recent water storage volumes and elevations for Water Years 2001 through 2018 in New Melones and Goodwin reservoirs are presented on Figures C.4-13 through C.4-16 (2018an, 2018ao, 2018ap, 2018aq). Recent mean daily flows in the Stanislaus River downstream of Goodwin Dam are presented on Figure C.4-17 (DWR 2018ar).

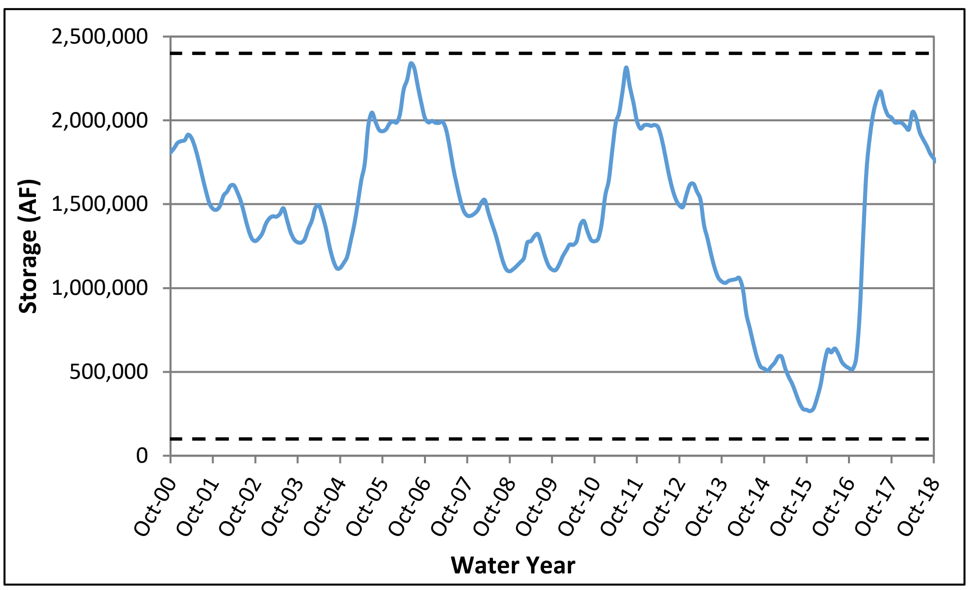

Figure C.4-13. New Melones Reservoir Storage

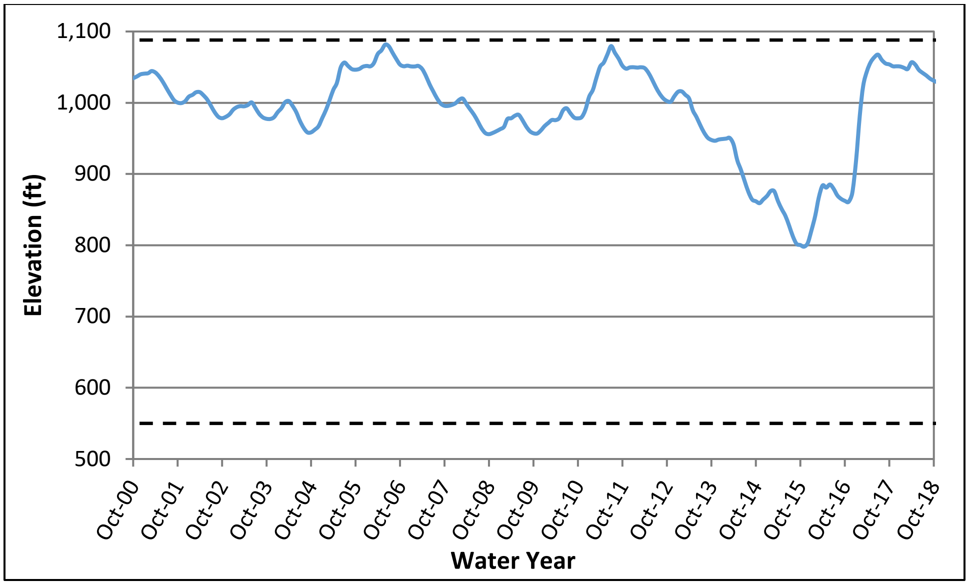

Figure C.4-14. New Melones Reservoir Elevation

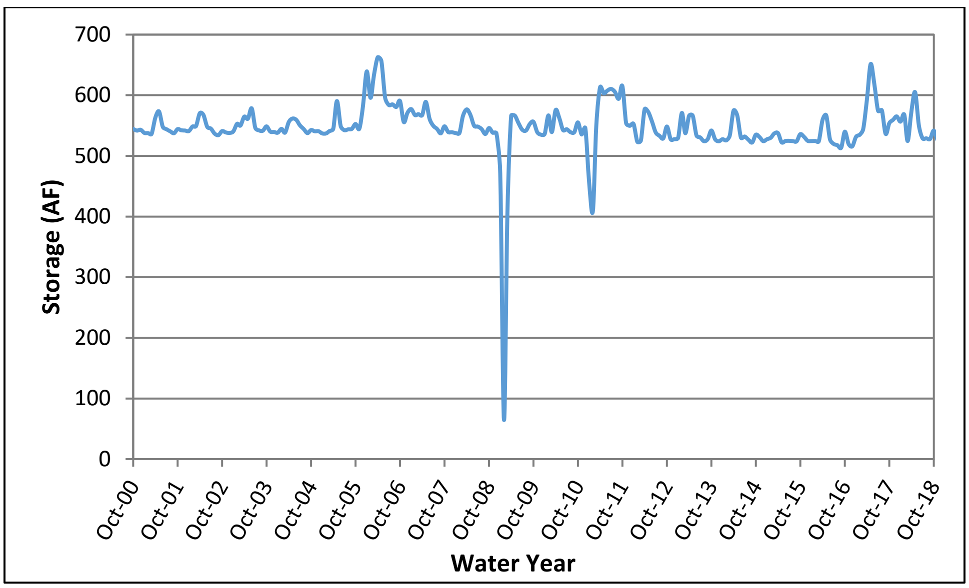

Figure C.4-15. Goodwin Reservoir Storage

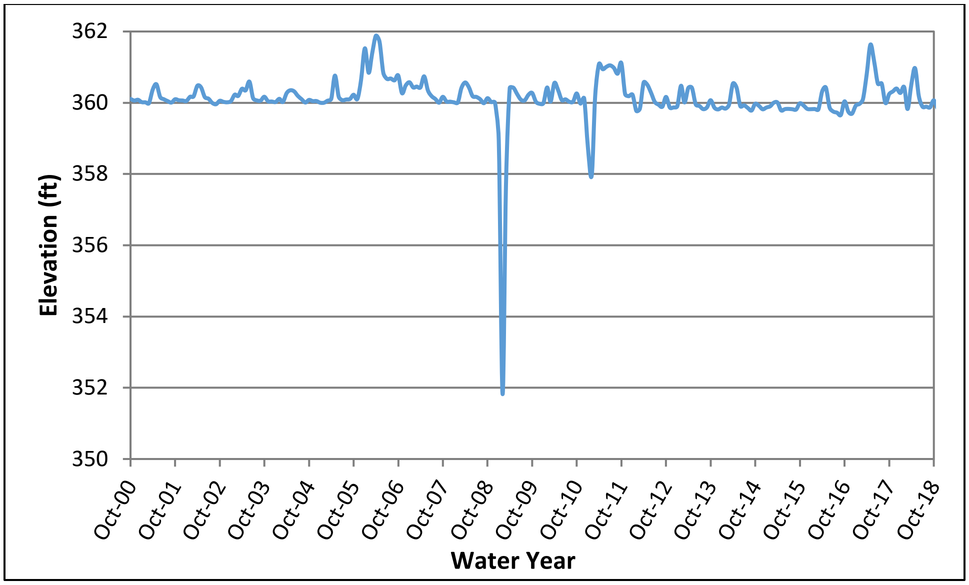

Figure C.4-16. Goodwin Reservoir Elevation

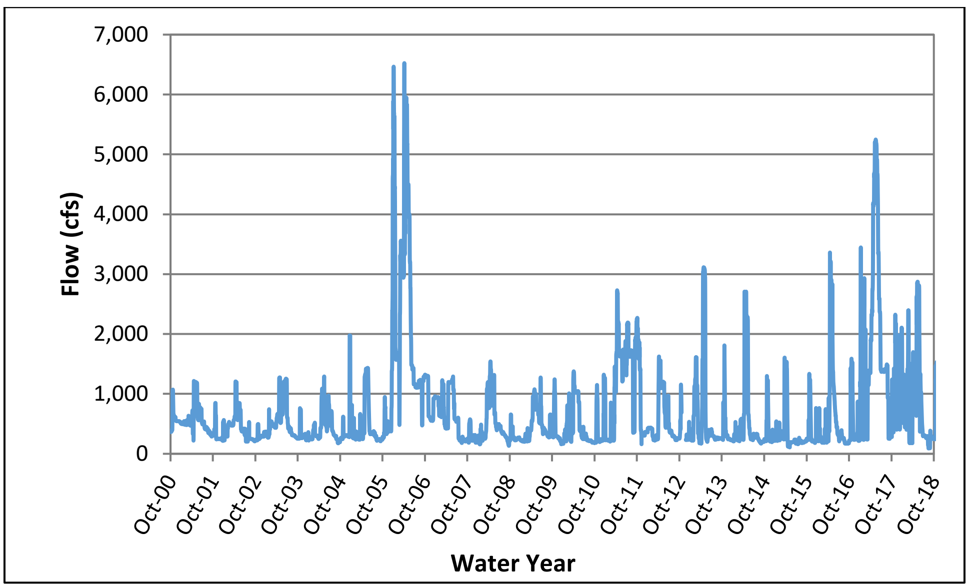

Figure C.4-17. Stanislaus River at Orange Blossom Bridge

C.4.2.3.1 Flood Control

The New Melones Reservoir flood control operation is coordinated with the operation of Tulloch Reservoir. The flood control objective is to maintain flood flows at the Orange Blossom Bridge at less than 8,000 cfs. When possible, however, releases from Tulloch Dam are maintained at levels that would not result in long-term downstream flows in excess of 1,500 cfs because of the past reported potential for seepage in agricultural lands adjoining the river associated with flows above this level. Up to 450 TAF of the 2.4 MAF storage volume in New Melones Reservoir is dedicated for flood control and 10 TAF of Tulloch Reservoir storage is set aside for flood control. Based upon the flood control diagrams prepared by USACE, part or all of the dedicated flood control storage may be used for conservation storage (storing allocated, excess waters), depending on the time of year and the current flood hazard.

C.4.2.3.2 Water Rights Requirements

The operating criteria for New Melones Reservoir are constrained by water rights requirements, flood control operations, contractual obligations, and federal requirements under the ESA and CVPIA.

Terms and conditions of Reclamation's water rights define the limitations within which Reclamation can directly divert water or divert water to storage, after senior water rights and in-basin demands are met. Senior water rights are both current and future upstream water right holders (whose priority is reserved in D-1422 and D-1616 and through protest settlement agreements with Tuolumne and Calaveras Counties), and current downstream water right holders and riparian rights (whose priorities are either senior to Reclamation or senior to appropriative rights in general, respectively). In-basin, instream demands include water quality and flow in the lower Stanislaus River and in part in the lower San Joaquin River and Delta (in that the Stanislaus River contributes to these systems). Downstream demands are first met, to the degree possible, by bypassing natural inflow through New Melones Reservoir. When natural flow is insufficient, stored water is released to meet demands specified either through calculated riparian demand, downstream instream objectives, or protest settlement agreements. Whenever possible, multiple demands are met with the same flow.

C.4.2.3.3 Senior Water Rights: Protest Settlement Agreements

Reclamation's application for assignment of state water right filings in the early 1970s was protested by future in-basin users, senior water rights holders, and the CDFW. To resolve the senior water rights' protest, Reclamation entered into a 1972 Agreement and Stipulation with OID, and SSJID. The 1972 Agreement and Stipulation specifies that it satisfies the yield for consumptive purposes of the OID and SSJID water rights on the Stanislaus River, through the provision of up to a maximum of 654 TAF per year of either natural inflow to New Melones Reservoir or water stored in New Melones for diversion at Goodwin Dam for direct use by OID and SSJID and for storage in Woodward Reservoir (36 TAF capacity).

In 1988, following a year of low inflow to New Melones Reservoir, the Agreement and Stipulation among Reclamation, OID, and SSJID was renegotiated, resulting in an agreement that depended less on actual inflow and more on Reclamation's storage in New Melones, in order to provide a more reliable, albeit slightly smaller maximum, supply. The 1988 agreement commits Reclamation to provide water in accordance with a formula based on inflow and storage of up to 600 TAF each year for diversion at Goodwin Dam by OID and SSJID to meet their demands. The 1988 Agreement and Stipulation created a "conservation account" in which the difference between the entitled quantity and the actual quantity diverted by OID and SSJID in a year may be carried over for use in subsequent years, depending on storage/flood control conditions in New Melones. This conservation account has a maximum volume of 200 TAF, and withdrawals are constrained by criteria in the agreement.

C.4.2.3.4 In-Basin Requirements in the Lower Stanislaus River

Based on a protest settlement agreement between Reclamation and CDFW, SWRCB D-1422 required Reclamation to bypass or release 98 TAF of water per year (69 TAF in critical years) through New Melones Reservoir to the Stanislaus River on a distribution pattern to be specified each year by CDFW for fish and wildlife purposes. Based on a second protest settlement agreement in 1987, SWRCB D-1616 as amended required increased releases from New Melones to enhance fishery resources for an interim period, during which habitat requirements were to be better defined and a study of Chinook Salmon fisheries on the Stanislaus River would be completed.

During the study period, releases for instream flows were to range from 98.3 to 302.1 TAF per year. The exact quantity to be released each year was to be determined based on a formulation involving storage, projected inflows, projected water supply, water quality demands, projected CVP contractor demands, and target carryover storage. Because of dry hydrologic conditions during the 1987 to 1992 drought period, the ability to provide increased releases was limited. USFWS published the results of a 1993 study, which recommended a minimum instream flow on the Stanislaus River of 155.7 TAF per year for spawning and rearing (Aceituno 1993).

The study period is near completion with all but one study (outlined in the 1987 agreement) completed at the time of this document. Reclamation is proposing a new plan of operations. This new plan is explained below and will replace the former CDFW and D-1641 downstream release requirements and satisfy ESA obligations.

Reclamation's New Melones water rights require that water be bypassed through or released from New Melones Reservoir to maintain applicable dissolved oxygen (DO) standards to protect the salmon fishery in the Stanislaus River. The 2004 San Joaquin Basin 5C Plan (Central Valley Regional Water Quality Control Board) designates the lower Stanislaus River with cold water and spawning beneficial uses, which have a general water quality objective of no less than 7 mg/L DO. This objective is therefore applied through the water rights to the Stanislaus River near Ripon.

C.4.2.3.5 Water Temperature Requirements

Water temperatures in the lower Stanislaus River are affected by many factors and operational tradeoffs. These include available cold-water resources in New Melones reservoir, Goodwin release rates for fishery flow management, ambient air conditions, and residence time in Tulloch Reservoir, as affected by local irrigation demand

C.4.2.3.6 Fish and Wildlife Requirements on the Stanislaus River

The 2009 NMFS BO RPA requires Reclamation to adaptively manage available flows to meet minimum instream flow, ramping flow, pulse flow, floodplain inundation, and geomorphic and function flow patterns, through the following actions. The available flows to meet the 2009 NMFS BO RPA are defined following compliance with water rights' needs.

- Minimum base flows to optimize available steelhead habitat for adult migration, spawning, and juvenile rearing by water year type, as measured downstream of Goodwin Dam, as specified in Appendix 2-E of the 2009 NMFS BO RPA.
- Fall pulse flows to improve instream conditions.
- Winter instability flows to simulate natural variability in the winter hydrograph and to enhance access to varied rearing habitats.
- Channel forming and maintenance flows in the 3,000 to 5,000 cfs range in above normal and wet years to maintain spawning and rearing habitat quality after March 1 to protect incubating eggs and to provide outmigration flow cues and late spring flows.
- Outmigration flow cues to enhance likelihood of anadromy.
- Late spring flows for conveyance and maintenance of downstream migratory habitat quality in the lowest reaches and into the Delta. Flows also are released to meet the following temperature requirements (see 2009 NMFS BO RPA for exception criteria) to protect steelhead. • October 1 (or initiation of fall pulse flow) through December 31: 56° F at Orange Blossom Bridge

- January 1 through May 31: 52° F at Knights Ferry and below 55° F at Orange Blossom Bridge
- June 1 through September 30: 65° F at Orange Blossom Bridge

Reclamation is also required to evaluate an approach to operate New Melones Reservoir flow releases to achieve floodplain inundation flows and improved freshwater migratory habitat for steelhead. Reclamation also participates in gravel augmentation to improve spawning habitat.

2009 NMFS BO RPA flows described above are often accounted for dedication of CVPIA 3406 (b)(2) water on the Stanislaus River below Goodwin Dam.

C.5 Delta and Suisun Marsh

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

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

Inflows to the Delta occur primarily from the Sacramento River system and Yolo Bypass, the San Joaquin River, and other eastside tributaries such as the Mokelumne, Calaveras, and Cosumnes rivers. In general, in any given year, approximately 77 percent of water enters the Delta from the Sacramento River, approximately 15 percent enters from the San Joaquin River, and approximately 8 percent enters from the eastside tributaries (DWR 1994). The Delta is tidally influenced; rise and fall varies from less than 1 foot in the eastern Delta to more than 5 feet in the western Delta (DWR 2013a).

Water quality in the Delta is highly variable and strongly influenced by inflows from the rivers and by seawater intrusion into the western and central portions of the Delta during periods of low outflow that may be affected by high volumes of export pumping. The concentrations of salts and other materials in the Delta are affected by river inflows, tidal flows, agricultural diversions, drainage flows, wastewater discharges, water exports, cooling water intakes and discharges, and groundwater accretions. Seawater intrusion into the Delta is dependent on tidal conditions, inflows to the Delta, and Delta channel geometry. Delta channels are typically less than 30 feet deep, unless dredged, and vary in width from less than 100 feet to more than 1 mile. Although some channels are edged with riparian and aquatic vegetation, steep mud or rip-rap covered levees border most channels. To enhance flow and aid in levee maintenance, vegetation is often removed from the channel margins. The tidal currents carry large volumes of seawater back and forth through the San Francisco Bay-Delta Estuary with the tidal cycle. The mixing zone of salt and fresh water can shift 2 to 6 miles daily depending on the tides and may reach far into the Delta during periods of low inflow.

The CVP's Delta Division consists of the CVP facilities in and south of the Sacramento-San Joaquin Rivers Delta, including the Delta Cross Channel (DCC), the Contra Costa Canal and Pumping Plants, Contra Loma Dam, Martinez Dam, the C.W. "Bill" Jones Pumping Plant (JPP) (formerly Tracy Pumping Plant), the Tracy Fish Collection Facility (TFCF), the Delta Mendota Canal (DMC), and Delta-Mendota Canal/California Aqueduct Intertie. Collectively these facilities are used to divert, convey and store water for irrigation, M&I, and fish and wildlife uses in the San Joaquin Valley, Santa Clara Valley, Contra Costa County, and San Benito County.

Salinity objectives adopted by the SWRCB were established to protect beneficial uses, including agricultural and municipal water supplies, and fisheries. The CVP and SWP facilities are operated to comply with the requirements that would protect the Delta water quality; operational requirements affect the hydrology in the Delta.

Hydrological conditions in the Delta and Suisun Marsh are substantially affected by structures that route water through the Delta towards the major Delta water diversions in the south Delta, including the CVP Jones Pumping Plant and the SWP Banks Pumping Plant. Structures that change flows in Delta channels include the Delta Cross Channel, the Suisun Marsh Salinity Control Gates, and temporary barriers in the south Delta. Diversion patterns for the major facilities also are regulated to maintain Delta water quality and to protect fish that are listed as threatened or endangered species under ESA in accordance with the SWRCB D-1641, 2008 USFWS BO, and the 2009 NMFS BO. The diversion patterns are implemented to maintain the ratio of exports at the Banks and Jones Pumping Plants to the Delta inflow (known as the E:I ratio); to maintain the ratio of San Joaquin River inflow to exports at the Banks and Jones Pumping Plants (known as the San Joaquin River I:E ratio); and to limit net reverse flow in Old and Middle rivers (known as the OMR criteria). Operations of the Jones and Banks pumping plants are affected by downstream CVP and SWP water demands and reservoir operations in San Luis Reservoir that is jointly used by the CVP and SWP.

To meet the Delta water quality requirements and water rights requirements of users located upstream of the Delta, the CVP and SWP are operated in a coordinated manner in accordance with Coordinated Operation Agreement (COA), as described in the below section.

C.5.1 Delta Cross Channel

The Delta Cross Channel (DCC) is a gated diversion channel in the Sacramento River near Walnut Grove and Snodgrass Slough. When the gates are open, water flows from the Sacramento River through the cross channel to channels of the lower Mokelumne and San Joaquin Rivers toward the interior Delta. The DCC operation improves water quality in the interior Delta by improving circulation patterns of good quality water from the Sacramento River towards Delta diversion facilities.

Reclamation operates the DCC in the open position to (1) improve the movement of water from the Sacramento River to the export facilities at the Banks and Jones Pumping Plants, (2) improve water quality in the southern Delta, and (3) reduce salt water intrusion rates in the western Delta. During the late fall, winter, and spring, the gates are often periodically closed to protect out migrating salmonids from entering the interior Delta. In addition, whenever flows in the Sacramento River at Sacramento reach 20,000 to 25,000 cfs (on a sustained basis) the gates are closed to reduce potential scouring and flooding that might occur in the channels on the downstream side of the gates.

Flow rates through the gates are determined by Sacramento River stage and are not affected by export rates in the south Delta. The DCC also serves as a link between the Mokelumne River and the Sacramento River for small crafts and is used extensively by recreational boaters and fishermen whenever it is open.

C.5.1.1 *Delta Cross Channel Operations*

- The SWRCB D-1641 requires closure of the DCC gates for fisheries protection as follows.
- From November through January, the DCC may be closed for up to 45 days for fishery protection purposes.
- From February 1 through May 20, the gates are closed for fishery protection purposes.
- The gates may also be closed for 14 days for fishery protection purposes during the May 21 through June 15 period.

Reclamation determines the timing and duration of the closures after discussion with USFWS, CDFW, and NMFS. These discussions occur through WOMT as part of the weekly review of CVP and SWP operations.

WOMT typically relies on monitoring for fish presence and movement in the Sacramento River and Delta, the salvage of salmon at the Tracy and Skinner facilities, and hydrologic cues when considering the timing of DCC closures. However, the overriding factors are current water quality conditions in the interior and western Delta. From mid-June to November, Reclamation usually keeps the gates open on a continuous basis. The DCC is also usually opened for the busy recreational Memorial Day weekend, if this is possible from a fishery, water quality, and flow standpoint.

The Salmon Decision Process is used by the fishery agencies and Project operators to facilitate the coordination issues surrounding DCC gate operations and the purposes of fishery protection closures, Delta water quality, and/or export reductions. Inputs such as fish life stage and size development, current hydrologic events, fish indicators (such as the Knight's Landing Catch Index and Sacramento Catch Index), and salvage at the export facilities, as well as current and projected Delta water quality conditions, are used to determine potential DCC closures and/or export reductions. The Salmon Decision Process includes "Indicators of Sensitive Periods for Salmon," such as hydrologic changes, detection of spring-run salmon or spring-run salmon surrogates at monitoring sites or the salvage facilities, and turbidity increases at monitoring sites, which trigger the Salmon Decision Process.

The 2009 NMFS BO RPA Action IV.1.2 requires Reclamation to close the DCC for additional days from October 1 through November 30; December 1 through December 14, unless closures cause adverse impacts on water quality conditions; and December 15 through January 31, if fish are present.

C.5.2 Temporary Agricultural Barriers

DWR initiated the South Delta Temporary Barrier Project (TBP) in 1991. Currently, the Department of Water Resources (DWR) has permits extending the TBP through 2022. The TBP Biological Opinions (BO) issued in 2018 by United States Fish Wildlife Service and the National Marine Fisheries Service to the United States Army Corps of Engineers (USACE) are mandatory requirements of the 5-year 404 permit for construction and removal of the barriers. USACE issued separate permits for both the agricultural barriers and the Head of Old River barrier (HORB) that run through 2022. The California Department of Fish and Wildlife Service (CDFW) issued two permits; the Incidental Take Permit and the Streambed Alteration Agreement, providing coverage through 2021, and finally, the 401 Water Quality Certification from the Regional Water Quality Control Board provides coverage through 2022.

The project consists of four rock barriers across south Delta channels. In various combinations, these barriers improve water levels for agricultural diversions and conditions for San Joaquin River origin salmonids in the south Delta. The existing TBP consists of the seasonal installation and the removal of temporary rock barriers at the following locations:

- Middle River near the Victoria Canal, about 0.5 miles south of the confluence of Middle River, Trapper Slough, and North Canal.
- Old River near Tracy, about 0.5 miles east of the DMC intake.
- Grant Line Canal near Tracy Boulevard Bridge, about 400 feet east of Tracy Boulevard Bridge.
- HOR at the confluence of Old River and San Joaquin River.

The temporary barriers on Middle River (MR), Old River near Tracy (ORT), and the Grant Line Canal (GLC) are referred to as the agricultural barriers (ag barriers) which are flow control facilities designed to improve water levels and circulation for agricultural diversions and are in place during the irrigation season. The installation of the ag barriers is coordinated with the installation of the spring HOR barrier that is authorized by the Central Valley Project Improvement Act because of its benefits to salmon.

If the spring HOR barrier is installed, installation of the ag barriers can begin as early as March 1, the same starting day of the HOR barrier, but the ag barriers must be closed before the closing of the HOR barrier to protect south Delta agricultural diverters from water level impacts associated with reduced flows from the San Joaquin River into Old River. The MR and ORT barriers must be closed before the closing of the HOR barrier; however, the GLC barrier is only partially closed due to the presence of the Delta smelt in the area during the spring. Prior to requesting permission to fully close GLC, a need for full closure must be demonstrated through documented water level complaints. In late May to early June, the USFWS upon evaluating the status of the Delta smelt, will typically grant permission to close the GLC barrier.

The operation of the spring HOR barrier begins on April l 1 and lasts until May 31. Starting on June 1, the removal operation of the HOR barrier begins. If the spring HOR barrier is not installed within a given year—usually due to high flows—the installation of the ag barrier may be delayed until early May. Another installation of the HORB takes place in the fall around mid-September at the discretion of the CA Department of Fish and Wildlife. This installation is to provide increased attractive flows for up-migrating adult salmonids and to increase the dissolved oxygen levels in the Stockton Deep Water Ship Channel. All the barriers must be completely removed by November 30th.

Any rock barrier operating on or after September 15 must be notched by September 15. The ag barriers must be notched to allow for the passage of adult salmon. At the GLC barrier, flashboards would be removed at the southern end of the barrier to form a notch. Detailed barrier installation and operation requirements are summarized in Table C.5-1 through C.5-3

Table C.5-1. HOR barrier installation and operation schedule.

Schedule	Activity
March 1	Spring installation of rock barrier may begin.
April 1-May 31	Full closure and/or operation of the spring barrier may occur.
	If a barrier at HOR is installed and the GLC barrier is breached due to Delta Smelt concerns OR: • the GLC barrier cannot be closed when the need is clearly demonstrated by DWR, • the HOR barrier must be breached and removed as soon as possible, unless otherwise instructed by the CDFW, NMFS and FWS.
May 15-May 31	Full closure and/or operation may continue, at the discretion of the CDFW, NMFS and FWS.
On or after September 1	Fall barrier installation may begin at the discretion of CDFW, NMFS and FWS.
November 30	Barrier must be completely removed.

Table C.5-2. Agricultural barrier installation and operation schedule, for years when the spring HOR barrier is not installed

	MR	ORT	GLC
May 1	Installation may begin.	Installation may begin.	Installation may begin.
May 15 to May 31	Full operation and closure may occur if: • the need for MR full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data shall be provided to the DFG, NMFS and USFWS one week in advance of closing the flapgates).	Full operation and closure may occur if: • the need for ORT full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data shall be provided to the DFG, NMFS and USFWS one week in advance of closing the flapgates).	Full operation and closure may occur if: the need for GLC full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data shall be provided to the DFG, NMFS and USFWS two weeks in advance of closing the flapgates and center sections of the barrier). AND: the incidental take concern level for delta smelt at the SWP/CVP facilities has not been reached. If the incidental take concern limit is reached at the SWP/CVP facilities and if reductions in project exports are determined to be inadequate to protect delta smelt, the DFG, NMFS and USFWS may require the flap gates to be tied in the open position and the center section to be removed.

	MR	ORT	GLC
June 1 to November 30	Full operation and closure may occur. Barrier elevation can be raised from 3.3 feet NAVD to 4.3 feet NAVD with DFG and USFWS approval.	Full operation and closure may occur.	Full operation and closure may occur. If the incidental take concern limit is reached at the SWP/CVP facilities and if reductions in project exports are determined to be inadequate to protect delta smelt, the DFG, NMFS and USFWS may require the flap gates to be tied in the open position and the center section to be removed.
September 15	Barrier must be notched to allow passage of adult salmon.	Barrier must be notched to allow passage of adult salmon.	Barrier must have enough flashboards removed to allow passage of adult salmon.
November 30	Barrier must be completely removed.	Barrier must be completely removed.	Barrier must be completely removed.

Table C.5-3. Agricultural barrier installation and operation schedule, for years when the spring HOR barrier is installed

	MR	ORT	GLC
May 1	Installation may begin.	Installation may begin.	Installation may begin.
May 15 to May 31	Full operation and closure may occur if: • the need for MR full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data shall be provided to the DFG, NMFS and USFWS one week in advance of closing the flapgates).	Full operation and closure may occur if: • the need for ORT full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data shall be provided to the DFG, NMFS and USFWS one week in advance of closing the flapgates).	Full operation and closure may occur if: the need for GLC full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data shall be provided to the DFG, NMFS and USFWS two weeks in advance of closing the flapgates and center sections of the barrier). AND: the incidental take concern level for delta smelt at the SWP/CVP facilities has not been reached. If the incidental take concern limit is reached at the SWP/CVP facilities and if reductions in project exports are determined to be inadequate to protect delta smelt, the DFG, NMFS and USFWS may require the flap gates to be tied in the open position and the center section to be removed.
June 1 to November 30	Full operation and closure may occur. Barrier elevation can be raised from 3.3 feet NAVD to 4.3 feet NAVD with DFG and USFWS approval.	Full operation and closure may occur.	Full operation and closure may occur. If the incidental take concern limit is reached at the SWP/CVP facilities and if reductions in project exports are determined to be inadequate to protect delta smelt, the DFG, NMFS and USFWS may require the flap gates to be tied in the open position and the center section to be removed.

	MR	ORT	GLC
September 15	Barrier must be notched to allow passage of adult salmon.	Barrier must be notched to allow passage of adult salmon.	Barrier must have enough flashboards removed to allow passage of adult salmon.
November 30	Barrier must be completely removed.	Barrier must be completely removed.	Barrier must be completely removed.

In addition to allowing construction and removal of the barriers, the permits also give DWR coverage for scientific studies that may take endangered fish species. According to NMFS and USFWS BO requirements, actions for each upcoming year—including barrier type, timing, and any scientific studies planned—must be submitted to the USACE by October 1 of each year. USACE requires NMFS and USFWS to append the actions for the upcoming year to the current BOs.

In 2009 and 2010, an experimental non-physical barrier was installed in lieu of the HOR spring rock barrier with the intention of deterring out-migrating juvenile salmonids from entering Old River. This experimental barrier is a patented technology using sound and light as a deterrent. Although high flows prohibited installation of the non-physical barrier in 2011, a without-barrier study of predator behavior was conducted. In 2012, a rock barrier with eight culverts was installed in the spring. The rock barrier with eight culverts is expected to be installed each spring unless installation is prevented by high flows in the San Joaquin River, or if new studies conclude the spring HOR barrier does not provide salmonid protections previously assumed.

To improve water circulation and quality, DWR coordinated with the South Delta Water Agency and Reclamation in 2007 to manually tie open the culvert flap gates at the Old River near Tracy barrier to improve water circulation and untie them when water levels fell unacceptably. This operation is expected to continue in subsequent years as needed to improve water quality. In addition, DWR consulted with USACE and received USFWS and NMFS approval to raise the Middle River weir height by 1 foot. The weir height can be raised during the summer irrigation season only after the Delta smelt concerns have passed. The requested modification was approved late in the 2010 irrigation season. The weir height has been raised every year since 2010 except in 2011 and 2017 due to high flow conditions in the south Delta. Upon notification and analysis of effects, current environmental permits allow for changes in the type and numbers of culverts through the barrier as well as weir elevations.

In the absence of permanent operable gates to replace the rock barriers, the TBP will continue to be planned and permitted. Computer model forecasts, real-time monitoring, and coordination with local, state, federal agencies, and stakeholders will help determine if the temporary rock barriers operations need to be modified during the transition period.

C.5.2.1 *Conservation Strategies and Mitigation Measures*

DWR has complied with the various measures and conditions required by regulatory agencies under past and current permits to avoid, minimize, and compensate for the TBP impacts. An ongoing monitoring plan is implemented each year that the barriers are installed, and an annual monitoring report is prepared to summarize the activities. The monitoring elements include fisheries monitoring, water quality analysis, salmon smolt survival investigations, barrier effects on SWP and CVP entrainment, Swainson’s Hawk monitoring, water elevation, water quality sampling, and hydrodynamic modeling.

The 2008 NMFS BO for the TBP requires a fishery monitoring program using biotelemetry techniques to examine the movements and survival of juvenile salmon and juvenile steelhead through the channels of the south Delta. Further the NMFS Biological Opinion for the long-term operations of the CVP and SWP required an evaluation of salmonid smolt survival and predation prior to requesting consultation for permanent operable gates. Information gained as part of the 2009 pilot study was used to develop the full-scale study that started in 2010. 2011 was the third and final year of the mandated studies. The study has been finalized and will be submitted to NMFS in late 2018. Additional studies of predatory fish behavior at the Head of Old River began in 2011 as required by CDFW. Studies continued and included a multi-year study lead by NMFS that looked at the predator and prey interactions on the San Joaquin River near the Head of Old River. The study showed that predatory fish removals did not significantly improve salmon out-migration survival in the stretch of the San Joaquin River between the Head of Old River and Stockton.

The current CDFW incidental take permit provides California Endangered Species coverage through 2021 and requires that all impacts on California Endangered Species be fully mitigated. This permit requires mitigation for all shallow water habitat impacts and required the purchase of 2.49 acres of shallow water habitat credits. TBP purchased a total of 3.0 acres from Liberty Island Holdings I, LLC for salmonid/smelt restoration conservation credits to satisfy anticipated mitigation requirements. The TBP has been mitigating for impacts over many years and in addition to numerous habitat bank credit purchases, DWR operates fish screens to offset TBP impacts at Sherman Island.

C.5.3 Delta Water Diversions

Water diversions in the Delta include the CVP Jones Pumping Plant, the SWP Banks Pumping Plant, the CVP Contra Costa Canal Pumping Plant at Rock Slough, the SWP Barker Slough Pumping Plant for the North Bay Aqueduct, Contra Costa Water District intakes on Mallard Slough, Old River, and Victoria Canal, and over 1,800 municipal and agricultural diversions for in-Delta use (DWR 2010). Also included are the City of Stockton Municipal Area (COSMA) intake and the Freeport Regional Water Authority intake.

Delta channels have been modified to allow transport of Delta inflow to the diversions throughout the Delta, including the CVP and SWP south Delta intakes, and to reduce the effects of pumping on the direction of flows and salinity intrusion within the Delta. The conveyance of water from the Sacramento River southward through the Delta to the CVP and SWP south Delta intakes is aided by the Delta Cross Channel (DCC), a constructed, gated channel that conveys water from the Sacramento River to the Mokelumne River.

C.5.3.1 *Diversion Facilities*

C.5.3.1.1 SWP North Bay Aqueduct – Barker Slough Intake

The Barker Slough Pumping Plant (BSPP) diverts water from Barker Slough into the NBA for delivery to the Solano County Water Agency (SCWA) and the Napa County Flood Control and Water Conservation District (Napa County FC&WCD) (NBA water contractors).

The NBA intake is located approximately 10 miles from the main stem Sacramento River at the end of Barker Slough. Water quality in Barker Slough becomes degraded during winter and spring rainfall events. The Barker Slough drainage basin is characterized by grazing lands, erodible soils, and urban uses. Rainfall runoff can include elevated levels of coliform bacteria, organic matter, turbidity, and pollutants. The water is costly to treat to meet drinking water standards.

C.5.3.1.2 Clifton Court Forebay

CCF is a 31 TAF reservoir located in the southwestern edge of the Delta, about 10 miles northwest of the city of Tracy. CCF provides storage to allow off-peak pumping of water exported through Banks Pumping Plant, moderates the effect of the pumps on the fluctuation of flow and stage in adjacent Delta channels, and collects sediment before it enters the California Aqueduct. Diversions from Old River into CCF are regulated by five radial gates.

Clifton Court Forebay Aquatic Weed and Algal Bloom Control Program

Excessive growth of submerged aquatic weeds in CCF can cause severe head loss and pump cavitation at Banks Pumping Plant when the stems of rooted plants break free, combine into “mats,” and accumulate on the primary and secondary trashracks. This mass of uprooted and fragmented vegetation essentially forms a watertight plug at the trashracks and vertical louver array. The resulting blockage necessitates a reduction in the water pumping rate to prevent potential equipment damage through pump cavitation. Cavitation creates excessive wear and deterioration of the pump impeller blades. Excessive floating weed mats also block the passage of fish into the Skinner Fish Facility, thereby reducing the efficiency of fish salvage operations. Algal blooms have occurred in CCF that produce compounds that cause unpleasant tastes and odors to finished drinking water.

Mechanical methods are implemented to manually remove aquatic weeds. A debris boom and an automated weed rake system continuously remove weeds entrained on the trashracks. During high weed load periods in late summer and fall when the plants senesce and fragment, boat-mounted harvesters are operated on an as-needed basis to remove aquatic weeds in the Forebay and the intake channel upstream of the trashracks and louvers. The objective is to decrease the weed load on the trashracks and to improve flows in the channel. Effectiveness is limited due to the sheer volume of aquatic weeds and the limited capacity and speed of the harvesters. Harvesting rate for a typical machine ranges from 0.5 to 1.5 acres per hour or 4 to 12 acres per day. Actual harvest rates may be lower due to travel time to off-loading site, unsafe field conditions such as high winds, and equipment maintenance.

DWR applies copper-based herbicides to control aquatic weeds and algal blooms on an as-needed basis dependent upon the level of vegetation biomass or concentration of taste and odor compounds. Aquatic weed treatment areas are typically about 900 acres, and no more than 50% of the 2,180 total surface acres.

Treatment areas for cyanobacteria blooms have varied considerably in past years. Treatment area is based on the distribution of the benthic algal bloom.

Applications of copper herbicides are applied at a concentration of 1 ppm. Applications for algal control are applied at a concentration of 0.2 to 1 ppm. Treatment is only permitted from July 1 to August 31.

Clifton Court Forebay Predation Studies

DWR has conducted the following studies on predation at Clifton Court Forebay:

- Clifton Court Forebay Predation Study Project Report (Wunderlich 2015a)
- 2013 CCF Predation Study Annual Progress Report (Wunderlich 2015b)
- 2014 CCF Predation Study Annual Progress Report (Wunderlich 2016)
- 2015 CCF Predation Study Annual Progress Report (Wunderlich 2017)
- 2016 CCF Predation Study Annual Progress Report (Wunderlich 2018)

- Quantification of Pre-Screen Loss of Juvenile Steelhead in Clifton Court Forebay (Clark et al 2009)
- 2007-2008 Fish Release Site Predation Study ("CHTR Element 2") Report (Miranda et al 2010)
- 2016 CCF Predator Reduction Electrofishing Study Annual Report (Cane 2016)
- 2017 CCF Predator Reduction Electrofishing Study Annual Report (Cane 2017)
- 2018 CCF Predator Reduction Electrofishing Study Annual Report (Wilder et al 2018)

Prescreen Loss

Pre-screen loss estimates for Chinook Salmon developed in the past 10 years are largely consistent with the historical studies outlined in Gingras (1997) which ranged from 63-99%. A summary of the findings of several contemporary studies are outlined below:

- Quantification of Pre-Screen Loss of Juvenile Steelhead in Clifton Court Forebay (Clark et al 2009)
    - Steelhead: This study calculated pre-screen loss rates from paired releases of PIT and acoustic tagged fish released at the CCF radial gates and at the Skinner Fish Facility trash rack. Pre-screen loss was calculated as 82±3% and 78±4% (when adjusted for emigration from CCF).
- Pre-screen loss and fish facility efficiency for Delta Smelt at the South Delta's State Water Project, California (Castillo et al 2012)
    - Delta Smelt: This study used releases of cultured, Calcein-marked juvenile and adult Delta Smelt released at the CCF radial gates and at the entrance to the Skinner Fish Facility. Pre-screen loss of adult Delta Smelt ranged from 89.9% to 100%. Pre-screen loss of juvenile Delta Smelt was 99.9%.
- 2013 CCF Predation Study Annual Progress Report (Wunderlich 2015)
    - Fall-run Chinook Salmon: This study utilized releases of PIT tagged, fall-run Chinook Salmon released at the radial gates and the Skinner Fish Facility in April and May of 2013. A pre-screen loss rate of 81.14% was reported, ranging from 41% to 100%.
- Preliminary SWP Chinook Salmon Survival Estimates for Water Year 2016 (Miranda 2016)
    - Chinook Salmon: This study utilized PIT tagged late-fall and fall run Chinook Salmon released at the CCF radial gates from January through May of 2016. Monthly estimates of mean Pre-screen Loss ranged from 75% to 91%, with a season mean estimate of 91%.
- Skinner Evaluation and Improvement Study 2017 Annual Report (Miranda 2019)
    - Chinook Salmon. This study utilized releases of PIT and acoustic tagged fall and late-fall run Chinook Salmon released at the CCF radial gates and at the head of the Skinner Fish Facility. Pre-screen loss was estimated as 77.16% for all races combined. Pre-screen loss was estimated as 56.07% (26.1% to 88.5%) for late-fall run Chinook Salmon, and 92.1% (92.1% to 98.5%) for fall run Chinook Salmon.

Measures to Reduce Mortality of ESA-Listed Fish Species

DWR plans to continue implementation of projects to reduce mortality of ESA listed fish species in response to the National Marine Fisheries Service (NMFS) letter dated April 9, 2015, requiring that the California Department of Water Resources (DWR) immediately implement interim measures to improve predator control until an acceptable alternative can be implemented. These interim measures that could be implemented include: (a) electro-shocking and relocating predators; (b) controlling aquatic weeds; (c) implementing the "Predatory Fish Relocation Study;" and (d) operational changes when listed species are present.

DWR recently completed work at the Curtis Landing Fish Release Site, the Fish Science Building and Warehouse, and two new fish release sites as part of its ongoing efforts to improve the survival of ESA listed and other Delta fish species. DWR also constructed new fish friendly count and transfer buckets, added an epoxy coating to the holding tanks, and refurbished the holding tank screens to prevent fish losses.

C.5.3.1.3 SWP John E. Skinner Delta Fish Protective Facility

The John E. Skinner Delta Fish Protective Facility is located west of the CCF, 2 miles upstream of the Banks Pumping Plant. The Skinner Fish Facility screens fish away from the pumps that lift water into the California Aqueduct. Large fish and debris are directed away from the facility by a 388-foot long trash boom. Smaller fish are diverted from the intake channel into bypasses by a series of metal louvers, while the main flow of water continues through the louvers and towards the pumps. These fish pass through a secondary system of screens and pipes into seven holding tanks, where a subsample is counted and recorded. The salvaged fish are then returned to the Delta in oxygenated tank trucks.

SWP John E. Skinner Delta Fish Protective Facility Operations

Louver Operations

Louver efficiency estimates for Chinook Salmon developed in the past 10 years are largely consistent with the findings of the original testing program for the Skinner Fish Facility (Skinner 1974) and used by DFW to calculate loss. A summary of the findings of several contemporary studies are outlined below:

- Quantification of Pre-Screen Loss of Juvenile Steelhead in Clifton Court Forebay (Clark et al 2009)
  - Steelhead: This study determined efficiency for steelhead trout using releases of PIT tagged steelhead released at the Skinner Fish Facility trash rack. The study reported two estimates of efficiency; 74% (17 to 100 %) and 82% (19 to 100%). The latter value incorporates an estimate of emigration from the study area (e.g. "swim out") which was documented in the study.
- Pre-screen loss and fish facility efficiency for Delta Smelt at the South Delta's State Water Project, California (Castillo et al 2012)
  - Delta Smelt: This study used releases of cultured, Calcein-marked juvenile and adult Delta Smelt released at the Skinner Fish Facility trash rack. Adult Delta Smelt efficiency was reported to range from 36% to 89%, while juvenile efficiency ranged from 24% to 30%.
- Skinner Evaluation and Improvement Study 2017 Annual Report (Miranda 2019)
  - Chinook Salmon: This study utilized releases of PIT and acoustic tagged, fall run and late-fall run Chinook Salmon released at the Skinner Fish Facility when the radial gates were open from January through June. Pre-screen loss was estimated to be 56.07% (ranging 26.1% to 88.5%) for late-fall run and 92.1% (ranging 92.1% to 98.5%) for fall run Chinook Salmon. Whole facility efficiency was reported as 81.7% (ranging 77.9% to 86.2%) and 55.0% (ranging 54.3% and 55.7%) for "Salmon" and "Striped Bass" Operating Criteria, respectively.

The Skinner Fish Facility was built with a modular design including multiple primary louver bays that can be isolated, two secondary channels, and two holding tank buildings. Under most circumstances, this design effectively mitigates fish losses as a result of routine maintenance and cleaning, and mechanical breakdowns. Maintenance, cleaning, and breakdowns normally result in a reduction in overall available capacity rather than exports without salvage.

However, in the event of an unplanned outage (e.g. a power loss), attempts are made to immediately rectify the issue through changes in either the configuration of the facility (e.g. changing bays) or backup systems (e.g. alternate power source) and CDFW is notified. In the event of an unplanned outage lasting greater than 1 hour, CDFW is immediately consulted and/or Banks exports may be temporarily halted.

Planned outages are typically scheduled to avoid periods of unscreened water export. For example, major maintenance activities are scheduled in the spring during a 1-week complete shutdown of Banks Pumping Plant coinciding with NMFS 2009 BO RPA Action IV.2.1 (previously VAMP). During other periods, export capacity of the facility is reduced accordingly.

The duration and frequency of louver cleaning operations fluctuates significantly due to a number of factors including pumping schedule, high fish counts, flow rates, debris loads, environmental factors, and staffing. In general:

- Cleaning of individual primary louver bays is performed weekly. It takes a minimum of 2 hours to clean each bay, and bays are isolated during cleaning to prevent fish losses. Cleaning is performed by lifting individual louver panels using a gantry crane and pressure washing them from both front and back.
- Cleaning of the secondary channels is performed twice weekly and is also used as a predator flush. It generally takes 30-60 minutes to clean each secondary bay. During cleaning, each channel is dewatered, and the louver or screen panels are pressure washed from each side using a fire hose. After the panels have been washed, the primary bypass valve(s) at the head each bay are opened rapidly to flush predators and debris into a holding tank for removal.

Operations and Monitoring

Approximately 52 different species of fish are entrained into the Skinner Fish Facility (and the Tracy Fish Collection Facility, discussed below) each year; however, the total numbers are significantly different for the various species salvaged. Also, it is difficult, if not impossible, to determine exactly how many safely make it all the way to the collection tanks, to be transported back to the Delta. Hauling trucks, used to transport salvaged fish to release sites, inject oxygen and contain an eight parts per thousand salt solution to reduce stress.

When south Delta hydraulic conditions allow, and within the original design criteria for the fish collection facilities, the louvers are operated based on the Biological Opinion objectives of achieving water approach velocities: for striped bass velocities of as close to 1 foot per second (ft/s) as possible from May 15 through October 31, and for salmon velocities of approximately 3 to 3.5 feet per second (ft/s) from November 1 through May 14.

Fish passing through the facility are sampled at intervals of 30 minutes every 2 hours year round. Fish observed during sampling intervals are identified by species, measured to fork length, examined for marks or tags, and placed in the collection facilities for transport by tanker truck to the release sites in the North Delta away from the pumps. In addition, fish collection facility personnel monitor for the presence of spent female Delta Smelt in anticipation of expanding the salvage operations to include sub-20 millimeter (mm) larval Delta Smelt detection.

Fish collection facility personnel monitor for the presence of spent female Delta Smelt by euthanizing all adult Delta Smelt that are collected in the 30-minute fish count, determine the gender and the gonadal or sexual maturation stage of the Delta Smelt, and determining if the eggs have reached Stage IV, the stage when eggs are ready for release (0.9-10 mm in diameter and easily stripped). Stages V (i.e. post-vitellogenic stage) and VI (i.e. post-ovulatory or "spent" stage) are expected soon after Stage IV observation. Stages are determined and reported real-time when a biologist is present or the following morning after smelt detection and collection. Stage or gonad maturation is determined using egg stage descriptions from Mager (1996).

Larval smelt sampling at the fish collection facilities commences once a trigger is met (detection of a spent female at CVP/SWP being one of three triggers). Fish count screen with a 2.4 mm mesh size opening is replaced with one that has a mesh size of 0.5 mm in order to retain larval fish. Sampling is done 4 times a day (04:00, 10:00, 16:00, 22:00) and all larval smelt are identified to species and reported the day after collection.

<u>Survival and Mortality</u>

The effects of Collection, Handling, Trucking, and release operations have been evaluated in a number of studies at the SDFPF, as outlined below. No attempt has been made to quantify post-release survival due to logistical challenges and because it likely fluctuates wildly based on a number of factors including, but not limited to, the number of fish being released, season, and frequency of release.

- Effects on Handling and Trucking on Chinook Salmon, Striped Bass, American Shad, Steelhead Trout, Threadfin Shad, and White Catfish Salvaged at the John E. Skinner Delta Fish Protective Facility (Raquel 1989)
    - Chinook Salmon: This study found that survival rates for Chinook Salmon were never less than 98% and in most cases was 100%. The loss equation used by CDFW to calculate SWP losses utilizes this 2% value.
    - Steelhead trout: Showed no detrimental effects from the handling and trucking process.
- Acute mortality and injury of Delta Smelt Associated with Collection, Handling, Transport, and Release at the State Water Project Fish Salvage Facility (Morinaka 2013)
    - Adult Delta Smelt: Mean survival rates at 0 and 48 hours after exposure to the CH only or full CHTR process were high, averaging above 93%. No significant differences in survival were detected at 48 hours among control, CH, and CHTR groups.
- Evaluation of Injury and Mortality in a Fish Release Pipe (Miranda and Padilla 2010)
    - Chinook Salmon: This study found that survival of juvenile Chinook Salmon exposed to a mock salvage release was 99.2%, 97.4%, and 98.4% in trials with no debris, moderate debris, and heavy debris, respectively. There was no significantly detectable effect on survival from the release process.
    - Adult Delta Smelt: This study found that survival of Adult Delta Smelt exposed to a mock salvage release was 98.7%, 97.1%, and 95.2% in trials with no debris, moderate debris, and heavy debris, respectively. There was no significantly detectable effect on survival from the release process.

C.5.3.1.4 SWP Harvey O. Banks Pumping Plant

The Harvey O. Banks (Banks) Pumping Plant is in the south Delta, about 8 miles northwest of Tracy and marks the beginning of the California Aqueduct. The plant provides the initial lift of water 244 feet into the California Aqueduct by means of 11 pumps, including two rated at 375 cfs capacity, five at 1,130 cfs capacity, and four at 1,067 cfs capacity. Even though the installed capacity of Banks Pumping Plant is 10,670 cfs, the maximum conveyance capacity of the California Aqueduct limits the pumping rate to 10,300 cfs.

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

Diversion Increase During July, August, and September

During the months of July, August, and September, the maximum allowable daily diversion rate into CCF was increased from 13,870 acre-feet to 14,860 acre-feet and 3-day average diversions from 13,250 acre-feet to 14,240 acre-feet (500 cfs per day equals 990 acre-feet per day). The increase in diversions was originally permitted in 2000 and was subsequently extended through 2020. The purpose of this diversion increase into CCF for use by the SWP is to recover export reductions made due to actions taken to benefit fisheries resources. The increased diversion rate does not result in any increase in water supply deliveries above those that would occur in the absence of the increased diversion rate. This increased diversion over the 3-month period could result in an amount not to exceed 90 TAF each year.

Variations to hydrologic conditions coupled with regulatory requirements may limit the ability of the SWP to fully utilize increased diversion rates. Also, facility capabilities may limit the ability of the SWP to fully utilize the increased diversion rate.

Implementation of this action is contingent on meeting the following conditions:

- The increased diversion rate would not result in greater annual SWP water supply allocations than would occur in the absence of the increased diversion rate. Water pumped due to the increased capacity would only be used to offset reduced diversions that occurred or would occur because of ESA or other, similar protective actions taken to benefit fisheries.
- Use of the increased diversion rate would be in accordance with all terms and conditions of existing BOs governing SWP operations.
- All three temporary agricultural barriers (Middle River, Old River near Tracy and Grant Line Canal) must be in place and operating when SWP diversions are increased.
- Prior to the start of, or during any time when the SWP has increased its diversion rate between July 1 and September 30, if the combined salvage of listed fish species reaches a level of concern, the Data Assessment Team (DAT) will convene to assess the need to modify the planned increase in SWP diversion rates. If DAT does not concur with the continued use of the increased SWP diversion rate, then the issue will be elevated to the Water Operations Management Team (WOMT). The WOMT will consider the DAT assessment as to whether the use of the SWP increased diversion rate should continue or be suspended. If the WOMT is unable to reach agreement on the operation, the relevant fish regulatory agency will determine whether the 500cfs increased diversion is or continues to be implemented.

C.5.3.1.5 CVP Jones Pumping Plant and Tracy Fish Collection Facility

The CVP's Jones Pumping Plant, located about 5 miles north of Tracy, has six available pumps. The Jones Pumping Plant has a physical capacity of approximately 5,200 cfs and sits at the end of an earth-lined intake channel about 2.5 miles long. Because of limited capacity in the Delta Mendota Canal, the facilities in which water pumped at Jones flows, the current, maximum pumping capacity at Jones is approximately 4,600 cfs. That capacity is available when Reclamation accesses the Delta-Mendota Canal/California Aqueduct Intertie, Jones Pumping Plant can be operated to its permitted capacity of 4600 cfs.

The TFCF is located in the south-west portion of the Delta at the head of the intake channel for the Jones Pumping Plant. The TFCF uses behavioral barriers consisting of primary louvers and four rotating traveling screens aligned in a single row 7 degrees to the flow of the water, to guide entrained fish into holding tanks before transport by truck to release sites at the confluence of the Delta. The TFCF was designed to handle smaller fish (<200 millimeters [mm]) that would have difficulty fighting the strong pumping plant induced flows since the intake is essentially open to the Delta and also impacted by tidal action.

The primary louvers are located in the primary channel just downstream of the trashrack structure. The traveling water screen is located in the secondary channel. The louvers allow water to pass through onto the pumping plant but the openings between the slats are tight enough and angled against the flow of water so as to prevent most fish from passing between them and to, instead, enable the fish to enter one of four bypass entrances along the louver arrays.

The “Operations and Monitoring” discussion for the Skinner Fish Facility also applies to the TFCF. When south Delta hydraulic conditions allow, and within the original design criteria for the TFCF, the louvers are operated based on the Biological Opinion objectives of achieving water approach velocities: for striped bass velocities of approximately 1 foot per second (ft/s) from May 15 through October 31, and for salmon velocities of approximately 3 feet per second (ft/s) from November 1 through May 14.

CDFW is leading studies of fish survival during the collection, handling, transportation, and release process, examining Delta Smelt injury, stress, survival, and predation. Thus far it has presented initial findings at various interagency meetings (Interagency Ecological Program [IEP], Central Valley Fish Facilities Review Team, and American Fisheries Society) showing relatively high survival and low injury. DWR has concurrently been conducting focused studies examining the release phase of the salvage process including a study examining predation at the point of release and a study examining injury and survival of Delta Smelt and Chinook Salmon through the release pipe. Based on these studies, improvements to release operations and/or facilities, including improving fishing opportunities in Clifton Court Forebay (CCF) to reduce populations of predator fish, have been implemented.

CDFW and USFWS evaluated pre-screen loss and facility/louver efficiency for juvenile and adult Delta Smelt at the Skinner Fish Facility of the SWP. DWR also conducted pre-screen loss and facility efficiency studies for steelhead and has ongoing studies to evaluate losses for Chinook Salmon.

Tracy Fish Collection Facility Operations

<u>Louver Operations</u>

Louver Efficiency

Louver efficiency at the Tracy Fish Collection Facility (TFCF) is dependent on the flow and velocities, fish species, and the fish size (life stage). The number of pumps (units) running at the Jones Pumping Plant (JPP) dictates the flow and velocity at the TFCF. There are 6 units at JPP but a maximum of 5 can used; each unit increases the velocity through the TFCF primary channel about 0.5 ft/sec.

For juvenile Chinook Salmon, the most recent whole facility efficiency evaluations completed using acoustic tag telemetry suggests that primary louver efficiency ranges from 50-100% with an average of approximately 88.7% (Karp et al. 2017, Wu et al. in progress). At higher pumping regimes of 4-5 JPP units, for juvenile Chinook Salmon, louver efficiency was high at 71.4-100 % (Karp et al. 2017).

For adult Delta Smelt, louver efficiency is 13% at high pumping regime of 5 units (3 ft/sec; Bowen et al. 2004). At lower pumping regime of 1 unit (~1 ft/sec), the louver efficiency improves to 34.2-82.5% (Bowen et al. 2004; Bridges et al., 2019 in press).

For juvenile Delta Smelt (32–40 mm FL), louver efficiency as low as 22% was observed in a bulk fish release study in 2010 (Bridges, unpublished data). Furthermore, in a comparison of wild non-smelt larval salvage at varying secondary channel velocities (1 vs 3 ft/sec) in 2012, more larvae were diverted by the louvers at the slower velocity (Reyes, unpublished data).

The equations used to calculate salmon louver efficiency at the TFCF were based on unpublished findings calculated almost 5 decades ago at Skinner and were not based on any work done at the TFCF. Below is the salmon loss calculation containing a louver efficiency estimate for Chinook salmon less than 101 mm FL and greater than 101 mm FL (Aasen 2013):

- If Length < 101 mm → ENCOUNT = SALVAGE/EFF1;
- If Length > 100 mm → ENCOUNT = SALVAGE/EFF2;
- EFF1 = 0.630 + [0.0494 * (Primary Channel Flow /[Primary Channel Depth*Width])]
- EFF2 = 0.568 + [0.0579 * (Primary Channel Flow /[Primary Channel Depth*Width])]

Louver Cleaning Procedures

Loss due to cleaning is not quantified in the current loss calculation. However, TFCF operators estimate that approximately 6.7% of juvenile Chinook Salmon that encounter the louvers are lost through the louvers when they are lifted for cleaning and approximately 33.3% of louver loss occurs during louver cleaning activity (Karp et al. 2017). This value, however, is preliminary and needs further verification. A TFFIP study plan is currently being developed to study the amount of loss occurring during louver cleaning.

The current primary louver cleaning procedures and operations involve lifting each individual louver panel, 36 total, out of the water in order to spray wash the debris. Generally, each primary louver panel is lifted and lowered back into place three times per day (generally at 0600-0800, 1400-1600, and 2300-0100), although frequency of cleaning may be increased or decreased according to pumping rate and debris loads (details in the next paragraph). It takes approximately 3-7 minutes to lift, spray clean, and lower each louver panel back into place. While export pumping may be reduced to address damaged louver panels, issues during cleaning, or other maintenance scenarios where facilities are not capable of effectively salvaging fish, complete shutdown of pumping usually does not occur due to issues related to the primary louvers.

Although no official SOP exists specifying the timing of louver cleaning, TFCF operators follow certain “guidelines”:

- At 5 JPP units, louvers are cleaned before the incoming tide as much as possible. The morning day shift usually begin cleaning as soon as they start their work, around 0600. During high debris periods, operators monitor differentials and clean before any problems arise. At a minimum, all 36 louver panels are cleaned 2-3 times a day but during heavy debris loads, operators clean 3-6 times a day.

- At 2-4 JPP units, operators determine when to clean and making sure the louvers do not reach 1 ft differential.
- At 1 JPP unit, operators will normally clean periodically during the incoming tide.

Generally, each primary louver panel is lifted, sprayed clean, and lowered back into place three times per day (generally 0600-0800, 1400-1600, and 2300-0100), although frequency of cleaning may be increased or decreased according to pumping rate and debris loads. As described above, cleaning frequency can be as high as 3-6 times per day during 5-unit JPP operation and during high debris periods. The 2018 louver cleaning data (Table C.5-4) suggests less frequent cleaning is required in early summer (low averages of 60 minutes per day) and much higher during the winter months (high averages of 440 minutes per day). This means that there is a louver panel lifted 1-7.5 hours per day depending on season, pumping rates, and debris loads.

Table C.5-4. Primary Louver Cleaning Time (2018)

Month	Average Daily Cleaning Time (minutes)
January	240
February	131
March	112
April	64
May	76
June	138
July	274
August	310
September	200
October	440
November	270
December	370

Secondary bypasses are not cleaned, although they are shut during cleaning of the primary louvers to prevent excessive debris from entering the holding tanks. When operators clean primary louver panels 1-9 (upstream-downstream) they close secondary bypass #1. When operators clean primary louver panels 10-18, operators close secondary bypass #2, while secondary bypass #3 is closed when they clean louver panels 19-27, and secondary bypass #4 is closed when they clean panels 28-36.

Prescreen Loss

"Pre-screen loss rate" is defined as "the rate of loss to entrained salmon during movement from the trash racks to the primary louvers" (Aasen 2013). In essence, the "pre-screen loss rate" is the predation rate within the primary channel. Although Chinook Salmon mortality has been observed in front of the TFCF trash rack (Vogel 2010), this mortality is not included in the pre-screen loss calculation since this is outside of the area between the trash rack and primary louvers. Currently, a 15 percent pre-screen loss rate due to predation is an agreed upon placeholder value (Reyes, personal communication) but is yet to be fully verified. For this placeholder, the predation rate within the primary channel is currently being verified with the use of Predation Detection Acoustic Tags (PDAT).

Prescreen loss at the TFCF is dependent on fish species, fish size (life-stage), and predator load within the primary channel. In addition, it appears that prescreen loss may be correlated with pumping rates (water velocity) and/or turbidity, although more data needs to be collected to adequately determine these relationships. Data from Karp et al. (2017) and Wu et al. (In Progress) suggest that prescreen loss ranges from 0-40% for juvenile Chinook Salmon. Low estimates of pre-screen loss (assuming all unknown fates in the primary channel are non-participants) from these studies average approximately 14.0%, while high estimates of prescreen loss (assuming all unknown fates in the primary channel are losses to predation) average approximately 15.9%. Therefore, preliminary results indicate that the predation rate (or prescreen loss) may be close to the 15 percent placeholder value mentioned above (Karp et al. 2017, Wu et al., in progress).

In an experiment several years ago (to be published this year as Bridges et al. 2019), Reclamation removed (by gillnetting) all predators from the primary channel and improved facility efficiency for Delta Smelt by 16.7% from 9.3% to 26%. This improvement of 16.7% is due almost entirely to the removal of predators.

Survival and Mortality

Salvage of fish occurs at the TFCF 24 hours per day, 365 days per year. Fish are salvaged in flow-through holding tanks (6.1-m diameter, 4.7-m deep) that provide continuous flows of water (Sutphin and Wu 2008). Fish are maintained in these holding tanks for 8-24 hours, depending on the species of fish that are being salvaged, the number of fish salvaged, and debris load. The number of fish that are salvaged in TFCF holding tanks is generally estimated by performing a 30 minute fish-count subsample every 120 minutes (2 hours). The number of each species of fish collected in the subsample is determined and then multiplied by 4 (120 pumping minutes/30 minute fish-count subsample = expansion factor of 4) to estimate the total number of each species of fish, as well as the total number of fish, that were salvaged in TFCF holding tanks during the 120 minute period. Pumping minutes and fish-count minutes could potentially deviate from 120 minutes and 30 minutes, respectively, which would change the expansion factor used to estimate total fish salvage.

If no Chinook Salmon, Steelhead, or Delta Smelt are salvaged, fish can be maintained in TFCF holding tank for up to 24 hours. If a Chinook Salmon or Steelhead is collected during fish-counts, fish can only be maintained in TFCF holding tanks for up to 12 hours. If a Delta Smelt is collected during fish-count, salvaged fish may only be held in TFCF holding tanks for up to 8 hours. When fish can be maintained in TFCF holding tanks for 24 hours, fish transport (fish-haul) generally occurs at approximately 0700 each day. When two fish-hauls per day are necessary, fish hauls generally occur at 0700 and 2130 each day. When three fish-hauls are necessary, they are usually completed at 0700, 1500, and 2130 each day. Fish-haul is also dictated by the Bates Tables which uses size classes, species, and water temperature as indicators for when to conduct a fish-haul.

During normal operations, salvaged fish are transported approximately 49.9 km and released at one of two Reclamation release sites near the confluence of the Sacramento and San Joaquin Rivers (Antioch Fish Release Site and Emmaton Fish Release Site). In general, the Emmaton Fish Release Site is used for fish-hauls performed during daytime hours and the Antioch Fish Release Site is used for fish-hauls performed during nighttime hours. This is done for safety and security reasons as the Antioch Fish Release Site has a gate that can be locked behind the operator after he/she enters the release site area. Upon arrival at release sites, operators measure certain important water quality parameters (dissolved oxygen, salinity, and temperature) prior to releasing fish. This is done to verify that water quality parameters remain acceptable during fish transport.

Salmon loss due to handling and trucking are generally low and are based on CDFW trucking and handling studies. Salmon loss is < 2 percent for salmon < 100 mm and zero percent for salmon > 100 mm (Aasen 2013, Raquel 1989). The survival of Delta Smelt following salvage and return are relatively high based and are also based on handling and trucking studies by CDFW (Churchwell et al. 2005, Morinaka 2013, Miranda and Padilla 2010).

Estimates of post-release survival and mortality are currently not available, although predation rates at and near release sites are being investigated by Reclamation (Fullard et al. In Progress) and results are anticipated within the next couple of years. It is hypothesized that loss to predation is the main source of post release mortality.

C.5.3.1.6 Delta Mendota Canal, San Luis Unit, and California Aqueduct

Water Demands

Water provided to the DMC and San Luis Unit primarily meet demands from three types of contractors: CVP water service contractors (including both agricultural (AG) and municipal and industrial (M&I), exchange contractors, and wildlife refuge contractors. Distinct relationships exist between Reclamation and each of these three groups.

Exchange contractors “exchanged” their senior rights to water in the San Joaquin River for a CVP water supply generally provided from the Delta. Reclamation provides water supply to meet the 840 TAF per annum Exchange Contract, with a maximum reduction under the Shasta critical year criteria to an annual water supply of 650 TAF.

South of Delta CVP agricultural water service contractors also receive their supply from the Delta, but their supplies are subject to the availability of CVP water supplies that can be developed after senior obligations are met. The CVP also contracts with refuges to provide water supplies to specific managed lands for wildlife purposes. These contracts are reduced under Shasta critical year criteria up to 25 percent.

The CVP also contracts with refuges to provide water supplies to specific managed lands for wildlife purposes. These contracts are also subject to the availability of CVP water supplies, but may be reduced under Shasta critical year criteria, up to 25 percent.

To achieve the best operation of the CVP, it is necessary to combine the contractual demands of these three types of contractors to achieve an overall pattern of requests for water. In most years, sufficient supplies are not available to meet all water demands because of reductions in CVP water supplies primarily due to restrictions placed on Delta pumping. In some dry or critically dry years, water deliveries are limited because there is insufficient storage in northern CVP reservoirs to meet all instream fishery objectives, including water temperatures, and to make additional water deliveries via the Jones Pumping Plant. Scheduling of water demands and the releases of water supplies from the northern CVP to meet those demands, is a CVP operational objective that is intertwined with Trinity, Sacramento, and American River operations.

Delta-Mendota Canal/California Aqueduct Intertie

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

- Up to 467 cfs may be pumped from the DMC to the California Aqueduct to ease DMC conveyance constraints related to Jones Pumping Plant capacity limitations.
- Up to 467 cfs may be pumped from the DMC to the California Aqueduct to minimize impacts on water deliveries due to temporary restrictions in flow or water levels on the lower DMC (south of the Intertie) or the upper California Aqueduct (north of the Intertie) for system maintenance or due to an emergency shutdown.
- Up to 900 cfs may be conveyed from the California Aqueduct to the DMC using gravity flow to minimize impacts on water deliveries due to temporary restrictions in flow or water levels on the lower California Aqueduct (downstream of the Intertie) or the upper DMC (upstream of the Intertie) for system maintenance or for an emergency shutdown.

San Luis Reservoir

The 2.027-MAF San Luis Reservoir, formed by Sisk Dam, is jointly operated by Reclamation and DWR, with approximately 0.965 MAF used by the CVP and 1.062 MAF used by the SWP. Water generally is diverted into San Luis Reservoir during late fall through early spring when irrigation water demands of CVP and SWP water users are low and are being met by Delta exports. Water storage volumes and water storage elevations for San Luis Reservoir for Water Years 2001 through 2018 are presented on Figures C.5-1 and C.5-2 (DWR 2018as, 2018at).

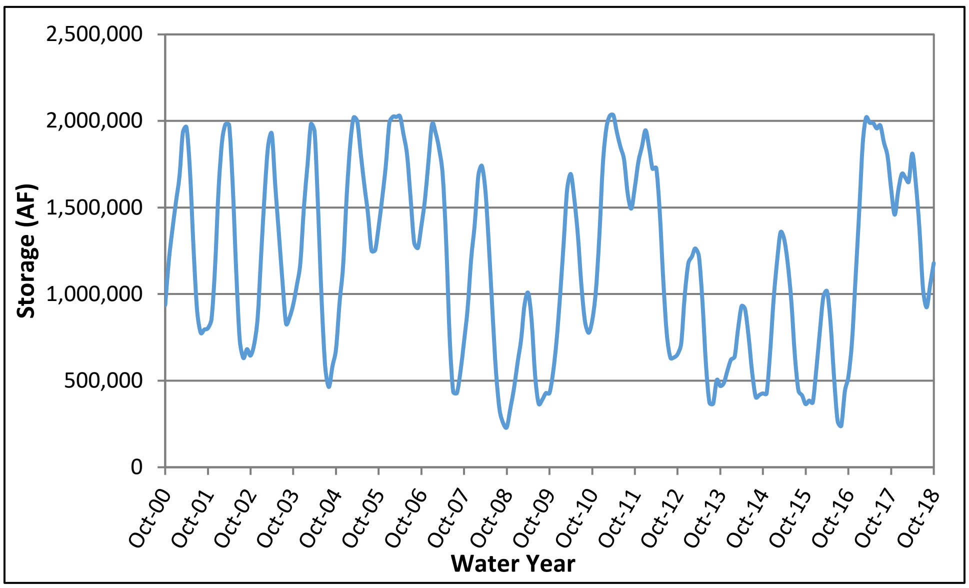

Figure C.5-1. San Luis Reservoir Storage

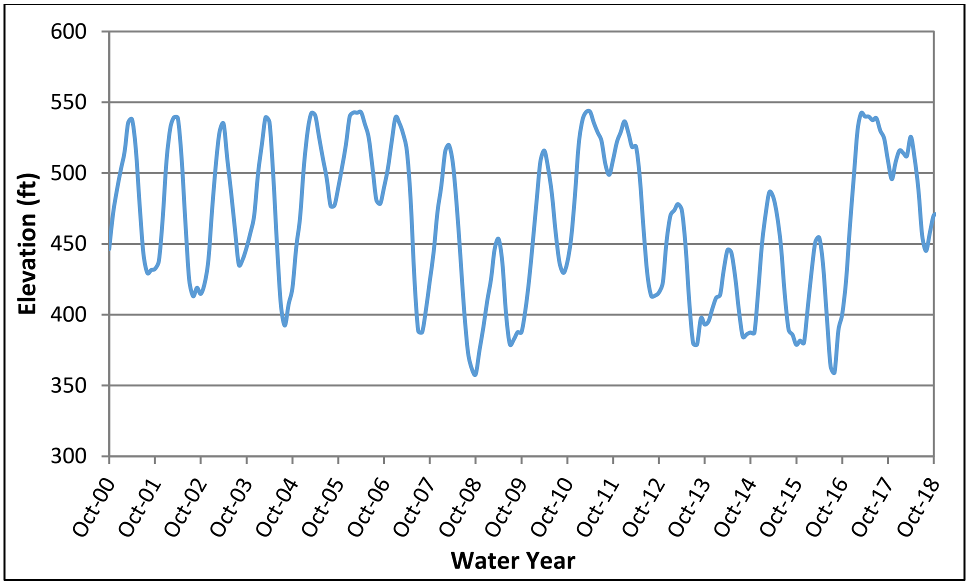

Figure C.5-2. San Luis Reservoir Elevation

The San Luis Complex consists of the following:

- O'Neill Pumping-Generating Plant (CVP facility)
- William R. Gianelli Pumping-Generating Plant (joint CVP and SWP facility)
- San Luis Canal (joint CVP and SWP facility)
- Dos Amigos Pumping Plant (joint CVP and SWP facility)
- Coalinga Canal (CVP facility)
- Pleasant Valley Pumping Plant (CVP facility)
- Los Banos and Little Panoche Detention Dams and Reservoirs (joint CVP and SWP facilities)

The CVP diverts water from San Luis Reservoir by the Pacheco Pumping Plant through the Pacheco Tunnel and Pacheco Conduit that conveys water to CVP water service contractors in Santa Clara and San Benito counties.

When all SWP demands are met, including diversion to storage facilities south of the Delta and Table A demands, and the Delta is in excess conditions, DWR would use available excess pumping capacity at Banks Pumping Plant to make excess water supplies, called Article 21 water under the long-term SWP water supply contracts, available to the SWP Contractors. Article 21 of the SWP water contracts describes the conditions under which water can be delivered in addition to the amounts specified in Table A of the contracts.

Unlike Table A water, which is an allocated annual SWP supply made available for scheduled delivery throughout the year, Article 21 water is an interruptible water supply made available only when certain conditions exist. However, while not a dependable supply, Article 21 water is an important part of the total SWP supplies provided to the SWP contractors. As with all SWP water, Article 21 water is pumped consistent with the existing terms and conditions of SWP water rights permits and is pumped from the Delta under the same environmental, regulatory, and operational constraints that apply to all SWP operations.

Article 21 water is only available as long as the required conditions exist as determined by DWR. As Article 21 deliveries are in addition to scheduled Table A deliveries, this supply is delivered to SWP contractors that can, on relatively short notice, put it to beneficial use. SWP contractors have used Article 21 water to meet needs such as additional short-term irrigation demands, replenishment of local groundwater basins, short-term substitution of local supplies and storage in local surface reservoirs for later use by the requesting SWP contractor, all of which provide SWP contractors with opportunities for better water management through more efficient coordination with their local water supplies. Allocated Article 21 water to a SWP contractor cannot be transferred.

Article 21 water is typically offered to SWP contractors on a short-term (daily or weekly) basis when all of the following conditions exist: the SWP share of San Luis Reservoir is physically full, or projected to be physically full; other SWP reservoirs south of the Delta are at their storage targets or the SWP conveyance capacity to fill these reservoirs is maximized; the Delta is in excess condition; current Table A and SWP operational demands are being fully met; and Banks Pumping Plant has export capacity beyond that which is needed to meet all Table A and other SWP operational demands. The increment of available unused Banks Pumping Plant capacity is offered as the Article 21 delivery capacity. SWP contractors then indicate their desired rate of delivery of Article 21 water. DWR allocates the available Article 21 water in proportion to the requesting SWP contractors annual Table A amounts if requests exceed the amount offered. Deliveries can be discontinued at any time when SWP operations change. In the modeling for Article 21, deliveries are only made in months when the SWP share of San Luis Reservoir is full. In actual operations, Article 21 may be offered a short period in advance of actual filling.

By April or May, demands from both agricultural and M&I SWP Contractors usually exceed the pumping rate at Banks Pumping Plant, and releases from San Luis Reservoir to the SWP facilities are needed to supplement the Delta pumping at Banks Pumping Plant to meet SWP contractor demands for Table A water.

California Aqueduct

Banks Pumping Plant lifts water into the California Aqueduct, which then flows to Bethany Reservoir. From Bethany Reservoir, the South Bay Pumping Plant lifts water into the South Bay Aqueduct to supply portions of Alameda and Santa Clara counties. The South Bay Aqueduct provided initial deliveries in 1962 and has been fully operational since 1965. South Bay Aqueduct facilities include Lake Del Valle and Patterson Reservoir.

From Bethany Reservoir, the 444-mile-long California Aqueduct conveys water to the primarily agricultural lands of the San Joaquin Valley and the mainly urban regions of Southern California. The first SWP deliveries to San Joaquin Valley contractors began in 1968. The first SWP deliveries to southern California began in 1972. The California Aqueduct winds along the west side of the San Joaquin Valley. It transports water to O'Neill Forebay. Water in the Forebay can be released to the San Luis Canal or pumped into San Luis Reservoir by the Gianelli Pumping Plant. San Luis Reservoir has a storage capacity of more than 39 MAF and is a joint facility of the DWR and Reclamation. The SWP's share of the reservoir's gross storage is about 1,062,180 af. DWR generally pumps water through the Gianelli Pumping-Generating Plant into San Luis Reservoir during late fall through early spring for temporary storage until water is released to meet late-spring and summer peaking demands of SWP contractors.

SWP water pumped directly from the Delta and water eventually released from San Luis Reservoir continues to flow south in the San Luis Canal, a portion of the California Aqueduct jointly used by the SWP and CVP. The joint use ends near Kettleman City, and the SWP portion of the California Aqueduct continues. As the water flows through the San Joaquin Valley, numerous turnouts convey the water to farmlands within the service areas of the SWP and CVP. Along its journey, four pumping plants—Dos Amigos, Buena Vista, Teerink, and Chrisman—lift the water more than 1,000 feet before it reaches the foot of the Tehachapi Mountains.

In the San Joaquin Valley near Kettleman City, Phase I of the Coastal Branch Aqueduct serves agricultural areas west of the California Aqueduct. The Coastal Branch's Phase II extended the conveyance facility to serve M&I water users in San Luis Obispo and Santa Barbara counties. Phase II became operational in 1997.

The remaining water conveyed by the California Aqueduct is delivered to Southern California, home to about one-half of California's total population. Before this water can be delivered, the water must first cross the Tehachapi Mountains. Pumps at Edmonston Pumping Plant, situated at the foot of the mountains, raise the water 1,926 feet—the highest single lift of any pumping plant in the world. From there, the water enters about 8 miles of tunnels and siphons as it flows into Antelope Valley, where the California Aqueduct divides into two branches; the East Branch and the West Branch.

The East Branch carries water through the Tehachapi East Afterbay, Alamo Powerplant, Pearblossom Pumping Plant, and Mojave Siphon Powerplant into Silverwood Lake in the San Bernardino Mountains, which stores 73,000 af. From Silverwood Lake, water flows through the San Bernardino Tunnel into Devil Canyon Powerplant. Water continues down the East Branch to Lake Perris, the terminus of the East Branch. Lake Perris lies just east of Riverside, has a capacity of 131,500 af, and serves as a regulatory and emergency water supply facility for the East Branch.

Phase I of the East Branch Extension of the California Aqueduct was completed in 2003 and provides conveyance facilities to deliver SWP water to San Gorgonio Pass Water Agency, and to the eastern portion of the San Bernardino Valley Municipal Water District, which will deliver water to areas such as Yucaipa, Calimesa, Beaumont, Banning, and other communities. The East Branch Extension is comprised of a combination of existing San Bernardino Valley Municipal Water District facilities and newly constructed SWP facilities. While the new pipelines were designed for the ultimate conveyance capacity, the installed Phase I pumping capacity is less than one-half the ultimate capacity—enough to meet the immediate foreseeable demand for SWP water. Phase II will bring the extension to its ultimate storage and conveyance capacity with new pipelines, pumping, and storage facilities. Currently, the DWR is in the planning stages of Phase II. A feasibility study and a Phase II Project Environmental Impact Report are being concurrently developed.

At the bifurcation of the California Aqueduct in Antelope Valley, the West Branch carries water through Oso Pumping Plant, Quail Lake, Lower Quail Canal, and William E. Warne Powerplant into Pyramid Lake in Los Angeles County. From there, water flows through the Angeles Tunnel, Castaic Powerplant, Elderberry Forebay, and Castaic Lake, terminus of the West Branch. Castaic Lake is located north of Santa Clarita, has a capacity of 324,000 af, and is a regulatory and emergency water supply facility for the West Branch. Castaic Powerplant is owned and operated by Los Angeles Department of Water and Power.

C.5.3.1.7 Contra Costa Water District Facilities

CCWD diverts water from the Delta for irrigation and M&I uses under its CVP contract, under its own water right permits and license issued by the SWRCB, and under East Contra Costa Irrigation District's pre-1914 water right. CCWD's water system includes the Mallard Slough, Rock Slough, Old River, and Middle River (on Victoria Canal) intakes; the Contra Costa Canal and shortcut pipeline; and the Los Vaqueros Reservoir. The Rock Slough Intake facilities, the Contra Costa Canal, and the shortcut pipeline are owned by Reclamation and operated and maintained by CCWD under contract with Reclamation.

Reclamation completed construction of a fish screen at the Rock Slough Intake in 2011. Federal legislation providing the authority for Reclamation to transfer title of the facilities was passed by Congress and signed by the President in March 2019. CCWD and Reclamation are beginning the title transfer process, which includes conducting the required environmental and property record review to execute the transfer. The process is anticipated to take approximately two years to complete. Mallard Slough Intake, Old River Intake, Middle River Intake, and Los Vaqueros Reservoir are owned and operated by CCWD.

The Mallard Slough Intake is located at the southern end of a 3,000-foot-long channel running south from Suisun Bay, near Mallard Slough (across from Chipps Island). The Mallard Slough Pump Station was refurbished in 2002, which included constructing a positive barrier fish screen at this intake. The Mallard Slough Intake can pump up to 39.3 cfs. CCWD's water right license and permit (License No. 10514 and Permit No. 19856) authorize diversions of up to 26,780 acre-feet per year at Mallard Slough. However, this intake is not used when salinity is high at this location. Pumping at the Mallard Slough Intake since 1993 has on average accounted for about 3 percent of CCWD's total diversions. Water diverted at the Mallard Slough Intake reduces CCWD's diversion of CVP water at its other intakes.

The Rock Slough Intake is located about four miles southeast of Oakley. Water is pumped west from Rock Slough through a positive barrier fish screen into the Contra Costa Canal using Pumping Plants #1 through #4. The fish screen at this intake was designed in accordance with the CVPIA and the 1993 USFWS BO for the Los Vaqueros Project to reduce take of fish through entrainment at the Rock Slough Intake. The Contra Costa Canal is 48 miles long. CCWD's Contra Costa Canal Replacement Project replaces the 4-mile long, earth-lined portion of the Contra Costa Canal between the Rock Slough Fish Screen and Pumping Plant #1 with a buried 10'-diameter concrete pipe. The remaining 44 miles of the Contra Costa Canal after Pumping Plant #1 are concrete-lined. The earth-lined portion of the Contra Costa Canal is subject to water quality degradation due to seepage into the canal from saline groundwater in the area, as well as seepage losses where the groundwater table is lower than canal water levels. Replacing the open channel with a buried pipe also eliminates evaporative losses. Removal of the open water facility also improves public safety, system security, and flood control, which are needed in light of the developing and planned urbanization in the vicinity. As of late 2018, approximately 3 miles of the earth-lined portion of the Canal has been replaced (from Pumping Plant #1 to the east) and the flood isolation structure near the fish screen has also been completed. Pumping Plant #1 has a permitted capacity to pump up to 350 cfs into the Canal. Diversions at Rock Slough Intake are typically taken under CVP contract or under East Contra Costa Irrigation District's pre-1914 water right. CCWD diverts approximately 30 percent to 50 percent of its total annual supply through the Rock Slough Intake, depending upon water quality in a given year.

Construction of the Old River Intake was completed in 1997 as a part of the Los Vaqueros Project. The Old River Intake is located on Old River near State Route 4. The intake has a positive-barrier fish screen and a pumping capacity of 250 cfs and can pump water via pipeline either to the Contra Costa Canal or to Los Vaqueros Reservoir. Diversions at Old River to the Contra Costa Canal are typically taken under CVP contract or under local water rights. Pumping to storage in Los Vaqueros Reservoir is limited to 200 cfs by the terms of the Los Vaqueros Project BOs and by the SWRCB water right decision for the Los Vaqueros Project (D-1629). Diversions to storage in Los Vaqueros Reservoir are typically taken under CVP contract or under CCWD's Los Vaqueros water right permit (Permit 20749). The CCWD's water diversions that are not made at Rock Slough are diverted at the Middle River and Old River intakes, as determined primarily by the CCWD water quality goals described below.

In 2010, CCWD completed construction of the Middle River Intake (formerly referred to as the Alternative Intake Project) on Victoria Canal. The Middle River Intake has a capacity of 250 cfs capacity, with positive-barrier fish screens and a conveyance pipeline to CCWD's conveyance facilities near its Old River Intake. Similar to the Old River Intake, the Middle River Intake can be used either to pump to the

Contra Costa Canal or to fill the Los Vaqueros Reservoir. Diversions to the Contra Costa Canal are typically taken under CVP contract, while diversions to storage in the Los Vaqueros Reservoir can be taken either under CVP contract or under CCWD's Los Vaqueros water right (Permit 20749).

CCWD operates its intake facilities to meet its delivered water quality goals and to protect listed species. The choice of which intake to use at any given time is based in large part upon salinity at the intakes, consistent with fish protection requirements in the BOs for the Middle River Intake and the Los Vaqueros Project. The Middle River Intake was built as a project to improve the water quality delivered to the CCWD service area, and does not increase CCWD's average annual diversions from the Delta. However, it can alter the timing and pattern of CCWD's diversions, because Middle River Intake salinity tends to be lower in the late summer and fall than salinity at CCWD's other intakes. This allows CCWD to decrease winter and spring diversions while still meeting water quality goals in the summer and fall through use of the new intake.

Los Vaqueros Reservoir is an off-stream reservoir in the Kellogg Creek watershed to the west of the Delta. Originally constructed as a 100 TAF reservoir in 1997 as part of the Los Vaqueros Project, the facility is used to improve delivered water quality and emergency storage reliability for CCWD's customers. Los Vaqueros Reservoir is filled with Delta water from either the Old River Intake or the Middle River Intake, when salinity in the Delta is low. When Delta salinity is high, typically in the fall months, CCWD releases low salinity water from Los Vaqueros Reservoir to blend with direct diversions from its Delta intakes to meet CCWD water quality goals. Releases from Los Vaqueros Reservoir are conveyed to the Contra Costa Canal via a pipeline. Water released from Los Vaqueros Reservoir does not re-enter Delta channels.

In 2012, Los Vaqueros Reservoir was expanded from 100 TAF to a total storage capacity of 160 TAF to provide additional water quality and water supply reliability benefits and maintain the initial functions of the reservoir. With the expanded reservoir, CCWD's average annual diversions from the Delta remain the same as they were with the 100 TAF reservoir. A feasibility study is ongoing to evaluate whether an additional expansion of this reservoir to 275 TAF is in the federal interest.

CCWD diverts approximately 127 TAF per year in total. Approximately 110 TAF is CVP contract supply. In winter and spring months when the Delta is relatively fresh (generally January through July), deliveries to the CCWD service area are made by direct diversion from the Delta. In addition, when salinity is low enough, Los Vaqueros Reservoir is filled at a rate of up to 200 cfs from the Old River Intake and Middle River Intake. The BOs for the Los Vaqueros Project, CCWD's Incidental Take Permit issued by CDFW, and SWRCB D-1629 include fisheries protection measures consisting of a 75-day period during which CCWD does not fill Los Vaqueros Reservoir (no-fill period) and a concurrent 30-day period during which CCWD halts all diversions from the Delta (no-diversion period), provided that Los Vaqueros Reservoir storage is above emergency levels. During the no-diversion period, CCWD customer demand is met by releases from Los Vaqueros Reservoir. The default dates for the no-fill and no-diversion periods are March 15 through May 31 and April 1 through April 30, respectively. USFWS, NMFS, and CDFW can change these dates to best protect the subject species. CCWD coordinates the filling of Los Vaqueros Reservoir with Reclamation and DWR to avoid water supply impacts on other CVP and SWP customers.

In addition to the 75-day no-fill period and the concurrent no-diversion 30-day period, CCWD operates to an additional term in the Incidental Take Permit issued by CDFW that provides for an additional no-fill period of up to 15 days. Under this term, CCWD shall not divert water to storage in Los Vaqueros Reservoir for 15 days from February 14 through February 28, provided that reservoir storage is at or above 90 TAF on February 1. If reservoir storage is at or above 80 TAF on February 1, but below 90 TAF, CCWD shall not divert water to storage in Los Vaqueros Reservoir for 10 days from February 19 through February 28. If reservoir storage is at or above 70 TAF on February 1, but below 80 TAF, CCWD shall not divert water to storage in Los Vaqueros Reservoir for 5 days from February 24 through February 28. These dates can be changed to better protect Delta fish species, at the direction of CDFW.

CCWD's operation of the diversion, storage, and conveyance facilities to divert water under CCWD's water rights and under CVP water rights pursuant to CCWD's CVP water service contract meets the permitting requirements of the ESA through BOs issued by USFWS and NMFS that are specific to the CCWD system. The NMFS BO issued on March 18, 1993 and USFWS BO issued on September 9, 1993 address the operation of the Los Vaqueros Project, including the Los Vaqueros Reservoir and the Mallard Slough, Rock Slough, and Old River intakes. NMFS BO 2005/00122 issued on July 13, 2007, and USFWS BO issued on April 27, 2007 and amended on May 16, 2007, address the Middle River Intake operations. Concurrence that CCWD's operations consistent with expansion of Los Vaqueros Reservoir to 160 TAF are not likely to adversely affect listed Delta fish species was provided by NMFS on October 15, 2010 and USFWS on November 1, 2010. Biological opinions for operation and maintenance of the Rock Slough Fish Screen were issued by NMFS on June 29, 2017 and USFWS on November 2, 2017.

C.5.3.2 *Regulatory Limitations on Operations of Delta Water Diversions*

Operations of the CVP and SWP are implemented in accordance with SWRCB water rights and water quality decisions, including SWRCB D-1641, and the 2008 USFWS BO and 2009 NMFS BO.

C.5.3.2.1 Decision 1641

The SWRCB adopted the 1995 Bay-Delta Plan on May 22, 1995, which became the basis of SWRCB D-1641 (adopted on December 29, 1999 and revised on March 15, 2000). The SWRCB D-1641 amended certain terms and conditions of the SWP and CVP water rights to include flow and water quality objectives to assure protection of beneficial uses in the Delta and Suisun Marsh. SWRCB also grants conditional changes to points of diversion for the CVP and SWP under SWRCB D-1641. The requirements in SWRCB D-1641 address the standards for fish and wildlife protection, water supply water quality, and Suisun Marsh salinity. These objectives include specific Delta outflow requirements throughout the year, specific export limits in the spring, and export limits based on a percentage of estuary inflow throughout the year. The water quality objectives are designed to protect agricultural, municipal and industrial, and fishery uses, and vary throughout the year and by water year type. D-1641 limits CVP and SWP exports at Banks and Jones Pumping Plants as a percentage of total Delta inflow (i.e., the export to inflow ratio or "E/I"). The maximum E/I set by D-1641 is 65% July through January and 35% February through June. The 35% E/I from February to June required in D-1641 was a significant change from D-1485. This spring requirement reduced the availability of "unstored" flow for export and storage in San Luis Reservoir. February to June became an unreliable season for conveying water across the Delta. Spring X2 reduced the "unstored flow" availability by dedicating a significant block of water to Delta outflow/salinity goals. The "spring X2" Delta outflow is specified from February through June to maintain freshwater and estuarine conditions in the western Delta to protect aquatic life. The criteria require operations of the CVP and SWP upstream reservoir releases and Delta exports in a manner that maintains a salinity objective at an "X2" location. X2 refers to the horizontal distance from the Golden Gate Bridge up the axis of the Delta estuary to where tidally averaged near-bottom salinity concentration of 2 parts of salt in 1,000 parts of water occurs; the X2 standard was established to improve shallow water estuarine habitat in the months of February through June and relates to the extent of salinity movement into the Delta (DWR, Reclamation, USFWS and NMFS 2013). The location of X2 is important to both aquatic life and water supply beneficial uses.

The Delta outflow and salinity goals under D-1641 requires reservoir releases at times. The effect of D-1641 shifted the export season to the summer, and the CVP and SWP entered the fall with lower reservoir levels and less need for flood releases in the fall and winter.

A Vernalis flow and salinity requirement was imposed for the San Joaquin Basin. D-1641 imposed a salinity standards for the San Joaquin Basin and also included requirements at Vernalis for both base flows and a large spring pulse flow, however it did not address how the requirement would be shared between the three major San Joaquin tributaries. In order to avoid protests and the need to immediately revise D-1641 to assign responsibility, the parties entered into the San Joaquin River Agreement (SJRA), which included flow commitments from all three tributaries, funding commitments, transfers and voluntary demand reductions. The agreement ended in 2009 but was extended to 2012. During the timeframe of this agreement, the parties expected the State Board to modify the San Joaquin River requirements and assign appropriate responsibility. Despite Reclamation extending the term of the SJRA to 2012, the SWRCB took no action and the SJRA expired. Absent the SJRA, responsibility for the Vernalis requirements were solely attached to the Reclamation water rights permits on the Stanislaus River for operating New Melones Dam and Reservoir, and it is the State Board's position that this requires approximately 300–700 TAF of storage releases from New Melones Reservoir each year (SWRCB, 1999, Figure V-6). Reclamation's view is that the Board's position lacks a rational basis and conflicts with Reclamation's long-term obligations under federal law.

Mean daily Delta outflow flows for Water Years 2001 through 2018 are presented on Figure C.5-3 (DWR 2018au). Mean daily flows for Water Years 2001 through 2018 are presented on Figures C.5-4 through C.5-9 for diversions at Jones, Banks, Barker Slough, and Contra Costa Canal Rock Slough Intake; and Contra Costa Water District intakes at Old River and Middle River (DWR 2018av, 2018aw, 2018ax, 2018ay, 2018az, 2018ba).

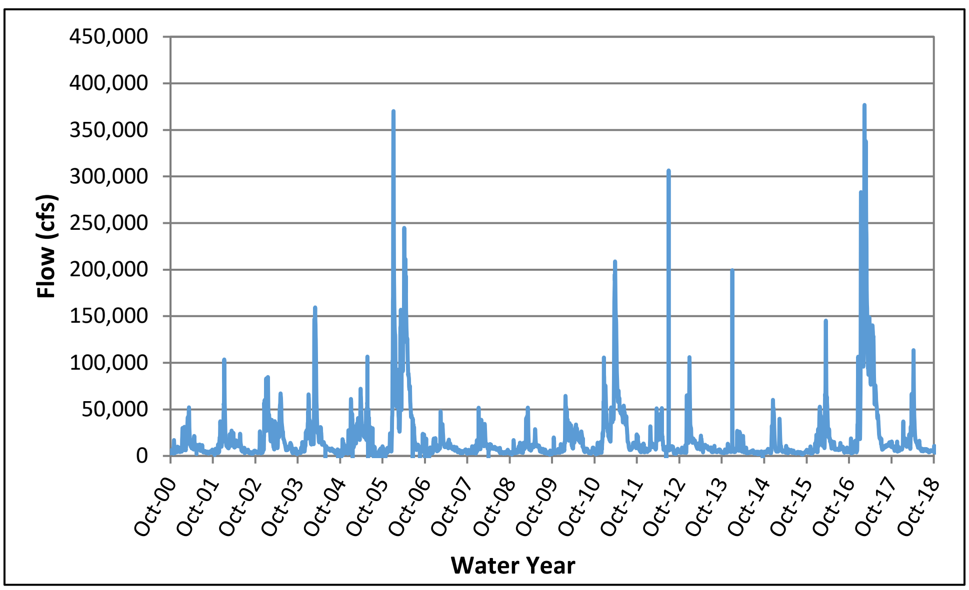

Figure C.5-3. Delta Outflow

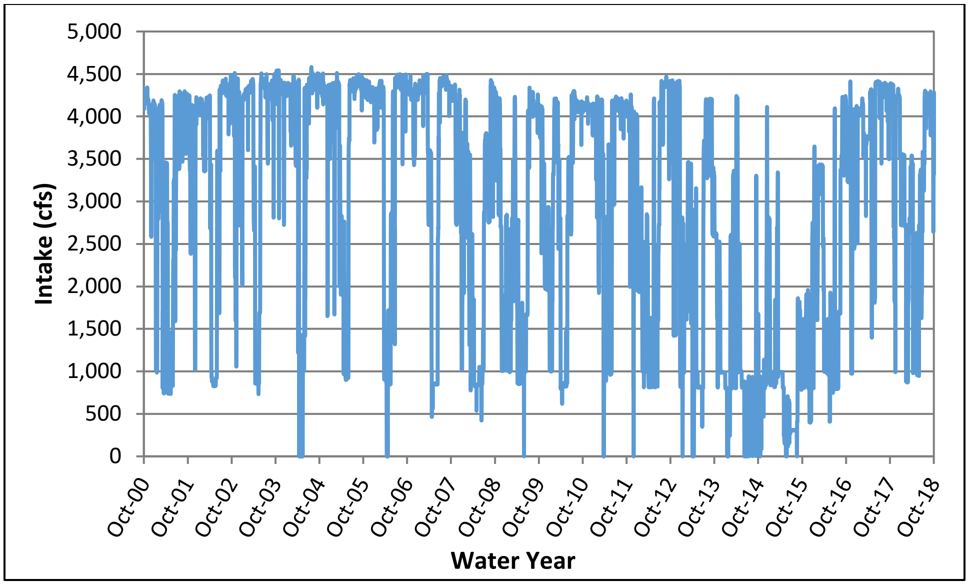

Figure C.5-4. Jones Pumping Plant

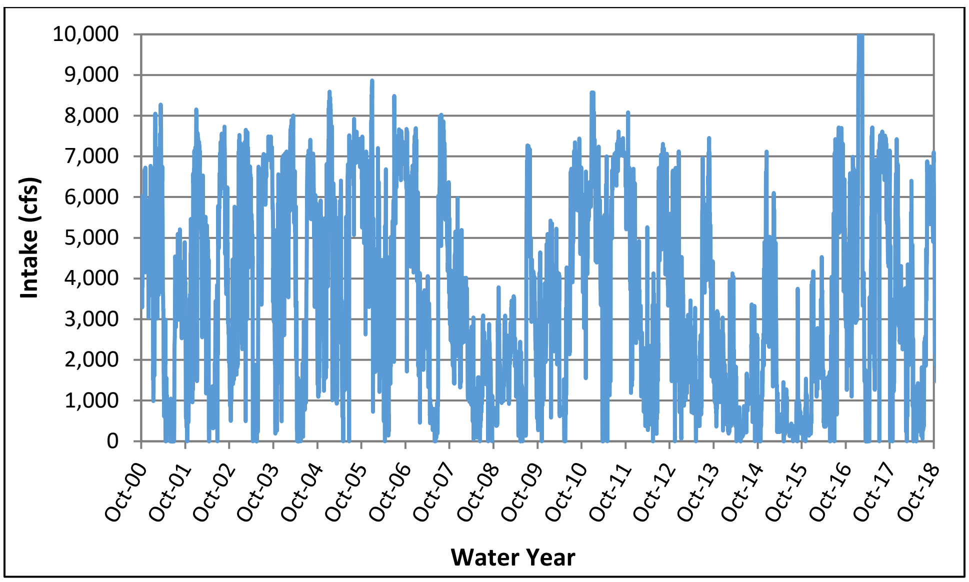

Figure C.5-5. Banks Pumping Plant

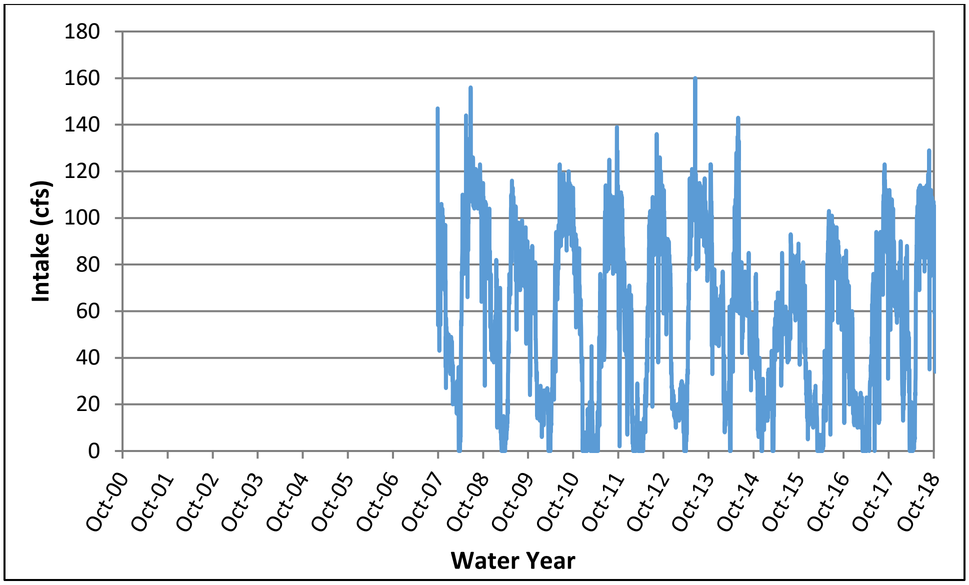

Figure C.5-6. Barker Slough Pumping Plant

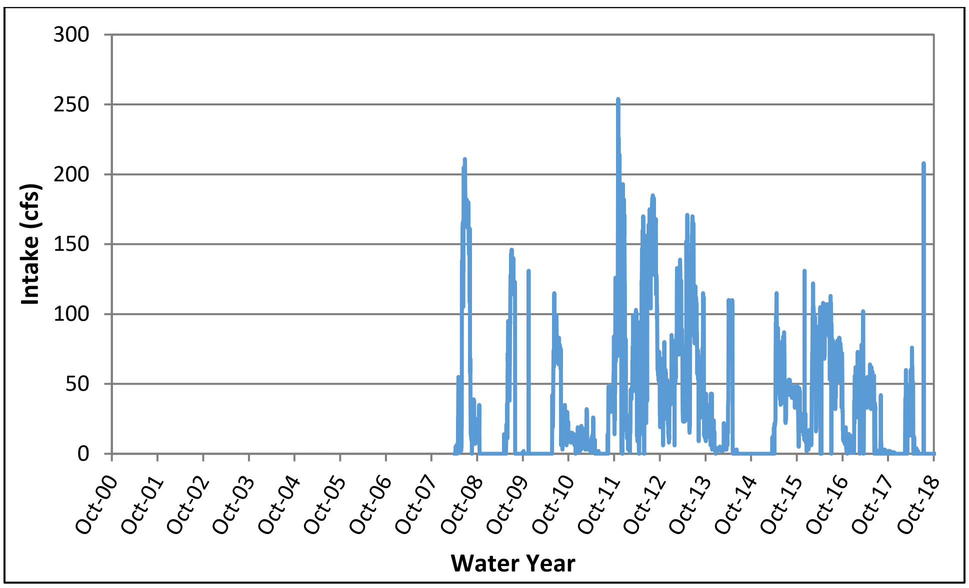

Figure C.5-7. Contra Costa Canal Rock Slough Intake

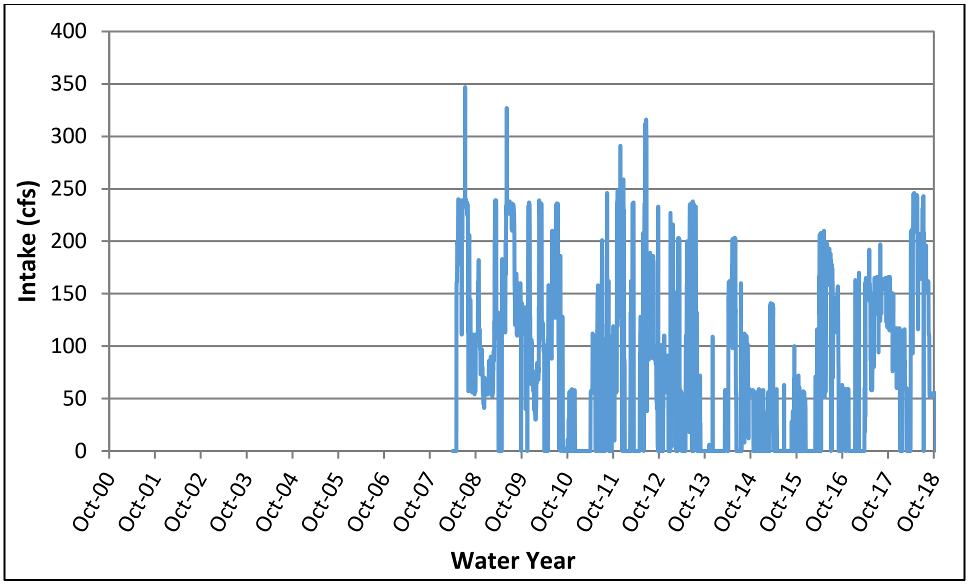

Figure C.5-8. Contra Costa WD Old River Intake

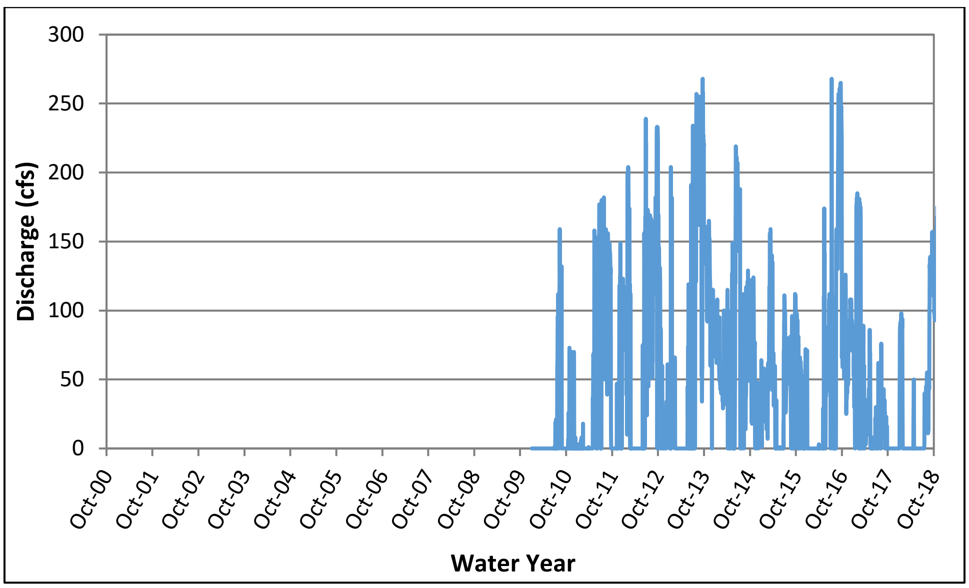

Figure C.5-9. Contra Costa WD Middle River Intake

C.5.3.2.2 Joint Point of Diversion

SWRCB D-1641 authorized the SWP and CVP to jointly use both Jones and Banks pumping plants in the southern Delta, with conditional limitations and required response coordination plans (referred to as Joint Point of Diversion [JPOD]). Use of JPOD is based on staged implementation and conditional requirements for each stage of implementation. The stages of JPOD in SWRCB D-1641 are:

- Stage 1—for water service to a group of CVP water service contractors (Cross Valley contractors, San Joaquin Valley National Cemetery and Musco Family Olive Company), and to recover export reductions implemented to benefit fish;
- Stage 2—for any purpose authorized under the current CVP and SWP water right permits; and
- Stage 3—for any purpose authorized, up to the physical capacity of the diversion facilities.

In general, JPOD capabilities are used to accomplish four basic CVP and SWP objectives:

- When wintertime excess pumping capacity becomes available during Delta excess conditions and total CVP and SWP San Luis storage is not projected to fill before the spring pulse flow period, the Project with the deficit in San Luis storage may elect to pursue the use of JPOD capabilities;
- When summertime pumping capacity is available at Banks Pumping Plant and CVP reservoir conditions can support additional releases, the CVP may elect to use JPOD capabilities to enhance annual CVP south of Delta water supplies;
- When summertime pumping capacity is available at Banks or Jones Pumping Plant to facilitate water transfers, JPOD may be used to further facilitate the water transfer; and
- During certain coordinated CVP and SWP operation scenarios for fishery entrainment management, JPOD may be used to shift CVP and SWP exports to the facility with the least fishery entrainment impact while minimizing export at the facility with the most fishery entrainment impact.

Each stage of JPOD has regulatory terms and conditions that must be satisfied in order to implement JPOD. All stages require a response plan to ensure water elevations in the southern Delta will not be lowered to the injury of local riparian water users (Water Level Response Plan); and a response plan to ensure the water quality in the southern and central Delta will not be significantly degraded through operations of the JPOD to the injury of water users in the southern and central Delta. Stage 2 has an additional requirement to complete an operations plan that will protect fish and wildlife and other legal users of water (Fisheries Response Plan). Stage 3 has an additional requirement to protect water levels in the southern Delta. All JPOD diversions under excess conditions in the Delta are junior to CCWD water right permits for the Los Vaqueros Project and must have an X2 location west of certain compliance locations consistent with the 1993 Los Vaqueros BO for Delta smelt.

C.5.3.2.3 Old and Middle River Reverse Flow Management

The 2008 USFWS BO and the 2009 NMFS BO restrict CVP and SWP diversions to reduce reverse flows in Old and Middle rivers (OMR). OMR flow for Water Years 2001 through 2018 is presented in Figure C.5-10 (USGS 2018a, 2018b).

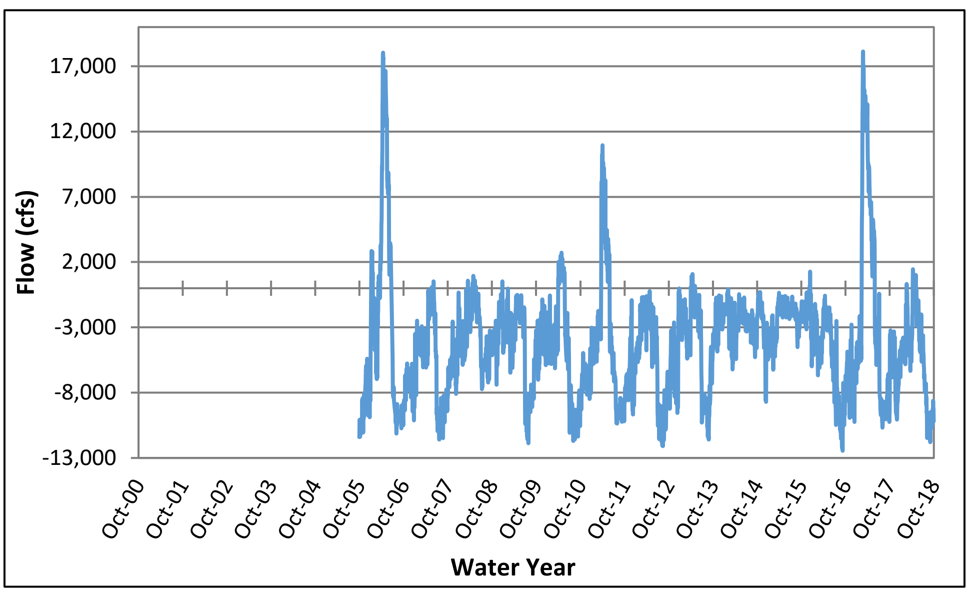

Figure C.5-10. OMR Flow (CFS)

2008 USFWS BO OMR Criteria

The 2008 USFWS BO limits reverse OMR flows as prescribed in the following three actions.

Action 1: to protect adult Delta Smelt migration and entrainment. Limits exports so that the average daily OMR flow is no more negative than 2,000 cfs for a total duration of 14 days, with a 5-day running average no more negative than -2,500 cfs (within 25 percent).

- December 1 to December 20 – Based upon turbidity data from turbidity stations (Prisoner's Point, Holland Cut, and Victoria Canal) and salvage data from CVP and SWP fish handling facilities at the south Delta intakes, and other parameters important to the protection of Delta Smelt including, but not limited to, preceding conditions of X2, Fall Midwater Trawl (FMWT) Survey, and river flows.
- After December 20 – The action would begin if the 3-day average turbidity at Prisoner's Point, Holland Cut, and Victoria Canal exceeds 12 nephelometric turbidity units (NTU).
- Triggers are based on:
    - Three-day average of 12 NTU or greater at all three turbidity stations; or
    - Three days of Delta Smelt salvage after December 20 at either facility or cumulative daily salvage count that is above a risk threshold based upon the "daily salvage index" approach reflected in a daily salvage index value of greater than or equal to 0.5 (daily Delta Smelt salvage is greater than one-half prior year FMWT index value). The window for triggering Action 1 concludes when either off-ramp condition described below is met. These off-ramp conditions may occur without Action 1 ever being triggered. If this occurs, then Action 3 is triggered, unless the Service concludes on the basis of the totality of available information that Action 2 should be implemented instead.
- Action 1 offramps when water temperature reaches 12 degrees Celsius (°C) based on a three station daily mean at the temperature stations: Mossdale, Antioch, and Rio Vista; or the onset of spawning based upon the presence of spent females in the Spring Kodiak Trawl Survey or at the CVP or SWP fish handling facilities.

Action 2: to protect adult Delta Smelt migration and entrainment. An action implemented using an adaptive process to tailor protection to changing environmental conditions after Action 1. As in Action 1, the intent is to protect pre-spawning adults from entrainment and, to the extent possible, from adverse hydrodynamic conditions. The range of net daily OMR flows would be no more negative than -1,250 to -5,000 cfs. Depending on extant conditions, specific OMR flows within this range are recommended by the USFWS Smelt Working Group (SWG) from the onset of Action 2 through its termination. The SWG would provide weekly recommendations based upon review of the sampling data, from real-time salvage data at the CVP and SWP, and utilizing most up-to-date technological expertise and knowledge relating population status and predicted distribution to monitored physical variables of flow and turbidity. The USFWS makes the final determination.

- Action 2 begins immediately following Action 1. If Action 1 is not implemented based upon triggers, the SWG may recommend a start date for Action 2.
- Action 2 is suspended when whenever a 3-day flow average is greater than or equal to 90,000 cfs in Sacramento River at Rio Vista and 10,000 cfs in San Joaquin River at Vernalis. Once such flows have abated, the OMR flow requirements of Action 2 are restarted.
- Offramps for Action 2 are related to water temperature reaches 12°C based on a three-station daily average at the temperature stations: Rio Vista, Antioch, and Mossdale; or the onset of

spawning based upon the presence of a spent female in the Spring Kodiak Trawl Survey or at the CVP or SWP fish handling facilities.

Action 3: to protect larval and juvenile Delta Smelt. Minimize the number of larval Delta Smelt entrained at the facilities by managing the hydrodynamics in the Central Delta flow levels pumping rates spanning a time sufficient for protection of larval Delta Smelt. Net daily OMR flow would be no more negative than -1,250 to -5,000 cfs based on a 14-day running average with a simultaneous 5-day running average within 25 percent of the applicable requirement for OMR. Depending on extant conditions, specific OMR flows within this range are recommended by the SWG from the onset of Action 3 through its termination.

- Action 3 begins when temperature reaches 12°C based on a three-station average at the temperature stations: Mossdale, Antioch, and Rio Vista; or onset of spawning based upon the presence of a spent female in the Spring Kodiak Trawl Survey or at the CVP or SWP fish handling facilities.
- Action 3 offramps by June 30; or if water temperature reaches a daily average of 25°C for three consecutive days 10 at Clifton Court Forebay.

2009 NMFS BO OMR Criteria

The 2009 NMFS BO includes OMR criteria (Action IV.2.3) to protect juvenile salmonids during winter and spring emigration downstream into the San Joaquin River, and to increase survival of salmonids and Green Sturgeon entering the San Joaquin River from Georgiana Slough and the lower Mokelumne River by reducing the potential for entrainment at the south Delta intakes. The action is implemented from January 1 through June 15 to limit negative flows to -2,500 to -5,000 c fs in Old and Middle Rivers, de pending on the presence of salmonids. The reverse flow would be managed within this range to reduce flows toward the pumps during periods of increased salmonid presence. The negative flow objective within the range shall be determine based on the following decision tree:

Date	Action Triggers	Action Responses
January 1 – June 15	January 1 – June 15	-5,000 cfs
January 1 – June 15 First Stage Trigger (increasing level of concern)	Daily SWP/CVP older juvenile loss density (fish per TAF) is 1) greater than incidental take limit divided by 2000, with a minimum value of 2.5 fish per TAF, or 2) daily loss is greater than daily measured fish density divided by 12 TAF, of 3) Coleman National Fish Hatchery coded wire tag late-fall run or Livingston Stone National Fish Hatchery coded wire tag winter-run cumulative loss greater than 0.5%, or 4) daily loss of wild steelhead (intact adipose fin) is greater than the daily measured fish density divided by 12 TAF.	-3,500 cfs for minimum of 5 days; and up to -5,000 cfs other times
January 1 – June 15 Second Stage Trigger (analogous to high level of concern)	Daily SWP/CVP older juvenile loss density (fish per TAF) is 1) greater than incidental take limit divided by 1000, with a minimum value of 2.5 fish per TAF, or 2) daily loss is greater than daily fish density divided by 8 TAF, or 3) Coleman National Fish Hatchery coded wire tag late-fall run or Livingston Stone National Fish Hatchery coded wire tag winter-run cumulative loss greater than 0.5%, or 4) daily loss of wild steelhead (intact	-2,500 cfs for minimum of 5 days; and up to -5,000 cfs other times

Date	Action Triggers	Action Responses
	adipose fin) is greater than the daily measured fish density divided by 8 TAF.	
End of Triggers	Continue action until June 15 or until average daily water temperature at Mossdale is greater than 72°F (22°C) for 7 consecutive days (1 week), whichever is earlier.	No OMR restriction.

Updated Incidental Take Statement

In January 2019, USFWS modified the take quantification methodology of the Incidental Take Statement for the federally threatened delta smelt in the 2008 USFWS BO. In recent years it has become clear that surveys are reaching their detection limits given the declining population of delta smelt, and in 2018, the FMWT Index was zero, indicating that the FMWT Index may no longer provide an accurate predictor of incidental take. In its place, USFWS has determined that an appropriate incidental take surrogate for individual delta smelt to be the ecological condition created by less negative OMR flow that reduces entrainment of delta smelt into the South Delta. When turbidity is high, OMR flow of approximately -5000 cfs, or more positive as necessary, creates an appropriate ecological condition. When turbidity conditions are low, there is no relationship between OMR flow and the proportion of the delta smelt population entrained. The risk of high entrainment will continue to be minimized via the active real time management of OMR flow and turbidity in the south Delta. It has been demonstrated that implementation of OMR flow of no more negative than -5000 cfs, particularly in conjunction with NMFS RPA actions has reduced the entrainment of delta smelt. However, this newer information shows that there are situations in which the management of OMR flow does not demonstrably affect delta smelt entrainment. This latter condition provides circumstances in which USFWS believes that operational flexibility to allow for OMR flow more negative than -5000 cfs for short periods can be implemented without generating entrainment losses higher than those the USFWS analyzed in its 2008 BO.

C.5.3.2.4 Fall X2

The 2008 USFWS BO also includes an additional Delta salinity requirement in September through November in wet and above normal water years (Action 4). This requirement is frequently referred to as "Fall X2." The action requires that in September and October, 2 Practical Salinity Units (psu) salinity is maintained at 74 kilometers (km) during wet years, and 81 km during above normal water years when the preceding year was wet or above normal based upon the Sacramento Basin 40-30-30 index in the SWRCB D-1641. In November of these years, there is no specific X2 requirement, however there is a requirement that all inflow into SWP and CVP upstream reservoirs be conveyed downstream to augment delta outflow to maintain X2 at the locations in September and October.

If storage increases during November under this action, the increased storage volume is to be released in December in addition to the requirements under SWRCB D-1641 net Delta Outflow Index.

C.5.3.2.5 San Joaquin River Inflow: Export Ratio

The 2009 NMFS BO Action IV.2.1 requires south Delta exports at Banks and Jones Pumping Plants to be reduced during April and May to protect emigrating steelhead from the lower San Joaquin River into the south Delta channels and intakes. The inflow:export ratio from April 1 through May 31 specifies that Reclamation operates the New Melones Reservoir to maintain the 2009 NMFS BO flow schedule for the Stanislaus River at Goodwin in accordance with Action III.1.3 and Appendix 2-E of the BO. In addition, the CVP and SWP pumps are operated to meet the following ratios, based upon a 14-day running average.

San Joaquin Valley Classification	San Joaquin River flow at Vernalis (cfs): CVP and SWP combined export ratio (cfs)
Critically dry	1:1
Dry	2:1
Below normal	3:1
Above normal	4:1
Wet	4:1
Vernalis flow equal to or greater than 21,750 cfs	Unrestricted exports until flood recedes below 21,750 cfs.

During multiple dry years, the ratio would be limited to 1:1 if the New Melones Index related to storage is less than 1,000 TAF and the sum s of the "indicator" numbers established for water year classifications in SWRCB D-1641 (based on the San Joaquin Valley 60-20-20 Water Year Classification in SWRCB D-1641) is greater than 6 for the past two years and the current year. The indicator numbers are 1 for a critically dry year, 2 for a dry year, 3 for a below normal year, 4 for an above normal year, and 5 for a wet year.

Implementation of the inflow:export ratio under all conditions would allow a minimum pumping rate of 1,500 cfs to meet public health and safety needs of communities that solely rely upon water diverted from the CVP and SWP pumping plants.

C.5.3.2.6 Water Transfers

California Water Law and the CVPIA promote water transfers as important water resource management measures to address water shortages provided certain protections to source areas and users are incorporated into the water transfer. Parties seeking water transfers generally acquire water from sellers who have available surface water who can make the water available through releasing previously stored water, pump groundwater instead of using surface water; fallow crops or substitute a crop that uses less water in order to reduce normal consumptive use of surface diversions. Water transfers (addressed in this document) occur when a water right holder within the Sacramento-San Joaquin River watershed undertakes actions to make water available for transfer. The SWP does not address the upstream operations that may be necessary to make water available for transfer. Nor does this document address the impacts of water transfers on terrestrial species.

Transfers requiring export from the Delta are done at times when pumping and conveyance capacity at the CVP or SWP export facilities is available to move the water to the buyer. Additionally, Reclamation and DWR must coordinate review of the transfer proposals and Project operations to assure that the Projects are not impacted including the ability to exercise their own water rights or to meet their legal and regulatory requirements are not diminished or limited in any way. To avoid impacts to Delta water quality the individual transfer is assessed a carriage water loss to account for flows required to avoid impacts to Delta water quality or flow objectives. All transfers would be in accordance with all existing regulations and requirements.

Purchasers of water for transfers may include Reclamation, CVP water contractors, DWR, SWP water contractors, other State and Federal agencies, and other parties. Reclamation and DWR have operated water acquisition programs in the past to provide water for environmental programs and additional supplies to CVP water contractors, SWP water contractors, and other parties. Past transfer programs include the following.

- DWR administered the 1991, 1992, 1994, and 2009 Drought Water Banks and Dry Year Programs in 2001 and 2002.

- Reclamation operated a forbearance program in 2001 by purchasing CVP contractors' water in the Sacramento Valley for CVPIA instream flows, and to augment water supplies for CVP contractors south of the Delta and wildlife refuges. Reclamation administers the CVPIA Water Acquisition Program for Refuge Level 4 supplies and fishery instream flows.
- DWR is a signatory to the Yuba River Accord Water Transfer Agreement through 2025 that provides fish flows on the Yuba River and also water supply that is exported at DWR and Reclamation Delta facilities for the CVP and SWP operations and for the SWP and CVP contractors.
- In the past, CVP contractors and SWP water contractors have independently acquired water and arranged for pumping and conveyance through SWP and CVP facilities.

Lower Yuba River Accord

The Lower Yuba River Accord (Yuba Accord) consists of three sets of agreements designed to protect and enhance fisheries resources in the Lower Yuba River, increase local water supply reliability, provide DWR with increased operational flexibility for protection of Delta fisheries resources, and provide added dry-year water supplies to CVP and SWP water contractors. These agreements are:

- The Lower Yuba River Fisheries Agreement (Fisheries Agreement).
- Agreements for the Conjunctive Use of Surface and Groundwater Supplies (Conjunctive Use Agreements).
- Agreement for the Long-term Purchase of Water from Yuba County Water Agency by DWR (Water Purchase Agreement).

The Fisheries Agreement is the cornerstone of the Yuba Accord. It was developed by state, federal, and consulting fisheries biologists, fisheries advocates, policy representatives, and the Yuba County Water Agency (YCWA). Compared to the interim flow requirements of the SWRCB Revised Water Right Decision 1644 (RD-1644), the Fisheries Agreement establishes higher minimum instream flows during most months of most water years.

To assure that YCWA's water supply reliability is not reduced by the higher minimum instream flows and water transfers, it and seven of its member units have signed conjunctive use agreements. These agreements establish a conjunctive use program that facilitates the integration of the surface water and groundwater supplies of the seven local irrigation districts and mutual water companies that YCWA serves in Yuba County. Integration of surface water and groundwater allows YCWA to increase the efficiency of its water management.

Under the Water Purchase Agreement, DWR administers the water transfer activities. The Water Transfer Agreement allows DWR to purchase water from YCWA to generally offset water costs resulting from export restrictions in winter and spring each year to benefit Delta Smelt and out-migrating San Joaquin River salmonids. This quantity of water is known as "Component 1 Water" under the Water Purchase Agreement and is quantified as the first 60 TAF of surface water above a defined baseline that Yuba releases each year. Assuming a 20 percent carriage water cost, approximately 48 TAF would reach the export pumps to produce a mitigation offset of approximately 48 TAF of reduced exports.

Additional water supplies purchased by the SWP water contractors and/or CVP contractors under the Water Purchase Agreement are administered by DWR as a water transfer program in drier years. These supplies include: (a) Component 2 water (15 TAF per year [TAF/yr] in Dry Years and up to 30 TAF/yr in Critical Years); (b) Component 3 water (up to 40 TAF/yr in specified lower SWP or CVP allocation years); and (c) Component 4 water (additional water that YCWA makes available from surface-water supplies and its groundwater substitution program). The San Luis and Delta-Mendota Water Authority is a Participating Contractor to provide benefits to certain of its member CVP contractors.

CEQA review for all of the Yuba Accord agreements (Fisheries, Water Purchase, and Conjunctive Use) was completed in 2007 and these agreements were fully executed between late 2007 and early 2008. SWRCB approved the instream flow schedules and water transfer aspects of the Yuba River Accord, with some corrections, on March 18, 2008. The Fisheries Agreement terminates when FERC issues a new long-term FERC license for the Yuba River Development Project. The Water Purchase Agreement will terminate on December 31, 2025, but the amounts of water that YCWA will transfer under the agreement after FERC issues a new long-term license for the Yuba River Development Project will be subject to negotiation by the parties to the agreement. The Conjunctive Use Agreements will terminate when the Fisheries Agreement and Water Purchase Agreement terminate. It is assumed in this EIS that the existing or similar agreements will be renewed by 2030.

Transfer Capacity

It is expected that water transfer programs for environmental and water supply augmentation will continue in some form, and that in most years (all but the driest), the scope of annual water transfers of water exported through the Delta will be limited by available Delta pumping capacity, and exports for transfers will be limited to the months of July-September. As such, looking at an indicator of available transfer capacity in those months is one way of estimating an upper boundary to the effects of transfers on an annual basis.

The CVP and SWP may provide Delta export pumping for transfers using pumping capacity at Banks and Jones pumping plants beyond that which is being used to deliver Project water supply, up to the diversion capacity, consistent with existing operational and regulatory restrictions.

The surplus capacity available for transfers varies a great deal with hydrologic conditions. In general, as hydrologic conditions get wetter, surplus capacity diminishes because the CVP and SWP are more fully using export pumping capacity for Project supplies. The CVP's Jones Pumping Plant has little surplus capacity, except in the driest hydrologic conditions. The SWP has the most surplus capacity in critical and some dry years, less or sometimes none in most median hydrologic conditions, and some surplus again in some above normal and wet years when demands may be lower because some water users may have alternative supplies.

The availability of water for transfer and the demand for transferred water may also vary with hydrologic conditions. Accordingly, since many transfers are negotiated between willing buyers and sellers under prevailing market conditions, price of water also may be a factor determining how much is transferred in any year. This document does not attempt to identify how much of the available and useable surplus export capacity of the CVP and SWP would actually be used for transfers in a particular year but given the recent history of water transfer programs and requests for individual water transfers, trends suggest a growing reliance on transfers to meet dry year water demands.

Under both the present and future conditions, capability to export transfers would often be capacity-limited, except in Critical and some Dry years. In Critical and some Dry years, both Banks and Jones pumping plants would likely have surplus capacity for transfers. As a result, export capacity is less likely to limit transfers in these years. During such years, low Project exports and high demand for water supply could make it possible to transfer significant amounts of transfer water when upstream water supplies are available.

Exports for Transfers

Although transfers may occur at any time of year, the 2008 USFWS BO and 2009 NMFS BO address proposed exports for transfers during only the months July through September. For transfers outside those months, or in excess of the maximum amounts (listed below), separate consultations would be required with the USFWS and NMFS. Based on the estimates of available capacity for export of transfers during July through September, and in recognition of the many other possible operational contingencies and constraints that may limit actual use of that capacity for transfers, as follows.

- Critical Water Year: Maximum Transfer Amount is 600 TAF
- Dry Water Year following Critical Water Year: Maximum Transfer Amount is 600 TAF
- Dry Water Year following Dry Water Year: Maximum Transfer Amount is 600 TAF
- All Other Water Years: Maximum Transfer Amount is 360 TAF

C.5.3.2.7 Coordinated Operation Agreement

The CVP and SWP are operated in a coordinated manner in accordance with Public Law 99-546 (October 27, 1986), directing the Secretary to execute the COA. The CVP and SWP are also operated under the SWRCB decisions and water right orders related to the CVP's and SWP's water right permits and licenses to appropriate water by diverting to storage, by directly diverting to use, or by re-diverting releases from storage later in the year or in subsequent years.

The CVP and SWP are permitted by SWRCB to store water, divert water and re-divert CVP and SWP water that has been stored in upstream reservoirs. The CVP and SWP have built water storage and water delivery facilities in the Central Valley to deliver water supplies to CVP and SWP contractors, including senior water users. The CVP's and SWP's water rights are conditioned by the SWRCB to protect the beneficial uses of water within the watersheds.

As conditions of the water right permits and licenses, SWRCB requires the CVP and SWP to meet specific water quality objectives within the Delta. Reclamation and DWR coordinate operation of the CVP and SWP, pursuant to the COA, to meet these and other operating requirements. The COA is an agreement between the Federal government and the State of California for the coordinated operation of the CVP and SWP. The agreement suspended a 1960 agreement and superseded annual coordination agreements that had been implemented following construction of the SWP.

Through the COA, Reclamation and DWR share the obligation for meeting in-basin uses. In-basin uses are defined in the COA as legal uses of water in the Sacramento Basin, including the water required under the provisions of Exhibit A of the COA [SWRCB Delta standards]. Each project is obligated to ensure water is available for these uses. The respective degree of obligation is dependent on several factors, as described below.

Balanced water conditions are defined in the COA as periods when it is mutually agreed that releases from upstream reservoirs plus unregulated flows approximately equal the water supply needed to meet Sacramento Valley in-basin uses plus exports. Excess water conditions are periods when it is mutually agreed that releases from upstream reservoirs plus unregulated flow exceed Sacramento Valley in-basin uses plus exports. Reclamation's Central Valley Operations Office (CVO) and DWR's SWP Operations Control Office jointly decide when balanced or excess water conditions exist. During balanced water conditions, the projects share the responsibility in meeting in-basin uses.

During excess water conditions, sufficient water is available to meet all beneficial needs, and the CVP and SWP are not required to supplement the supply with water from reservoir storage. Under Article 6(g) of the COA, Reclamation and DWR have the responsibility (during excess water conditions) to store and export as much water as possible, within physical, legal, and contractual limits.

Implementation of the COA principles has continuously evolved since 1986 as changes have occurred to CVP and SWP facilities, to operating criteria, and to the overall physical and regulatory environment. For example, updated water quality and flow standards adopted by the SWRCB, CVPIA, and ESA responsibilities have affected both CVP and SWP operations. The 1986 COA incorporated D-1485 provisions regarding Delta salinity, outflow, and export restrictions and provided a methodology to incorporate future regulatory changes, like Delta salinity requirements. Both D-1641 and the 2008 and 2009 biological opinions included various export restrictions that were not explicitly addressed in the 1986 COA. Prior to 2019, the available export capacity as a result of these export restrictions was shared between the projects in the absence of a formal update.

In December 2018, Reclamation and DWR modified four key elements of the COA to address changes since COA was originally signed: (1) in-basin uses; (2) export restrictions; (3) CVP use of Banks Pumping Plant up to 195,000 acre-feet per year; and (4) the periodic review. COA sharing percentages for meeting Sacramento Valley in-basin uses now vary from 80 percent responsibility of the United States and 20 percent responsibility of the State of California in wet year types to 60 percent responsibility of the United States and 40 percent responsibility of the State of California in critical year types. In a dry or critical year following two dry or critical years, the United States and State will meet to discuss additional changes to the percentage sharing of responsibility to meet in-basin use. When exports are constrained, and the Delta is in balanced conditions, Reclamation may pump up to 65 percent of the allowable total exports with DWR pumping the remaining capacity. In excess conditions, these percentages change to 60/40.

C.5.3.2.8 Accounting and Coordination of Operations

Reclamation and DWR coordinate on a daily basis to determine target Delta outflow for water quality, reservoir release levels necessary to meet in-basin demands, schedules for joint use of the San Luis Unit facilities, and for the use of each other’s facilities for pumping and wheeling. During balanced water conditions, daily water accounting is maintained for the CVP and SWP obligations. This accounting allows for flexibility in operations and avoids the necessity of daily changes in reservoir releases that originate several days’ travel time from the Delta.

The accounting language of the COA provides the mechanism for determining the responsibility of each project for Delta outflow influenced standards; however, real-time operations dictate actions. For example, conditions in the Delta can change rapidly. Weather conditions combined with tidal action can quickly affect Delta salinity conditions, and therefore, the Delta outflow required to maintain standards. If, in this circumstance, it is decided the reasonable course of action is to increase upstream reservoir releases, then the response may be to increase Folsom Reservoir releases first because the released water will reach the Delta before flows released from other CVP and SWP reservoirs. Lake Oroville water releases require about three days to reach the Delta, while water released from Shasta Lake requires five days to travel from Keswick Reservoir to the Delta. As water from the other reservoirs arrives in the Delta, Folsom Reservoir releases can be adjusted downward. Any imbalance in meeting each project’s initial shared obligation would be captured by the COA accounting.

Reservoir release changes are one means of adjusting to changing in-basin conditions. Increasing or decreasing project exports can also immediately achieve changes to Delta outflow. As with changes in reservoir releases, imbalances in meeting the CVP and SWP initial shared obligations are captured by the COA accounting.

The duration of balanced water conditions varies from year to year. Some very wet years have had no periods of balanced conditions, while very dry years may have had long continuous periods of balanced conditions, and still other years may have had several periods of balanced conditions interspersed with excess water conditions.

C.5.4 Joint Facilities in Suisun Marsh

Since the early 1970s, the California Legislature, SWRCB, Reclamation, CDFW, Suisun Resource Conservation District (SRCD), DWR, and other agencies have worked to preserve beneficial uses of Suisun Marsh in mitigation for perceived impacts of reduced Delta outflow on the salinity regime. Early on, salinity standards were set by SWRCB to protect alkali bulrush production, a primary waterfowl plant food. The most recent standard under SWRCB D-1641 acknowledges that multiple beneficial uses deserve protection.

A contractual agreement among DWR, Reclamation, CDFW, and SRCD contains provisions for DWR and Reclamation to mitigate the effects on Suisun Marsh channel water salinity from SWP and CVP operations and other upstream diversions. The Suisun Marsh Preservation Agreement (SMPA) requires DWR and Reclamation to meet salinity standards, sets a timeline for implementing the Plan of Protection, and delineates monitoring and mitigation requirements. In addition to the contractual agreement, SWRCB D-1485 codified salinity standards in 1978, which have been carried forward to SWRCB D-1641.

There are two primary physical mechanisms for meeting salinity standards set forth in SWRCB D-1641 and the SMPA: (1) the implementation and operation of physical facilities in the Marsh; and (2) management of Delta outflow (i.e., facility operations are driven largely by salinity levels upstream of Montezuma Slough and salinity levels are highly sensitive to Delta outflow). Physical facilities, described below, have been operating since the early 1980s and have proven to be a highly reliable method for meeting standards.

C.5.4.1 *Suisun Marsh Salinity Control Gates*

The SMSCG are located on Montezuma Slough about two miles downstream from the confluence of the Sacramento and San Joaquin Rivers, near Collinsville. The objective of Suisun Marsh Salinity Control Gate operation is to decrease the salinity of the water in Montezuma Slough. The gates control salinity by restricting the flow of higher salinity water from Grizzly Bay into Montezuma Slough during incoming tides and retaining lower salinity Sacramento River water from the previous ebb tide. Operation of the gates in this fashion lowers salinity in Suisun Marsh channels and results in a net movement of water from east to west.

When Delta outflow is low to moderate and the gates are not operating, tidal flow past the gate is approximately 5,000 to 6,000 cfs while the net flow is near zero. When operated, flood tide flows are arrested while ebb tide flows remain in the range of 5,000 to 6,000 cfs. The net flow in Montezuma Slough becomes approximately 2,500 to 2,800 cfs. The USACE permit for operating the SMSCG requires that it be operated between October and May only when needed to meet Suisun Marsh salinity standards. Historically, the gate has been operated as early as October 1, although in some years (e.g., 1996) the gate was not operated at all. When the channel water salinity decreases sufficiently below the salinity standards, or at the end of the control season, the project provides unrestricted movement through Montezuma Slough. Details of annual gate operations can be found in Summary of Salinity Conditions in

Suisun Marsh During Water Years 1984–1992 (DWR 1994), or the Suisun Marsh Monitoring Program Data Summary produced annually by DWR's Division of Environmental Services.

The approximately 2,800 cfs net flow induced by SMSCG operation is effective at moving the salinity downstream in Montezuma Slough. Salinity is reduced by roughly 100 percent at Belden's Landing, and by lesser amounts farther west along Montezuma Slough. At the same time, the salinity field in Suisun Bay moves upstream as net Delta outflow (measured nominally at Chipps Island) is reduced by gate operation. Net outflow through Carquinez Strait is not affected.

The SMSCG are operated during the salinity control season, which spans from October to May. Operational frequency is affected by hydrologic conditions, weather, Delta outflow, tide, fishery considerations, and other factors. The gates have also been operated for scientific studies. After discussions with NMFS based on study findings, the boat lock portion of the gate is now held open at all times during SMSCG operation to allow for continuous salmon passage opportunity. Adaptive management of the gates continues to improve, and salinity standards have been met with less frequent gate operation since 2006. In low outflow years gate operation was used from 35 to 42 days. The operation was limited to 17 to 69 days in 2009, 2010, 2011 and 2013. Assuming no significant long-term changes in the drivers mentioned above, it is expected that gate operations will remain at current levels (17 to 69 days per year) except perhaps during the most critical hydrologic conditions and other conditions that affect Delta outflow.

C.5.4.1.1 SMSCG Fish Passage Studies

The SMSCG were constructed and operate under USACE Permit 16223E58, which includes a special condition to evaluate the nature of delays to migrating fish. Ultrasonic telemetry studies in 1993 and 1994 showed that the physical configuration and operation of the gates during the control season have a negative effect on adult salmonid passage (Tillman et al. 1996; Edwards et al. 1996).

The Department coordinated additional fish passage studies in 1998, 1999, 2001, 2002, 2003, and 2004. Migrating adult fall-run Chinook Salmon were tagged and tracked by telemetry in the vicinity of the SMSCG to assess potential measures to increase the salmon passage rate and decrease salmon passage time through the gates. a

Results in 2001, 2003, and 2004 indicate that leaving the boat lock open during the Control Season when the flashboards are in place at the SMSCG and the radial gates are tidally operated provides a nearly equivalent fish passage to the noncontrol season configuration when the flashboards are out and the radial gates are open. This approach minimizes delay and blockage of adult Sacramento River winter-run Chinook Salmon, Central Valley spring-run Chinook Salmon, and Central Valley Steelhead migrating upstream during the Control Season while the SMSCG is operating. However, the boat lock gates may be closed temporarily to stabilize flows to facilitate safe passage of watercraft through the facility.

C.5.4.2 *Roaring River Distribution System*

The Roaring River Distribution System (RRDS) is located in the southeastern Suisun Marsh and was constructed by the DWR and Reclamation in 1979 to mitigate for the effects on Marsh channel water salinity caused by Central Valley Project and State Water Project operations. The distribution system is used to convey less saline water from Montezuma Slough to managed 5,000 acres of private and 3,000 acres of CDFW managed wetlands on Simmons, Hammond, Van Sickle, Wheeler, and Grizzly Islands.

Salinity control is mandated by State Water Resources Control Board (SWRCB), Suisun Marsh Protection Plan (SFBCDC 1976), Plan of Protection for Suisun Marsh (DWR 1984b) and associated

Environmental Impact Report, and in response to D-1485, Order 7, superseded by D-1641. DWR and Reclamation are required under the Suisun Marsh Preservation Agreement (Reclamation et al. 1987, 2005) to operate and maintain the RRDS to provide lower salinity water to adjacent State and private landowners in the Marsh.

Diversions from Montezuma Slough typically occur from August through June. Water is diverted from RRDS to the managed wetlands and circulated. The water is drained from the managed wetlands in spring, taking with it salts from the soil.

The RRDS includes an intake structure from Montezuma Slough consisting of eight 60-inch culverts with flap gates and slide gates. Managed wetlands north and south of the RRDS receive water, as needed, through publicly and privately-owned turnouts on the system. Between 1981 and 1982 fish screens were placed over the intake according to California Department of Fish and Wildlife (CDFW) standards. After the listing of Delta Smelt, RRDS diversion rates have been controlled to maintain an average approach velocity below 0.7 ft/s at the intake fish screen. The intake discharges to the 40-acre Hammond Island pond at the southeast corner of CDFW property. Motorized slide gates in Montezuma Slough and flap gates in the pond control flows through the culverts into the pond. A manually operated flap gate and flashboard riser are located at the confluence of Roaring River and Montezuma Slough to allow drainage back into Montezuma Slough for controlling water levels in the distribution system and for flood protection. DWR owns and operates this drain gate to ensure the Roaring River levees are not compromised during extremely high tides. Approximately 8 miles of channel run from Hammond Island pond to the western edge of Simmons Island. Several turnouts along RRDS are operated and maintained by the DFW and adjacent private landowners.

DWR conducts routine maintenance of the system, primarily maintaining the levee roads and fish screens. RRDS, like other levees in the marsh, have experienced subsidence.

C.5.4.3 *Morrow Island Distribution System*

The Morrow Island Distribution System (MIDS) was constructed in 1979 and 1980 in the southwestern Suisun Marsh as part of the Initial Facilities in the Plan of Protection for the Suisun Marsh. The contractual requirement for Reclamation and DWR is to provide water to the ownerships so that lands may be managed according to approved local management plans. The system was constructed primarily to channel drainage water from the adjacent managed wetlands for discharge into Suisun Slough and Grizzly Bay. This approach increases circulation and reduces salinity in Goodyear Slough.

The MIDS is used year-round, but most intensively from September through June. When managed wetlands are filling and circulating, water is tidally diverted from Goodyear Slough just south of Pierce Harbor through three 48-inch culverts. Drainage water from Morrow Island is discharged into Grizzly Bay by way of the C-Line Outfall (two 36-inch culverts) and into the mouth of Suisun Slough by way of the M-Line Outfall (three 48-inch culverts), rather than back into Goodyear Slough. This helps prevent increases in salinity due to drainage water discharges into Goodyear Slough. The M-Line ditch is approximately 1.6 miles long and the C-Line ditch is approximately 0.8 miles long.

Reclamation and DWR operate the Goodyear Slough Outfall to improve water circulation in the marsh. This structure consists of four 48-inch diameter culverts with flap gates designed to drain water from the southern end of Goodyear Slough into Suisun Bay. On flood tides, the gates reduce the amount of tidal inflow into Goodyear Slough.

C.5.4.4 *Suisun Marsh Wildlife Habitat Management, Preservation, and Restoration Plan*

The Suisun Marsh Habitat Management, Preservation, and Restoration Plan (SMP) was developed by the Suisun Principal Agencies including USFWS, Reclamation, CDFW, DWR, NMFS, and Suisun Resource Conservation. The SMP is a 30-year comprehensive plan designed to address the various conflicts regarding use of Marsh resources, with the focus on achieving an acceptable multi-stakeholder approach. The plan balances the benefits of tidal wetland restoration with other habitat uses in the Marsh by evaluating alternatives that provide a politically acceptable change in Marshwide land uses, such as salt marsh harvest mouse habitat, managed wetlands, public use, and upland habitat. The SMP is intended to address the full range of issues in the Marsh, which are linked geographically, ecologically, and ideologically. The objectives of the SMP are to:

1. Implement the CALFED Ecosystem Restoration Program Plan (ERPP) restoration target for the Suisun Marsh ecoregion of 5,000 to 7,000 acres of tidal marsh and protection and enhancement of 40,000 to 50,000 acres of managed wetlands;
2. Maintain the heritage of waterfowl hunting and other recreational opportunities and increase the surrounding communities' awareness of the ecological values of Suisun Marsh;
3. Maintain and improve the Suisun Marsh levee system integrity to protect property, infrastructure, and wildlife habitats from catastrophic flooding; and
4. Protect and, where possible improve, water quality for beneficial uses in Suisun Marsh, including estuarine, spawning, and migrating habitat uses for fish species as well as recreational uses and associated wildlife habitat.

In June of 2013, the USFWS issued a BO (File Number: 08ESMF00-2012-F-0602-2) to the Bureau of Reclamation that addresses the effects of the SMP on the endangered threatened along with their designated critical habitat. The SMP BO analyses both a project-level plan for managed wetlands and a programmatic action for tidal restoration. Tidal wetland restoration helps achieve the restoration goals established for the Marsh by the CALFED ERP Plan, San Francisco Bay Area Wetlands Ecosystem Goals Project, and the USFWS's Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California for the Suisun Bay Area Recovery Unit. The BO details requirements for proposed tidal marsh restoration projects that maybe appended to the BO.

C.5.5 Non-CVP and SWP Reservoirs that Store CVP and SWP Water

The CVP and SWP water is delivered to water agencies. Some of those water agencies store the water in regional and local reservoirs. These reservoirs frequently store non-CVP and SWP water supplies, including local runoff or water diverted under separate water rights or contracts. The capacities of these reservoirs are listed in Tables C.1-5, C.1-6, and C.1-7.

In the San Francisco Bay Area Region, CVP water is stored in the Contra Costa Water District Los Vaqueros Reservoir and the East Bay Municipal Utility District Upper San Leandro, San Pablo, Briones, and Lafayette reservoirs and Lake Chabot. The Los Vaqueros Reservoir, as previously described, also stores water diverted from the Delta under separate water rights. The East Bay Municipal Utility District reservoirs primarily store water diverted under water rights on the Mokelumne River.

In the Central Coast Region, a portion of the SWP water supply diverted in the Coastal Branch can be stored in Cachuma Lake for use by southern Santa Barbara County communities. Cachuma Lake is a facility owned and operated by Reclamation in Santa Barbara County as part of the Cachuma Project (not the CVP).

In the Southern California Region, SWP water is stored in the Metropolitan Water District of Southern California's Diamond Valley Lake and Lake Skinner; United Water Conservation District's Lake Piru; City of Escondido's Dixon Lake; City of San Diego's San Vicente, El Capitan, Lower Otay, Hodges, and Murray reservoirs; Helix Water District's Lake Jennings; Sweetwater Authority's Sweetwater Reservoir; and San Diego County Water Authority's Olivenhain Reservoir. There are future plans to expand local and regional water surface water storage.

C.5.6 Water Supplies Used by Central Valley Project and State Water Project Water Users

The CVP and SWP water supplies are the only water supplies available to some water users, many of the CVP Sacramento River Settlement Contractors, communities near Redding (Centerville, Clear Creek, and Shasta community services districts; Shasta County Water Agency), communities in the San Joaquin Valley (cities of Avenal, Coalinga, and Huron), and some communities served by the Antelope Valley-East Kern Water Agency. Other CVP and SWP water users rely upon other surface water supplies and groundwater. However, when the CVP and SWP water supplies are limited due to climate conditions and hydrology, the other surface water supplies are also limited.

Several CVP and SWP water users also rely upon other imported water supplies, including water from Solano Project (used by the Solano County Water Agency), San Francisco Public Utilities Commission (used by portions of the service areas of Alameda County Water District, Santa Clara Valley Water District, and Zone 7 Water Agency), and the Colorado River (used by portions of the service area of the Metropolitan Water District of Southern California and Coachella Valley Water District). These surface water supplies are also subject to reductions due to hydrologic conditions. In the case of water users that rely upon Colorado River water supplies, Delta water is used to dilute the salts and trace elements (e.g., selenium) in the Colorado River water in addition to providing direct water supplies (Reclamation 2012).

In response to recent reductions in CVP and SWP water supply reliability, water agencies have been improving regional and local water supply reliability through enhanced water conservation efforts, wastewater effluent and stormwater recycling, construction of surface water and groundwater storage facilities, and construction of desalination treatment plants for brackish water sources and ocean water sources. In addition, many agencies have constructed conveyance facilities to allow sharing of water supplies between communities, including the recent Bay Area Regional Water Supply Reliability project that provided conveyance opportunities between several CVP and SWP water users in the San Francisco Bay Area Region.

Water conservation is an integral part of water management in the study area. Water use efficiency programs and initiatives reduce the need for more expensive water supplies by facilitating the efficient use of existing water supplies. For example, a cost-effective component of many water plans is to reduce water use through educational tools that include commercial and residential guidance for water efficient landscapes, water use calculators for agricultural and municipal users, and conservation websites. All of these efforts are implemented to meet the statewide goals to reduce municipal per capita water use by 20 percent by 2020 and to optimize agricultural water use efficiency.

Water transfers also are an integral part of water management. Historically, water transfers primarily were in-basin transfers (e.g., Sacramento Valley water seller to Sacramento Valley water user) (Reclamation 2013b; DWR, Reclamation, USFWS and NMFS 2013). However, between 2001 and 2012, water transfers from the Sacramento Valley to the areas located south of the Delta of up to 298,806 acre-feet occurred (not including water transfers under the Environmental Water Account Program in the early 2000s) (DWR, Reclamation, USFWS and NMFS 2013). These transfers occurred in drier years. In the 2012 and 2013, the following types of water transfers occurred (DWR and Reclamation 2015).

Until recently, most of the water transfers extended for one or two years. In 2008, one of the first long-term water transfer agreements was approved by the SWRCB for the Lower Yuba River Accord. The plan was designed to protect and enhance fisheries resources in the Lower Yuba River, increase local water supply reliability, provide DWR with increased operational flexibility for protection of Delta fisheries resources, and provide added dry-year water supplies to CVP and SWP water users. In 2013, Reclamation approved an overall program for a 25-year period (2014 to 2038) to transfer up to 150,000 acre-feet per year of water from the San Joaquin River Exchange Contractors Water Authority to DOI for refuge water supplies or CVP and SWP water users (Reclamation 2013b). Reclamation is currently planning a long-term water transfer program between water sellers in the Sacramento Valley and water users located in the San Francisco Bay Area and south of the Delta (DWR and Reclamation 2015).

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RECLAMATION
Managing Water in the West

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

Central Valley Project, California
Mid-Pacific Region

Draft Alternatives Development Technical Memorandum

U.S. Department of the Interior
Bureau of Reclamation **July 2019**

Mission Statements

The Department of the Interior conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

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

Table of Contents

Tables

Figures

Acronyms and Abbreviation

ACWA	Association of California Water Agencies
AF	acre-feet
Banks Pumping Plant	Harvey O. Banks Pumping Plant
Bay-Delta	San Francisco Bay/Sacramento–San Joaquin Delta
BO	Biological Opinion
CDFW	California Department of Fish and Wildlife
cfs	cubic feet per second
COA	Coordinated Operations Agreement
CSAMP	Collaborative Science and Adaptive Management Program
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
Delta	Sacramento–San Joaquin Delta
DFG	California Department of Fish and Game
DPIIC	Delta Plan Interagency Implementation Committee
DWR	California Department of Water Resources
EBMUD	East Bay Municipal Utility District
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
IEP	Interagency Ecological Program
M&I	municipal and industrial
MAF	million acre-feet
NGOs	nongovernmental organizations
NMFS	National Marine Fisheries Service
OCO	State Water Project Operations Control Office
OMR	Old and Middle River
PR&G	Principles, Requirements and Guidelines for Water and Related Land Resources Implementation Studies
Reclamation	Bureau of Reclamation
RPA	Reasonable and Prudent Alternative
SMSCG	Suisun Marsh Salinity Control Gates
SWP	State Water Project
SWRCB	California State Water Resources Control Board
TAF	thousand acre-feet
TM	Technical Memorandum
USFWS	United States Fish and Wildlife Service
WOMT	Water Operations Management Team
WRO	Water Rights Order

Chapter 1 Introduction

This Alternative Development Technical Memorandum (TM) documents Reclamation's efforts to identify, screen, and refine alternatives for consideration.

1.1 Study Area Location and Description

The study area includes areas that could be affected directly or indirectly by the alternatives. For purposes of this TM, the study area encompasses the following reservoirs, rivers, and land between the levees adjacent to the rivers:

- Trinity Reservoir and the Trinity River downstream of Lewiston Reservoir;
- Sacramento River from Shasta Lake downstream to, and including, the Delta;
- Clear Creek from Whiskeytown Reservoir to its confluence with the Sacramento River;
- Feather River from the Federal Energy Regulatory Commission (FERC) boundary downstream to its confluence with the Sacramento River;
- American River from Folsom Reservoir downstream to its confluence with the Sacramento River;
- Stanislaus River from New Melones Reservoir to its confluence with the San Joaquin River;
- San Joaquin River from Friant Dam downstream to, and including, the Delta;
- San Francisco Bay and Suisun Marsh;
- Nearshore Pacific Ocean on the coast from Point Conception to Cape Falcon in Oregon; and
- Areas that receive water from the CVP or SWP.

Figure 1.1-1 is a map of the study area.

Figure 1.1-1. Study Area Map

Chapter 2 Alternative Development Process

The purpose of the alternative development process is to identify a reasonable range of alternatives for inclusion in the EIS.

2.1 Process Overview

The alternatives development process involved input and review from water contractors, resource agencies, nongovernmental organizations (NGOs), and stakeholders. Resource agencies and water contractors were involved at a detailed level, including participation in meetings to identify the Proposed Action and range of potential alternatives. The process began in 2016 with the reinitiation of Section 7 consultation.

The alternatives development process included public scoping conducted in January 2018. Public scoping allowed Reclamation to solicit ideas for achieving the purpose and need, understand the scope of environmental issues that should be evaluated, and learn of potential impacts.

After the public scoping process, Reclamation collected initial components 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. Reclamation added to the list of components suggested at scoping by identifying components from scientific research, asking resource agencies and water contractors, and building on the technical understanding of the project team.

After identifying a list of initial components, Reclamation screened the components to identify the ones that could meet the purpose and need and help form a reasonable range of alternatives for analysis in the EIS. The components remaining after screening were combined into alternatives. Section 2.2 lists the components, Chapter 3 describes the screening effort, and Chapter 4 describes the range of alternatives moving forward for additional analysis in the EIS.

2.2 Components

Table 2.2-1 shows the list of initial components by area, with descriptions provided by the agency or individual that proposed the component. This list formed the foundation for the screening effort described in Chapter 3.

Table 2.2-1. Initial Components

Region	Name	Description
CVP-wide	2003 guidance under CVPIA	Implement the 2003 guidance, as described under CVPIA that allows 800,000 AF for the purpose of the environment
CVP-wide	Alternate energy sources	CVP facilities should use solar or wind power
CVP-wide	Change definition of renewable energy	Change California's definition of renewable energy to include existing CVP hydropower facilities
CVP-wide	Coordinated Operations Agreement revisions	Revise the Coordinated Operations Agreement to improve sharing of resources and obligations between the CVP and SWP
CVP-wide	CVP termination	Terminate the CVP in its entirety
CVP-wide	D-1641 operations	Operate CVP and SWP facilities to meet D-1641 requirements (without additional flow requirements)
CVP-wide	Dam safety	Evaluate the safety of all CVP dams, specifically the earthen dam at Trinity Lake
CVP-wide	Decrease development in forests	Decrease forest cutting, road building, and development in the Cascade-Sierra Mountains
CVP-wide	Improve hatchery management	Improve management and use of fish hatcheries
CVP-wide	Limit hydraulic fracturing	Limit the transfer of CVP and SWP water from agriculture and municipal uses for energy extraction like hydraulic fracturing
CVP-wide	Nonflow measures	Construct habitat restoration and conduct intervention
CVP-wide	Recalculate flood curves	Reoperate reservoirs and recalculate flood curves to increase supply and storage
CVP-wide	Reduce predation	Reduce predation by nonnative fish on listed native fish
CVP-wide	Refuge supplies	Facilitate carryover storage of winter water for spring irrigation in San Luis Reservoir for South-of-Delta refuges
CVP-wide	Reservoir expansion	Focus on raising Shasta Dam and expanding San Luis Reservoir, Los Vaqueros Reservoir, Temperance Flat Dam, and Sites Reservoir
CVP-wide	Restoration studies	Conduct studies to reduce uncertainty in restoration actions, including genetic and otolith research, steelhead population estimates and trends, fall-run population model, and sediment transport model, and to address how to avoid hatchery competition or genetic introgression with wild salmon
CVP-wide	Sediment management	Construct small dams near inflow points of lakes or reservoirs and annually dredge out sediments behind these small dams, sending the sediments to nearby farmlands
CVP-wide	Small screen program	Screen small diversions throughout system to reduce fish entrainment
CVP-wide	Specified release or transfer values	Release or transfer 25 to 100,000 AF per year for the next 10 years; releases would be made available March to May; any water not released would be stored by Reclamation, pursuant to a Warren Act contract
CVP-wide	Storage integration	Better integrate operations of storage facilities (see ACWA Storage Integration Study (MBK Engineers 2017))

Region	Name	Description
CVP-wide	Watershed management	Rehabilitate the Cascade-Sierra Mountains watershed to manage mountain meadows and restore wildfire into the fire-evolved ecosystem
Klamath River	Restore Lower Klamath Lake	Restore the Lower Klamath Lake and clean the Klamath Project's wastewater prior to reaching the Klamath River; restoring Lower Klamath Lake can provide additional water storage
Klamath River	Transfer groundwater in the Klamath Project	Use Klamath Project facilities to convey groundwater for transfer
Trinity River	Cold water conveyance system	Construct a cold water conveyance system from Trinity Reservoir through Lewiston Reservoir to Trinity River; more water from Trinity Reservoir would be available to valley users for power generation later in the season
Trinity River	Dam removal	Remove Trinity and Lewiston Dams
Trinity River	Grass Valley Creek flows	Increase releases from Buckhorn Dam for channel maintenance and provide migration flows for adult Coho Salmon
Trinity River	Lewiston Reservoir temperature management	Address the temperature issue at Lewiston Reservoir
Trinity River	Minimum pool volume at Trinity Reservoir	Establish a minimum pool volume of 900,000 to 1,000,000 AF at Trinity Reservoir to protect an adequate lake level for boating facilities and a cold water source for fishery restoration on the Trinity River; if unable to establish request, mitigate the impact by funding the construction of low-water boat launch facilities and Trinity Center and Fairview
Trinity River	Trinity flow augmentation	Augment Trinity River flows beyond the requirements of the 2000 Trinity River Record of Decision as necessary for preservation and propagation of fish
Trinity River	Upgrade hatchery facilities on Trinity River	Upgrade the Trinity River division hatchery facilities and fund Hoopa Valley Tribe plans for additional selective harvest; transfer hatchery facility management to the Hoopa Valley Tribe
Sacramento River	Adult rescue	Rescue adults stranded in locations without adequate fish passage (such as Fremont Weir)
Sacramento River	Increase floodplain	Increase the floodplain using setback levees along streams and the main stem of the Sacramento River between Red Bluff and Colusa; include the purchase of private lands within the floodplains
Sacramento River	Intake lowering near Wilkins Slough	Lower water intakes near Wilkins Slough so that navigation flow requirement can be relaxed, if appropriate, without affecting water supply
Sacramento River	Juvenile trap and haul	Collect juveniles to transport them past areas with high temperatures
Sacramento River	Reduce redd dewatering	Reduce the dewatering of Fall-Run Redds in the Sacramento River after Keswick Dam releases are ramped down
Sacramento River	Reservoir storage targets	Implement storage targets in reservoirs, as suggested by NMFS in 2017
Sacramento River	Rice decomposition smoothing	Deliver rice decomposition water over a longer period to reduce the short period of high flow

Region	Name	Description
Sacramento River	Sacramento River spawning and rearing habitat restoration	Restore spawning and rearing habitat in the Sacramento River
Sacramento River	Shasta Lake cold water pool management	Change operations of Shasta Lake to improve year-round management of cold water pool, incorporate a spring pulse, and schedule fall and winter flows to balance storage and redd maintenance
Sacramento River	Shasta Dam TCD improvements	Improve function of Shasta Dam TCD
Sacramento River	Yolo Bypass habitat restoration	Deliver water to the Yolo Bypass in support of juvenile salmon rearing habitat and multibenefit projects
American River	American River flows	Incorporate the 2017 Modified Flow Management Standard
American River	American River spawning and rearing habitat restoration	Restore spawning and rearing habitat in the lower American River
American River	Drought temperature facility improvements	Construct improvements to temperature facilities to improvement management in dry years
Bay-Delta	Addition of pipeline to Jones Pumping Plant	Add 30-foot diameter pipeline from Sherman Island to Jones Pumping Plant to capture water on north side of Sherman Island
Bay-Delta	Clifton Court Forebay Aquatic Weed and Algal Bloom Management	Manage aquatic weeds and algal blooms through mechanical means and pesticides
Bay-Delta	Delta Cross Channel gate improvements	Evaluate improvements to automate and streamline operation of the gates to maximize water supply deliveries
Bay-Delta	Delta fish species conservation hatchery	Operate a conservation hatchery for Delta Smelt
Bay-Delta	Delta gate system	Construct a gate system to limit the intrusion of saltwater into the Delta
Bay-Delta	Enhance Delta inflow and outflow	Include Delta inflow and outflow requirements to achieve recovery of federally listed and state-listed species
Bay-Delta	Flexible OMR management	Reduce OMR restrictions when they have less benefit to fish
Bay-Delta	Focusing on reduction of water	Consider alternatives that focus on reduction of water exports, including one or more alternatives that are consistent with the flow and export limitations identified in the SWRCB 2017 Final Scientific Basis Report
Bay-Delta	Improved Delta Cross Channel operations	Modify Delta Cross Channel operations in anticipation of water quality exceedance (rather than waiting for water quality exceedance to modify operations)
Bay-Delta	Increased exports during high flows	Capture and export more water during periods of high Delta outflow
Bay-Delta	Modify OMR restrictions specific to diversion site	Connect OMR restrictions to relative impact of individual diversion facilities; consider prescreen loss at Clifton Court Forebay
Bay-Delta	No Fall X2 action	Eliminate the USFWS RPA Fall X2 Action (Action 4) and Component 3 (improved Delta Smelt habitat) (in the USFWS 2008 BO)

Region	Name	Description
Bay-Delta	North Delta food subsidies	Route water from Colusa Drain into Yolo Bypass and Cache Slough to augment food supplies for Delta Smelt
Bay-Delta	Protection of winter and spring flows	Protect winter and spring flows as proposed in the Bay-Delta plan update process for the San Joaquin and Sacramento Rivers; consult with fisheries' genetic experts on how to improve the duration and timing of these flows to benefit spring and winter runs
Bay-Delta	Reintroduction efforts from Fish Conservation and Culture Laboratory	Construct an improved conservation hatchery focused on capturing existing genetic diversity; operations could expand to accommodate reintroduction
Bay-Delta	Remove San Joaquin River inflow and export requirement	Remove limitation on exports that is tied to inflow from the San Joaquin River
Bay-Delta	Replace levee with fish screen	Replace Clifton Court Forebay's 1.5-mile levee with a fish screen, specifically ZeeWeed fish screen; fill Clifton Court Forebay at nighttime and use only natural flows during the daytime; increase capacity of Clifton Court Forebay by dredging
Bay-Delta	Restore Delta natural flow regimes	Restore natural flow regimes in the Bay-Delta, which would provide water within basins for local use
Bay-Delta	RPA water temperature objectives	Eliminate RPA water temperature objectives because they either are met or cannot be met
Bay-Delta	Skinner Fish Facility improvements	Improve operations and effectiveness at Skinner Fish Facility
Bay-Delta	Suisun Marsh food subsidies	Add fish food to Suisun Marsh by coordinating managed wetland flood and drain operations, Roaring River Distribution System food production, and reoperation of SMSCG
Bay-Delta	Suisun Marsh Salinity Control Gate operations	Operate SMSCG in June through September to increase food production for Delta Smelt
Bay-Delta	Tidal habitat restoration	Complete 8,000 acres of tidal habitat restoration that DWR has begun
Bay-Delta	Tracy Fish Collection Facility improvements	Improve operations and effectiveness at Tracy Fish Collection Facility
Bay-Delta	Water transfers	Allow water transfers for a period longer than July through September
Stanislaus River	Alterations to New Melones Reservoir index	Change index for New Melones Reservoir to a hydrologic index for river releases so that it is more reactive to current hydrologic conditions of the year (e.g., 60-20-20 for the San Joaquin River Basin)
Stanislaus River	New Melones Reservoir allocations	Reschedule guidelines related to New Melones Reservoir for Stockton East Water District and Central San Joaquin Water Conservation District
Stanislaus River	Revert to previous New Melones agreements	Revert to DFG 1988 agreement flows that are a condition of the New Melones project permits
Stanislaus River	Stanislaus River dissolved oxygen standard relaxation	Petition SWRCB to relax the dissolved oxygen objective for New Melones Reservoir and the Stanislaus River

Region	Name	Description
Tuolumne River	Tuolumne River conveyance facility	Consider a conveyance facility to move excess Tuolumne River water to Oakdale Irrigation District; back up Oakdale Irrigation District deliveries to New Melones Reservoir
CVP and SWP service area	Address Friant-Kern Canal subsidence	Provide a permanent fix to recently identified issues relating to land subsidence along the Friant-Kern Canal
CVP and SWP service area	Alternate water supplies	Incorporate alternate water supplies, such as desalinization plants, rain water retention ponds, urban storm water recapture, recycling, and water reuse (e.g., grey water)
CVP and SWP service area	Connection of Folsom South Canal to EBMUD aqueducts	Connect the Folsom South Canal via the Freeport pipeline extension 10.7 miles south to connect to EBMUD aqueducts; improve conveyance of and storage of water; using a "Lucid Pipe" can add hydroelectric power generation
CVP and SWP service area	Eastside San Joaquin Valley storage and groundwater banking	Include a proposed 100,000 AF per year Tulare Lake storage and floodwater protection project, a 100,000 AF per year Kern fan groundwater storage project, and a proposed 30,000 AF per year groundwater bank partnership between Delano-Earlimart Irrigation District and Pixley Irrigation District on the east side of San Joaquin Valley.
CVP and SWP service area	Fix aging infrastructure	Repair any aging infrastructure to improve capacity
CVP and SWP service area	Identify priority areas for delivery	Prioritize water deliveries based on crop type, soil portfolio, and groundwater conditions
CVP and SWP service area	Improve irrigation distribution systems	Update district irrigation delivery systems to provide water to farmers when needed
CVP and SWP service area	Land retirement	Retire land and water rights
CVP and SWP service area	Modified planting practices	Plant drought-tolerant crops, avoid permanent orchard crops, and improve irrigation practices
CVP and SWP service area	Restore Tulare Lake basin	Restore Tulare Lake Basin for increased storage capacity South-of-Delta and for percolation ponds to restore groundwater
CVP and SWP service area	Water to Salton Sea	Supply water to the Salton Sea to avoid air quality impacts
CVP and SWP service area	Water use efficiency	Increase efficiency in use of existing supplies

ACWA = Association of California Water Agencies, AF = acre-feet, Bay-Delta = San Francisco Bay/Sacramento–San Joaquin Delta, BO = biological opinion, CVP = Central Valley Project, CVPIA = Central Valley Project Improvement Act, DFG = Department of Fish and Game, EBMUD = municipal utility district, NMFS = National Marine Fisheries Service, OMR = Old and Middle River, RPA = Reasonable and Prudent Alternative, SMSCG = Suisun Marsh Salinity Control Gates, SWP = State Water Project, SWRCB = State Water Resources Control Board, TCD = Temperature Control Device, USFWS = U.S. Fish and Wildlife Service

Chapter 3 Alternative Development Process

3.1 Component Screening

Reclamation considered a number of screening criteria to identify components that should be combined into alternatives. Each criterion was considered consecutively, so if a component was screened out after the first criterion, it was not compared to the subsequent criteria.

3.1.1 Study Area

The first screening criterion considers whether the component is within the study area. Many suggestions received through scoping were outside of the study area considered in this effort, as defined in Section 1.1. Components outside the study area (such as changes to the Klamath Project) were not considered further.

3.1.2 Project Scope

Reclamation considers the project scope to be focused on flexibility for maximizing water deliveries and managing listed species through operational changes to the CVP and SWP. Components that Reclamation is implementing through other efforts are not within the scope of this effort. Components that are not in the project scope were not considered further.

3.1.3 Purpose and Need

This screening criterion focuses on how well each component would meet the purpose and need. If a component did not contribute to meeting the purpose and need, it was not considered further.

3.1.4 Results

Table 3.1-1 shows the results of the alternative screening effort. Table 3.1-1 includes notes that help explain why components were not retained for further evaluation.

Attachment 1 includes a description of the components remaining after screening. These descriptions were used during the alternative formulation process and may have been updated in the alternative descriptions in Chapter 4.

Table 3.1-1. Component Screening Results

Name	Description	Screening Criteria: Reason to Screen Out *Is not within the study area*	*Is not in the project scope*	*Does not contribute to meeting the purpose and need*	Notes	Retained/Not Retained for Further Evaluation
CVP-wide						
2003 guidance under CVPIA	Implement the 2003 guidance, as described under CVPIA, that allows 800,000 AF for the purpose of the environment		X		CVPIA implementation is following guidance currently	Not Retained as a separate component
Alternate energy sources	CVP facilities should use solar or wind power			X	Limited changes to water supply and no contribution to protect fish and wildlife; changing power sources would not change power marketability	Not Retained
Change definition of renewable energy	Change California's definition of renewable energy to include existing CVP hydropower facilities			X	Not an operational change to the CVP or SWP or addressing listed species	Not Retained
Coordinated Operations Agreement revisions	Revise the Coordinated Operations Agreement to improve sharing of resources and obligations between the CVP and SWP					Retained
CVP termination	Terminate the CVP in its entirety			X	Terminating the CVP would have adverse effects on water users and listed species	Not Retained
D-1641 operations	Operate CVP and SWP facilities to meet D-1641 requirements (without additional flow requirements)					Retained
Dam safety	Evaluate safety of all CVP dams, specifically the earthen dam at Trinity Lake		X		Dam safety is analyzed by a different program within Reclamation	Not Retained
Decrease development in forests	Decrease forest cutting, road building, and development in the Cascade-Sierra Mountains		X		Improved watershed management would have limited effects on water supply and listed fish	Not Retained
Improve hatchery management	Improve management and use of fish hatcheries					Retained
Limit hydraulic fracturing	Limit the transfer of CVP and SWP water from agriculture and municipal uses for energy extraction like hydraulic fracturing		X		Not an operational change to the CVP or SWP or addressing listed species	Not Retained
Nonflow measures	Construct habitat restoration and conduct intervention					Retained
Recalculate flood curves	Reoperate reservoirs and recalculate flood curves to increase supply and storage		X		This measure is not within the project scope	Not Retained
Reduce predation	Reduce predation by nonnative fish on listed native fish					Retained
Refuge supplies	Facilitate carryover storage of winter water for spring irrigation in San Luis Reservoir for South-of-Delta refuges			X	Component would not increase water deliveries but would reallocate water from agriculture or M&I uses to refuges	Not Retained
Reservoir expansion	Focus on raising Shasta Dam and expanding San Luis Reservoir, Los Vaqueros Reservoir, Temperance Flat Dam, and Sites Reservoir		X		Reservoir expansion projects are being evaluated through separate programs at Reclamation	Not Retained
Restoration studies	Conduct studies to reduce uncertainty in restoration actions, including genetic and otolith research, steelhead population estimates and trends, fall-run population model, and sediment transport model and address how to avoid hatchery competition or genetic introgression with wild salmon					Retained
Sediment management	Construct small dams near inflow points of lakes or reservoirs and annually dredge out sediments behind these small dams, sending the sediments to nearby farmlands		X		Large reservoirs have substantial carryover storage; they would require multiple small dams, and the reservoir would have a lot of water that would make dredging impractical	Not Retained
Small screen program	Screen small diversions throughout system to reduce fish entrainment					Retained
Specified release or transfer values	Release or transfer 25 to 100,000 AF per year for the next 10 years; releases would be made available March to May; any water not released would be stored by Reclamation pursuant to a Warren Act contract.		X		Component would not increase water supply but would reallocate existing supplies in a forced way	Not Retained

Name	Description	Screening Criteria: Reason to Screen Out *Is not within the study area*	*Is not in the project scope*	*Does not contribute to meeting the purpose and need*	Notes	Retained/Not Retained for Further Evaluation
Storage integration	Better integrate operations of storage facilities (see ACWA Storage Integration Study)		X		Reclamation regularly considers options to improve integration of storage operations, within the operational restrictions at each facility	Not Retained
Watershed management	Rehabilitate the Cascade-Sierra Mountains watershed to manage mountain meadows and restore wildfire into the fire-evolved ecosystem		X		Improved watershed management would have limited effects on water supply and listed fish	Not Retained
Klamath River						
Restore Lower Klamath Lake	Restore the Lower Klamath Lake and clean the Klamath Project's wastewater prior to reaching the Klamath River. Restoring Lower Klamath Lake can provide additional water storage.	X			Klamath Lake is not within the study area or project scope	Not Retained
Transfer groundwater in Klamath Project	Use Klamath Project facilities to convey groundwater for transfer	X			Klamath Lake is not within the study area or project scope	Not Retained
Trinity River						
Cold water conveyance system	Construct a cold water conveyance system from Trinity Reservoir through Lewiston Reservoir to the Trinity River; more water from Trinity Reservoir would be available to valley users for power generation later in the season		X		This construction project is not within the project scope	Not Retained
Dam removal	Remove Trinity and Lewiston Dams		X		Dam removal is not within the project scope	Not Retained
Grass Valley Creek flows	Increase releases from Buckhorn Dam for channel maintenance and provide migration flows for adult Coho Salmon					Retained
Lewiston Reservoir temperature management	Address the temperature issue at Lewiston Reservoir		X		Component does not provide specific ways to address temperature other than flows; flows are managed by the existing Trinity River Restoration Program Record of Decision	Not Retained
Minimum pool volume at Trinity Reservoir	Establish a minimum pool volume of 900,000 to 1,000,000 AF at Trinity Reservoir to protect an adequate lake level for boating facilities and a cold water source for fishery restoration on the Trinity River; if unable to establish request, mitigate the impact by funding the construction of low-water boat launch facilities and Trinity Center and Fairview		X		Revising flow releases and carryover storage from the Trinity River Restoration Program Record of Decision is not in the project scope	Not Retained
Trinity flow augmentation	Augment Trinity River flows beyond the requirements of the 2000 Trinity River Record of Decision as necessary for preservation and propagation of fish		X		Revising flow releases and carryover storage from the Trinity River Restoration Program Record of Decision is not in the project scope	Not Retained
Upgrade hatchery facilities on the Trinity River	Upgrade the Trinity River division hatchery facilities and fund Hoopa Valley Tribe plans for additional selective harvest; transfer hatchery facility management to the Hoopa Valley Tribe		X		Changes to fish management is part of the Trinity River Restoration Program Record of Decision and is not in the project scope	Not Retained
Sacramento River						
Adult rescue	Rescue adults stranded in locations without adequate fish passage (such as Fremont Weir)					Retained
Increase floodplain	Increase the floodplain using setback levees along streams and the main stem of the Sacramento River between Red Bluff and Colusa; include the purchase of private lands within the floodplains					Retained
Intake lowering near Wilkins Slough	Lower water intakes near Wilkins Slough so that navigation flow requirement can be relaxed, if appropriate, without affecting water supply					Retained
Juvenile trap and haul	Collect juveniles to transport them past areas with high temperatures					Retained
Reduce redd dewatering	Reduce the dewatering of Fall-Run Redds in the Sacramento River after Keswick Dam releases are ramped down					Retained

Name	Description	Screening Criteria: Reason to Screen Out *Is not within the study area*	*Is not in the project scope*	*Does not contribute to meeting the purpose and need*	Notes	Retained/Not Retained for Further Evaluation
Reservoir storage targets	Implement storage targets in reservoirs, as suggested by NMFS in 2017			X	Reservoir storage targets would not meet the purpose and need as they reduce operational flexibility, reducing water deliveries	Not Retained
Rice decomposition smoothing	Deliver rice decomposition water over a longer period to reduce the short period of high flow					Retained
Sacramento River spawning and rearing habitat restoration	Restore spawning and rearing habitat in the Sacramento River					Retained
Shasta Lake cold water pool management	Change operations of Shasta Lake to improve year-round management of cold water pool, incorporate a spring pulse, and schedule fall and winter flows to balance storage and redd maintenance					Retained
Shasta Dam TCD improvements	Improve function of Shasta Dam TCD					Retained
Yolo Bypass habitat restoration	Deliver water to Yolo Bypass in support of juvenile salmon rearing habitat and multibenefit projects					Retained
American River						
American River flows	Incorporate the 2017 Modified Flow Management Standard					Retained
American River spawning and rearing habitat restoration	Restore spawning and rearing habitat in the Lower American River					Retained
Drought temperature facility improvements	Construct improvements to temperature facilities to improvement management in dry years					Retained
Bay-Delta						
Addition of pipeline to Jones Pumping Plant	Add 30-foot diameter pipeline from Sherman Island to Jones Pumping Plant to capture water on north side of Sherman Island			X	A pipeline in this location would not help fish or increase times that water could be diverted	Not Retained
Barker Slough PP sediment and aquatic weed removal	Remove sediment and aquatic weeds through mechanical means					Retained
Clifton Court Forebay Aquatic Weed and Algal Bloom Management	Manage aquatic weeds and algal blooms through mechanical means and herbicides					Retained
Delta Cross Channel gate improvements	Evaluate improvements to automate and streamline operation of the gates					Retained
Delta fish species conservation hatchery	Operate a conservation hatchery for Delta Smelt					Retained
Delta gate system	Construct a gate system to limit the intrusion of saltwater into the Delta		X		New gates would be a challenge to permit and would cause problems for movement of fish	Not Retained
Enhance Delta inflow and outflow	Increase Delta inflow and outflow requirements to achieve recovery of federally listed and state-listed species					Retained
Flexible OMR management	Reduce OMR restrictions when they have less benefit to fish					Retained
Focus on water reduction	Consider alternatives that focus on water export reductions, including one or more alternatives consistent with the flow and export limitations identified in the SWRCB 2017 Final Scientific Basis Report					Retained
Improved Delta Cross Channel operations	Modify Delta Cross Channel operations in anticipation of a water quality exceedance (rather than waiting for a water quality exceedance to modify operations)					Retained

		Screening Criteria:	Reason to Screen Out			
Name	**Description**	*Is not within the study area*	*Is not in the project scope*	*Does not contribute to meeting the purpose and need*	**Notes**	**Retained/Not Retained for Further Evaluation**
Increased exports during high flows	Capture and export more water during periods of high Delta outflow					Retained
Modify OMR restrictions specific to diversion site	Connect OMR restrictions to the relative impact of individual diversion facilities; consider prescreen loss at Clifton Court Forebay		X		Sharing of instream requirements (such as OMR) is controlled by the Coordinated Operations Agreement	Not Retained
No Fall X2 action	Eliminate Fall X2 Action (Action 4) and Component 3 (improved Delta Smelt habitat) of the USFWS RPA (in USFWS 2008 BO)					Retained
North Delta food subsidies	Route water from Colusa Drain into Yolo Bypass and Cache Slough to augment food supplies for Delta Smelt					Retained
Protection of winter and spring flows	Protect winter and spring flows as proposed in the Delta plan update process for the San Joaquin and Sacramento Rivers; consult with fisheries' genetic experts on how to improve the duration and timing of these flows to benefit spring and winter runs					Retained
Reintroduction efforts from Fish Conservation and Culture Laboratory	Construct an improved conservation hatchery focused on capturing existing genetic diversity; operations could expand to accommodate reintroduction					Retained
Remove San Joaquin River inflow and export requirement	Remove export limitations tied to the inflow from the San Joaquin River					Retained
Replace levee with fish screen	Replace Clifton Court Forebay's 1.5-mile levee with a fish screen, specifically ZeeWeed fish screen; fill the Clifton Court Forebay at nighttime and use only natural flows during the daytime; increase capacity of Clifton Court Forebay by dredging		X		This large construction component is not within the project scope	Not Retained
Restore Delta natural flow regimes	Restore natural flow regimes in the Delta, which would provide water within basins for local use			X	Ending exports (or drastically reducing them) does not meet the purpose and need of the project	Not Retained
RPA water temperature objectives	Eliminate RPA water temperature objectives because they either are met or cannot be met					Retained
Skinner Fish Facility improvements	Improve operations and effectiveness at Skinner Fish Facility					Retained
Suisun Marsh food subsidies	Add fish food to Suisun Marsh by coordinating managed wetland flood and drain operations, Roaring River Distribution System food production, and reoperation of SMSCG					Retained
Suisun Marsh Salinity Control Gates operations	Operate SMSCG in June through September to increase food production for Delta Smelt					Retained
Tidal habitat restoration	Complete 8,000 acres of tidal habitat restoration that DWR has begun					Retained
Tracy Fish Collection Facility improvements	Improve operations and effectiveness at Tracy Fish Collection Facility					Retained
Water transfers	Allow water transfers for a period longer than July through September					Retained
Stanislaus River						
Alterations to New Melones Reservoir index	Change index for New Melones Reservoir to a hydrologic index for river releases so that it is more reactive to current hydrologic conditions of the year (e.g., 60-20-20 for the San Joaquin River Basin)					Retained
New Melones Reservoir allocations	Reschedule guidelines related to New Melones Reservoir for Stockton East Water District and Central San Joaquin Water Conservation District		X		Rescheduling water as carryover between seasons could further complicate New Melones Reservoir operations	Not Retained

Name	Description	Screening Criteria: Reason to Screen Out — *Is not within the study area*	*Is not in the project scope*	*Does not contribute to meeting the purpose and need*	Notes	Retained/Not Retained for Further Evaluation
Revert to previous New Melones agreements	Revert to DFG 1988 agreement flows that are a condition of the New Melones project permits		X		New Melones operations continue to move forward based on new information; reverting to old agreements would not benefit water supply or listed fish	Not Retained
Stanislaus River dissolved oxygen standard relaxation	Petition SWRCB to relax the dissolved oxygen objective for New Melones Reservoir and the Stanislaus River					Retained
Tuolumne River						
Tuolumne River conveyance facility	Consider a conveyance facility to move excess Tuolumne River water to Oakdale Irrigation District; back up Oakdale Irrigation District deliveries to New Melones		X		This large construction project is not within the project scope	Not Retained
CVP and SWP Service Area						
Address Friant-Kern Canal subsidence	Provide a permanent fix to recently identified issues relating to land subsidence along the Friant-Kern Canal		X		Reclamation is evaluating options to address subsidence through a separate project with the Friant Water Authority	Not Retained
Alternate water supplies	Incorporate alternate water supplies, such as desalinization plants, rain water retention ponds, urban storm water recapture, recycling, and water reuse (e.g., grey water)		X		Water users are working to develop alternate water supplies to address limited CVP and SWP supplies; component does not accomplish the purpose and need to increase CVP and SWP water deliveries	Not Retained
Connection of Folsom South Canal to EBMUD aqueducts	Connect Folsom South Canal via the Freeport pipeline extension 10.7 miles south to connect to the EBMUD aqueducts; improve conveyance and storage of water; using a “Lucid Pipe” can add hydroelectric power generation		X		Construction is not within the project scope, and component would not enable increased CVP and SWP water deliveries	Not Retained
Eastside San Joaquin Valley storage and groundwater banking	Include a proposed 100,000 AF per year Tulare Lake storage and floodwater protection project, a 100,000 AF per year Kern fan groundwater storage project, and a proposed 30,000 AF per year groundwater bank partnership between Delano-Earlimart Irrigation District and Pixley on the east side of San Joaquin Valley		X		Groundwater storage facilities are currently available and do not need Reclamation involvement	Not Retained
Fix aging infrastructure	Repair any aging infrastructure to improve capacity		X		Districts are working on this effort without Reclamation involvement	Not Retained
Identify priority areas for delivery	Prioritize water deliveries based on crop type, soil portfolio, and groundwater conditions		X		Component would not meet the purpose and need because it does not increase water deliveries	Not Retained
Improve irrigation distribution systems	Update district irrigation delivery systems to provide water to farmers when needed		X		Districts are working on this effort without Reclamation involvement	Not Retained
Land retirement	Retire land and water rights			X	Component would not meet the purpose and need because it does not increase water deliveries or benefit listed species	Not Retained
Modified planting practices	Plant drought-tolerant crops, avoid permanent orchard crops, and improve irrigation practices		X		Component would not meet the purpose and need because it does not increase water deliveries or benefit listed species	Not Retained
Restore Tulare Lake basin	Restore Tulare Lake Basin for increased storage capacity South-of-Delta and as percolation ponds to restore groundwater		X		Restoring Tulare Lake Basin for storage would have substantial effects on agricultural land use and economics in the area	Not Retained
Water to Salton Sea	Supply water to the Salton Sea to avoid air quality impacts	X			Measure is not in the study area and it would not help achieve the purpose and need	Not Retained
Water use efficiency	Increase efficiency in use of existing supplies					Retained

ACWA = Association of California Water Agencies, AF = acre-feet, Bay-Delta = San Francisco Bay/Sacramento–San Joaquin Delta, CVP = Central Valley Project, CVPIA = Central Valley Project Improvement Act, Delta = Sacramento–San Joaquin Delta, DFG = Department of Fish and Game, DWR = California Department of Water Resources, EBMUD = East Bay Municipal Utility District, M&I = municipal and industrial, NMFS = National Marine Fisheries Service, OMR = Old and Middle River, Reclamation = United States Department of the Interior, Bureau of Reclamation, RPA = Reasonable and Prudent Alternative, SWP = State Water Project, SWRCB = California State Water Resources Control Board, USFWS = U.S. Fish and Wildlife Service

3.2 Alternative Formulation

The purpose of this screening exercise is to develop a reasonable range of alternatives for consideration in the EIS. Reclamation considered this purpose during the screening effort and retained some components because those components would help establish a reasonable range. Reclamation combined components into four alternatives that help assess how different operational regimes could affect water deliveries and fish. Reclamation wanted to develop alternatives that would be different enough to characterize the benefits and impacts of different types of operational regimes.

The components remaining after screening generally fall into three categories: (1) flow-related components (changing flows or modifying facilities to accommodate changes in flows), (2) habitat restoration, and (3) intervention (such as improving fish passage or juvenile trap and haul).

The components retained after screening were combined into alternatives:

- Alternative 1: Combine all three component categories;
- Alternative 2: Focus on flows required by existing legal decisions (SWRCB D-1641 and other water rights decisions);
- Alternative 3: Use flows from Alternative 2 but add restoration and intervention measures; and
- Alternative 4: Operate storage reservoirs differently in order to increase flows for fish, which would decrease Delta exports.

Table 3.2-1 shows how the components were included in each alternative. Alternative 2 addresses comments to consider the potential benefits and impacts of removing flow requirements and increasing operational flexibility. Alternative 4 addresses the scoping comments to consider an alternative that would increase instream flow requirements and decrease exports from the Delta to benefit fish species. Some scoping comments specified that the instream flow requirements should be based on SWRCB efforts to update the Bay-Delta Water Quality Control Plan and incorporate specified flow targets on the San Joaquin River, Sacramento River, and their tributaries. However, the details have not yet been developed about how these flow targets would be integrated with cold water pool management in reservoirs, so Alternative 4 does not meet these flow targets during drier years.

Table 3.2-1. Components Included in Each Alternative

Component Name	Description	Alternative
Coordinated Operations Agreement revisions	Revise the Coordinated Operations Agreement to improve sharing of resources and obligations between the CVP and SWP	All
D-1641 operations	Operate CVP and SWP facilities to meet D-1641 requirements (without additional flow requirements)	2, 3
Improve hatchery management	Improve management and use of fish hatcheries	1, 3
Nonflow measures	Construct habitat restoration and conduct intervention	1, 3
Reduce predation	Reduce predation by nonnative fish on listed native fish	1, 3
Studies	Conduct studies to reduce uncertainty in restoration actions	1, 3
Small screen program	Screen small diversions throughout system to reduce fish entrainment	1, 3

Component Name	Description	Alternative
Grass Valley Creek flows	Increase releases from Buckhorn Dam for channel maintenance and provide migration flows for adult Coho Salmon	4
Adult rescue	Rescue adults stranded in locations without adequate fish passage (such as Fremont Weir)	1, 3
Increase floodplain	Increase the floodplain using setback levees along streams and the main stem of the Sacramento River between Red Bluff and Colusa; include the purchase of private lands within the floodplains	1, 3
Intake lowering near Wilkins Slough	Lower water intakes near Wilkins Slough so that navigation flow requirement can be relaxed, if appropriate, without affecting water supply	1, 3
Juvenile trap and haul	Collect juveniles to transport them past areas with high temperatures	1, 3
Reduce redd dewatering	Reduce the dewatering of Fall-Run redds in the Sacramento River after Keswick Dam releases are ramped down	1
Rice decomposition smoothing	Deliver rice decomposition water over a longer period to reduce the short period of high flow	1
Sacramento River spawning and rearing habitat restoration	Restore spawning and rearing habitat in the Sacramento River	1, 3
Shasta Lake cold water pool management	Change operations of Shasta Lake to improve year-round management of cold water pool, incorporate a spring pulse, and schedule fall and winter flows to balance storage and redd maintenance	1
Shasta Dam TCD improvements	Improve function of Shasta Dam TCD	1, 3
Yolo Bypass habitat restoration	Deliver water to Yolo Bypass in support of juvenile salmon rearing habitat and multibenefit projects	1, 3
American River flows	Incorporate the 2017 Modified Flow Management Standard	1
American River spawning and rearing habitat restoration	Restore spawning and rearing habitat in the lower American River	1, 3
Drought temperature facility improvements	Construct improvements to temperature facilities to improvement management in dry years	1, 3
Barker Slough PP sediment and aquatic weed removal	Remove sediment and aquatic weed through mechanical means	1.3
Clifton Court Forebay Aquatic Weed and Algal Bloom Management	Manage aquatic weeds and algal blooms through mechanical means and herbicides	1, 3
Delta Cross Channel gate improvements	Evaluate improvements to automate and streamline gate operations	1, 3
Delta fish species conservation hatchery	Operate a conservation hatchery for Delta Smelt	1–4
Enhance Delta inflow and outflow	Increase Delta inflow and outflow requirements to achieve recovery of federally listed and state-listed species	4
Flexible OMR management	Reduce OMR restrictions when they have less benefit to fish	1
Reduce water deliveries to increase water for other purposes	Consider alternatives that focus on reduction of water exports, including one or more alternatives consistent with the flow and export limitations identified in the SWRCB 2017 Final Scientific Basis Report	4

Component Name	Description	Alternative
Improved Delta Cross Channel operations	Modify Delta Cross Channel operations in anticipation of a water quality exceedance (rather than waiting for a water quality exceedance to modify operations)	1
Increased exports during high flows	Capture and export more water during periods of high Delta outflow	1, 2, 3
No Fall X2 action	Eliminate Fall X2 Action (Action 4) and Component 3 (improved Delta Smelt habitat) of the USFWS RPA (in USFWS 2008 BO)	1, 2, 3
North Delta food subsidies	Route water from Colusa Drain into Yolo Bypass and Cache Slough to augment food supplies for Delta Smelt	1, 3
Protection of winter and spring flows	Protect winter and spring flows as proposed in the Delta plan update process for the San Joaquin and Sacramento Rivers and consult with fisheries' genetic experts on how to improve the duration or timing of these flows to benefit spring and winter runs	4
Reintroduction efforts from Fish Conservation and Culture Laboratory	Construct an improved conservation hatchery focused on capturing existing genetic diversity; operations could expand to accommodate reintroduction	1, 3
Remove San Joaquin River inflow and export requirement	Remove export limitations tied to inflow from the San Joaquin River	1-4
RPA water temperature objectives	Eliminate RPA water temperature objectives because they either are met or cannot be met	2, 3
Skinner Fish Facility improvements	Improve operations and effectiveness at Skinner Fish Facility	1, 3
Suisun Marsh food subsidies	Add fish food to Suisun Marsh by coordinating managed wetland flood and drain operations, Roaring River Distribution System food production, and reoperation of SMSCG	1, 3
Suisun Marsh Salinity Control Gates operations	Operate SMSCG in June through September to increase food production for Delta Smelt	1
Tidal habitat restoration	Complete 8,000 acres of tidal habitat restoration that DWR has begun	1, 3
Tracy Fish Collection Facility improvements	Improve operations and effectiveness at Tracy Fish Collection Facility	1, 3
Water transfers	Allow water transfers for a period longer than July through September	1
Alterations to New Melones index	Change index for New Melones to a hydrologic index for river releases so that it is more reactive to current hydrologic conditions of the year (e.g., 60-20-20 for the San Joaquin River Basin)	1
Stanislaus River dissolved Oxygen standard relaxation	Petition the SWRCB to relax the dissolved oxygen objective for New Melones and the Stanislaus River	1
Water use efficiency	Increase efficiency in use of existing supplies	4

AF = acre-feet, Bay-Delta = San Francisco Bay/Sacramento–San Joaquin Delta, BO = biological opinion, CVP = Central Valley Project, Delta = Sacramento–San Joaquin Delta, DFG = California Department of Fish and Game, NMFS = National Marine Fisheries Service, OMR = Old and Middle River flows, RPA = Reasonable and Prudent Alternative, SMSCG = Suisun Marsh Salinity Control Gates, SWP = State Water Project, SWRCB = California State Water Resources Control Board, TCD = temperature control device, USFWS = U.S. Fish and Wildlife Service

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Chapter 4 Alternative Descriptions

This chapter describes the alternatives that are moving forward for further consideration in the EIS. Table 4-1 summarizes key components of the different alternatives.

4.1 Components Common to All Alternatives

The following sections describe information that is applicable to the No Action Alternative and the Action Alternatives. In developing these alternatives, Reclamation considered conditions estimated to occur through 2030. If conditions past 2030 are similar to the analysis period, new environmental documentation would not be needed. If new information is needed to address U.S. Endangered Species Act (ESA) requirements, Reclamation would reinitiate formal consultation and complete appropriate National Environmental Policy Act compliance.

4.1.1 Coordinated Operation Agreement

Reclamation and DWR would operate their respective facilities in accordance with the Agreement between the United States of America and the State of California for Coordinated Operation of the Central Valley Project and the State Water Project (hereinafter referred to as COA). COA defines the project facilities and their water supplies, sets forth procedures for coordinating operations, and identifies formulas for sharing joint responsibilities for meeting Delta standards and other legal uses of water. COA further identifies how unstored flow is shared, sets up a framework for exchange of water and services between the projects, and provides for periodic review of the agreement.

Through the COA, Reclamation and DWR share the obligation for meeting in-basin uses. In-basin uses are defined in the COA as legal uses of water in the Sacramento Basin, including the water required under the provisions of COA Exhibit A, Standards for the Sacramento-San Joaquin Delta. Each project is obligated to ensure water is available for the in-basin uses as defined in the COA. The respective degree of obligation depends on several factors, described below.

The COA defines balanced water conditions as periods when it is agreed that releases from upstream reservoirs plus unregulated flows approximately equal the water supply needed to meet Sacramento Valley in-basin uses plus exports. The COA defines excess water conditions as periods when it is agreed that releases from upstream reservoirs plus unregulated flow exceed Sacramento Valley in-basin uses plus exports.

Reclamation's Central Valley Operations Office and DWR's SWP Operations Control Office (OCO) jointly decide when balanced or excess water conditions exist. During balanced water conditions, the CVP and the SWP share responsibility in meeting in-basin uses.

During excess water conditions, sufficient water is available to meet all beneficial needs, and the CVP and SWP are not required to supplement the supply with water from reservoir storage. Under COA Article 6(g), Reclamation and DWR have the responsibility (during excess water conditions) to store and export as much water as possible within physical, legal, and contractual limits.

Table 4.1-1. Comparison of Alternatives

No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Sacramento River				
NMFS RPA I.2.1-I.2.4: Shasta Temperature Management, WRO 90-5 downstream temperature targets	Temperature management based on use of Shasta cold water pool for Winter-Run survival, including WRO 90-5.	WRO 90-5 downstream temperature targets	WRO 90-5 downstream temperature targets	WRO 90-5, and minimum instream flow requirement of 55% of unimpaired flow at Red Bluff (reduced flows during Shasta Critical years)
No spring pulses	Spring pulses if projected May 1 storage > 4 MAF	Releases to meet Delta standards; no additional releases required	Releases to meet Delta standards; no additional releases required	Minimum instream flow requirement of 55% of unimpaired flow (limited during Shasta Critical years)
3,250 cfs minimum flow	Measures to reduce Fall-Run redd dewatering and rebuild cold water pool, e.g., when end-of-September storage is: ≤ 2.2 MAF, flow is 3,250 cfs; ≤ 2.8 MAF, flow is 4,000 cfs; ≤ 3.2 MAF, flow is 4,500 cfs; > 3.2 MAF, flow is 5,000 cfs.	Releases to meet Delta standards and WRO 90-5; no additional releases required	Releases to meet Delta standards and WRO 90-5; no additional releases required	Minimum instream flow requirement of 55% of unimpaired flow (limited during Shasta Critical years)
Shasta Lake end-of-September minimum storage established by NMFS 2004 Winter-run BO (1900 TAF in non-critically dry years), and NMFS BO (Jun 2009) Action I.2.1	No minimum end-of-September storage	No minimum end-of-September storage	No minimum end-of-September storage	No minimum end-of-September storage
Livingston-Stone National Fish Hatchery	Increased use of Livingston-Stone National Fish Hatchery during droughts	Livingston-Stone National Fish Hatchery operations as in NAA	Increased use of Livingston-Stone National Fish Hatchery during droughts	Livingston-Stone National Fish Hatchery operations as in NAA

No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
No additional habitat restoration	Spawning and rearing habitat restoration	No additional habitat restoration	Spawning and rearing habitat restoration	No additional habitat restoration
No additional intervention measures	Intervention measures (small screens, adult rescue, juvenile trap and haul)	No additional intervention measures	Intervention measures (small screens, adult rescue, juvenile trap and haul)	No additional intervention measures
Trinity River				
Trinity ROD Flows + Lower Klamath Augmentation Flows	Trinity ROD Flows + Lower Klamath Augmentation Flows	Trinity ROD Flows + Lower Klamath Augmentation Flows	Trinity ROD Flows + Lower Klamath Augmentation Flows	Trinity ROD Flows + Lower Klamath Augmentation Flows + Little Grass Valley Flows
Clear Creek				
Base flow of 50–100 cfs based on downstream water rights, 2000 agreement between Reclamation, USFWS, and DFG, predetermined CVPIA 3406(b)(2) flows, and NMFS BO Action I.1.1	Base flow of 200 cfs from October through May, 150 cfs from June through September in all except critical years, downstream water rights, 2000 agreement between Reclamation, USFWS, and DFG	Base flow of 50–100 cfs based on downstream water rights, 2000 agreement between Reclamation, USFWS, and DFG	Base flow of 50–100 cfs based on downstream water rights, 2000 agreement between Reclamation, USFWS, and DFG	Downstream water rights, 2000 agreement between Reclamation, USFWS, and DFG, and minimum instream flow requirement of 55% of unimpaired flow at Igo
Channel maintenance flows when flood operations occur	10 TAF for channel maintenance, unless flood control operations provide similar releases, using the river release outlets, in all but dry and critical years	No channel maintenance flows	No channel maintenance flows	Channel maintenance from 55% unimpaired flow
Two pulse flows in Clear Creek in May and June of at least 600 cfs for at least 3 days for each pulse per year	10 TAF for pulse flows, using the river release, in all but critical years	No pulse flows	No pulse flows	Pulse flows from minimum instream flow requirement of 55% of unimpaired flow

No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Daily water temperature of: (1) 60º F at the Igo gage from June 1 through September 15; and (2) 56ºF at the Igo gage from September 15 to October 31.	Daily water temperature in below normal and wetter years of: (1) 60ºF at the Igo gage from June 1 through September 15; and (2) 56ºF or less at the Igo gage from September 15 to October 31; operate as close as possible to these targets in dry and critical years.	No temperature thresholds	No temperature thresholds	Temperatures controlled by minimum instream flow requirements
Feather River				
1983 DWR, DFG Agreement (600 cfs) minimum flow below Thermalito Diversion Dam (in Low Flow Channel)	1983 DWR, DFG Agreement (600 cfs)	1983 DWR, DFG Agreement (600 cfs)	1983 DWR, DFG Agreement (600 cfs)	1983 DWR, DFG Agreement (600 cfs)
1983 DWR, DFG Agreement (750-1,700 cfs) minimum flow below Thermalito Afterbay outlet	1983 DWR, DFG Agreement (750-1,700 cfs)	1983 DWR, DFG Agreement (750-1,700 cfs)	1983 DWR, DFG Agreement (750-1,700 cfs)	1983 DWR, DFG Agreement (750-1,700 cfs) and minimum instream flow requirement of minimum of 55% of unimpaired flow below Thermalito (reduced flows under low storage or inflow conditions)
American River				
American River 2006 Flow Management Standard	American River 2017 Flow Management Standard: Flows range from 500 to 2,000 cfs based on time of year and annual hydrology, and “planning minimum”	American River 2006 Flow Management Standard	American River 2006 Flow Management Standard	American River 2017 Flow Management Standard and minimum instream flow requirement of 55% of unimpaired flow below Nimbus (reduced flows under low storage or inflow conditions)

No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Daily average water temperature of 65°F or lower at Watt Avenue Bridge from May 15 through October 31. 56°F temperature target November 1 through December 31.	May 15 through October 31 daily average water temperature of 65°F (or target temperature determined by temperature model) or lower at Watt Avenue Bridge. When the target temperature requirement cannot be met because of limited cold water availability in Folsom Reservoir, then the target daily average water temperature at Watt Avenue may be increased incrementally (i.e., no more than 1°F every 12 hours) to as high as 68°F. November 1 through December 31 daily average water temperature of 56°F target if cold water pool allows. A temperature higher than 56°F may be targeted based on temperature modeling results.	No temperature thresholds	No temperature thresholds	55% unimpaired flow and qualitative cold water habitat objective
No additional habitat restoration	Spawning and rearing habitat restoration	No additional habitat restoration	Spawning and rearing habitat restoration	No additional habitat restoration
Delta				
Exports controlled by D-1641 requirements; and OMR requirements based on USFWS RPA Actions 1-3 and NMFS RPA Actions IV.2.1 and IV.2.3	Exports controlled by D-1641 requirements; and risk-based OMR management incorporating real-time monitoring and models	Exports controlled by D-1641 requirements	Exports controlled by D-1641 requirements	Export constraints from April through May depending on San Joaquin River flows, consistent with NMFS RPA Action IV.2.1

No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
DCC operations based on D-1641 and NMFS RPA that requires consultation to avoid exceeding water quality standards	DCC operations based on D-1641, closures for fish protections, and operations that avoid exceeding water quality standards	DCC operations based on D-1641	DCC operations based on D-1641	DCC operations based on D-1641 and NMFS RPA that requires consultation to avoid exceeding water quality standards
Delta outflow to meet D-1641 requirements; and maintain average X2 for September and October no greater (more eastward) than 74 km in the fall following wet years and 81 km in the fall following above normal years	Delta outflow to meet D-1641 requirements and Delta Smelt Summer-Fall Habitat management structured decision-making process	Delta outflow to meet D-1641 requirements	Delta outflow to meet D-1641 requirements	Bypass of reservoir releases for fish so they become Delta outflows (with adjustment for downstream natural depletions and accretions)
Old and Middle River Reverse Flows based on calendar date and workgroups per USFWS RPA Actions 1-3 and NMFS RPA Action IV.2.3	Old and Middle River Reverse flows based on species distribution, modeling, and risk analysis with provisions for capturing storm flows	No management of reverse flows	No management of reverse flows	Positive Old and Middle River flows from March through May
HORB installed between September 15 and November 30 of most years when flows at Vernalis is <5,000 cfs; occasionally also between April 15 and May 30 if Delta Smelt entrainment is not a concern	No HORB installed	HORB not ordered in D-1641	HORB not ordered in D-1641	HORB not ordered in D-1641
U.C. Davis Fish Culture Center Refugial Population	Increased use of the U.C. Davis Fish Culture Center and a Delta Fish Species Conservation Hatchery for the introduction of cultured fish into the wild	U.C. Davis Fish Culture Center Refugial Population as in NAA	Delta Fish Species Conservation Hatchery and the introduction of cultured fish into the wild	U.C. Davis Fish Culture Center Refugial Population as in NAA

No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
1986 COA with 2018 Addendum	1986 COA with 2018 Addendum	1986 COA with 2018 Addendum	1986 COA with 2018 Addendum	1986 COA with 2018 Addendum
No additional restoration measures	Fall Delta Smelt habitat, food subsidies, tidal habitat restoration	No additional restoration measures	Food subsidies, tidal habitat restoration, food studies, and 25,000 acres of habitat restoration	No additional restoration measures
No additional intervention measures	Intervention measures included (Barker Slough PP sediment and aquatic weed removal, Clifton Court aquatic weed removal, fish collection facility improvements, predator hotspot removal)	No additional intervention measures	Intervention measures included (Barker Slough PP sediment and aquatic weed removal, Clifton Court aquatic weed removal, fish collection facility improvements, predator hotspot removal)	No additional intervention measures
Stanislaus River				
1987 Reclamation, DFG agreement and flows required for NMFS BO Action III.1.2 and III.1.3	Stepped Release Plan	1987 Reclamation, DFG agreement	1987 Reclamation, DFG agreement	Stepped Release Plan
7.0 mg/L DO requirement at Ripon from June 1 to September 30	7.0 mg/L DO requirement at Orange Blossom Bridge from June 1 to September 30	7.0 mg/L DO requirement at Ripon from June 1 to September 30	7.0 mg/L DO requirement at Ripon from June 1 to September 30	7.0 mg/L DO requirement at Ripon from June 1 to September 30
No additional restoration measures	Spawning and rearing habitat restoration	No additional restoration measures	Spawning and rearing habitat restoration	No additional restoration measures
San Joaquin River				
San Joaquin River Restoration Program flows	San Joaquin River Restoration Program flows	San Joaquin River Restoration Program flows	San Joaquin River Restoration Program flows	San Joaquin River Restoration Program flows

No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
No additional restoration on the Lower San Joaquin River	Lower San Joaquin River rearing habitat restoration	No additional restoration on the Lower San Joaquin River	Lower San Joaquin River rearing habitat restoration	No additional restoration on the Lower San Joaquin River
South-of Delta Water Contractors				
Water use efficiency measures as included in CVPIA and required by state law/Executive Order	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Increased water use efficiency

Implementation of the COA principles has evolved since 1986, as changes have occurred to CVP and SWP facilities, operating criteria, and overall physical and regulatory environment. For example, updated water quality and flow standards adopted by SWRCB, CVPIA, and ESA responsibilities have affected both CVP and SWP operations. The 1986 COA incorporated the SWRCB Water Right Decision 1485 (D-1485) provisions regarding Delta salinity, outflow, and export restrictions. D-1485 included implementation provisions for the Bay-Delta WQCP that was current at the time, but has since been updated with Water Right Decision 1641 (D-1641). COA envisioned and provided a methodology to incorporate future regulatory changes, such as Delta salinity requirements, but did not explicitly envision or address sharing of export restrictions. D-1641 and the 2008 USFWS BO and 2009 NMFS BO include various export restrictions not explicitly addressed in the 1986 COA. However, the available export capacity as a result of these export restrictions was shared between the CVP and the SWP in absence of a formal update to the COA.

In 2018, Reclamation and DWR modified four key elements of the COA to address changes since the COA was signed: (1) in-basin uses; (2) export restrictions; (3) CVP use of Banks Pumping Plant up to 195,000 AF per year; and (4) periodic review. The COA sharing percentages for meeting Sacramento Valley in-basin uses now vary from 80% responsibility of the United States and 20% responsibility of the State of California in wet year types to 60% responsibility of the United States and 40% responsibility of the State of California in critical year types. In a dry or critical year following two dry or critical years, the United States and State of California will meet to discuss additional changes to the percentage sharing of responsibility to meet in-basin uses. When exports are constrained and the Delta is in balanced conditions, Reclamation may pump up to 65% of the allowable total exports with DWR pumping the remaining capacity. In excess conditions, these percentages change to 60/40.

4.1.2 CVP Water Contracts

Based on the provisions of federal reclamation law, the CVP delivers water pursuant to water service and water repayment contracts, as well as settlement, exchange, and refuge contracts. Reclamation delivers water pursuant to temporary Section 215 Contracts (not to exceed 1 year) when there are surplus flood flows. Pursuant to the Warren Act, Reclamation provides for conveyance of non-CVP water, which includes SWP water, when there is excess capacity available in CVP facilities. This consultation covers the operation of the CVP and the SWP to deliver water under the terms of all existing contracts up to full contract amounts, which includes the impacts of maximum water deliveries and diversions under the terms of existing contracts and agreements, including timing and allocation. Reclamation is not proposing to execute any new contracts or amend any existing contracts as part of this consultation.

Reclamation operates the CVP to meet its obligations to deliver water to senior water right holders who received water prior to construction of the CVP, wildlife refuge areas identified in the CVPIA, and water service contractors.

Many senior water right holders, such as Sacramento River Settlement Contractors and San Joaquin River Exchange Contractors, executed contracts with Reclamation. The terms of those contracts differ from water service contracts. The pattern of water diversion under a water service contract depends on the use of the water, with irrigation water typically diverted and used during the irrigation season (March through October), and M&I water diverted and used year-round. All water service contracts contain a shortage provision allowing Reclamation to reduce the amount of water made available for a variety of reasons, such as droughts. Table 4.1-2 summarizes the number of CVP water service and repayment contracts and the amount of water under contract.

Table 4.1-2. CVP Water Service and Repayment Contracts

CVP Division	Number of Contracts	Contract Quantity[1] (Acre-Feet)
Tehama-Colusa Canal, Corning Canal, Redding Area, and Trinity River Division	36	468,890
American River	9	328,750
New Melones/Eastside Contracts	2	155,000
South-of-Delta	44	2,112,898
Friant Division	27	2,249,475
Contra Costa Water District	1	195,000

[1] Contract quantities do not reflect actual deliveries due to system conditions.

CVP water service and repayment contracts include shortage provisions such as:

Article 12, Constraints on the Availability of Water, which provides for a Condition of Shortage, which is defined in Article 1(c) as

> "...a condition respecting the Project during any Year such that the Contracting Officer is unable to deliver sufficient water to meet the Contract Total." Article 12(c) provides "In any Year in which there may occur a shortage for any of the reasons specified in subdivision 12(b) above, the Contracting Officer shall apportion Project Water among the Contractor and others entitled, under existing contracts and future contracts (to the extent such future contracts are permitted under subsections (a) and (b) of Section 3404 of the CVPIA) and renewals thereof, to receive Irrigation Water consistent with the contractual obligations of the United States."

Article 12(d) states, "Project Water furnished under this Contract will be allocated in accordance with the then-existing Project M&I Water Shortage Policy. Such policy shall be amended, modified, or superseded only through a public notice and comment procedure."

The largest contracts belong to Sacramento River Settlement Contractors (approximately 2.1 MAF) and San Joaquin River Exchange Contractors (approximately 840 TAF). In very dry years, Reclamation and DWR are often limited to operating the CVP and the SWP solely to meet these and other senior water right requirements and to meet refuge water supply requirements and minimum instream and Delta flows, M&I deliveries pursuant to the CVP M&I Water Shortage Policy, and SWP exports for health and safety.

In recent drought years, limited water supplies, dry hydrology, and regulatory restrictions made it difficult for Reclamation to make water available to satisfy contracts already reduced by 25% in those years. Reclamation delivers Level 2 refuge water primarily from the CVP and acquires Incremental Level 4 water from voluntary measures, which include water conservation, conjunctive use, purchase, lease, donations, or similar activities, or a combination of such activities that do not require involuntary reallocations of project yield. The alternatives include operations to deliver up to full contract amounts, including full Level 4 refuge contract amounts. Table 4.1-3 summarizes CVP senior water rights holders and the amount of water under contract.

Table 4.1-3. CVP Settlement Agreements

Contractor	Number of Contracts	Contract Quantity (Acre-Feet)
Sacramento River Settlement	132	2,112,194 (1,775,313 Base + 336,881 Project)
San Joaquin River Exchange	4	840,000
Oakdale/S. San Joaquin ID Agreement and Stipulation	1	≤ 600,000
American River Contracts	13	578,441
Friant Division Riparian Holding Contracts	n/a	5 cfs past each diversion
South-of-Delta Settlement Contractors	9	35,623
North-of-Delta Refuges—Level 2 CVP	2	179,000
South-of-Delta Refuges—Level 2 CVP	3	376,515

Contract quantities do not reflect actual deliveries due to system conditions.
≤ = less than or equal to, cfs = cubic feet per second

The contracts referenced above usually include articles such as Article 5, Constraints on the Availability of Water, which states, "in a Critical Year, the Contractor's Base Supply and Project Water agreed to be diverted during the period April through October of the Year in which the principal portion of the Critical Year occurs and, each monthly quantity of said period shall be reduced by 25 percent."

4.1.3 SWP Water Contracts

The SWP has signed long-term contracts with 29 water agencies statewide to deliver water supplies developed from the SWP system. These contracts are with both M&I water users and agricultural water users. The contracts specify the charges that will be made to the water agency for both conservation of water and conveyance of water. The foundational allocation of water to each contractor is based on its respective Table A entitlement (the maximum amount of water delivered annually by the SWP to the contractor). Typically, for a variety of reasons, annual water deliveries to individual agencies are less than the contractor's maximum Table A amount.

DWR operates the SWP in accordance with contracts with senior water right holders in the Feather River Service Area (approximately 983 TAF). Further, under State Water Contracts, DWR allocates Table A water as an annual supply made available for scheduled delivery throughout the year. Table A contracts total 4,173 TAF, with over 3 MAF for San Joaquin Valley and Southern California water users.

Article 21 of the long-term SWP water supply contracts provides an interruptible water supply made available only when certain conditions exist: (1) the SWP share of San Luis Reservoir is physically full or projected to be physically full; (2) other SWP reservoirs south-of-Delta are at their storage targets or the conveyance capacity to fill these reservoirs is maximized; (3) the Delta is in excess water conditions; (4) current Table A demand is being fully met; and (5) Banks Pumping Plant has export capacity beyond that which is needed to meet current Table A and other SWP operational demands.

4.1.3.1 *SWP Settlement Agreements*

DWR has water rights settlement agreements to provide water supplies with entities north of Lake Oroville, along the Feather River and Bear River, and in the Delta. These agreements provide users with water supplies that they were entitled to prior to construction of the SWP Oroville Complex. Collectively, these agreements provide over 1 MAF of water each year. DWR also has agreements with several (more than 60) riparian diverters along the Feather, Yuba, and Bear Rivers to provide water for diversion. Table 4.1-4 summarizes the volumes under the water rights settlement agreements.

Table 4.1-4. SWP Settlement Agreements

Location	Entity	Amount (Acre-Feet)
North of Oroville	Andrew Valberde	135
North of Oroville	Jane Ramelli	800
North of Oroville	Last Chance Creek Water District	12,000
Feather River	Garden Highway Mutual Water	18,000
Feather River	Joint Water Districts Board	620,000
Feather River	South Feather Water & Power	17,555
Feather River	Oswald Water District	3,000
Feather River	Plumas Mutual Water	14,000
Feather River	Thermalito Irrigation District	8,200
Feather River	Tudor Mutual Water	5,000
Feather River	Western Canal/Pacific Gas & Electric Company	295,000
Bear River	South Sutter/Camp Far West	4,400
Delta	Byron-Bethany Irrigation District	50,000
Delta	East Contra Costa Irrigation District	50,000
Delta	Solano County/Fairfield, Vacaville, and Benicia	31,620

4.1.3.2 *SWP Contracting Agencies*

The SWP has signed contracts with 29 parties to provide water supplies developed by the SWP. Table 4.1-5 shows the maximum contracted annual water supply per DWR's most recent water supply reliability report.

Table 4.1-5. SWP Water Service Contracts

Contracting Agency	Maximum Supply (Acre-Feet)
Butte County	27,500
Plumas County	2,700
Yuba City	9,600
Napa County Flood Control and Water Conservation District	29,025
Solano County	47,756
Alameda County—Zone 7	80,619
Alameda County Water District	42,000
Santa Clara Valley Water District	100,000
Oak Flat Water District	5,700
Kings County	9,305
Dudley Ridge Water District	45,350
Empire West Side Irrigation District	3,000
Kern County Water Agency	982,730
Tulare Lake Water Storage District	87,471
San Luis Obispo County	25,000

Contracting Agency	Maximum Supply (Acre-Feet)
Santa Barbara County	45,486
Antelope Valley-East Kern Water Agency	144,844
Santa Clarita Valley Water Agency	95,200
Coachella Valley Water District	138,350
Crestline-Lake Arrowhead Water Agency	5,800
Desert Water Agency	55,750
Littlerock Creek Irrigation District	2,300
Metropolitan Water District of Southern California	1,911,500
Mojave Water Agency	85,800
Palmdale Water District	21,300
San Bernardino Valley Municipal Water District	102,600
San Gabriel Valley Municipal Water District	28,800
San Gorgonio Pass Water Agency	17,300
Ventura County Watershed Protection District	20,000

Source: DWR 2018

4.1.4 Allocation and Forecasts

Reclamation allocates CVP water on an annual basis in accordance with contracts. Reclamation bases north-of-Delta allocations primarily on available water supply within the north-of-Delta system along with expected controlling regulations throughout the year. For south-of-Delta allocations, Reclamation relies on upstream water supply, previously stored water south-of-Delta (in San Luis Reservoir) and conveyance capability through the Delta. Flows on the San Joaquin River often limit conveyance, as these flows are a driver of the flow direction within the Delta and, through their influence on Old and Middle River net reverse flow, can affect entrainment levels at the state and federal pumps.

The water allocation process for the CVP begins in the fall when Reclamation makes preliminary assessments of the next year's water supply possibilities, given current storage conditions combined with a range of hydrologic conditions. Reclamation may refine these preliminary assessments as the water year progresses. Beginning February 1, Reclamation prepares forecasts of water year runoff using precipitation to date, snow water content accumulation, and runoff to date. All of CVP's Sacramento River Settlement Contractors' water rights contracts and San Joaquin River Exchange Contractors' contracts require contractors be informed no later than February 15 of any possible deficiency in their supplies. Reclamation targets February 20 as the date for the first announcement of all CVP contractors' forecasted water allocations for the upcoming contract year. Reclamation updates, at least monthly, forecasts of runoff and operations plans between February and May.

Reclamation intends to use a conservative forecast for seasonal planning of reservoir releases (including developing initial and updated allocations) and temperature management planning. Starting in January, Reclamation reviews various exceedances of inflow forecasts to determine a conservative monthly operations outlook. In many cases, Reclamation develops monthly release forecasts and associated allocations based on a 90% exceedance inflow forecast through September. Reclamation may deviate from relying on the 90% exceedance inflow forecast in order to develop a conservative outlook. Such instances include scenarios when a wetter hydrology produces a more conservative outlook, or the actual conditions are significantly drier than the existing forecast such that a more conservative forecast is appropriate. This conservative approach is intended to minimize the frequency where real-time management results in a drier or warmer (water temperature) condition than forecasted.

Reclamation performs operations forecasting on a 12-month look-ahead cycle each month to determine how the available water resources can best be used to meet project objectives and requirements. Reclamation bases forecasts on the 12-month projected runoff volumes that would occur naturally and considers potential upstream operations where relevant. For October and November, projected runoff is based entirely on historical hydrology as no snowpack data are available. In December and January, inflow forecasts may include snow pillow information and precipitation, as well as historical hydrology. For the February through May period, the runoff volume estimates are based on the observed inflow to date and current snowpack measurements made at the end of each preceding month, projections through September, and historical hydrology for the next water year. These forecasts represent the uncertainty inherent in making runoff predictions. This uncertainty may include sources such as unknown future weather conditions, the various prediction methodologies, and the spatial coverage of the data network in a given basin.

In most years, the combination of carryover storage and runoff into CVP reservoirs and the Central Valley is not enough to provide sufficient water to meet all CVP contractors' contractual demands. Multiple legislative, contractual, and settlement obligations have created an increased tension in Reclamation's ability to make contractual deliveries of water to water users and to meet other legal obligations. As provided in Section 9 of the Reclamation Projects Act of 1939, Section 215 of the Reclamation Reform Act of 1982, and Section 3404(b) of CVPIA, Reclamation is authorized to enter into temporary contracts, not to exceed 1 year, for delivery of surplus flood flows.

4.1.4.1 *SWP Allocation and Forecasting*

At the beginning of each new water year, there is significant uncertainty as to the hydrologic conditions that will exist several months in the future and thus the water supplies that will be allocated by the SWP to its water contractors. In recognition of this uncertainty, DWR used a forecasting water-supply allocation process that is updated monthly, incorporates known conditions in the Central Valley watershed to date, and forecasts future hydrologic conditions in a conservative manner to provide an accurate estimate of SWP water supplies projected to be delivered to SWP contractors as the water year progresses.

There are many factors considered in the forecast water-supply process. Factors include:

- Water storage in Lake Oroville (both updated and end-of-water-year [September 30])
- Water storage in San Luis Reservoir (both updated and end-of-calendar-year)
- Flood operations constraints at Lake Oroville
- Snowpack surveys (updated monthly February through May)
- Forecasted runoff in the Central Valley (reflects both snowpack and precipitation)
- Feather River settlement agreement obligations
- Feather River fishery flows and temperature obligations
- Anticipated depletions in the Sacramento and Delta Basins
- Anticipated Delta standards and conditions
- Anticipated CVP operations for joint responsibilities
- Contractor supply requests and delivery patterns

Staff from the OCO and the SWP Analysis Office (SWPAO) coordinate their efforts to determine the current water supply allocations. The OCO primarily focuses on runoff and operations models to determine allocations. The SWPAO requests updated information on supply requests and delivery patterns from the contractors to determine allocations. Both OCO and SWPAO staff meet at least monthly with the DWR director to make final decisions on the OCO and SWPAO proposed allocations.

The initial allocation for SWP deliveries is made by December 1 of each year, with a conservative assumption of future precipitation to avoid over-allocating water before the hydrologic conditions are well-defined for the year. As the water year unfolds, Central Valley hydrology and water supply delivery estimates are updated using measured and known information and conservative forecasts of future hydrology. Monthly briefings are held with the DWR director to determine formal approvals of delivery commitments announced by DWR.

Another water supply consideration is the contractual ability of SWP contractors to carry over allocated (but undelivered) Table A allocations from one year to the next if space is available in San Luis Reservoir. The carryover storage is often used to supplement an individual contractor’s current year Table A allocations if conditions are dry. Carryover supplies left in San Luis Reservoir by SWP contractors can result in higher storage levels in San Luis Reservoir. As project pumping fills San Luis Reservoir, the contractors are notified to take, or lose, their carryover supplies. Carryover water not taken, after notice is given to remove it, becomes project water available for reallocation to all contractors in a given year.

Article 21 (surplus to Table A) water that is delivered early in the calendar year may be reclassified as Table A later in the year, depending on final allocations, hydrology, and contractor requests. Reclassification does not affect the amount of water carried over in San Luis Reservoir and it does not alter pumping volumes or schedules.

4.1.4.2 *Daily Operations*

After the allocations and forecasting process, Reclamation and DWR coordinate their operations on a daily basis. Some factors considered by Reclamation and DWR when coordinating their joint operations include required in-Delta flows, Delta outflow, water quality, schedules for the joint use facilities, pumping and wheeling arrangements, and any facility limitations. Both projects must meet the flood obligations of individual reservoirs. The CVP operations must consider navigational flows at Wilkins Slough.

During balanced water conditions, Reclamation and DWR maintain a daily water accounting of CVP and SWP obligations. This accounting allows for flexible operations and avoids the need to change reservoir releases made several days in advance (due to travel time from the Delta). Therefore, adjustments can be made “after the fact,” using actual observed data rather than by prediction for the variables of reservoir inflow, storage withdrawals, and in-basin uses. This iterative process of observation and adjustment results in a continuous truing up of the running COA account. The project that is “owed” water (i.e., the project that provided more or exported less than its COA-defined share) may request the other project adjust its operations to reduce or eliminate the accumulated account within a reasonable time.

The COA provides the mechanism for determining each project’s responsibility for meeting in-basin use, but real-time conditions dictate real-time actions. Conditions in the Delta can change rapidly. For example, weather conditions combined with tidal action can quickly affect Delta salinity conditions and therefore the Delta outflow required to maintain joint salinity standards under D-1641.

Increasing or decreasing project exports can achieve changes to Delta outflow immediately. Imbalances in meeting each project’s initial shared obligations are captured by the COA accounting and are balanced out later.

When more reaction time is available, reservoir release changes are used to adjust changing in-basin conditions. For example, if Reclamation decides the reasonable course of action is to increase upstream reservoir releases, then the response may be to increase Folsom Reservoir releases first because the released water will reach the Delta before flows released from other CVP and SWP reservoirs. DWR's Lake Oroville water releases require about 3 days to reach the Delta while water releases from Reclamation's Shasta Lake require 5 days to travel from Keswick Reservoir to the Delta. As water from another reservoir arrives in the Delta, Reclamation can adjust Folsom Reservoir releases downward. Alternatively, if sufficient time exists for water to reach the Delta, Reclamation may choose to make initial releases from Shasta Reservoir. Each occurrence is evaluated on an individual basis, and appropriate action is taken based on multiple factors. COA accounting captures imbalances in meeting each project's initial shared obligation.

The duration of balanced water conditions varies from year to year. Balanced water conditions never occur in some very wet years while very dry years may have long continuous periods of balanced water conditions, and other years may have several periods of balanced water conditions interspersed with excess water conditions. Account balances continue from one balanced water condition to an excess water condition to another balanced water condition. When the project that is owed water enters into flood control operations, which could be Shasta Reservoir for the CVP or Lake Oroville for the SWP, the accounting is zeroed out for that project.

4.1.5 Agricultural Barriers

DWR initiated the South Delta Temporary Barrier Project in 1991. Currently, DWR has permits extending the project through 2022. The South Delta Temporary Barrier Project BO issued in 2018 by USFWS and NMFS to USACE includes mandatory requirements of the 5-year Section 404 permit for construction and removal of the barriers. USACE issued separate permits for the agricultural barriers that run through 2022. The California Department of Fish and Wildlife Service (CDFW) issued two permits: the Incidental Take Permit and the Streambed Alteration Agreement, which provide coverage through 2021, and the Regional Water Quality Control Board Section 401 Water Quality Certification, which provides coverage through 2022.

The project consists of three rock barriers across south Delta channels. In various combinations, these barriers improve water levels for agricultural diversions and conditions for San Joaquin River origin salmonids in the south Delta. All alternatives include the seasonal installation and the removal of temporary rock barriers at the following locations:

- Middle River near the Victoria Canal, about 0.5 miles south of the confluence of Middle River, Trapper Slough, and North Canal.
- Old River near Tracy, about 0.5 miles east of the Delta-Mendota Canal (DMC) intake.
- Grant Line Canal near Tracy Boulevard Bridge, about 400 feet east of Tracy Boulevard Bridge.

The temporary barriers on Middle River (MR), Old River near Tracy (ORT), and the Grant Line Canal (GLC) are referred to as the agricultural barriers, which are flow control facilities designed to improve water levels and circulation for agricultural diversions and are in place during the irrigation season.

4.1.6 Suisun Marsh Preservation Agreement

The Suisun Marsh Preservation Agreement (SMPA) among DWR, Reclamation, CDFW, and Suisun Resource Conservation District (SRCD) contains provisions for DWR and Reclamation to mitigate the effects on Suisun Marsh channel water salinity from SWP and CVP operations and other upstream diversions. The SMPA requires DWR and Reclamation to meet salinity standards in accordance with D-

1641, sets a time line for implementing the plan of protection, and delineates monitoring and mitigation requirements.

There are two primary physical mechanisms for meeting salinity standards set forth in D-1641 and the SMPA: (1) implementation and operation of physical facilities in the Marsh and (2) management of Delta outflow (i.e., facility operations are driven largely by salinity levels upstream of Montezuma Slough, and salinity levels are highly sensitive to Delta outflow). Physical facilities (described below) have been operating since 1988 and have proven to be a highly reliable method for meeting standards.

The Suisun Marsh Salinity Control Gates (SMSCG) are located on Montezuma Slough about 2 miles downstream from the confluence of the Sacramento and San Joaquin Rivers, near Collinsville, California. The objective of SMSCG operation is to decrease the salinity of the water in Montezuma Slough. The gates control salinity by restricting the flow of higher salinity water from Grizzly Bay into Montezuma Slough during incoming tides and retaining lower salinity Sacramento River water from the previous ebb tide. Operation of the gates in this fashion lowers salinity in Suisun Marsh channels and results in a net movement of water from east to west through Suisun Marsh.

The SMSCG are operated during the salinity control season, which spans from October to May. Operational frequency is affected by hydrologic conditions, weather, Delta outflow, tide, fishery considerations, and other factors. The boat lock portion of the gate is held open at all times during SMSCG operation to allow for continuous salmon passage opportunity. However, the boat lock gates may be closed temporarily to stabilize flows to facilitate safe passage of watercraft through the facility. Assuming no significant long-term changes in the drivers mentioned above, it is expected that gate operations would remain at current levels (17–69 days per year) except perhaps during the most critical hydrologic conditions.

The Roaring River Distribution System (RRDS) was constructed to provide lower salinity water to 5,000 acres of private wetlands and 3,000 acres of CDFW-managed wetlands on Simmons, Hammond, Van Sickle, Wheeler, and Grizzly Islands. The RRDS includes a 40-acre intake pond that supplies water to Roaring River Slough. Water is diverted through a bank of eight 60-inch-diameter culverts equipped with fish screens into the Roaring River intake pond on high tides to raise the water surface elevation in RRDS above the adjacent managed wetlands. The intake to the RRDS is screened to prevent entrainment of fish larger than approximately 25 millimeters. After the listing of Delta Smelt, RRDS diversion rates have been controlled to maintain an average approach velocity below 0.7 feet per second at the intake fish screen.

The Morrow Island Distribution System (MIDS) allows Reclamation and DWR to provide water so that lands may be managed according to approved local management plans. The system was constructed primarily to channel drainage water from the adjacent managed wetlands for discharge into Suisun Slough and Grizzly Bay. This approach increases circulation and reduces salinity in Goodyear Slough. The MIDS is used year-round, but most intensively from September through June. When managed wetlands are filling and circulating, water is tidally diverted from Goodyear Slough just south of Pierce Harbor.

The Suisun Marsh Habitat Management, Preservation, and Restoration Plan (SMP) was developed by the Suisun Principal Agencies including USFWS, Reclamation, CDFW, DWR, NMFS, and SRCD. The SMP is a 30-year comprehensive plan designed to address the various conflicts regarding use of marsh resources, with the focus on achieving an acceptable multistakeholder approach. The plan balances the benefits of tidal wetland restoration with other habitat uses in the marsh by evaluating alternatives that provide a politically acceptable change in marshwide land uses, such as salt marsh harvest mouse habitat, managed wetlands, public use, and upland habitat. The SMP is intended to address the full range of issues in the marsh, which are linked geographically, ecologically, and ideologically.

4.1.7 CVPIA

Reclamation would operate in accordance with its obligations under the CVPIA, including but not limited to CVPIA 3406 (b)(2). DOI accounts for the following actions in meeting the 3406 (b)(2) requirement:

1. Primary Purposes: Any fish action (export reduction or upstream release) that predominantly contributes to one of the enumerated 3406(b) programs identified by the courts, including 3406(b)(1), (4), (5), (8), (9), (12), (18) and (19), must be counted against the up to 800 TAF of (b)(2) water. Thus, any upstream release or export reduction that predominantly contributes to one of those purposes will be deducted from the 3406(b)(2) account.
2. Secondary Purposes: Water operations in accordance with ESA and fish and wildlife objectives of D-1641 water quality actions may also be included in (b)(2) accounting. Upstream releases mandated by ESA Biological Opinions may also count towards 3406 (b)(2). Export reductions in ESA Biological Opinions or specified under D-1641 for fish and wildlife objectives may also count towards 3406 (b)(2). Releases for other water quality actions (i.e., net delta outflow) under D-1641 may also count towards 3406 (b)(2).

Pursuant to section 3406(b)(2)(C) the Secretary of the Interior may temporarily reduce deliveries of the quantity of water dedicated under this paragraph up to 25 percent of such total whenever reductions due to hydrologic circumstances are imposed upon agricultural deliveries of Central Valley Project water. The Secretary may also make water available for other purposes if the Secretary determines that the 800,000 acre feet identified in section 3406(b)(2) is not needed to fulfill the purposes of section 3406.

4.2 No Action Alternative

Under the No Action Alternative, Reclamation would continue with current CVP operations. Those operations are described below by system.

4.2.1 Upper Sacramento River (Shasta and Sacramento Divisions)

Reclamation operates the CVP Shasta Division for flood control, navigation, agricultural water supplies, M&I water supplies, fish and wildlife, hydroelectric power generation, Delta water quality, and water quality in the upper Sacramento River. Water rights, contracts, and agreements specific to the upper Sacramento River include SWRCB Water Right Decisions 990, 90-5, 91-1, and 1641, settlement contracts, the exchange contract, and water service contracts. Facilities include the Shasta Dam, Shasta Lake (4.552 MAF capacity), and Shasta Power Plant; Keswick Dam, Keswick Reservoir, and Keswick Power Plant; and Shasta TCD. The CVP Sacramento Division includes the Red Bluff Pumping Plant, Corning Pumping Plant, and Corning and Tehama-Colusa Canals, for irrigation of over 150,000 acres of land in Tehama, Glenn Colusa, and Yolo Counties.

Flood control limits releases to less than 79,000 cubic feet per second (cfs) at the tailwater of Keswick Dam and a stage of 39.2 feet in the Sacramento River at Bend Bridge gauging station (approximately 100,000 cfs) to avoid inundating populated areas downstream. Flood control operations are based on regulating criteria developed by USACE pursuant to provisions of the Flood Control Act of 1944. Flood control may reserve up to 1.3 MAF of storage behind Shasta Dam, leaving 3.2 MAF for storage management.

Historical commerce on the Sacramento River resulted in a CVP authorization to maintain minimum flows of 5,000 cfs at Chico Landing to support navigation in accordance with the River and Harbors Act of 1935 and of 1937. Although no commercial traffic persists, long-time water users diverting from the river have set their pump intakes based on minimum navigation flows. Therefore, the CVP operates to approximately 5,000 cfs at the Wilkins Slough gage during periods when the intakes are being operated. This flow often is a challenge to meet under critical water supply conditions due to both water supply and cold water pool limitations, in which cases Reclamation has operated to approximately 4,000 cfs although impacts on senior diverters occur.

The intake that serves both the Tehama-Colusa Canal and the Corning Canal is located on the Sacramento River approximately 2 miles southeast of Red Bluff. Water is diverted from the Sacramento River through a 2,000 cfs pumping plant (with ability to expand to 2,500 cfs) into a settling basin for continued conveyance in the Tehama-Colusa Canal and the Corning Canal.

The Anderson-Cottonwood Irrigation District holds senior water rights and has a settlement contract with Reclamation. Water is diverted to its main canal (on the right bank of the river) from a diversion dam located in Redding, California, about 5 miles downstream from Keswick Dam. Reclamation coordinates with the irrigation district to ensure safe operation of the diversion dam during the irrigation season, from April through October.

In 1990 and 1991, SWRCB issued Water Rights Orders 90-05 and 91-01, modifying Reclamation's water rights for the Sacramento River. The orders stated Reclamation shall operate Keswick and Shasta Dams and the Spring Creek Power Plant to meet a daily average water temperature of 56°F as far downstream in the Sacramento River as practicable during periods when higher temperature would be harmful to Winter-Run Chinook Salmon. Under the orders, the water temperature compliance point may be modified to an upstream location when the objective cannot be met at Red Bluff Pumping Plant. In addition, Order 90-05 modified the minimum flow requirements initially established in the 1960 Memorandum of Agreement (MOA) for the Sacramento River below Keswick Dam. The water rights orders also recommended construction of a Shasta TCD to improve the management of the limited cold water resources and monitoring and coordination.

As a result, Shasta Dam is equipped with a TCD that allows temperature operations without affecting power generation. The TCD allows Reclamation to control the temperature of the water released from Shasta Dam. The TCD has four levels of gates from which water can be drawn: upper gates, middle gates, pressure relief gates (PRG gates) (i.e., lower gates), and side gates (coldest configuration).

The last tool to reduce temperatures is to operate the TCD in the full side gate position, drawing the lowest (and coldest) possible water from the reservoir. Reclamation must balance the objectives of pulse flows or water supply releases early in the season, which can conflict with the goal of maintaining a cold water pool sufficient to meet species' needs toward end of spawning and incubation season in the fall.

To operate the Shasta TCD, a defined amount of reservoir elevation above each set of gates is required to ensure safe operation. This requirement is reflected in Table 4.2-1 as 35 feet of submergence above the top of the gates.

Table 4.2-1. Shasta TCD Gates with Elevation and Storage

TCD Gates	Shasta Elevation with 35 feet of Submergence of the TCD Gates (feet)	Shasta Storage (MAF)
Upper Gates	1,035	approx. 3.66
Middle Gates	935	approx. 1.64
Pressure Relief Gates	840	approx. 0.59
Side Gates	720[1]	approx. 0.08

[1] Low level intake bottom

4.2.1.1 *Seasonal Operations*

Reclamation operates in the winter for flood control, including both the channel capacity within the Sacramento River and the Shasta Reservoir flood conservation space. USACE is responsible for developing and maintaining the Water Control Manual for Shasta Reservoir. On a given date, Reclamation is not to exceed the top of the conservation pool storage level set by the USACE Water Control Manual. Releases for flood control would vary depending on current storage, forecasted inflow, and flow in the mainstem Sacramento River at Bend Bridge. Reclamation operates Shasta Dam releases to keep flows at Bend Bridge below 100,000 cfs and therefore reservoir elevations may temporarily exceed the top of conservation pool storage to protect downstream populated areas. During the winter period, there can be significant flow fluctuations from Keswick Dam due to the flood control operations. When not operating for flood control, Shasta Dam is operated primarily to conserve storage while meeting minimum flows both down the Sacramento River and in the Delta. These minimum flows are held until irrigation demands require increased releases.

During the winter to spring period there are accretions (flows from unregulated creeks) into the Sacramento River below Shasta Dam. These local accretions help to meet both instream demands and outflow requirements, minimizing the need for additional releases from Shasta and Folsom Reservoirs. In wetter year types, Reclamation may be able to operate mostly for flood control and minimum instream requirements because of the large volumes of accretions to the Sacramento River. In drier years, these accretions may be lower and therefore require Reclamation to release a higher level of releases from the upstream reservoirs to meet state permit requirements and CVP exports in the Delta.

In the spring, releases are fairly steady (unless Shasta Reservoir is in flood control operations) until flows are needed to support instream demands on the mainstem Sacramento River and Delta Outflow requirements. Releases for Delta Outflow requirements are balanced between Shasta Reservoir and Folsom Reservoir. Both reservoirs have substantial temperature control requirements, and both need to substantially fill to fully meet their temperature control requirements. Therefore, releases must be carefully balanced to allow each reservoir to fill without negatively affecting the other. An overarching goal for Reclamation when operating the CVP is to fill the reservoirs as much as possible by the end of the flood control season (end of May) while meeting all other authorized project purposes.

Currently, the seasonal operation of the TCD is generally as follows: during mid-winter and early spring the highest possible elevation gates are used to draw from the upper portions of the lake to conserve deeper colder resources. During late spring and summer, the operators begin the seasonal progression of opening deeper gates as Shasta Reservoir elevation decreases and cold water resources are used. In late summer and fall, the TCD side gates are opened to use the remaining cold water resource.

During summer, operational considerations are mainly flows required for Delta outflows, instream demands, and temperature control. In river temperatures below Shasta Dam can be controlled via two methods. The first method is changing release volume or shifting releases between Trinity and Sacramento Reservoirs. The second method is selective withdrawal through the TCD. Determination of which method to use is made on a daily basis as operators balance releases from multiple reservoirs to meet downstream needs.

Fall operations are dominated by temperature control and provision of fish spawning habitat. By late fall, the remaining cold water pool in Shasta Reservoir is usually limited. This can be a delicate balancing act in that if the early fall flows are too high then the fish may make their redds higher up on the edge of the river and they become subject to the possibility of dewatering when the flows are reduced later in the fall. Sacramento River releases cannot be too low early in the fall, as there are still significant instream diversion demands on the mainstem of the Sacramento River between Keswick Dam and Wilkins Slough, and depending on conditions, SWRCB Delta requirements may require upstream reservoir releases. This necessitates maintaining higher releases to support the instream demands until they fall off later in the season. At that time, Reclamation's objective is to drop Keswick Dam releases to a lower level to conserve storage.

4.2.2 Trinity River Division

Congress authorized the Trinity River Division in 1955 as an integrated component of the CVP to increase water supplies for irrigation and other beneficial uses in the Central Valley, recognizing that water "surplus" to the present and future needs of the Trinity and Klamath Basins could be diverted to the Central Valley "without detrimental effect to the [Klamath-Trinity Basin's] fishery resources."

Accordingly, Reclamation operates the Trinity River Division both to export water to the Sacramento River system and to ensure necessary flow releases into the Trinity-Klamath Basin, such as through implementation of the U.S. Department of the Interior Trinity River Mainstem Fishery Restoration Record of Decision (2000 ROD). Transbasin exports transfer water from the Trinity River to the Sacramento River system through Lewiston Reservoir, Carr Tunnel, Whiskeytown Reservoir, and Spring Creek tunnel.

4.2.2.1 *Seasonal Operations*

Diversion of Trinity Basin water to the Sacramento Basin (transbasin diversion) provides water supply and major hydroelectric power generation for the CVP and plays a key role in water temperature control in the Trinity River and upper Sacramento River. Transbasin diversions are managed to support water supply and temperature objectives within the Sacramento system and are regulated by the 2000 ROD and Trinity Reservoir supply. The 2000 ROD strictly limits Reclamation's transbasin diversions to 55% of annual inflow on a 10-year average basis to legal and trust mandates for the restoration and protection of the Trinity River fishery and restricts the amount of water authorized for exportation to the Central Valley. Reducing transbasin diversions was intended to improve the cold water pool in Trinity Reservoir to improve conditions for fall spawning down the Trinity River. This limitation on transbasin diversions significantly affects Reclamation's temperature operations on the Sacramento River and Reclamation's ability to satisfy senior water right holder and/or the Sacramento River Settlement Contractors commitments within the CVP system.

Trinity River exports are first conveyed through Carr Power Plant, which flows directly into Whiskeytown Lake, a heavily used recreation facility. From Whiskeytown Lake, the exported water continues to flow into Spring Creek Power Plant, ultimately outflowing into the Sacramento River below Keswick Dam, or water is released from Whiskeytown Lake to Clear Creek. Although Whiskeytown Lake is primarily used as conveyance system for transbasin transfers, operations at both Carr and Spring Power Plants are done in a manner to maintain specified elevations for supporting recreation (based on season).

The amounts and timing of Trinity River basin exports into the Sacramento River basin are determined by subtracting Trinity River scheduled flow and targeted carryover storage from the forecasted Trinity River water supply. Reclamation maintains at least 600 TAF in Trinity Reservoir, except during the 10 to 15% of water years when Shasta Reservoir is drawn down. Reclamation addresses end-of-water-year carryover on a case-by-case basis in Dry and Critically Dry water year types described in the water operations governance process below.

The seasonal timing of Trinity River exports is a result of determining how to make best use of a limited volume of Trinity River exports (in concert with releases from Shasta Reservoir) to help conserve cold water pools and meet water temperature objectives on the upper Sacramento and Trinity Rivers, as well as power production economics.

These exports support better Trinity River temperatures by maintaining cold water and reducing residence time within Lewiston Reservoir. Transbasin diversions also typically help meet Sacramento River temperatures by providing additional cold water resources to the Sacramento River. As a result, Trinity River export operations are completely integrated with Shasta Dam operations.

4.2.2.2 *Trinity River Record of Decision*

The 2000 ROD prescribed increase flows to be released from Lewiston Dam down the Trinity River to meet federal statutory and other responsibilities to protect and restore the basin's fishery resources. Specifically, it entails: (1) variable annual instream flows for the Trinity River from the Trinity River Division based on forecasted hydrology for the Trinity River Basin; (2) mechanical habitat rehabilitation projects along with sediment management and watershed restoration efforts; and (3) an adaptive management program. The 2000 ROD flow release schedules vary among water-year classes and were designed to address the environmental requirements of anadromous fish and fluvial geomorphic function. The five water year classes and associated annual water volumes for release to the Trinity River are Critically Dry (369 TAF), Dry (453 TAF), Normal (636 TAF), Wet (701 TAF), and Extremely Wet (815 TAF).

Total river release can reach up to 11,000 cfs below Lewiston Dam (flood criteria) due to local high water concerns in the floodplain and local bridge flow capacities. Flood criteria provides seasonal storage targets and recommended releases November 1 to March 31.

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

In various years since 2003, particularly since 2013, certain fishery agencies, together with tribal governments, have requested additional late-season flows in the Trinity River above the 2000 ROD baseline flows (primarily in August and September) to prevent fish illness from instream crowding and warm waters in the lower Klamath River in drier years. In some cases, these releases were made in successive dry years and therefore had cumulative effects year to year, leading to lower storage in Trinity Reservoir and water supply and temperature impacts in the Sacramento and Trinity Rivers and Clear Creek.

Reclamation released the Record of Decision for the Long-Term Plan to Protect Adult Salmon in the Lower Klamath River in 2017 (2017 ROD), which identified an adaptive management approach, a process, and criteria for Reclamation to determine if and when to provide supplemental flows from mid-August to late September from Lewiston Dam and to prevent an episodic disease outbreak in the lower Klamath River in years when the criteria for such flows are met. These flows include a preventative base flow component of a supplemental release of up to 40 TAF from Lewiston Dam over approximately 30 days, beginning on or about August 23, with the intent of meeting and/or maintaining a target of up to 2,800 cfs in the lower Klamath River; a preventative pulse flow component of up to 10 TAF release over 4 days to achieve a peak of 5,000 cfs in the lower Klamath River; and an emergency flow component of release up to 34 TAF from Lewiston Dam over no more than 8 days, beginning on or about September 20 to meet a target of 5,000 cfs in the lower Klamath River. The 2017 ROD cited Proviso 1 of Section 2 of the 1955 Act as authority for the releases.

4.2.3 Clear Creek

4.2.3.1 *Whiskeytown Reservoir Operations*

Reclamation operates Whiskeytown Reservoir to (1) regulate inflows for power generation and recreation, (2) support upper Sacramento River temperature objectives, and (3) provide for releases to Clear Creek, as proposed below. Two temperature curtains in Whiskeytown Reservoir were installed to pass cold water through the bottom layer of the reservoir and limit warming from Carr Power Plant to Clear Creek or Spring Creek Power Plant.

Whiskeytown Lake is annually drawn down by approximately 35 TAF during November through April to regulate flows for winter and spring flood management. Heavy rainfall events occasionally result in spillway discharges to Clear Creek. Operations at Whiskeytown Lake during flood conditions are complicated by its operational relationship with the Trinity River, the Sacramento River, and Clear Creek. On occasion, imports of the Trinity River water to Whiskeytown Reservoir may be suspended to avoid aggravating high flow conditions in the Sacramento Basin. Joint temperature control objectives similarly interact among the Trinity River, Clear Creek, and the Sacramento River.

4.2.3.2 *Clear Creek Flows*

Reclamation operates Clear Creek flows in accordance with the 2000 agreement between Reclamation, USFWS, and DFG, and the April 15, 2002 SWRCB permit, which established minimum flows to be released to Clear Creek at Whiskeytown Dam. Reclamation manages Whiskeytown releases to meet a daily average water temperature of (1) 60°F at the Igo gage from June 1 through September 15 and (2) 56°F at the Igo gage from September 15 to October 31.

4.2.3.3 *Spring Creek Debris Dam*

Runoff containing acid mine drainage from several inactive copper mines and exposed ore bodies at Iron Mountain Mine is stored in Spring Creek Reservoir. In January 1980, Reclamation, CDFW, and SWRCB executed a memorandum of understanding (MOU) to implement actions that protect the Sacramento River system from heavy metal pollution from Spring Creek and adjacent watersheds. However, since 1990, concentrations of toxic metals in acidic drainage from Iron Mountain Mine have progressively decreased due to several significant remedial actions by the EPA. The completion of several efforts has resulted in a reduction of approximately 95 percent of the toxic metals that historically emptied into the Sacramento River:

- EPA’s Minnesota Flats Iron Mountain Mine Acid Mine Drainage Treatment Plant (lime neutralization plant) in 1994,
- Slickrock Creek Retention Reservoir in 2004, and
- Dredging of approximately 180,000 cubic yards of contaminated sediments from the Spring Creek arm of Keswick Reservoir in 2009-10.

Lower concentrations of copper and zinc resulting from controlled and uncontrolled Spring Creek Debris Dam releases are expected as compared to pre-1990. The extent of heavy metal influence is usually limited to regions immediately downstream of Keswick Dam.

As a result of dramatic changes to the water quality in the vicinity of the Iron Mountain Mine watershed, Reclamation CDFW, SWRCB and USEPA are progressing towards a revision of the 1980 MOU to address the improvements and changed conditions. Operation of the Spring Creek Debris

Dam and Shasta Dam have deviated from the 1980 MOU to accommodate for these changes. Reclamation expects a revised MOU with similar guidelines to the interim operation.

The interim operation includes actions that protect the Sacramento River system from heavy metal pollution (i.e., acid mine runoff) from Spring Creek Dam and adjacent watersheds. This includes water quality criteria at the point of compliance (Below Keswick) shown in Table 4.2-2 and based upon the criteria for protection of aquatic life in the upper Sacramento River described in the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins (Basin Plan) (SWRCB 1995) and the California Toxics Rule (CTR) (SWRCB 2003).

Table 4.2-2. Water Quality Criteria for Surface Water Downstream of Keswick Dam

Analyte	Maximum Concentration for Acute Exposure (µg/L) [a]	Maximum Concentration for Chronic Exposure (µg/L) [b]
Dissolved copper	5.6 [c,d]	4.1 [e,f]
Dissolved zinc	16 [c,d]	54 [e,f]

[a] The maximum concentration for acute exposure of the 1-hour average concentration.
[b] The maximum chronic exposure is the continuous concentration (4-day average concentration).
[c] Based upon surface water with a hardness of 40 mg/L. Where deviations in water hardness from 40 mg/L occur, the criteria, in µg/L, shall be determined by using the following formulas:
Dissolved Copper = (e[0.905 x ln(hardness) - 1.612])
Dissolved Zinc = (e[0.830 x ln(hardness) – 0.289])
[d] Based upon Water Quality Control Plan for the Sacramento River and San Joaquin River Basins (Basin Plan) (Water Board, 1998)
[e] Based upon surface water with a hardness of 40 mg/L. Where deviations in water hardness from 40 mg/L occur, the criteria, in µg/L, shall be determined by using the following formulas:
Dissolved Copper = 0.96 x (e[0.8545 x ln(hardness) - 1.702])
Dissolved Zinc = 0.986 x (e[0.8473 x ln(hardness) – 0.884])
[f] Based upon the California Toxics Rule (CTR) (provided in Water Board, 2003)

Reclamation expects continued monitoring of the water quality of Spring Creek Debris Dam, Spring Creek Power Plan, Keswick, and Shasta and increased frequency of monitoring if Spring Creek Debris Dam releases water through the spillway or drops below the minimum elevation threshold. The operation described herein is also dependent on the water treatment capabilities afforded by USEPA.

When storage within Spring Creek Reservoir is less than capacity at 795 feet (approximately 5 TAF) and above 720 feet (note Reclamation's operation is conservative and includes an operational factor of safety of 5 feet), Reclamation would be able to make controlled undiluted releases that result in allowable concentrations of total copper and zinc in the Sacramento River below Keswick Dam. These undiluted releases from Spring Creek Debris Dam could occur throughout the year, typically December through June and less frequently in other months.

When Spring Creek Reservoir storage exceeds the capacity of the reservoir at 795 feet (approximately 5 TAF) water must be released through the spillway. In this situation, Reclamation anticipates an "emergency" relaxation of the criteria, as consistent with past protocol, of: a 50 percent increase in the objective concentrations of copper and zinc. Although the general operational goal is to avoid use of the Spring Creek Debris Dam spillway, some storm events or series of events would be unavoidable. The spillway operation would typically occur during a large storm or series of events, January through April, and would be coincident with large flood management flows released from Keswick Dam. In recent years, USEPA, Reclamation, CDFG, and the RWQCB have agreed not to use the emergency criteria until a spill is imminent. During significant rain events, Spring Creek Debris Dam releases may target a dilution ratio with Keswick releases to achieve an acceptable water quality below Keswick Dam. Spring Creek Reservoir spillway dilution flows from Keswick would likely be coincident with large flood management flows and would be unlikely to impact water supply or coldwater pool resources.

Reclamation would not plan to operate Spring Creek Reservoir below elevation 720 feet to avoid potentially significant degraded water quality when reservoir soils are exposed. However, if Spring Creek Reservoir were less than 720 feet, then a minimum dilution flow of 250 cfs from Spring Creek Power Plant and increased water quality monitoring would be expected.

At any time that dilution flows are necessary, Reclamation would minimize the build-up of toxic metals in the Spring Creek arm of Keswick Reservoir. To accomplish this, the releases from the debris dam would be coordinated with releases from Spring Creek Powerplant (Spring Creek Power Plant draws water from Whiskeytown Reservoir) to keep the metals in circulation within the main body of Keswick Reservoir.

4.2.3.4 *Clear Creek Restoration Program*

Since the early 1980s, numerous studies were conducted to evaluate methods to rehabilitate and/or restore habitat along lower Clear Creek. In the 1990s, additional studies were conducted following the adoption of the CVPIA. The Western Shasta Resource Conservation District (WSRCD) watershed management plan evaluated methods to achieve healthy fish populations, diverse biological habitats, recreational opportunities, clean and safe conditions for visitors, and protection of property rights developed by the Lower Clear Creek Coordinated Resource Management and Planning Group of local landowners, stakeholders, and agencies (WSRCD 1998). The plan's recommendations included:

- Removal of the McCormick-Saeltzer Dam;
- Inject gravel downstream of Whiskeytown Dam and reconstruct gravel channels below McCormick-Saeltzer Dam to reduce stranding;
- Modify water release patterns from Whiskeytown Dam;
- Reduce exotic vegetation along Clear Creek; and
- Reduce sands in Clear Creek through erosion control programs in the lower watershed.

This and other studies led to the formation of the Lower Clear Creek Floodway Rehabilitation Project that was implemented under CVPIA. Initial actions under this project included gravel augmentation initiated in 1996, increase in Whiskeytown Dam releases initiated in 2001, removal of the McCormick-Saeltzer Dam in 2001, reconstruction and revegetation of the floodway, and reduction of watershed erosion.

4.2.4 Feather River

Oroville Dam and its related facilities comprise a multipurpose complex. The reservoir stores winter and spring runoff, which is released into the Feather River to meet the SWP's needs, Delta requirements, and fish and wildlife protection. The Oroville Complex provides power generation including pumpback operations, flood control storage, and recreation opportunities.

The Oroville project creates a lake with a maximum surface area of 15,810 acres, has total storage capacity of 3,538 TAF, and is fed by the north, middle, and south forks of the Feather River. Average annual unimpaired runoff into the lake is about 4.5 MAF.

Approximately 4 miles downstream of Oroville Dam and Edward Hyatt Power Plant is the Thermalito Diversion Dam. The Thermalito Diversion Dam consists of a 625-foot-long, concrete gravity section with a regulated ogee spillway that releases water to the low flow channel of the Feather River. On the right abutment is the Thermalito Power Canal regulating headwork structure.

The purpose of the diversion dam is to divert water into the 2-mile-long Thermalito Power Canal that conveys water in either direction and creates a tailwater pool (Thermalito Diversion Pool) for Edward Hyatt Power Plant. The Thermalito Diversion Pool acts as a forebay when the Edward Hyatt Power Plant is pumping water back into Lake Oroville. On the left abutment is the Thermalito Diversion Dam Power Plant, with a capacity of 615 cfs that releases water to the low-flow section of the Feather River.

Thermalito Power Canal hydraulically links the Thermalito Diversion Pool to the Thermalito Forebay (11.768 TAF), which is the off-stream regulating reservoir for Thermalito Power Plant.

Thermalito Power Plant is a generating-pumping plant operated in tandem with the Edward Hyatt Power Plant. Energy prices and availability have historically been the two main factors that determine if pumpback operations are desirable for economic benefits. Pumpback operations typically occurred during off-peak hours when energy prices are lower. However, due to recent changes in the energy market (i.e., solar power contributions) and a desire to reduce operational stress on aging infrastructure, pumpback operations have been infrequent recently. The Oroville Thermalito Complex has a capacity of approximately 17,000 cfs through the power plants. Water is returned to the Feather River via the Thermalito Afterbay river outlet.

The Feather River Fish Hatchery provides mitigation for the construction of Oroville Dam, rears Chinook Salmon and steelhead, and is operated by CDFW. Both indirect and direct take resulting from hatchery operations are authorized through ESA Section 4(d) through NMFS-approved hatchery and genetic management plans. DWR and CDFW are jointly preparing hatchery and genetic management plans for the Spring-Run and Fall-Run Chinook Salmon and steelhead production programs at the hatchery.

4.2.4.1 *Flow Requirements*

DWR maintains a minimum flow of 600 cfs within the Feather River Low Flow Channel (LFC) as required by the 1983 CDFW Agreement (except during flood events when minimum flows are governed by USACE’s Water Control Manual and under certain other conditions as described in the 1984 Federal Energy Regulatory Commission (FERC) order). Downstream of the Thermalito Afterbay outlet, in the high flow channel, per the license and the 1983 CDFW Agreement, minimum releases for flows in the Feather River are 1,000 cfs from April through September and 1,700 cfs from October through March, when the April to July unimpaired runoff in the Feather River is greater than 55% of normal. When the April to July unimpaired runoff is less than 55% of normal, the minimum flow requirements are 1,000 cfs from March to September and 1,200 cfs from October to February. The 1983 CDFW Agreement states that if the April 1 runoff forecast in a given year indicates that the reservoir level would be drawn down to 733 feet, water releases for fish may be reduced, but not by more than 25%.

In addition, according to the 1983 CDFW Agreement, during the period of October 15 to November 30, if the average highest 1-hour flow of combined releases exceeds 2,500 cfs, then the minimum flow must be no lower than 500 cfs less than that flow through the following March 31 (with the exception of flood management, accidents, or maintenance.) In practice, flows are maintained below 2,500 cfs from October 15 to November 30 to prevent spawning in the overbank areas.

4.2.4.1.1 Flow Change Rates

Maximum allowable ramp-down release requirements are intended to prevent rapid reductions in water levels that could potentially cause dewatering and stranding of juvenile salmonids and other aquatic organisms. Ramp-down release requirements to the LFC during periods outside of flood management operations, and to the extent controllable during flood management operations, are shown in Table 4.2-3.

Table 4.2-3. Lower Feather River Ramping Rates

Releases to the Feather River Low Flow Channel (cfs)	Rate of Decrease (cfs)
5,000 to 3,501	1,000 per 24 hours
3,500 to 2,501	500 per 24 hours
2,500 to 600	300 per 24 hours

Source: National Marine Fisheries Service 2004

4.2.4.2 *Federal Energy Regulatory Commission Relicensing of the Oroville Project*

The original FERC license to operate the Oroville project expired in January 2007. Since 2007, annual license renewals have been issued, requiring DWR to operate to the original FERC license conditions. The new FERC license has not been adopted by FERC. Until a new license for the Oroville project is issued by FERC, DWR is operating the Oroville facilities in accordance with the current (original) license conditions. In the future, DWR will operate to the new FERC license when it is issued.

4.2.5 American River Division

Reclamation operates the CVP American River Division for flood control, M&I and agricultural water supplies, hydroelectric power generation, fish and wildlife protection, recreation, and Delta water quality. Facilities include Folsom Dam, reservoir (967 TAF capacity), power plant, urban water supply and temperature control device, and the Joint Federal Project auxiliary spillway, as well as Nimbus Dam, Lake Natoma, Nimbus Power Plant, and Folsom South Canal.

Folsom Reservoir is the main storage and flood control reservoir on the American River. Numerous other smaller reservoirs in the upper basin (not owned by Reclamation) provide hydroelectric generation and water supply without specific flood control responsibilities. The total upstream reservoir storage above Folsom Reservoir is approximately 820 TAF, and these reservoirs are operated primarily for hydropower production. Five reservoirs contain 90% of this upstream storage: French Meadows (136 TAF), Hell Hole (208 TAF), Loon Lake (76 TAF), Union Valley (271 TAF), and Ice House (46 TAF). Reclamation coordinates with the reservoirs' operators to aid in planning for Folsom Reservoir operations. Releases from Folsom Dam are reregulated approximately 7 miles downstream by Nimbus Dam. Nimbus Dam creates Lake Natoma, which serves as a forebay for diversions to the Folsom South Canal. Releases from Nimbus Dam to the American River pass through the Nimbus Power Plant or the spillway gates at flows in excess of 5,000 cfs. Because Folsom Reservoir is the closest reservoir to the Delta, releases from Folsom Reservoir can more quickly address Delta water quality requirements under D-1641.

Releases to the lower American River are governed by multiple factors. Minimum releases are set based on the flow management study minimum river release. Releases above the minimum river release can be required for many reasons: instream temperature control, releases to help meet Delta outflow or salinity requirements, flood control releases, and export needs.

Reclamation would ramp down releases in the American River below Nimbus Dam as shown in Table 4.2-4.

Table 4.2-4. American River Ramping Rates

Lower American River Daily Rate of Change (cfs)	Amount of decrease in 24 hrs (cfs)	Maximum change per step (cfs)
20,000 to 16,000	4,000	1,350
16,000 to 13,000	3,000	1,000
13,000 to 11,000	2,000	700
11,000 to 9,500	1,500	500
9,500 to 8,300	1,200	400
8,300 to 7,300	1,000	350
7,300 to 6,400	900	300
6,400 to 5,650	750	250
5,650 to 5,000	650	250
<5,000	500	100

Ramping rates would not apply during flood control or if needed for facility operational concerns. The working groups may also determine a need for a variance.

4.2.5.1 *Decision 893*

The minimum allowable flows in the lower American River are defined by SWRCB Water Rights Decision 893 (D-893), which states, in the interest of fish conservation, releases should not ordinarily fall below 250 cfs between January 1 and September 15 or below 500 cfs at other times. D-893 minimum flows are rarely the controlling objective of CVP operations at Nimbus Dam. Nimbus Dam releases are nearly always controlled during significant portions of a water year by either flood control requirements or are coordinated with other CVP and SWP releases to meet downstream SWRCB Bay-Delta WQCP requirements and CVP water supply objectives. Power regulation and management needs occasionally control Nimbus Dam releases. Nimbus Dam releases are expected to exceed the D-893 minimum flows in all but the driest of conditions.

4.2.5.2 *2006 Flow Management Standard*

In July 2006, Reclamation, the Sacramento Area Water Forum, and other stakeholders completed a draft technical report establishing a flow and temperature regime intended to improve conditions for fish in the lower American River (i.e., the Lower American River Flow Management Standard (Reclamation, et al 2006)). Minimum flow requirements during October, November, and December are primarily intended to address Fall-Run Chinook Salmon spawning, and flow requirements during January and February address Fall-Run Chinook Salmon egg incubation and steelhead spawning. From March through May, minimum flow requirements are primarily intended to facilitate steelhead spawning and egg incubation, as well as juvenile rearing and downstream movement of Fall-Run Chinook Salmon and steelhead. The June through September flows are designed to address over-summer rearing by juvenile steelhead, although this period partially overlaps with adult Fall-Run Chinook Salmon immigration. Reclamation began operating to the flow management study immediately thereafter.

4.2.5.3 *American River Flows to Meet Delta Salinity Requirements*

Folsom Reservoir is operated by Reclamation to release water to help meet Delta salinity and flow objectives established to improve fisheries conditions. Weather conditions combined with tidal action and local accretions from runoff and return flows can quickly affect Delta salinity conditions and require increases in Delta inflow to maintain salinity standards. In accordance with federal and state regulatory requirements, the CVP and SWP are frequently required to release water from upstream reservoirs to maintain Delta water quality. Because Folsom Lake is closer to the Delta than Lake Oroville and Shasta Lake, if the need for salinity control is immediate, releases may be made first from Folsom Reservoir. As water from the other reservoirs arrives in the Delta, Folsom Reservoir releases can be reduced. In general, however, as the CVP is operated as an integrated project, releases to meet downstream needs are sourced from multiple locations, e.g., both Shasta Reservoir and Folsom Reservoir and SWP contributions from Lake Oroville. Water released from Lake Oroville and Shasta Lake generally reaches the Delta in approximately 3 days and 5 days, respectively. Travel time is considered when release decisions are made as part of operating as an integrated project.

4.2.6 Bay-Delta

The Delta and Suisun Marsh area constitutes a natural floodplain that covers 1,315 square miles and drains approximately 40% of the state (DWR 2013). The Delta and Suisun Marsh have a complex web of channels and islands and are located at the confluence of the Sacramento and San Joaquin Rivers.

The CVP and SWP facilities in the Delta provide for delivery of water supply to areas within and immediately adjacent to the Delta and to regions south-of-Delta. The major CVP features are the Delta Cross Channel (DCC), Contra Costa Canal and Rock Slough intake facilities, Jones Pumping Plant, and Tracy Fish Collection Facility (TFCF). The main SWP Delta features are Suisun Marsh facilities, Banks Pumping Plant, Clifton Court Forebay (CCF), Skinner Fish Facility, and Barker Slough Pumping Plant. Delta conditions are controlled by D-1641 (SWRCB 2000), which sets forth the water right requirements to meet the objectives in the Bay-Delta WQCP (SWRCB 1995).

The CVP Jones Pumping Plant, located about 5 miles north of the city of Tracy, has six fixed-speed pumps. It has a permitted diversion capacity of 4,600 cfs and sits at the end of an earth-lined intake channel about 2.5 miles long. The Jones Pumping Plant discharges into the head of the DMC. The upper portion of the DMC is heavily affected by subsidence that limits the maximum pumping rates to less than the permitted capacity. The SWP Banks Pumping Plant, located near the Jones Pumping Plant, has 11 variable speed pumps that allow for more control over the diversion rate. Pumping is limited to a maximum permitted capacity of 10,300 cfs per day. The Banks Pumping Plant discharges into the California Aqueduct. The DMC/California Aqueduct Intertie (capacity 467 cfs from DMC to California Aqueduct and capacity 900 cfs from California Aqueduct to DMC) is used to move water between the California Aqueduct and the DMC. This structure was built to help both CVP and SWP more effectively move water from the Delta into San Luis Reservoir. This helps both CVP and SWP when there are system restrictions that may prevent one party from moving water.

Banks Pumping Plant pumps water directly from storage in CCF. The CCF radial gates are closed during critical periods of the ebb and flood tidal cycle to protect water levels experienced by local agricultural water diverters in the south-of-Delta area. As a practical matter, Banks Pumping Plant pumping rates are constrained operationally by limits on CCF diversions from the Delta. The maximum daily diversion limit from the Delta into CCF is 13,870 AF per day (6,990 cfs per day) and the maximum averaged diversion limit over any 3 days is 13,250 AF per day (6,680 cfs per day). In addition to these requirements, DWR may increase diversions from the Delta into CCF by one-third of the San Joaquin River flow at Vernalis from mid-December through mid-March when flows at Vernalis exceed 1,000 cfs. These limits are listed in USACE Public Notice 5820A Amended (October 13, 1981).

During July through September, the maximum daily diversion limit from the Delta into CCF is increased from 13,870 AF per day (6,990 cfs per day) to 14,860 AF per day (7,490 cfs per day) and the maximum averaged diversion limit over any 3 days is increased from 13,250 AF per day (6,680 cfs per day) to 14,240 AF per day (7,180 cfs per day). These increases are for recovering water supply losses incurred earlier in the same year and to protect ESA-listed fish species. The increases are a separate action permitted for short-term time periods. Banks Pumping Plant will pump 195,000 AF to the CVP per the 2018 COA addendum.

The Barker Slough Pumping Plant diverts water from Barker Slough into the North Bay Aqueduct (NBA) for delivery to the Solano County Water Agency and the Napa County Flood Control and Water Conservation District (Napa County FC&WCD) (NBA entitlement holders).

4.2.6.1 *Seasonal Operations*

Winter and spring pumping operations generally maximize exports of excess, unregulated, and unstored water to help meet project demands later in the season and for Delta water quality. To minimize and avoid adverse effects on listed species, actions have been taken or imposed in the past to protect fish migration and minimize fish entrainment at Jones and Banks Pumping Plants. These restrictions limit the CVP's and SWP's ability to export excess water in the winter and spring and place a higher reliance on exporting previously stored water in the summer and fall.

Summer is generally a period of higher export potential. During the summer, the CVP and SWP typically operate to convey previously stored water across the Delta for exporting at the CVP and SWP pumps or other Delta facilities. Delta concerns during the summer are typically focused on maintaining salinity and meeting outflow objectives while maximizing exports with the available water supply.

Fall Delta operations typically begin as demands decrease, accretions increase within the system, and reservoir releases are decreasing to start conserving water. Exports are typically maximized to export available water in the system and may decrease if the fall remains dry. As precipitation begins to fall within the Sacramento and San Joaquin Basins, the reservoirs focus on building storage and managing for flood control.

In order to meet health and safety needs, critical refuge supplies, and obligations to senior water rights holders, the combined CVP and SWP export rates at Jones Pumping Plant and Banks Pumping Plant would not be required to drop below 1,500 cfs.

4.2.6.2 *Delta Cross Channel*

The DCC is a controlled diversion channel between the Sacramento River and Snodgrass Slough. When DCC gates are open, water is diverted from the Sacramento River through a short excavated channel into Snodgrass Slough and then flows through natural channels for about 50 miles to the vicinity of Banks and Jones Pumping Plants.

Reclamation operates the DCC in the open position to (1) improve the movement of water from the Sacramento River to the export facilities at the Banks and Jones Pumping Plants, (2) improve water quality in the central and southern Delta, and (3) reduce salinity intrusion rates in the western Delta. During the late fall, winter, and spring, the gates are often periodically closed to protect out-migrating salmonids from entering the interior Delta and to facilitate meeting the D-1641 Rio Vista flow objectives for fish passage. In addition, whenever flows in the Sacramento River at Sacramento reach 20,000 to 25,000 cfs (on a sustained basis), the gates are closed to reduce potential scouring and flooding that might occur in the channels on the downstream side of the gates.

4.2.6.3 *Delta Water Diversions*

4.2.6.3.1 SWP NBA – Barker Slough Intake

The Barker Slough Pumping Plant diverts water from Barker Slough into the NBA for delivery to the Solano County Water Agency and the Napa County FC&WCD (NBA water contractors). The NBA intake is located approximately 10 miles from the main stem Sacramento River at the end of Barker Slough. Water quality in Barker Slough becomes degraded during winter and spring rainfall events. The Barker Slough drainage basin is characterized by grazing lands, erodible soils, and urban uses. Rainfall runoff can include elevated levels of coliform bacteria, organic matter, turbidity, and pollutants. The water is costly to treat to meet drinking water standards.

4.2.6.3.2 Clifton Court Forebay

The CCF is a 31 TAF reservoir located in the southwestern edge of the Delta, about 10 miles northwest of Tracy, California. The CCF provides storage to allow off-peak pumping of water exported through Banks Pumping Plant, moderates the effect of the pumps on the fluctuation of flow and stage in adjacent Delta channels, and collects sediment before it enters the California Aqueduct. Diversions from Old River into CCF are regulated by five radial gates.

Clifton Court Forebay Aquatic Weed and Algal Bloom Management

Aquatic weeds dominate CCF from late spring through fall. Surveys of the aquatic plant community in CCF show aquatic weeds were present in 91% of the forebay's surface area in 2014 compared to only 38% in 2006. Dense growth of submerged aquatic weeds in CCF can cause severe head loss and pump cavitation at Banks Pumping Plant when the stems of rooted plants break free, combine into "mats," and accumulate on the primary and secondary trashracks. This mass of uprooted and fragmented vegetation essentially forms a watertight plug at the trashracks and vertical louver array. The resulting blockage necessitates a reduction in the water pumping rate to prevent potential equipment damage through pump cavitation and excessive weight on the louver array causing collapse of the structure. Cavitation creates excessive wear and deterioration of the pump impeller blades. Excessive floating weed mats also block the passage of fish into the Skinner Fish Facility, thereby reducing the efficiency of fish salvage operations. Ultimately, this results in a reduction in the volume of water diverted by the SWP. In addition, dense stands of aquatic weeds provide cover for unwanted predators that prey on listed species within the CCF.

Mechanical methods are implemented to manually remove aquatic weeds. A debris boom and an automated weed rake system continuously remove weeds entrained on the trashracks. During high weed load periods in late summer and fall when the plants senesce and fragment or during periods of hyacinth entrainment, boat-mounted harvesters are operated on an as-needed basis to remove aquatic weeds in the forebay and the intake channel upstream of the trashracks and louvers. The objective is to decrease the weed load on the trashracks and to improve flows in the channel. Effectiveness is limited due to the sheer volume of aquatic weeds and the limited capacity and speed of the harvesters. Harvesting rate for a typical weed harvester ranges from 0.5 to 1.5 acres per hour or 4 to 12 acres per day. Actual harvest rates may be lower due to travel time to off-loading site, unsafe field conditions such as high winds, and equipment maintenance.

Aquatic weed assemblages change from year to year in the CCF from predominantly Brazilian waterweed (*Egeria densa*) to one dominated by curly-leaf pondweed, sago pondweed, and southern naiad. In past years, DWR has applied herbicides to control aquatic weeds, from July 1 to August 31.

Attached benthic cyanobacteria blooms have occurred in CCF that produce compounds that cause unpleasant tastes and odors to finished drinking water. The finished drinking water secondary maximum contaminant level (MCL) for taste and odor compounds is 10 ng/L of geosmin and 5 ng/L of 2-methylisoborneol (MIB). Copper sulfate was applied to the nearshore areas of CCF when results of solid phase microextraction analysis exceed the control tolerances (MIB < 5 ng/L and geosmin < 10 ng/L).

In recent years (2016-2018), DWR received approval to apply Aquathol K aquatic herbicide from June 29 to August 31, but this application has not been permitted in the long term and is not included in the No Action Alternative.

4.2.6.3.3 SWP John E. Skinner Delta Fish Protective Facility

The John E. Skinner Delta Fish Protective Facility (Skinner Fish Facility) is located west of the CCF, 2 miles upstream of the Banks Pumping Plant. The facility screens fish away from the pumps that lift water into the California Aqueduct. Large fish and debris are directed away from the facility by a 388-foot-long trash boom. Smaller fish are diverted from the intake channel into bypasses by a series of metal louvers while the main flow of water continues through the louvers and towards the pumps. These fish pass through a secondary system of screens and pipes into seven holding tanks, where a subsample is counted and recorded. The salvaged fish are then returned to the Delta in oxygenated tank trucks.

CDFW and USFWS evaluated prescreen loss and facility and louver efficiency for juvenile and adult Delta Smelt at the Skinner Fish Facility, and DWR conducted prescreen loss and facility efficiency studies for Steelhead.

4.2.6.3.4 SWP Banks Pumping Plant

The Banks Pumping Plant is in south-of-Delta, about 8 miles northwest of Tracy, California, and marks the beginning of the California Aqueduct. The plant provides the initial lift of water 244 feet into the California Aqueduct by means of 11 pumps, including two rated at 375 cfs capacity, five at 1,130 cfs capacity, and four at 1,067 cfs capacity. Even though the installed capacity of the plant is 10,670 cfs, the maximum conveyance capacity of the California Aqueduct limits the pumping rate to 10,300 cfs.

Permits issued by USACE regulate the rate of diversion of water into CCF for pumping at the plant. This diversion rate is normally restricted to 6,680 cfs as a 3-day average inflow to CCF and 6,993 cfs as a 1-day average inflow to CCF. The 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.

4.2.6.3.5 CVP Jones Pumping Plant and Tracy Fish Collection Facility

The Jones Pumping Plant, located about 5 miles north of Tracy, California, has six available pumps. The plant has a physical capacity of approximately 5,200 cfs and sits at the end of an earth-lined intake channel about 2.5 miles long. Because of limited capacity in the DMC, the facilities in which water pumped at the plant flows have current maximum pumping capacity at the plant is approximately 4,600 cfs. The plan can be operated to its permitted capacity of 4,600 cfs when Reclamation accesses the DMC/California Aqueduct Intertie.

The TFCF is located in the southwest portion of the Delta at the head of the intake channel for the Jones Pumping Plant. The TFCF uses behavioral barriers consisting of primary louvers and four rotating traveling screens aligned in a single row 7 degrees to the flow of the water to guide entrained fish into holding tanks before transport by truck to release sites at the confluence of the Delta. The TFCF was designed to handle smaller fish (less than 200 mm) that would have difficulty fighting the strong pumping plant-induced flows, as the intake is essentially open to the Delta and impacted by tidal action.

The primary louvers are located in the primary channel just downstream of the trashrack structure. The traveling water screen is located in the secondary channel. The louvers allow water to pass through onto the pumping plant, but the openings between the slats are tight enough and angled against the flow of water to prevent most fish from passing between them and to enable the fish to enter one of four bypass entrances along the louver arrays.

Approximately 52 different species of fish are entrained into the TFCF each year; however, the total numbers are significantly different for the various species salvaged. It is difficult, if not impossible, to determine exactly how many safely make it all the way to the collection tanks to be transported back to the Delta. Hauling trucks used to transport salvaged fish to release sites inject oxygen and contain an 8 parts per thousand salt solution to reduce stress.

When south Delta hydraulic conditions allow, and conditions within the original design criteria for the TFCF, the louvers are operated to achieve water approach velocities for striped bass of approximately 1 foot per second from May 15 through October 31 and for salmon of approximately 3 feet per second from November 1 through May 14.

Fish passing through the facility are sampled at intervals of 30 minutes every 2 hours year-round. Fish observed during sampling intervals are identified by species, measured to fork length, examined for marks or tags, and placed in the collection facilities for transport by tanker truck to the release sites in the north Delta away from the pumps. In addition, TFCF personnel monitor for the presence of spent female Delta Smelt in anticipation of expanding the salvage operations to include sub-20 mm larval Delta Smelt detection.

TFCF personnel monitor for the presence of spent female Delta Smelt by euthanizing all adult Delta Smelt that are collected in the 30-minute fish count, determine the gender and the gonadal or sexual maturation stage of the Delta Smelt, and determine if the eggs have reached Stage IV, the stage when eggs are ready for release (0.9 to 10 mm in diameter and easily stripped). Stages V (i.e. postvitellogenic stage) and VI (i.e., postovulatory, or spent stage) are expected soon after Stage IV observation. Stages are determined and reported real-time when a biologist is present or the following morning after smelt detection and collection. Stage or gonad maturation is determined using egg stage descriptions from Mager (1996).

Larval smelt sampling at the TFCF commences once a trigger is met (detection of a spent female at CVP and SWP being one of three triggers). Fish count screen with a 2.4 mm mesh size opening is replaced with one that has a mesh size of 0.5 mm to retain larval fish. Sampling is done four times a day (04:00, 10:00, 16:00, 22:00) and all larval smelt are identified to species and reported the day after collection.

4.2.6.3.6 <u>Contra Costa Water District Operations</u>

CCWD diverts water from the Delta for irrigation and M&I uses under its CVP contract, under its own water right permits and license issued by the SWRCB and under East Contra Costa Irrigation District's (ECCID's) pre-1914 water right. CCWD's water system includes the Mallard Slough, Rock Slough, Old River, and Middle River (on Victoria Canal) intakes; Rock Slough Fish Screen (constructed in 2011 under the authority of CVPIA 3406(b)(5)); Contra Costa Canal and shortcut pipeline; and Los Vaqueros Reservoir.

The Rock Slough Intake, Contra Costa Canal, and shortcut pipeline are owned by Reclamation and are operated and maintained by CCWD under contract with Reclamation. Mallard Slough Intake, Old River Intake, Middle River Intake, and Los Vaqueros Reservoir are owned and operated by CCWD. Federal legislation providing the authority for Reclamation to transfer title of the facilities was passed by Congress and signed by the President in March 2019. CCWD and Reclamation are beginning the title transfer process, which includes conducting the required environmental and property record review to execute the transfer. The process is anticipated to take approximately two years to complete. These facilities are described in Appendix C.

Operations at CCWD's intakes and Los Vaqueros Reservoir are governed by NMFS BOs (NMFS 1993, 2007, 2010, 2017) and USFWS BOs (USFWS 1993, 2000, 2007, 2010, 2017), an MOU with CDFW (CDFG 1994), and an incidental take permit from CDFG (CDFG 2009), which are separate from the BOs for the coordinated long-term operation of the CVP and SWP. CCWD's operations in the No Action Alternative are consistent with the current implementation of the operational criteria specified in those separate BOs.

CCWD operates its intake facilities to meet its delivered water quality goals and to protect listed species. The choice of which intake to use at any given time is based in large part upon salinity at the intakes, consistent with fish protection requirements in the CCWD-specific BOs and permits listed above. In winter and spring months when the Delta is relatively fresh (generally January through July), deliveries to the CCWD service area are made by direct diversion from the Delta. In addition, when salinity is low enough, Los Vaqueros Reservoir is filled at a rate of up to 200 cfs from the Old River Intake and Middle River Intake. When salinity in the Delta is high (generally late summer and fall months), CCWD releases previously stored water from Los Vaqueros Reservoir to blend with its direct Delta diversions to meet its water quality goals.

The BOs for the Los Vaqueros Project, CCWD's Incidental Take Permit issued by CDFW, and SWRCB D-1629 include fisheries protection measures consisting of a 75-day period during which CCWD does not fill Los Vaqueros Reservoir (no-fill period) and a concurrent 30-day period during which CCWD halts all diversions from the Delta (no-diversion period), provided that Los Vaqueros Reservoir storage is above emergency levels. During the no-diversion period, CCWD customer demand is met by releases from Los Vaqueros Reservoir. The default dates for the no-fill and no-diversion periods are March 15 through May 31 and April 1 through April 30, respectively. USFWS, NMFS, and CDFW can change these dates to best protect the subject species.

In addition to the 75-day no-fill period and the concurrent 30-day no-diversion period, CCWD operates to an additional term in the Incidental Take Permit issued by CDFW that provides for an additional no-fill period of up to 15 days between February 14 and February 28. These dates can be changed to better protect Delta fish species, at the direction of CDFW.

CCWD currently coordinates the filling of Los Vaqueros Reservoir with Reclamation and DWR to avoid water supply impacts on other CVP and SWP customers. This coordination would also continue under the No Action Alternative.

4.2.6.3.7 Regulatory Limitations on Operations of Delta Water Diversions

Operations of the CVP and SWP are implemented in accordance with SWRCB water rights and water quality decisions, including D-1641, the 2008 USFWS BO, and the 2009 NMFS BO.

Decision 1641

The SWRCB adopted the 1995 Bay-Delta Plan on May 22, 1995. The plan became the basis of D-1641 (adopted December 29, 1999 and revised March 15, 2000). D-1641 amended certain terms and conditions of the SWP and CVP water rights to include flow and water quality objectives to assure protection of beneficial uses in the Delta and Suisun Marsh. (SWRCB grants conditional changes to points of diversion for the CVP and SWP under SWRCB D-1641.) The requirements in D-1641 address the standards for fish and wildlife protection, water supply water quality, and Suisun Marsh salinity. These objectives include specific Delta outflow requirements throughout the year, specific export limits in the spring, and export limits based on a percentage of estuary inflow throughout the year. The water quality objectives are designed to protect agricultural, municipal and industrial, and fishery uses, and vary throughout the year and by water year type.

The export to inflow ratio limited exports at Banks and Jones pumping plants to 35% of total Delta inflow from February through June. The 35% E/I Ratio from February to June required in D-1641 was a significant change from D-1485. This spring requirement reduced the availability of unstored flow for export and storage in San Luis Reservoir. February to June became an unreliable season for conveying water across the Delta. Spring X2 reduced the unstored flow availability by dedicating a significant block of water to Delta outflow and salinity goals. The spring X2 Delta outflow is specified from February through June to maintain freshwater and estuarine conditions in the western Delta to protect aquatic life. The criteria require operations of the CVP and SWP upstream reservoir releases and Delta exports in a manner that maintains a salinity objective at an X2 location. The X2 standard was established to improve shallow water estuarine habitat in the months of February through June and relates to the extent of salinity movement into the Delta (DWR, Reclamation, USFWS, and NMFS 2013). The location of X2 is important to both aquatic life and water supply beneficial uses.

Joint Point of Diversion

D-1641 authorized the SWP and CVP to jointly use both Jones and Banks Pumping Plants in the south Delta, with conditional limitations and required response coordination plans (referred to as Joint Point of Diversion [JPOD]). Use of JPOD is based on staged implementation and conditional requirements for each stage of implementation. The stages of JPOD in D-1641 are:

- Stage 1, for water service to a group of CVP water service contractors (Cross Valley contractors, San Joaquin Valley National Cemetery, and Musco Family Olive Company) and recovery of export reductions implemented to benefit fish;
- Stage 2, for any purpose authorized under the current CVP and SWP water right permits; and
- Stage 3, for any purpose authorized, up to the physical capacity of the diversion facilities.

In general, JPOD capabilities are used to accomplish four basic CVP and SWP objectives:

- When wintertime excess pumping capacity becomes available during Delta excess conditions and total CVP and SWP San Luis storage is not projected to fill before the spring pulse flow period, the project with the deficit in San Luis storage may elect to pursue use of JPOD capabilities;
- When summertime pumping capacity is available at Banks Pumping Plant and CVP reservoir conditions can support additional releases, the CVP may elect to use JPOD capabilities to enhance annual CVP south-of-Delta water supplies;
- When summertime pumping capacity is available at Banks or Jones Pumping Plant to facilitate water transfers, JPOD may be used to further facilitate the water transfer; and

- During certain coordinated CVP and SWP operation scenarios for fishery entrainment management, JPOD may be used to shift CVP and SWP exports to the facility with the least fishery entrainment impact while minimizing export at the facility with the most fishery entrainment impact.

Each JPOD stage has regulatory terms and conditions that must be satisfied to implement JPOD. All stages require a response plan (i.e., water level response plan) to ensure water elevations in the south Delta will not be lowered to the injury of local riparian water users and a response plan to ensure the water quality in the south and central Delta will not be significantly degraded through operations of the JPOD to the injury of water users in the south and central Delta. Stage 2 has an additional requirement to complete an operations plan (i.e., fisheries response plan) that will protect fish and wildlife and other legal users of water. Stage 3 has an additional requirement to protect water levels in the south Delta. All JPOD diversions under excess conditions in the Delta are junior to CCWD water right permits for the Los Vaqueros Project and must have an X2 location west of certain compliance locations consistent with the 1993 Los Vaqueros BO for Delta Smelt.

Old and Middle River Reverse Flow Management

Old and Middle River Net Flows (OMR) provides a surrogate indicator for how exports at Banks and Jones Pumping Plants and San Joaquin River inflow influence hydrodynamics in the south Delta. The management of OMR, in combination with other environmental variables, can minimize or avoid the entrainment of fish in the South Delta and at CVP and SWP salvage facilities. Under the No Action Alternative, Reclamation and DWR would continue to operate the CVP and SWP to meet the RPA requirements in USFWS' 2008 BO RPA Actions 1-3 and NMFS 2009 BO RPA Action IV.2.3.

4.2.6.4 *Water Transfers*

The No Action Alternative includes water transfers through CVP and SWP facilities. Water transfers occur through various methods, including groundwater substitution, release from storage, and cropland idling, and include individual and multiyear transfers. The quantity and timing of Keswick releases would be similar to those that would occur absent the transfer. Water transfers would occur from July through September in total annual volumes up to those described in Table 4.2-5.

Table 4.2-5. Water Transfers in the No Action Alternative

Water Year Type	Maximum Transfer Amount (TAF)
Critical	Up to 600
Dry (following critical)	Up to 600
Dry (following dry)	Up to 600
All other years	Up to 360

4.2.7 Stanislaus River

Reclamation operates the CVP East Side Division for flood control, agricultural water supplies, hydroelectric power generation, fish and wildlife protection, and recreation. In the Stanislaus River watershed, Reclamation owns and operates New Melones Dam and New Melones Reservoir (2.4 MAF capacity). The Tri-Dam Project, a partnership between the Oakdale Irrigation District (OID) and South San Joaquin Irrigation District (SSJID), consists of Donnells and Beardsley Dams, located upstream of New Melones Reservoir on the middle fork Stanislaus River, and Tulloch Dam and Power Station, located approximately 6 miles downstream of New Melones Dam on the mainstem Stanislaus River. Releases from Donnells and Beardsley Dams affect inflows to New Melones Reservoir. The main water diversion point on the Stanislaus River is Goodwin Dam, located approximately 2 miles downstream of Tulloch Dam. The OID and SSJID manage the Tulloch and Goodwin Dams infrastructure through separate agreements with both Reclamation and Reclamation's CVP water service contractors (Stockton East Water District and Central San Joaquin Water Conservation District) to meet Reclamation's Stanislaus River objectives, CVP contractor deliveries, and deliveries to the OID and SSJID service areas.

The Stanislaus River watershed has annual obligations that exceed the average annual runoff in a given year due to a number of factors, including SWRCB water rights decisions D-1641, D-1422, and D-1616; 1987 CDFG agreement; CVPIA objectives; 2009 BO; 1988 agreement and stipulation with OID and SSJID; riparian water right diverters; and CVP water delivery contracts.

Over the past decade, Reclamation has worked with Stanislaus River water users and related agencies in developing a revised operating plan for New Melones Reservoir to addresses multiple objectives, including a more predictable and sustainable operation, minimize low storage conditions in successive drought years, and provide flows to support listed species and critical habitat. These efforts have allowed multiple agencies and stakeholders to provide input on potential solutions; a final plan has not been completed.

4.2.7.1 *Reservoir Operations*

The operating criteria for New Melones Reservoir are constrained by water rights requirements, flood control operations, contractual obligations, and federal requirements under the ESA and the CVPIA. Reclamation must operate New Melones Reservoir to meet senior water rights and in-basin demands. Senior water rights are defined for both current and future upstream water right holders in accordance with D-1422 and D-1616, through protest settlement agreements with Tuolumne and Calaveras Counties, and for current downstream water right holders and riparian rights whose priorities are either senior to Reclamation or senior to appropriative rights in general. Reclamation is required to make full contract amounts available to Stockton East Water District and Central San Joaquin Water Conservation District except for when contractual shortage provisions apply.

Under the No Action Alternative, New Melones Reservoir releases would be controlled by Appendix 2E of the 2009 NMFS Biological Opinion, which specifies releases for endangered fish.

Tulloch Reservoir is owned and operated by the Tri-Dam Project for recreation, power, and flow re-regulation of New Melones Reservoir releases. Water released by Tulloch Reservoir and Power Station flows downstream to Goodwin Reservoir, where water is either diverted to canals to serve Oakdale Irrigation District, South San Joaquin Irrigation District, and Stockton East Water District or is released from Goodwin Reservoir to the lower Stanislaus River (SWRCB 2012).

Below Goodwin Dam, the lower Stanislaus River flows approximately 40 miles to the confluence with the San Joaquin River. Agricultural return flows and operational spills from irrigation canals enter the lower Stanislaus River.

4.2.7.2 *Dissolved Oxygen Requirement*

Reclamation's New Melones Reservoir water rights require that water be bypassed through or released from New Melones Reservoir to maintain applicable dissolved oxygen standards to protect the salmon fishery in the Stanislaus River. The Central Valley Regional Water Quality Control Board's 2004 San Joaquin Basin 5C Plan designates the lower Stanislaus River with cold water and spawning beneficial uses, which have a general water quality objective of no less than 7 milligrams per liter (mg/L) dissolved oxygen. This objective is applied through Reclamation's water rights to the Stanislaus River near Ripon.

4.2.8 San Joaquin River

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

4.2.8.1 *San Joaquin River Restoration Program*

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

The Stipulation of Settlement of *NRDC v. Rogers* is based on two goals: Restoration Goal and Water Management Goal. To achieve the Restoration Goal, the Stipulation of Settlement calls for, among other things, releases of water from Friant Dam to the confluence of the Merced River (referred to as Restoration Flows) according to the hydrographs in Exhibit B of the Stipulation of Settlement. To achieve the Water Management Goal, the Stipulation of Settlement calls for the development and implementation of a plan for recirculation, recapture, reuse, exchange, or transfer of restoration flows for the purpose of reducing or avoiding impacts caused by restoration flows on water deliveries to the Friant contractors. Recapture of restoration flows may occur upstream of a capacity restricted reach or downstream of the Merced River confluence. Recapture can occur at Banta-Carbona, Patterson, or West Stanislaus Irrigation District facilities or at Jones or Banks Pumping Plants. Recapture of restoration flows in the Delta would average 65 TAF, ranging from approximately 25 TAF to 78 TAF, depending on the year type.

4.2.8.2 *San Joaquin River from Merced River to the Delta*

Flows in the San Joaquin River below the Merced River confluence to the Delta are controlled in large part by releases from reservoirs, located on the tributary systems, to satisfy contract deliveries and instream flow requirements, as well as operational agreements such as D-1641. The Merced and Tuolumne Rivers, two tributaries to this reach of the San Joaquin River, are described below. The Stanislaus River was described in Section 4.2.6.

4.2.8.2.1 <u>Merced River</u>

The Merced River flows west out of the Sierra Nevada to its confluence with the San Joaquin River at the end of Reach 5. Merced River stream flows are regulated primarily by New Exchequer and McSwain Dams, which form Lake McClure and Lake McSwain, respectively. The Crocker-Hoffman Diversion Dam is located downstream from New Exchequer and McSwain Dams. Lake McClure is a water supply, hydropower, and flood control reservoir. Lake McSwain is a regulating reservoir approximately 6 miles downstream from Lake McClure. Both reservoirs are owned and operated by the Merced Irrigation District. Minimum flow standards were established in 1964 (Project No. 2179) by a FERC license and the

Davis-Grunsky Contract No. D-GGR17 between Merced Irrigation District and DWR. During high-flow events, a portion of the Merced River flows are conveyed to the San Joaquin River through Merced Slough.

4.2.8.2.2 Tuolumne River

The Tuolumne River enters the San Joaquin River downstream from the Merced River. The largest reservoir on the Tuolumne River is New Don Pedro Lake, owned and operated by the Turlock Irrigation District and Modesto Irrigation District for water supply, hydropower, and flood control purposes. La Grange Reservoir below New Don Pedro Lake is jointly owned by the two irrigation districts and is operated as a diversion dam. The 1995 New Don Pedro Settlement Agreement contains instream flow requirements on the Tuolumne River for the anadromous fishery downstream from the project (FERC 2009).

4.2.9 South-of-Delta

4.2.9.1 *DMC, San Luis Unit, and California Aqueduct Intertie*

4.2.9.1.1 Water Demands

Water provided to the DMC and San Luis Unit primarily meet demands from three types of contractors: CVP water service contractors (including both agricultural and M&I, exchange contractors, and wildlife refuge contractors. Distinct relationships exist between Reclamation and each contractor.

Exchange contractors "exchanged" their senior rights to water in the San Joaquin River for a CVP water supply generally provided from the Delta. Reclamation provides water to meet the 840 TAF per annum exchange contract obligation, with a maximum reduction under the Shasta critical year criteria to an annual water supply of 650 TAF.

South-of-Delta CVP agricultural water service contractors receive their supply from the Delta, but their supplies are subject to the availability of CVP water supplies that can be developed after senior obligations are met. The CVP also contracts with wildlife refuges to provide water supplies to specific managed lands for wildlife purposes. These contracts are subject to the availability of CVP water supplies but may be reduced under Shasta critical year criteria up to 25%.

4.2.9.1.2 DMC/California Aqueduct Intertie

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

- Up to 467 cfs may be pumped from the DMC to the California Aqueduct to ease DMC conveyance constraints related to Jones Pumping Plant capacity limitations;
- Up to 467 cfs may be pumped from DMC to the California Aqueduct to minimize impacts on water deliveries due to temporary restrictions in flow or water levels on the lower DMC (south of the intertie) or the upper California Aqueduct (north of the intertie) for system maintenance or due to an emergency shutdown; or

- Up to 900 cfs may be conveyed from the California Aqueduct to DMC using gravity flow to minimize impacts on water deliveries due to temporary restrictions in flow or water levels on the lower California Aqueduct (downstream of the intertie) or upper DMC (upstream of the intertie) for system maintenance or for an emergency shutdown.

4.2.9.1.3 San Luis Reservoir

The San Luis Reservoir (2.027 MAF), formed by Sisk Dam, is jointly operated by Reclamation and DWR, with approximately 0.965 MAF used by the CVP and 1.062 MAF used by the SWP. Water generally is diverted into San Luis Reservoir during late fall through early spring, when irrigation water demands of CVP and SWP water users are low and are being met by Delta exports.

4.2.9.1.4 Non-CVP and SWP Reservoirs That Store CVP and SWP Water

The CVP and SWP water is delivered to water agencies, and some of those agencies store the water in their own regional and local reservoirs. These reservoirs frequently store non-CVP and SWP water supplies, including local runoff or water diverted under separate water rights or contracts.

In the San Francisco Bay Area region, CVP water is stored in the CCWD Los Vaqueros Reservoir and the East Bay Municipal Utility District Upper San Leandro, San Pablo, Briones, and Lafayette Reservoirs and Lake Chabot. The Los Vaqueros Reservoir stores water diverted from the Delta under separate water rights. The East Bay Municipal Utility District reservoirs primarily store water diverted under water rights on the Mokelumne River.

In the Central Coast region, a portion of the SWP water supply diverted in the Coastal Branch can be stored in Cachuma Lake for use by southern Santa Barbara County communities. Cachuma Lake is a facility owned and operated by Reclamation in Santa Barbara County as part of the Cachuma Project (not the CVP).

In the Southern California region, SWP water is stored in the Metropolitan Water District of Southern California’s Diamond Valley Lake and Lake Skinner; United Water Conservation District’s Lake Piru; City of Escondido’s Dixon Lake; City of San Diego’s San Vicente, El Capitan, lower Otay, Hodges, and Murray Reservoirs; Helix Water District’s Lake Jennings; Sweetwater Authority’s Sweetwater Reservoir; and San Diego County Water Authority’s Olivenhain Reservoir. There are future plans by local water agencies to expand local and regional water surface water storage.

4.3 Alternative 1

Alternative 1 includes a combination of flow-related actions, habitat restoration, and intervention measures. Table 4.3-1 shows each of the components of Alternative 1, including operational changes, nonflow habitat, and facility improvements. The table shows whether each action is covered at a project or program level of analysis in this EIS and whether it involves construction actions. Alternative 1 components within each basin are described in more detail in the sections following the table. If not mentioned in the table, the operations of the No Action Alternative remain.

Table 4.3-1. Components of the Alternative 1

Title	Project Level Analysis or Program-Level Analysis	Construction Effects
Upper Sacramento		
Spring Pulse Flows	Project	–
Shasta Cold Water Pool Management	Project	–
Fall and Winter Refill and Redd Maintenance	Project	–
Rice Decomposition Smoothing	Project	–
Spring Management of Spawning Locations	Program	–
Cold Water Management Tools (e.g., Battle Creek Restoration, Intake Lowering near Wilkins Slough, Shasta TCD Improvements)	Program	X
Spawning and Rearing Habitat Restoration	Program	X
Small Screen Program	Program	X
Winter-Run Conservation Hatchery Production	Program	X
Adult Rescue	Program	–
Juvenile Trap and Haul	Program	X
Trinity		
Whiskeytown Reservoir Operations/Clear Creek Minimum Flows	Project	–
Feather River		
FERC Project #2100-134 controls operations; Alt 1 analyzes downstream of the FERC boundary	Project	–
American River		
2017 Flow Management Standard Releases and Planning Minimum	Project	–
Spawning and Rearing Habitat Restoration	Program	X
Drought Temperature Facility Improvements	Program	X
Stanislaus		
Stanislaus Stepped Release Plan	Project	–
Alteration of Stanislaus DO Requirement	Project	–
Spawning and Rearing Habitat Restoration	Program	X
Temperature Management Study	Program	–
San Joaquin		
Lower San Joaquin River Habitat	Program	X
Bay-Delta		
Delta Cross Channel Operations	Project	–
Water Transfers	Project	–
Barker Slough PP Sediment and Aquatic Weed Removal	Project	-
Clifton Court Aquatic Weed and Algal Bloom Management	Project	–
OMR Management	Project	–
Tracy Fish Collection Facility CO2 Injector and Release Sites	Project	–

Title	Project Level Analysis or Program-Level Analysis	Construction Effects
Operations		
Delta Smelt Summer-Fall Habitat	Project	–
San Joaquin Basin Steelhead Telemetry Study	Project	–
Sacramento Deepwater Ship Channel Food Study	Program	–
North Delta Food Subsidies/Colusa Basin Drain Study	Program	–
Suisun Marsh Food Subsidies Study	Program	–
Habitat Restoration		
Predator Hot Spot Removal	Program	–
Facility Improvements		
Delta Cross Channel Gate Improvements	Program	X
Tracy Fish Facility Improvements	Program	X
Skinner Fish Facility Improvements	Program	X
Small Screen Program	Program	X
Fish Intervention		
Reintroduction efforts from Fish Conservation and Culture Laboratory	Project	–
Delta Fish Species Conservation Hatchery	Program	X

OMR = Old and Middle River flows; TCD = temperature control device

4.3.1 Upper Sacramento River (Shasta and Sacramento Divisions)

4.3.1.1 *Seasonal Operations*

Reclamation would continue to operate by season with the same primary purpose during each season as described for the No Action Alternative. For spring base flows under wetter hydrology, during the March through May time period, downstream demands are minimal and are generally met through unstored accretions to the system. Under these conditions, Reclamation aims to reduce Keswick flows during the fall-winter period. Operations under these conditions help build storage in those types of years. Other changes to specific operations are described below.

In addition to the requirements under D-1641, ramping rates for Keswick Dam between July 1 – March 31 would be reduced between sunset and sunrise:

- Keswick releases > 6,000 cfs, reductions in releases may not exceed 15% per night, and no more than 2.5% per hour.
- Keswick releases 4,000 cfs to 5,999 cfs reductions in releases may not exceed 200 cfs per night, or 100 cfs per hour.
- Keswick releases between 3,250 cfs and 3,999 cfs; reductions in releases may not exceed 100 cfs per night.

Ramping rates would not apply during flood control or if needed for facility operational concerns. The working groups may also determine a need for a variance.

4.3.1.2 *Spring Pulse Flows*

Under Alternative 1, Reclamation would release spring pulse flows when the projected total May 1 Shasta Reservoir indicates a likelihood of sufficient cold water to support summer cold water pool management. Total storage provides a surrogate for the likely cold water pool and would inform the decision in addition to monthly winter reservoir temperature measurements and climate forecasts. Reclamation would evaluate the projected May 1 Shasta Reservoir storage at the time of the February forecast to determine whether a spring pulse would be allowed in March, and would evaluate the projected May 1 Shasta Reservoir storage at the time of the March forecast to determine whether a spring pulse would be allowed in April. If Shasta Reservoir total storage on May 1 is projected to be sufficient for cold water pool management, Reclamation could make a spring pulse release of up to 150 TAF in coordination with the Upper Sacramento scheduling team. Reclamation would make a determination of whether water could be released without affecting temperature management; Reclamation thinks that this volume is about 4 MAF, which is used as a surrogate for planning and analysis. Reclamation would not make a Spring pulse release if the release would cause Reclamation to drop into a Tier 4 Shasta summer cold water pool management (i.e. the additional flow releases would decrease cold water pool such that summer Shasta temperature management drops in Tier 4) or interfere with the ability to meet other anticipated demands on the reservoir. Reclamation would also not release a spring pulse when Shasta Reservoir is making flood releases. An interagency and stakeholder group to determine the timing, duration, and frequency of the spring pulse within the 150 TAF volume. Figure 4.3-1 summarizes this operational regime. This figure shows timing of pulse flows potentially in March, April, or May, but only one pulse flow would occur during the March through May period (up to 150 TAF total).

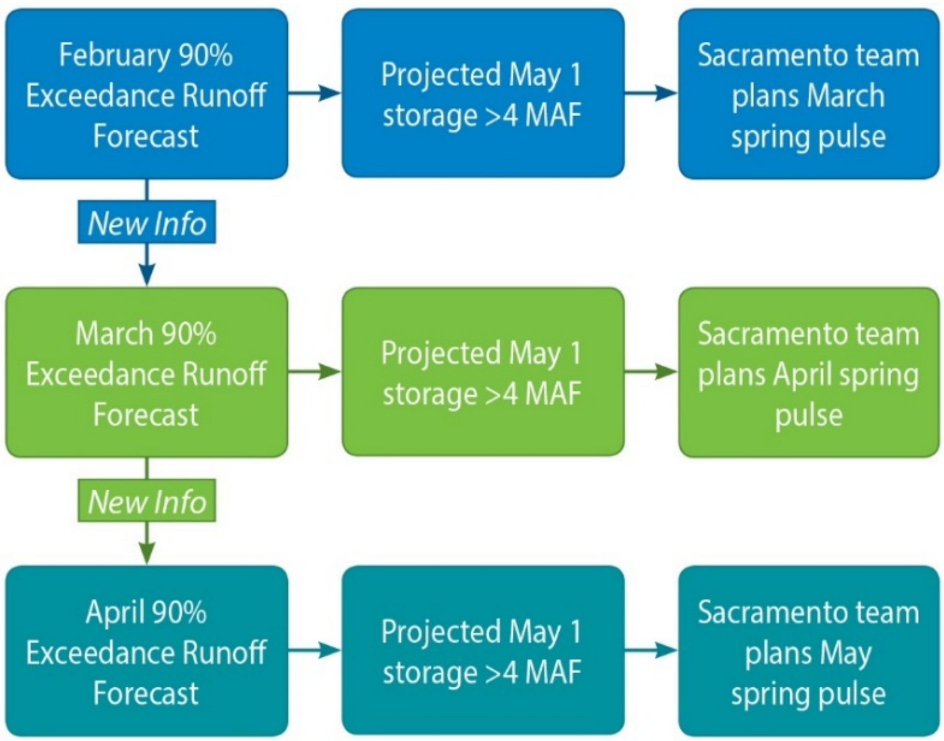

Figure 4.3-1. Lake Shasta Spring Pulse Flow Operations

4.3.1.3 *Cold Water Pool Management*

The closer Shasta Reservoir is to full by the end of May, the greater the likelihood of being able to meet the Winter-Run Chinook Salmon temperature control criteria throughout the entire temperature control season. If Shasta Reservoir storage is high enough to use the Shasta TCD upper shutters by the end of May, Reclamation can maximize the cold water pool potential. Storage of 3.66 MAF allows water to pass through Shasta TCD's upper gates, but historical relationships suggest that storage of 4 MAF on May 1 generally provides enough storage to continue operating through the upper gates and develop a sufficient cold water pool to meet a daily average temperature of 53.5°F on the Sacramento River above Clear Creek (at the CCR gaging station) for Winter-Run Chinook Salmon spawning and egg incubation. Figure 4.3-2 provides an approximate rule of thumb for the relationship between temperature compliance, total storage in Shasta Reservoir, and cold water pool in Shasta Reservoir.

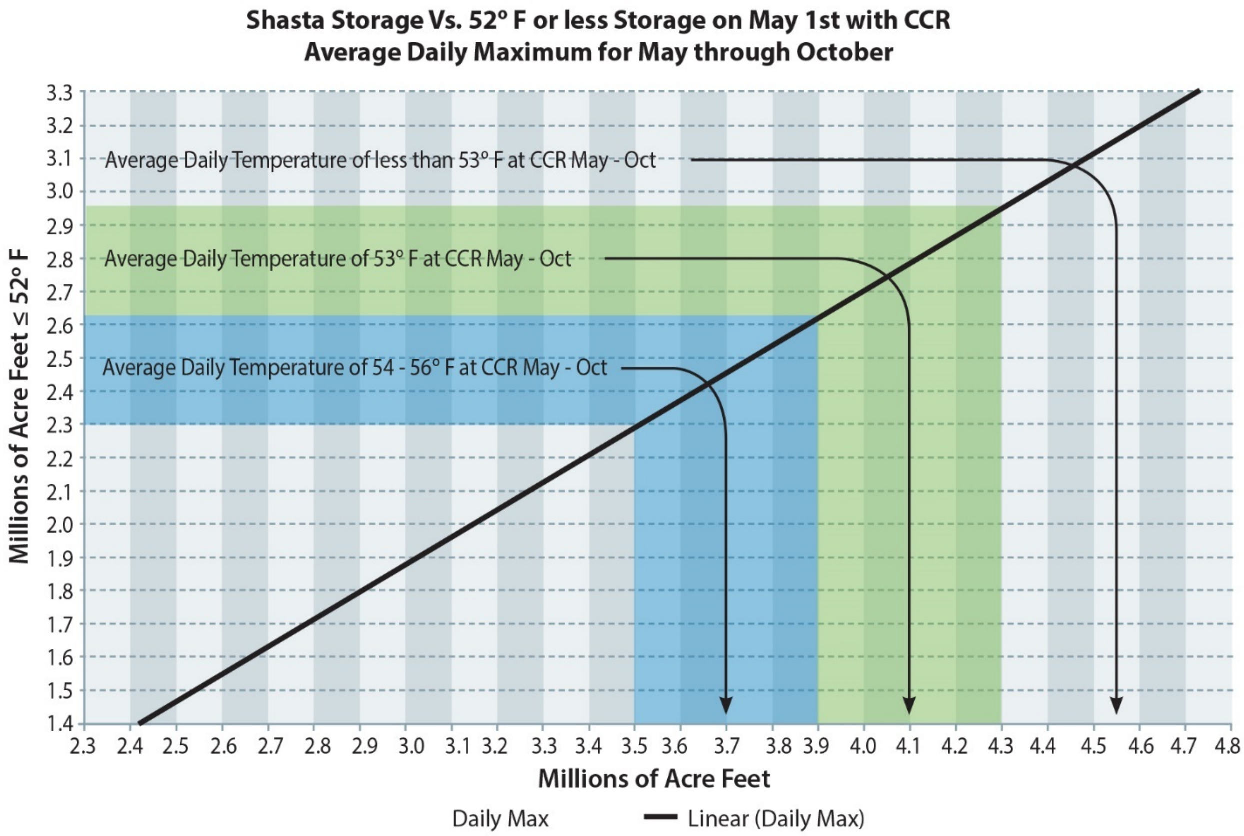

Figure 4.3-2. Relationship between Temperature Compliance, Total Storage in Shasta Reservoir, and Cold Water Pool in Shasta Reservoir

4.3.1.3.1 <u>Summer Cold Water Pool Management</u>

Under Alternative 1, Reclamation would operate the Shasta Dam TCD to continue providing temperature management in accordance with CVPIA Section 3406(b)(6) while minimizing impacts on power generation. Cold water pool is defined as the volume of water in Shasta Reservoir that is less than 52°F, which Reclamation would determine based on monthly (or more frequent) reservoir temperature profiles. The Sacramento River above Clear Creek (CCR) gage is a surrogate for the downstream extent of most Winter-Run Chinook Salmon redds. Temperature management would start after May 15 or when the monitoring working group determines, based on real-time information, that Winter-Run Chinook Salmon have spawned, whichever is later. Temperature management would end October 31 or when the monitoring working group determines, based on real-time monitoring, that 95% of Winter-Run Chinook Salmon eggs have hatched and alevin have emerged, whichever is earlier.

Reclamation would address cold water management using a tiered strategy that allows for strategically selected temperature objectives, based on projected total storage and cold water pool, meteorology, Delta conditions, and habitat suitability for incoming fish population size and location. The tiered strategy recognizes that cold water is a scarce resource that can be managed to achieve desired water temperatures for fisheries objectives. Figure 4.3-3 shows examples of water temperatures at CCR under the four tiers. The proposed tiers are described below, along with storage levels that are likely to provide for cold water management within the tier. Actual operations would depend upon the available cold water and modeling. In any given year, cold water pool and storage could result in Reclamation switching between tiers within the year if needed to optimally use the cold water pool.

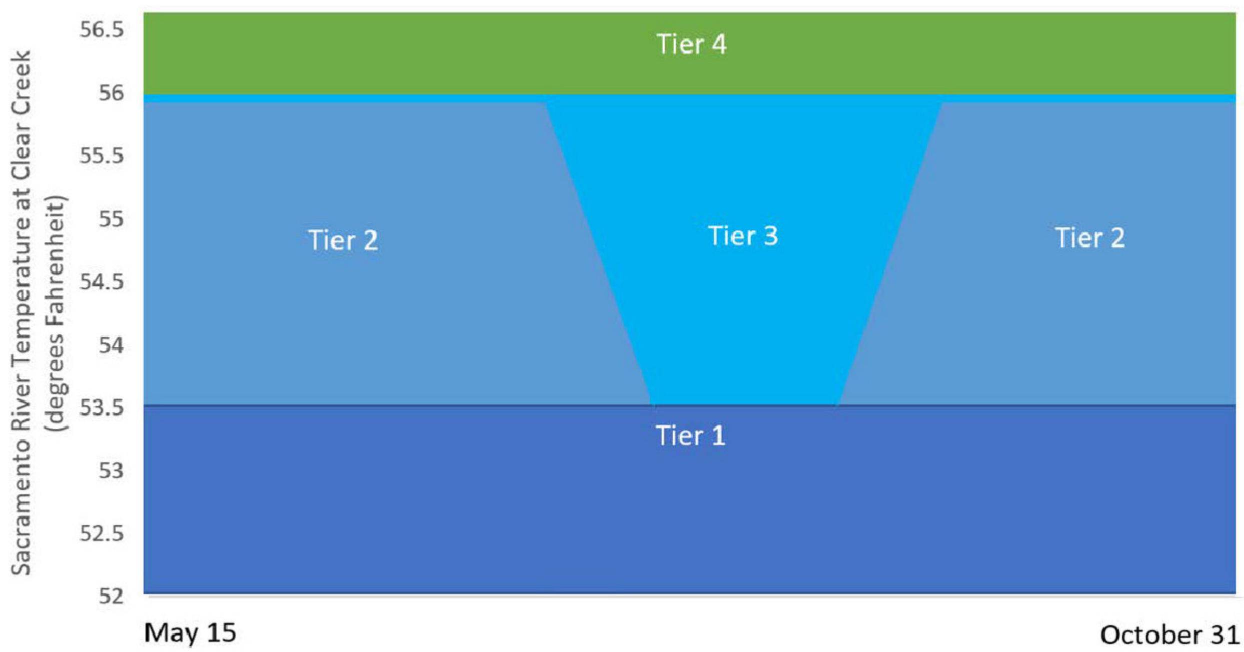

Figure 4.3-3. Tiered Temperature Management Strategy

Tier 1. In years when Reclamation determines that cold water pool is sufficient (e.g., more than 2.8 MAF of cold water pool in Shasta Reservoir at the beginning of May or modeling suggests that a daily average temperature of 53.5°F at CCR can be maintained from May 15 to October 31), Reclamation would operate to a daily average temperature of 53.5°F at the CCR gaging station to minimize temperature-dependent mortality.

Tier 2. In years when cold water pool is insufficient to allow Tier 1 (e.g., less than 2.8 MAF of cold water pool in Shasta Reservoir at the beginning of May or modeling suggests that the 53.5°F at CCR cannot be maintained from May 15 to October 31), Reclamation would optimize use of cold water for Winter-Run Chinook Salmon eggs based on life stage-specific requirements, reducing the duration of time of operating to 53.5°F target temperatures. Water temperatures at CCR would vary based on real-time monitoring of redd timing and life stage-specific temperature-dependent mortality models (Anderson 2017). The time period of a daily average temperature of 53.5°F at CCR would be centered on the projected time period when the winter-run eggs have the highest dissolved oxygen requirement (37 to 67 days postfertilization). At 2.79 MAF of cold water pool, Reclamation would operate to 53.5°F from 37 days after the first observed redd to 67 days after the last observed redd, as long as the last day is earlier than October 31. The duration of the 53.5°F protection would decrease in proportion to the available cold water pool on May 1. Reclamation would determine this time period by running different temperature scenarios through the latest egg mortality model(s) and real-time monitoring of redds. Reclamation would operate to daily average temperatures at CCR during the temperature management season outside of the life stage-specific critical window no warmer than a daily average temperature of 56°F.

Tier 3. When Reclamation determines that life stage-specific temperature targets cannot be met per Tier 2 (e.g., less than 2.3 MAF of cold water pool in Shasta Reservoir at the beginning of May or modeling suggests that maintaining a daily average temperature of 53.5°F at CCR would have higher mortality than a warmer temperature), Reclamation would use cold water pool releases to maximize Winter-Run Chinook Salmon redd survival by increasing the coldest water temperature target. At the highest storage levels in Tier 3, the targeted temperature at CCR would be daily average 53.5°F and as storage decreases would warm in the life stage-specific critical period up to 56°F. Reclamation would increase the temperature while minimizing adverse effects to the greatest extent possible, as determined by the latest egg mortality models, real-time monitoring, and expected and current water availability. This tier would be in effect until Reclamation could no longer meet 56°F at CCR at which point Reclamation would shift to tier 4.

Tier 4. If there is less than 2.5 MAF of total storage (note the use of “total” storage as opposed to the “cold water pool” used in the previous criteria) in Shasta Reservoir at the beginning of May, or if Reclamation cannot meet a daily average temperature of 56°F at CCR, Reclamation would attempt to operate to a less than optimal temperature target and period that would be determined in real-time with technical assistance from NMFS and USFWS. Reclamation would explore improved coordination of downstream diversions, and the potential for demand shifting. In addition, Reclamation would implement intervention measures (e.g., increasing hatchery intake and trap and haul, as described in the paragraph below).

At the March forecast (mid-March), if the forecasted Shasta Reservoir total storage is projected to be below 2.5 MAF at the end of May, Reclamation would initiate discussions with USFWS and NMFS on potential intervention measures should this low storage condition continue into April and May, as described in Tier 4. Reclamation would perform the first temperature model run in April after DWR Bulletin 120 has been received and the operations forecast has been completed. The first temperature model run would be the first month that a model run would be feasible based on temperature profiles. Prior to April, there would be insufficient stratification in Shasta Reservoir to allow a temperature model to provide meaningful results. The April temperature model scenario is used to develop an initial temperature plan for submittal to SWRCB. This temperature plan may be updated as Reclamation has improved data on reservoir storage and cold water pool via the reservoir profiles at the end of May and throughout the temperature control season. Figure 4.3-4 provides a decision tree explaining the decision points for Shasta Reservoir temperature management.

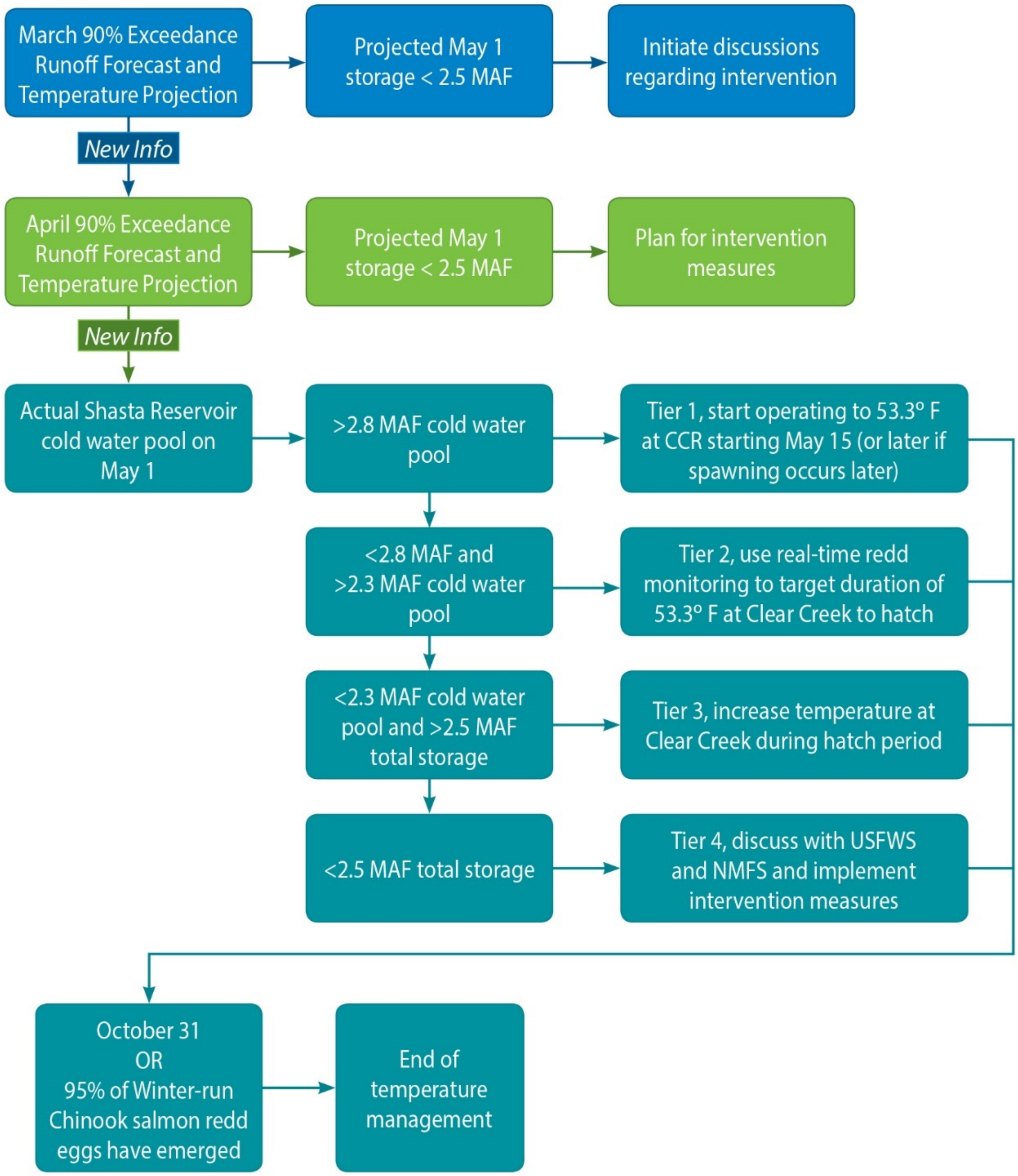

Figure 4.3-4. Decision Tree for Shasta Reservoir Temperature Management

Reclamation intends to provide temperature profile measurements for Shasta, Whiskeytown, and Trinity Reservoirs as shown in Table 4.3-2.

Table 4.3-2. Temperature Profile Measurements for Shasta, Whiskeytown, and Trinity Reservoirs

Reservoir	Every Month	Every 2 Weeks	Every Week	Comment
Shasta	January through February, December	March through April, November 15 – November 30	May 1 through November 14	25-foot intervals for "every month;" otherwise, 5-foot intervals
Whiskeytown	January through December	–	–	25-foot intervals
Trinity	January through December	–	–	25-foot intervals

Reclamation would provide a draft temperature management plan to the Sacramento River Temperature Task Group (SRTTG) in April for its review and comment, consistent with WRO 90-5. The draft temperature management plan would describe which of the four tiers Reclamation forecasts for that year's summer temperature management season, along with a temperature modeling scenario and the operations forecast. The scenario would include projected reservoir releases, assumed meteorological conditions, and anticipated water temperatures and target locations for the planned water temperature targets (including allowable tolerances). Reclamation expects that tolerances would be based on conditions and modeling for that year. For the final temperature management plan, Reclamation would use conservative assumptions for determining the Shasta Cold Water Management Plan including relying on the actual May 1st storage, a conservative forecast for inflow May through September, proposed releases based on a conservative forecast, and a conservative historical meteorology. Reclamation would aim to achieve a 90% level of confidence in the aggregate although certain circumstances may lead Reclamation to use different confidence levels to incorporate a more conservative approach. Reclamation would share forecast assumptions with NMFS through the SRTTG. Reclamation anticipates NMFS would provide technical assistance through the SRTTG.

Consistent with the Shasta Cold Water Management Plan, Reclamation would operate the temperature control device at Shasta Dam to manage water temperatures below Keswick Dam and would monitor the results. If monitored water temperatures exceed the target temperature (with allowable tolerances) in the Shasta Cold Water Management Plan for longer than 3 consecutive days, Reclamation would notify NMFS of what actions, if any, are being taken to address the exceedances and would arrange for a follow-up on day 5 if the actions do not resolve the issue.

4.3.1.3.2 Commitment to Cold Water Management Tiers

Once the initial tier is selected by May 15th, Reclamation would not cause a shift into a warmer tier during real-time implementation of the Shasta Cold Water Management Plan except in the event of responding to emergency and/or unforeseen conditions. Examples of emergency and/or unforeseen conditions may include, but are not limited to, higher water quality control plan compliance requirements, warmer meteorology, changes in forecasted inflow quantities and temperatures to Shasta, facility malfunctions, and higher than expected non-project water diversions (e.g. diverters other than those exercising water service and repayment contracts with Reclamation such as in-Delta diversions, riparian diversions, etc.).

Reclamation would re-evaluate the temperature management plan (and associated tier) at least monthly and would notify NMFS within 2 business days of determining a potential change to the plan is necessary. Reclamation may be able to adjust operations to overcome unexpected events without changing to a lower tier. Should Reclamation be unable to remain within the same or cooler tier identified by the Shasta Cold Water Pool Management Plan, Reclamation would coordinate with NMFS on the need to charter an independent panel, at the end of the temperature management season, consistent with "Chartering of Independent Panels) under the "Governance" section of Alternative 1. The purpose of the independent review would be to evaluate the conditions experienced during the years under review, the success of the implementation of the tiered strategy, the effect of the implementation on the species, and, if needed, to develop recommendations to improve its implementation.

4.3.1.3.3 Upper Sacramento Performance Metrics

Reclamation would apply performance metrics for assessing cold water management under the different tiers. The objective is to ensure that the performance falls within the modeled range, and shows a tendency towards performing at least as well as the distribution produced by the simulation modeling of Alternative 1.

Reclamation reviewed the estimated temperature dependent mortality over the CalSim II period of record (1922-2002) with their modeled tier associated with each year. Reclamation's objective would be to meet the temperature criteria associated with each tier and expects the associated biological performance would fall within the full range of modeled performance. The summary of modeled results is listed below with the median, average, maximum and minimum, and standard deviation values with the years. Reclamation intends for an independent panel to review and refine potential alternative steps if the objectives are not occurring.

The summary of modeled temperature-dependent mortality:

- Tier 1 - Maximum (39%); Average (6%); Median (2%); Minimum (0.4%); Std. Dev (+/-9%)
- Tier 2 - Maximum (46%); Average (15%); Median (9%); Minimum (1%); Std. Dev (+/-16%)
- Tier 3 - Maximum (77%); Average (34%); Median (24%); Minimum (6%); Std. Dev (+/-31%)
- Tier 4 - Appropriate performance metrics would be addressed under "Drought and Dry Year Actions" consistent with the "Governance" section of Alternative 1.

Reclamation reviewed the observed egg-to-fry survival over the past 21 years, excluding years with atypical temperature conditions (2015). Reclamation's objective in undertaking habitat restoration and facility improvements under Alternative 1 would be to improve the egg-to-fry survival associated with each tier and expects the associated biological performance to increase over time. The summary of results is listed below with the average, maximum and minimum values within the years analyzed. Reclamation intends for an independent panel to review and refine potential alternative steps if the objectives are not occurring.

Summary of historic egg-to-fry survival:

- Tier 1 - Average (29%); Maximum (49%); Minimum (15%); Median (28%); Std. Dev (10%)
- Tier 2/3 - Average (21%); Maximum (34%); Minimum (15%); Median (20%); Std. Dev (6%)
- Tier 4 - Appropriate performance metrics would be addressed under "Drought and Dry Year Actions" consistent with the "Governance" section of Alternative 1.

The 75th percentile values of the historical egg to fry survival would be included as a surrogate for expected improvements in egg-to-fry survival for each tier from the habitat restoration projects recently completed, currently underway, or proposed to be completed under Alternative 1. These values are: Tier 1 – 32%; and Tiers 2/3 – 27%. These values would be updated with the appropriate metrics once modeled results are available on the expected improvements from these projects.

In the course of developing “Drought and Dry Year” actions, Reclamation and DWR would develop a range of alternative strategies for temperature management. The SRTTG may consider alternative strategies to the approach described for Alternative 1 during development of plans for Tier 3 years. In acknowledging that Tier 3 years are expected to produce a range of outcomes that increase the threat of viability to salmonid species, Reclamation would work to limit those effects through the SRTTG. These alternative strategies may be based on new or evolving science on the key biological drivers of temperature dependent mortality. These strategies may require additional analytical methods and monitoring specific to the hydrologic and temperature conditions. Reclamation would evaluate and report upon the effectiveness of strategies. These strategies would be coordinated with the conservation measure that addresses two successive years with total egg-to-fry survival less than 15% in each year.

Reclamation would measure upper Sacramento River fisheries populations, in collaboration with federal, state, and local partners, to estimate the total survival from egg incubation to juvenile migration to Red Bluff Diversion Dam. Reclamation would estimate and report on the direct mortality and sublethal effects to egg incubation associated with water temperatures below Keswick Dam (temperature dependent mortality) using, at a minimum, the Martin et al. (2017) approach unless superseded by mutual agreement with NMFS. Reclamation would report annually on total survival and temperature dependent mortality. The Annual Reporting would include a technical team (e.g., SRTTG) hindcast evaluation of whether the total egg-to-fry survival or the temperature dependent mortality exceeded the tier objective. This evaluation would consider the central tendency of modeled expected survival results and would contribute to determining whether an independent review of the year is required. The annual accomplishments in each year would be compared to the metrics by the review panels in 2024 and 2028, consistent with “Four Year Reviews” under the “Governance” section of Alternative 1, to review whether there is a tendency or trajectory that would not lead to matching or exceeding the distribution of the modeled results over the long-term.

If the actual temperature dependent mortality or egg-to-fry survival fall outside the range described above in any single year, Reclamation would convene with NMFS to determine if an independent panel is necessary. If a panel is deemed necessary, Reclamation would charter an independent panel consistent with “Chartering of Independent Panels” under the “Governance” section of Alternative 1. If the actual results are within the ranges described above, Reclamation would still convene an independent panel consistent with “Four Year Review” under the “Governance” section of Alternative 1. The purpose of either panel would be to:

1. Review the drivers behind the management of cold water within the tiers including reservoir storage, releases, meteorology, hydrology, and other conditions affecting building and use of cold water (e.g. emergency, uncertainty, etc.).

2. Review the performance objectives, including the methods for determining temperature dependent mortality and methods for determining total survival.

3. Review the tier types that have occurred during the performance periods and the performance within each tier as compared to expected performance. The selected metrics are the average, median, standard deviation, min, and max of the base dataset. Additional higher-order time series statistics may be used at the request of the review panel. The objective is to ensure that the performance falls within the modeled range, and shows a tendency towards performing at least as well as the distribution produced by the simulation modeling of Alternative 1.

4. Recommend potential modifications to CVP and SWP operations that would improve cold water pool management that are within the agencies’ authorities.

5. Review the effectiveness of habitat restoration, facility improvements, intervention, and research measures.

The panel would prepare a report incorporating discussion of the above items and recommendations, including alternate strategies. NMFS and Reclamation would meet and confer to discuss the report and any response.

Prior to the initial Four-Year Review independent panel, Reclamation would refine performance objectives for temperature dependent mortality and the total survival of winter-run Chinook salmon from egg incubation to juvenile migration at Red Bluff Diversion Dam. Reclamation expects to participate in an effort by NMFS to establish early life stage survival rates that are required for a positive cohort replacement rate. Reclamation expects NMFS would submit for independent review temperature dependent mortality and egg-to-fry survival values that, as the species experts and with support from separate analyses, it expects would provide continued support of a viable population. Reclamation expects to participate in the panel and offer technical assistance regarding operations, understanding that these values, or any that result from addressing recommendations from the independent panel, could be adopted with mutual agreement as revised performance metrics for operations.

4.3.1.4 *Fall and Winter Refill and Redd Maintenance*

Under Alternative 1, Reclamation would rebuild storage and cold water pool during fall and winter for the subsequent year. Maintaining releases to keep late spawning Winter-Run Chinook Salmon redds underwater may drawdown storage necessary for temperature management in a subsequent year. Reclamation would minimize effects with a risk analysis of the remaining Winter-Run Chinook Salmon redds, the probability of sufficient cold water in a subsequent year, and a conservative distribution and timing of subsequent Winter-Run Chinook Salmon redds. If the combined productivity of the remaining redds plus a conservative scenario for the following year is less than the productivity of maintaining releases, Reclamation would reduce releases to rebuild storage. The conservative scenario for the following year would include a 75% (dry) hydrology; 75% (warm) climate; a median distribution for the timing of redds, and the ability to remain within Tier 3 or higher (colder) tiers. The forecast for flows in the fall would include any approved water transfers that may be moved during this period.

If, based on the above analysis, Reclamation determines releases need to be reduced to rebuild storage, targets for winter base flows (December 1 through the end of February) from Keswick would be set in October based on Shasta Reservoir end-of-September storage. These targets would be set based on end-of-September storage and the current hydrology after accounting for winter-run red stranding. Base flows would be set based on historic performance to accomplish improved refill capabilities for Shasta Reservoir to build cold water pool for the following year. Table 4-9 shows examples of possible Keswick Releases based on Shasta Reservoir storage condition; these would be refined through future modeling efforts as part of the seasonal operations planning.

Table 4.3-3. Keswick Dam Release Schedule for End-of-September Storage

Keswick Release	Shasta End-of-September Storage
3,250 cfs	≤ 2.2 MAF
4,000 cfs	≤ 2.8 MAF
4,500 cfs	≤ 3.2 MAF
5,000 cfs	> 3.2 MAF

High storage years are not necessarily correlated with a following wetter fall and winter. As a result, Reclamation would manage the real time releases based on conditions observed. In scenarios where higher storage exists at the end of September but the fall hydrology is dry (generally defined as below 90% exceedance of historical hydrology), Reclamation would coordinate with appropriate agencies, including NMFS and CDFW at a minimum, to reduce flows below those described in the table, if possible.

4.3.1.5 *Additional Operations Components*

In addition to the changes to Shasta Reservoir cold water pool operations, Alternative 1 includes multiple components to increase water deliveries and protect listed fish:

- Rice Decomposition Smoothing: Following the emergence of Winter-Run Chinook Salmon and prior to the majority of Fall-Run Chinook Salmon spawning, upstream Sacramento Valley CVP contractors and Sacramento River Settlement Contractors would work to synchronize their diversions to lower peak rice decomposition demand. With lower late October and early November flows, Fall-Run Chinook Salmon are less likely to spawn in shallow areas that would be subject to dewatering during winter base flows. Early reductions (late October to early November) would balance the potential for dewatering late spawning Winter-Run Chinook Salmon redds and early Fall-Run Chinook Salmon dewatering.
- Spring Management of Spawning Locations: Reclamation would coordinate with NMFS to establish experiments to refine the state of the science and determine if keeping water colder earlier induces earlier spawning or if keeping April to May Sacramento River temperatures warmer induces later spawning.
- Cold Water Management Tools: Reclamation would explore additional opportunities to extend the cold water pool. Options include:
    - *Temperature Modeling Platform*: Reclamation would continue working with Watercourse Engineering as part of a collaborative model development effort to develop a new temperature model for the Upper Sacramento River (Shasta and Keswick Reservoirs). NMFS Science Center, among others, would participate in the collaborative process. This new model would be on the CEQUAL-W-2 platform with the intention of developing similar platforms for all of Reclamation's major reservoirs.
    - *Battle Creek Restoration:* Reclamation would accelerate implementation of the Battle Creek Salmon and Steelhead Restoration Project, which is intended to reestablish approximately 42 miles of prime salmon and steelhead habitat on Battle Creek and an additional 6 miles on its tributaries. Winter-Run Chinook Salmon are currently limited to a single population that spawns in a 5-mile stretch of the Sacramento River, but they are being reintroduced to Battle Creek (around 200,000 juveniles were released in Battle Creek in 2018). This new population would benefit from the restoration efforts. An additional population of Winter-Run Chinook Salmon on Battle Creek would provide temperature compliance flexibility.
    - *Lower Intakes near Wilkins Slough:* Due to temperature requirements, Sacramento River flows at or near Wilkins Slough can drop below the 5,000 cfs minimum navigational flow set by Congress. As many of the fish screens at diversions in this region were designed to meet the 5,000 cfs minimum, they may not function properly at the lower flows and as a result not meet state and federal fish screening requirements during the lower flows (NCWA 2014). This could result in take of state-protected and federally protected species that use this section of the river. This action would provide grants to water users within this area to install new diversions and screens that would operate at lower flows, which would allow Reclamation to have greater flexibility in managing Sacramento River flows and temperatures for both water users and wildlife, including listed salmonids (NCWA 2014). The authority for this action is

CVPIA Section 3406(b)(21). One example project under this program is screening of Meridian Farms.

- *Shasta TCD Improvements:* Reclamation would study the feasibility of infrastructure improvements to enhance TCD performance, including reducing the leakage of warm water into the structure.

4.3.1.6 *Habitat Restoration Components*

Alternative 1 includes the following habitat restoration components:

- Spawning Habitat: Reclamation would create additional spawning habitat by approximately 15,000 to 40,000 tons of gravel annually into the Sacramento River to 2030, using the following sites: Keswick Dam Gravel Injection Site, Market Street Injection Site, Redding Riffle, Turtle Bay, Tobiasson Island, Shea Levee sites, and Kapusta.
- Rearing Habitat: Reclamation, in coordination with Sacramento River Settlement Contractors would create 40 to 60 acres of side channel and floodplain habitat at 10 sites in the Sacramento River by 2030. The potential sites include Salt Creek, Turtle Bay Island, Kutras Lake Rearing Structures, Painter's Riffle maintenance, North Cypress maintenance, Cypress South, North Tobiasson Rearing Structures maintenance, Tobiasson Side Channel, Shea Side Channel, Kapusta Side Channel, Kapusta 1-A Side Channel maintenance, Kapusta 1-B Side Channel, Anderson River Park Side Channels, Cow Creek Side Channel, I-5 Side Channel, China Gardens, Rancheria Island Side Channel, Rancho Breisgau, Lake California Side Channel maintenance, Rio Vista Side Channel, East Sand Slough Side Channel, La Barranca Side Channel, Woodson Bridge Bank Rearing Improvement, Jellys Ferry, Dog Island, Altube Island, Blackberry Island, Oklahoma Avenue, Mooney Island, McClure Creek, Blethen Island, Wilsons Landing, McIntosh Island, Shaw, Larkins, Reilly Island, Hanson Island, and Broderick.
- Small Screen Program: Reclamation and DWR would continue to work within existing authorities (e.g., Anadromous Fish Screen Program) to screen small diversions throughout Central Valley CVP and SWP streams and the Bay-Delta.

4.3.1.7 *Intervention Components*

Alternative 1 includes the following intervention components:

- Winter-Run Chinook Salmon Conservation Hatchery Production: In a Tier 4 year, Reclamation would increase production of Winter-Run Chinook Salmon. Increased production during drought could help populations continue over multiple years. Increased production would aim to offset temperature dependent mortality on the Sacramento River. Reclamation would consider New Zealand or Great Lake Winter-Run Chinook Salmon stock for augmenting conservation hatchery stock to improve heterozygosity. Reclamation would coordinate with USFWS and NMFS as part of the "Drought and Dry Year Actions" under the "Governance" section of Alternative 1 to determine the need to improve the facility and associate collection facilities. Improvements may include permanent chillers, additional tanks, and other features.
- Adult Rescue: Reclamation would trap and haul adult salmonids and sturgeon from Yolo and Sutter Bypasses during droughts and after periods of bypass flooding, when flows from the bypasses are most likely to attract upstream migrating adults, and move them up the Sacramento River to spawning grounds. This trap and haul are in addition to weir fish passage projects that are part of Alternative 1 elsewhere. This measure would improve survival of the adults, leading to increased juvenile production in the following year and more flexibility with salvage.

- Trap and Haul: If Reclamation projects a Tier 4 year (less than 2.5 MAF of storage at the beginning of May), Reclamation would implement a downstream trap and haul strategy for the capture and transport of juvenile Chinook Salmon and Steelhead in the Sacramento River watershed in drought years when low flows and resulting high water temperatures are unsuitable for volitional downstream migration and survival. Reclamation would place temporary juvenile salmon collection traps (e.g., rotary screw traps, fyke nets, floating juvenile collectors, weirs, trawls, seines), at key feasible locations, downstream of spawning areas in the Sacramento River. Reclamation would transport collected fish to a safe release location(s) in the Delta upstream of Chipps Island or in the bay. Juvenile trap and haul activities would occur from December 1 through May 31, consistent with the migration period for juvenile Chinook Salmon and steelhead (NMFS 2014), depending on hydrologic conditions. In the event of high river flows or potential flooding, trapping operations would cease and traps would be removed as appropriate.
- In the event of two successive years with total egg-to-fry survival less than 15% in each year, Reclamation would convene a meeting of the Regional Directors of DWR, NMFS, USFWS, and CDFW no later than the end of November. The Directors would meet and confer to develop a list of actions to address the potential for a third year of low survival. The Directors would continue to meet monthly, or more often as appropriate, through the next operational season. The Directors would hold a similar meeting in each of the two following Novembers to ensure that the years following the two-year emergency condition appropriately address the need to recover from the multi-year event.

4.3.2 Trinity River Division

Seasonal operations in Trinity Reservoir would continue to be integrated with Shasta Reservoir operations, as described in the No Action Alternative. Additionally, Reclamation would continue to implement the Trinity River Restoration Program ROD and lower Klamath River augmentation flows that are described in the No Action Alternative. Whiskeytown Reservoir operations would be similar to those described for the No Action Alternative, with minor changes to accommodate Clear Creek flow measures described below. Spring Creek Debris Dam operations and the Clear Creek Restoration Program would continue as described in the No Action Alternative.

4.3.3 Clear Creek

Reclamation would release Clear Creek flows in accordance with the 2000 agreement between Reclamation, USFWS, and DFG and the April 15, 2002 SWRCB permit, which established minimum flows to be released to Clear Creek at Whiskeytown Dam. Under Alternative 1, Reclamation would release a minimum base flow in Clear Creek of 200 cfs from October through May and 150 cfs from June through September in all water year types except critical water year types. In critical years, Clear Creek base flows may be reduced below 150 cfs based on available water from Trinity Reservoir. Additional flow may be required for temperature management during the fall.

In addition, Reclamation would create pulse flows for both channel maintenance and spring attraction flows. For spring attraction flows, Reclamation would release 10 TAF (measured at the release), with daily release up to the safe release capacity (approximately 900 cfs, depending on reservoir elevation and downstream capacity), in all water year types except for critical water year types to be shaped by the Clear Creek Implementation Team in coordination with the Central Valley Operations Office. For channel maintenance flows, Reclamation would release 10 TAF from Whiskeytown Dam, with a daily release up to the safe release capacity, in all water year types except dry and critical (based on the Sacramento Valley index) to be shaped by the Clear Creek Implementation Team in coordination with the Central Valley Operations Office. Pulses would be scheduled with the Central Valley Operations Office. No channel maintenance flows would be scheduled before January 1. For each storm event that results in a

Whiskeytown Gloryhole spill of at least 3,000 cfs for 3 days, Reclamation would reduce the channel maintenance flow volume for this year or the following year by 5,000 AF. If two Whiskeytown Gloryhole spills that meet this criterion in a year occur, additional channel maintenance flows would not be released in that year. In critical years, Reclamation would release one spring attraction flow of up to the safe release capacity (approximately 900 cfs) for up to 3 days and would not release any channel maintenance flows. Reclamation could instead, or in addition, use mechanical methods to mobilize gravel or shape the channel if needed to meet biological objectives.

The outlet from Whiskeytown Reservoir to Clear Creek is equipped with outlets at two different elevations. Releases can be made from either or both outlets to manage downstream temperature releases. Reclamation would manage Whiskeytown releases to meet a daily average water temperature of 60°F at the IGO gage from June 1 through September 15 and 56°F or less at the IGO gage from September 15 to October 31. Reclamation may not be able to meet these temperatures in critical or dry water year types. In these years, Reclamation would operate as close to these temperatures as possible.

4.3.4 Feather River

DWR would operate Oroville Dam consistent with the NMFS, USFWS, and CDFW environmental requirements applicable for the current FERC license for the Oroville Complex (FERC Project #2100-134), as under the No Action Alternative. If FERC issues a new license, DWR would operate to the terms in that license. The downstream boundary of the FERC Oroville Project area is the Feather River above the City of Gridley. During the summer, DWR typically releases water from Lake Oroville to meet the requirements of instream flows and D-1641. Additional releases are made for local deliveries and exports at Banks Pumping Plant. DWR balances the cumulative storage between Lake Oroville and San Luis Reservoir to meet its flood control requirements and Delta requirements and to deliver water supplies to its contracted water agencies consistent with all environmental constraints. Lake Oroville may be operated to convey water through the Delta to San Luis Reservoir via Banks Pumping Plant under different schedules depending on Delta conditions, reservoir storage volumes, storage targets, and regulatory requirements. Decisions as to when to move water from Lake Oroville to San Luis Reservoir are based on many real-time factors.

4.3.5 American River Division

Reclamation would operate Folsom Reservoir to meet water rights, contracts, and agreements that are specific to the American River Division and to those that apply to the entire CVP, including the Delta Division. For lower American River flows (below Nimbus Dam), Reclamation would adopt the minimum flow schedule and approach proposed by the Water Forum in 2017 in the document titled “Lower American River – Standards for Minimum Flows” dated December 2018. Flows range from 500 to 2,000 cfs based on time of year and annual hydrology. The flow schedule is intended to improve cold water pool and habitat conditions for steelhead and Fall-Run Chinook Salmon. Specific flows are determined using an index intended to define the current and recent hydrology. Although Reclamation has assumed the index proposed by the Water Forum in 2017 for the purposes of modeling and analysis within this EIS, Reclamation intends to continue discussions with the Water Forum to ensure the index used for implementation is appropriate to meet the intended objectives under continuously changing hydrology.

Under Alternative 1, Reclamation would work together with the American River water agencies to define an appropriate amount of storage in Folsom Reservoir that represents the lower bound for typical forecasting processes at the end of calendar year (i.e., the planning minimum). The Folsom Reservoir planning minimum brings Reclamation's forecasting process together with potential local actions that either increase Folsom storage or reduce demand out of Folsom Reservoir. The implementation of a planning minimum would allow Reclamation to work with the American River Group to identify conditions when local water actions may be necessary to ensure storage is adequate for diversion from the municipal water intake at Folsom Dam and/or the extreme hydrology presents a risk that needs to be properly communicated to the public and surrounding communities. This planning minimum would be a single value (or potentially a series of values for different hydrologic year types) to be used for each year's forecasting process into the future. The objective of incorporating the planning minimum into the forecasting process is to provide releases of salmonid-suitable temperatures to the lower American River and reliable deliveries (using the existing water supply intakes and conveyance systems) to American River water agencies that are dependent on deliveries or releases from Folsom Reservoir. This planning minimum would be initially defined in 2019; however, it would be continuously evaluated between Reclamation and the Water Forum throughout implementation.

Reclamation expects infrequent scenarios where the forecasted storage may fall below the planning minimum due to a variety of circumstances and causes. In those instances, Reclamation and the American River water agencies would develop a list of potential off-ramp actions that may be taken to either improve forecasted storage or decrease demand on Folsom Reservoir. In its forecasting process for guiding seasonal operations, Reclamation would plan to maintain or exceed the planning minimum at the end of the calendar year. Reclamation has no legal liability should it fall below the planning minimum. When Reclamation estimates, using the forecasting process, it would not be able to maintain Folsom Reservoir storage at or above the planning minimum for that water year type (such as in extreme hydrologic conditions) or unexpected events cause the storage level to be at risk, American River water agencies would coordinate with Reclamation to identify and implement appropriate actions to improve forecasted storage conditions, and the American River water agencies would work together to educate the public on the actions that have been agreed upon and implemented and the reasons and basis for them. If potential changes to Folsom Dam operations would have impacts on other aspects of the CVP and SWP or the entire integrated system, Reclamation would meet and discuss these potential changes and impacts with water contractors. Reclamation would ramp down to the revised minimum flows from Folsom Reservoir as soon as possible in the fall and maintain these flows, where possible.

4.3.5.1 *Seasonal Operations*

In the winter and spring, flood control releases typically dominate the flow regime in the American River Division. Flood control operations occur to safely pass large storm events without exceeding the identified downstream levee capacity. This includes making dry-weather releases to ensure the maximum storage adheres to the flood control elevation identified in the applicable Water Control Manual. Reclamation would not reduce flows more than 500 cfs per day or more than 100 cfs per hour except if necessary for flood control operations. Reclamation would minimize releases above 4,000 cfs during sensitive life stages (e.g., eggs, incubation, rearing) of salmonids and steelhead to the extent feasible.

As part of the 2017 Flow Management Standard, Reclamation would implement redd dewatering protective adjustments to limit potential redd dewatering due to reductions in the minimum release during the January through May period. Redd dewatering protective adjustments should limit the amount of dewatering due to a reduction of the minimum release, not the actual river release, and as such would not always minimize dewatering impacts to the same extent. In January and February, there is a Chinook Salmon redd dewatering protective adjustment, and in February through May there is a steelhead redd dewatering protective adjustment.

During nonflood control operations within the fall and winter months, Reclamation would operate to build storage by making minimum releases and capturing inflows, although drier conditions may require releases for Delta requirements. To the extent possible, releases would be held relatively consistent to minimize potential redd dewatering.

Spring releases would be controlled by flood control requirements or, in drier hydrology, Delta requirements and water supply. Reclamation would operate Folsom Dam in a manner designed to maximize capture of the spring runoff to fill as close to full as possible. To the extent practicable, Reclamation would accommodate requests for spring pulse flows by reshaping previously planned releases; however, these requests would not be accommodated in times when they may compromise temperature operations later in the year. Reclamation would follow the 2017 Flow Management Standard, which includes a pulse flow event at some time during the period extending from March 15 to April 15 by supplementing normal operational releases from Folsom Dam under certain conditions when no such flow event has occurred between the preceding February 1 and March 1 time frame. This spring pulse flow would provide a juvenile salmonid emigration cue before relatively low-flow conditions and associated unsuitable thermal conditions later in the spring and downstream in the lower Sacramento River.

Reclamation would continue making summer releases for instream temperature control, Delta outflow, and exports, typically above the planning minimum flows. By late October, it is typical for Folsom Reservoir to have depleted the cold water pool. The primary way to provide additional instream cooling is to release water from the lower outlet works. This operation bypasses the power penstocks and has a significant impact on power generation. To optimize power generation, Reclamation would limit power bypass operations solely to respond to emergency or unexpected events or during extreme drought years when a drought emergency has been declared by the governor of California.

4.3.5.2 *Temperature Management*

Reclamation would prepare a draft temperature management plan by May 15 for the summer through fall temperature management season using the best available (as determined by Reclamation) decision support tools. The information provided by the operations forecast would be used in the development of the draft plan. The draft plan would contain forecasts of hydrology and storage and a modeling run(s), using the operations forecasts to demonstrate what temperature compliance schedule can be attained. Reclamation would use an iterative approach, varying shutter configurations, with the objective to attain the best possible temperature schedule for the compliance point at Watt Avenue Bridge. The draft plan would be shared with the American River Group before finalization and may be updated monthly based on system conditions.

Reclamation would manage the Folsom and Nimbus Dams complex and the water temperature control shutters at Folsom Dam to maintain a daily average water temperature of 65°F (or other temperature as determined by the temperature modeling) or lower at Watt Avenue Bridge from May 15 through October 31 to provide suitable conditions for juvenile steelhead rearing in the lower American River. If the temperature is exceeded for 3 consecutive days, Reclamation would notify NMFS and outline steps being taken to bring the water temperature back into compliance. During the May 15 to October 31 period, if the temperature management plan-defined temperature requirement cannot be met because of limited cold water availability in Folsom Reservoir, then the target daily average water temperature at Watt Avenue may be increased incrementally (i.e., no more than 1°F every 12 hours) to as high as 68°F. The priority for use of the lowest water temperature control shutters at Folsom Dam would be to achieve the water temperature requirement for listed species (i.e., steelhead), and thereafter may also be used to provide cold water for Fall-Run Chinook Salmon spawning.

4.3.5.3 *Water Operations Component*

In addition to the changes to Folsom Reservoir operations, Alternative 1 includes a component to increase water deliveries and protect listed fish:

- Drought Temperature Management: In severe or worse droughts, Reclamation would evaluate and implement alternative shutter configurations at Folsom Dam to allow temperature flexibility.

4.3.5.4 *Habitat Restoration Components*

Alternative 1 includes the following habitat restoration components:

- Spawning and Rearing Habitat Named Projects: Project activities include primarily side channel and floodplain creation, expansion, and grading, spawning gravel and large cobble additions, and woody material additions. Pursuant to CVPIA Section 3406(b)(13), Reclamation would implement the following projects: Paradise Beach, Howe Avenue to Watt Avenue rearing habitat, William Pond Outlet, Upper River Bend, Ancil Hoffman, El Manto, Sacramento Bar-North, Sacramento Bar-South, Lower Sunrise, Sunrise, Upper Sunrise, Lower Sailor Bar, Upper Sailor Bar, Nimbus main channel and side channel, Discovery Park, Cordova Creek Phase II, Carmichael Creek Restoration and Sunrise Stranding Reduction.
- Reclamation would continue maintenance activities at Nimbus Basin, Upper Sailor Bar, Lower Sailor Bar, Upper Sunrise, Lower Sunrise, and River Bend restoration sites.

4.3.5.5 *Intervention Components*

Alternative 1 would include improvements to Nimbus Fish Hatchery to improve management. Reclamation would complete a Hatchery Genetics Management Plan for Steelhead and a Hatchery Management Plan for Fall-Run Chinook Salmon as part of Nimbus Fish Hatchery Management. Reclamation would work with USFWS and NMFS to establish clear goals, appropriate time horizons, and reasonable cost estimates for this effort.

4.3.6 Bay-Delta

As described in the No Action Alternative, the CVP and SWP divert water in the Delta through the Tracy and Banks Pumping Plants for delivery to the Central Valley and Southern California. Operations of these facilities would continue in Alternative 1 with the changes described below.

4.3.6.1 *Delta Cross Channel*

Under Alternative 1, Reclamation would operate the DCC gates to reduce juvenile salmonid entrainment risk beyond actions described in D-1641, consistent with Delta water quality requirements in D-1641. From October 1 to November 30, if the Knights Landing Catch Index or Sacramento Catch Index are greater than three fish per day Reclamation would operate based on Tables 4.3-4 and 4.3-5 to determine whether to close the DCC gates and for how long. From December 1 to January 31, the DCC gates would be closed. If drought conditions were observed (i.e., fall inflow conditions were less than 90% of historic flows), Reclamation and DWR would consider opening the DCC gates for up to 5 days for up to two events within this period to avoid D-1641 water quality exceedances. Reclamation and DWR would coordinate with USFWS, NMFS, and the SWRCB on how to balance D-1641 water quality and ESA-listed fish requirements. Reclamation and DWR would conduct a risk assessment that would consider the Knights Landing Rotary Screw Trap monitoring, Delta juvenile fish monitoring program (Sacramento trawl, beach seines), Rio Vista flow standards, acoustic telemetered fish monitoring information as well as DSM2 modeling informed with recent hydrology, salinity, and tidal data. Reclamation would also consider the cumulative entrainment from prior years. Reclamation would evaluate this information to determine if fish responses may be altered by DCC operations. If the risk assessment determines that survival, route entrainment, or behavior change to create a new adverse effect or a greater range of an adverse effect, not considered under this alternative, Reclamation would not open the DCC. During a DCC gate opening between December 1 and January 31, the CVP and SWP would divert at health and safety pumping levels.

From May 21 to June 15, Reclamation would close the DCC gates for 14 days during this period, consistent with D-1641. Reclamation and DWR's risk assessment would consider the Knights Landing Rotary Screw Trap, Delta juvenile fish monitoring program (Sacramento trawl, beach seines), Rio Vista flow standards, acoustic telemetered fish monitoring information, DSM2 modeling informed with recent hydrology, salinity, and tidal data. Reclamation would evaluate this information to determine if fish responses may be altered by DCC operations. If the risk assessment determines that survival, route entrainment, or behavior change to create a new adverse effect not considered under Alternative 1, Reclamation would not open the DCC.

Table 4.3-4. Delta Cross Channel October 1–November 30 Action

Date	Action Triggers	Action Responses
October 1–November 30	Water quality criteria per D-1641 are met and either the KLCI or SCI is greater than five fish per day.	Within 48 hours, close the DCC gates and keep closed until the catch index is less than three fish per day at both the Knights Landing and Sacramento monitoring sites.
	Water quality criteria per D-1641 are met and either KLCI or the SCI are greater than three fish per day but less than or equal to five fish per day.	Within 48 hours of trigger, DCC gates are closed. Gates would remain closed for 3 days.
	Water quality criteria per D-1641 are met, real-time hydrodynamic and salinity modeling shows water quality concern level targets are not exceeded during 28-day period following DCC closure, and there is no observed deterioration of interior Delta water quality.	Within 48 hours of start of LMR attraction flow release, close the DCC gates for up to 5 days (dependent upon continuity of favorable water quality conditions).
	Water quality criteria per D-1641 are met and real time hydrodynamic and salinity modeling shows water quality concern level targets are exceeded during 14-day period following DCC closure.	No closure of DCC gates.
	The KLCI or SCI triggers are met but water quality criteria are not met per D-1641 criteria.	Monitoring groups review monitoring data and provide to Reclamation. Reclamation and DWR determine what to do with a risk assessment.

DCC = Delta Cross Channel; KLCI = Knights Landing Catch Index; LMR = Lower Mokelumne River; SCI = Sacramento Catch Index

Table 4.3-5. Water Quality Concern Level Targets

Water Quality Concern Level Targets (Water Quality Model Simulated 14-day Average Electrical Conductivity)	
Jersey Point	1800 umhos/cm
Bethel Island	1000 umhos/cm
Holland Cut	800 umhos/cm
Bacon Island	700 umhos/cm

umhos/cm = micromhos per centimeter

4.3.6.2 *North Bay Aqueduct Operations*

The North Bay Aqueduct and Barker Slough Pumping Plant would continue to operate under applicable regulatory requirements.

4.3.6.2.1 Sediment Removal

Sediment accumulates in the concrete apron sediment trap in front of the Barker Slough Pumping Plant fish screens and within the pump wells behind the fish screens. Sediment removal from the sediment trap and the pump wells would be removed as needed.

Accumulated sediment from the apron in front of the fish screen and in the pump wells behind the fish screen would be removed by suction dredge. Removal of sediment from within the pump wells would occur as needed, year-round. Removal of sediment from the apron area in front of the fish screens would occur during summer and early fall months and during the annual North Bay Aqueduct shutdown in March. The North Bay Aqueduct is annually taken off-line for one-to-two weeks for routine maintenance and repairs, and the Barker Slough Pumping Plant is non-operational during the shutdown.

4.3.6.2.2 Aquatic Weed Removal

Aquatic weeds would be removed, as needed, from in front of the fish screens at Barker Slough Pumping Plant. Aquatic weeds accumulate on the fish screens, blocking water flow, and causing water levels to drop behind the screens in the pump wells. The low water level inside of the pump wells causes the pumps to automatically shut off to protect the pumps from cavitation. The aquatic weed removal system consists of grappling hooks attached by chains to an aluminum frame. A boom truck, staged on the platform in front of the Barker Slough Pumping Plant pumps, would lower the grappling system into the water to retrieve the accumulated aquatic vegetation. The removed aquatic weeds would be transported to two aggregate base spoil sites located near the pumping plant. Removal of aquatic weeks from the fish screens would typically occur during summer and fall months when aquatic weed production is highest. Floating aquatic vegetation (i.e., water hyacinth) may need to be removed during spring months if it becomes entrained into Barker Slough and accumulates in front of the fish screens.

4.3.6.3 *Contra Costa Water District Operations*

Contra Costa Water District operations under Alternative 1 would remain unchanged from the No Action Alternative (discussed in Section 4.2.6.3.6).

4.3.6.4 *Water Transfers*

Reclamation and DWR would continue to transfer project and nonproject water supplies through CVP and SWP facilities, including north-to-south transfers and Sacramento River north-to-north transfers. Alternative 1 would include the same volume of transfers as included in the No Action Alternative, but Reclamation and DWR would provide an extended transfer window from July 1 through November 30. Allowing fall transfers is expected to have water supply benefits and may provide flexibility to improve Sacramento River temperature operations during dry conditions, such as those that occurred during the 2014–2015 drought conditions. Quantities and timing would be similar to the transfers implemented in 2014. Real-time operations may restrict transfers within the transfer window so that Reclamation and DWR can meet other authorized project purposes, e.g., when pumping capacity is needed for CVP or SWP water. This EIS analyzes the potential effects that water transfers from the Sacramento and San Joaquin river systems have on the operations of the CVP and SWP. Making water available for transfer is assessed through separate environmental documentation because the potential effects are dependent on the regions where water could be made available and the types of transfer.

4.3.6.5 *Clifton Court Aquatic Weed and Algal Bloom Management*

DWR would continue to apply copper-based aquatic herbicides and algaecides to control aquatic weeds and algal blooms and use mechanical harvesters on an as-needed basis in CCF (as described in the No Action Alternative), but would also apply Aquathol® K aquatic herbicide and peroxygen-based algaecides (e.g. PAK 27) and extend the treatment window beyond July 1 to August 31. Aquathol® K is effective at controlling pondweed species that are not affected by copper herbicides. Peroxygen-based algaecides are used to control algal blooms that can degrade drinking water quality through tastes and odors and production of algal toxins. Treatment areas would typically be about 900 acres and no more than 50% of the 2,180 total surface acres.

Aquatic weed and algae treatments would occur on an as-needed basis depending upon the level of vegetation biomass, the cyanotoxin concentration from the harmful algal blooms (HABs), or the concentration of taste and odor compounds. The frequency of aquatic herbicide applications to control aquatic weeds is not expected to occur more than twice per year. Aquatic herbicides are ideally applied early in the growing season when plants are susceptible to them during rapid growth and formation of plant tissues, or later in the season when plants are mobilizing energy stores from their leaves towards their roots for overwintering senescence. The frequency of algaecide applications to control HABs is not expected to occur more than once every few years, as indicated by monitoring data and demonstrated by the history of past applications.

Aquatic weed assemblages change from year to year in the CCF from predominantly *Egeria densa* to one dominated by curly-leaf pondweed, sago pondweed, and southern naiad. To effectively treat a dynamic aquatic weed assemblage and harmful algal blooms, multiple aquatic pesticide compounds are required to control aquatic weeds and algal blooms in CCF. The preferred products are:

- Aquathol K, an endothall-based aquatic herbicide, that is effective on pondweeds;
- Copper-based compounds that are effective on *E. densa*, cyanobacteria and green algae. The copper-based aquatic herbicides include copper sulfate pentahydrate and chelated copper herbicides; and
- Peroxygen-based algaecides (e.g., PAK 27) that are effective on cyanobacteria.

4.3.6.5.1 <u>Aquathol K</u>

The dipotassium salt of endothall is used for control of aquatic weeds and is the active ingredient in Aquathol® K (liquid formulation). Aquathol K is a widely used herbicide to control submerged weeds in lakes and ponds, and the short residual contact time (12-48 hours) makes it effective in both still and slow-moving water. Aquathol K is effective on many weeds, including hydrilla, milfoil, and curly-leaf pondweed, and begins working on contact to break down cell structure and inhibit protein synthesis. Without the ability to grow, the weed dies. Full kill takes place in 1 to 2 weeks. As weeds die, they sink to the bottom and decompose. Aquathol K is not effective at controlling *E. densa*.

Aquathol K is registered for use in California and has effectively controlled pondweeds and southern naiad in CCF and in other lakes. Endothall has low acute and chronic toxicity effects to fish. The LC50 for salmonids is 20-40 times greater than the maximum concentration allowed to treat aquatic weeds. The EPA maximum concentration allowed for Aquathol K is 5 ppm. A recent study (Courter et al. 2012) of the effect of Cascade® (same endothall formulation as Aquathol K) on salmon and steelhead smolts showed no sublethal effects until exposed to 9-12 ppm, that is, 2-3 times greater than the 5 ppm maximum concentration allowed by the EPA and about 4-6 times greater than the 2-3 ppm applied in past CCF treatments. In the study, steelhead and salmon smolts showed no statistical difference in mean survival between the control group and treatment groups, however, steelhead showed slightly lower survival after 9 days at 9-12 ppm. Based on the studies with salmonids, Aquathol K applied at or below the EPA maximum allowable concentration of 5 ppm poses a low to no toxicity risk to salmon, steelhead and other fish. No studies have assessed the exposure risk to green sturgeon.

When aquatic plant survey results indicate that pondweeds are the dominant species in CCF, Aquathol K would be selected due to its effectiveness in controlling these species. Aquathol K would be applied according to the label instructions, with a target concentration dependent upon plant biomass, water volume, and forebay depth. The target concentration of treatments is 2 to 3 ppm, which is well below the concentration of 9-12 ppm where sublethal effects have been observed (Courter et al. 2012). DWR monitors herbicide concentration levels during and after treatment to ensure levels do not exceed the Aquathol K application limit of 5 ppm. Additional water quality testing may occur following treatment for drinking water intake purposes. Samples are submitted to a laboratory for analysis. There is no “real time” field test for endothall. No more than 50% of the surface area of CCF would be treated at one time. A minimum contact time of 12 hours is needed for biological uptake and treatment effectiveness, but the contact time may be extended up to 24 hours to reduce the residual endothall concentration for NPDES compliance purposes.

Copper-based Aquatic Herbicides and Algaecides

Copper herbicides and algaecides include chelated copper products and copper sulfate pentahydrate crystals. When aquatic plant survey results indicate that *E. densa* is the dominant species, copper-based compounds would be selected due to their effectiveness in controlling this species. *E. densa* is not affected by application of Aquathol K. Copper-based algaecides are effective at controlling algal blooms (cyanobacteria) that produce cyanotoxins or taste and odor compounds.

Copper herbicides and algaecides would be applied in a manner consistent with the label instructions, with a target concentration dependent upon target species and biomass, water volume, and the depth of the forebay. Applications of copper herbicides for aquatic weed control would be applied at a concentration of 1 ppm with an expected dilution to 0.75 ppm upon dispersal in the water column. Applications for algal control would be applied at a concentration of 0.2 to 1 ppm with expected dilution within the water column. DWR would monitor dissolved copper concentration levels during and after treatment to ensure levels do not exceed the application limit of 1 ppm, per NPDES permit required procedures. Treatment contact time would be up to 24 hours. If the dissolved copper concentration falls below 0.25 ppm during an aquatic weed treatment, DWR may opt to open the radial gates after 12 hours but before 24 hours to resume operations. Opening the radial gates prior to 24 hours would enable the rapid dilution of residual copper and thereby shorten the exposure duration of ESA-listed fish to the treatment. No more than 50% of the surface area of CCF would be treated at one time.

Peroxygen-Based Algaecides

PAK 27 algaecide active ingredient is sodium carbonate peroxyhydrate. An oxidation reaction occurs immediately upon contact with the water destroying algal cell membranes and chlorophyll. There is no contact or holding time requirement, as the oxidation reaction occurs immediately and the byproducts are hydrogen peroxide and oxygen. There are no fishing, drinking, swimming, or irrigation restrictions following the use of this product. PAK 27 has NSF/ANSI Standard 60 Certification for use in drinking water supplies at maximum-labeled rates and is certified for organic use by the Organic Materials Reviews Institute (OMRI).

PAK 27, or equivalent product, would be applied in a manner consistent with the label instructions, with permissible concentrations in the range of 0.3 to 10.2 ppm hydrogen peroxide. No more than 50% of the surface area of CCF would be treated at one time.

Operational Procedures

The following are operational procedures to minimize impacts on listed species during aquatic herbicide treatment for application of Aquathol K and copper-based products and algaecide treatment for application of peroxide-based algaecides in CCF:

- Apply Aquathol K and copper-based aquatic pesticides, as needed, from June 28 to August 31.
- Apply Aquathol K and copper-based aquatic pesticides, as needed, prior to June 28 or after August 31 if the average daily water temperatures within CCF is at or above 25°C or and if Delta Smelt, salmonids, and green sturgeon are not at additional risk from the treatment as conferred by NMFS and USFWS.
    - Prior to treatment outside of the June 28 to August 31 timeframe, DWR would notify and confer with NMFS and USFWS on whether ESA-listed fish species are present and at risk from the proposed treatment.
- Apply Aquathol K and copper-based aquatic pesticides, as needed, during periods of activated Delta Smelt and salmonid protective measures when average daily water temperature in CCF is below 25°C if the following conditions are met:
    - Prior to treatment outside of the June 28 to August 31 timeframe, DWR would notify and confer with NMFS and USFWS on whether ESA-listed fish species are present and at risk from the proposed treatment.
    - The herbicide application does not begin until after the radial gates have been closed for 24 hours or after the period of predicted Delta Smelt and salmonid survival within CCF (e.g., after predicted mortality has occurred due to predation or other factors) has been exceeded; and
    - The radial gates remain closed for 24 hours after the completion of the application, unless it is conferred that rapid dilution of the herbicide would be beneficial to reduce the exposure duration to listed fishes present within the CCF.
- Apply peroxygen-based aquatic algaecides, as needed, year-round.
- There are no anticipated impacts on fish with the use of peroxygen-based aquatic algaecides in CCF during or following treatment.
- Monitor the salvage of listed fish at the Skinner Fish Facility prior to the application of the aquatic herbicides and algaecides in CCF.
- For Aquathol K and copper compounds, the radial intake gates would be closed at the entrance to CCF prior to the application of pesticides to allow fish to move out of the targeted treatment areas and toward the salvage facility and to prevent any possibility of aquatic pesticide diffusing into the Delta.
- For Aquathol K and copper compounds, the radial gates would remain closed for a minimum of 12 and up to 24 hours after treatment to allow for the recommended duration of contact time between the aquatic pesticide and the treated vegetation or cyanobacteria in the forebay, and to reduce residual endothall concentration for drinking water compliance purposes. (Contact time is dependent upon pesticide type, applied concentration, and weed or algae assemblage). Radial gates would be reopened after a minimum of 36 hours (24 hours pre-treatment closure plus 12 hours post-treatment closure).

- For peroxide-based algaecides, the radial gates would be closed prior to the application of the algaecide to prevent any possibility of the algaecide diffusing into the Delta. The radial gates may reopen immediately after the treatment as the required contact time is less than 1 minute and there is no residual byproduct of concern.
- Application would be made by a licensed applicator under the supervision of a California-certified pest control advisor.
- Aquatic herbicides and algaecides would be applied by boat or by aircraft.
    - Boat applications would be by subsurface injection system for liquid formulations and boat-mounted hopper dispensing system for granular formulations. Applications would start at the shoreline and move systematically farther offshore, enabling fish to move out of the treatment area.
    - Aerial applications of granular and liquid formulations would be by helicopter or aircraft. No aerial spray applications would occur during windspeeds above 15 mph to prevent spray drift.
- Application would be to the smallest area possible that provides relief to SWP operations or water quality. No more than 50% of CCF would be treated at one time.
- Water quality samples to monitor copper and endothall concentrations within or adjacent to the treatment area, per the NPDES permit requirements, would be collected before, during, and after application. Additional water quality samples may be collected during and following treatment for drinking water compliance purposes. No monitoring of copper or endothall concentrations in the sediment or detritus is proposed.
- No monitoring of peroxide concentration in the water column would occur during and after application as the reaction is immediate and there is no residual. Dissolved oxygen concentration would be measured prior to and immediately following application within and adjacent to the treatment zone.
- A spill prevention plan would be implemented in the event of an accidental spill.

Aquatic weed and algae treatments would occur on an as-needed basis. The timing of application is an avoidance measure and is based on the life history of Chinook Salmon and steelhead in the Central Valley's Delta region and of Delta Smelt. Green sturgeon is present in the area year-round. Migrations of juvenile Winter-Run Chinook Salmon and Spring-Run Chinook Salmon primarily occur outside of the summer period in the Delta. Central Valley Steelhead have a low probability of being in the South Delta during late June when water temperatures exceed 25°C through the first rainfall flush event, which can occur as late at December in some years (Grimaldo 2009). Delta Smelt are not expected to be in CCF during this time period. Delta Smelt are not likely to survive when water temperatures reach a daily average of 25°C, and they are not expected to occur in the Delta prior to the first flush event. Therefore, the likelihood of herbicide exposure to Chinook Salmon, Central Valley Steelhead, and Delta Smelt during the proposed herbicide treatment timeframe in CCF is negligible.

Additional protective measures would be implemented to prevent or minimize adverse effects from herbicide applications. As described above, applications of aquatic herbicides and algaecides would be contained within CCF. The radial intake gates to CCF would be closed prior to, during, and following the application. The radial gates would remain closed during the recommended minimum contact time based on herbicide type, application rate, and aquatic weed or algae assemblage. Additionally, following the gate closure and prior to the applications of Aquathol K and copper-based pesticides, the water would be drawn down in the CCF via the Banks Pumping Plant. This drawdown would help facilitate the movement of fish in the CCF toward the fish diversion screens and into the fish protection facility, lower the water level in the CCF to decrease the total amount of herbicide needed to be applied, per volume of water, and aid in the dilution of any residual pesticide post-treatment. Following reopening of the gates and refilling of CCF, the rapid dilution of any residual pesticide and the downstream dispersal of the treated water into the California Aqueduct via Banks PP would reduce the exposure time of any ESA-listed fish species present in CCF.

4.3.6.6 *OMR Management*

Under Alternative 1, Reclamation and DWR would operate the CVP and SWP in a manner that maximizes exports while minimizing entrainment of fish and protecting critical habitat. Net flow OMR provides a surrogate indicator for how export pumping at Banks and Jones Pumping Plants influence hydrodynamics in the south Delta. The management of OMR, in combination with other environmental variables, can minimize or avoid the entrainment of fish in the south Delta and at CVP and SWP salvage facilities. Reclamation and DWR would maximize exports by incorporating real-time monitoring of fish distribution, turbidity, temperature, hydrodynamic models, and entrainment models into the decision support for the management of OMR to focus protections for fish when necessary and provide flexibility where possible, consistent with the Water Infrastructure Improvements for the Nation Act Sections 4002 and 4003. Estimates of species distribution would be described by multiagency, Delta-focused technical teams.

From the onset of OMR management to the end, Reclamation and DWR would operate to an OMR index no more negative than a 14-day moving average of −5,000 cfs unless a storm event occurs (described below). Grimaldo et al. (2017) indicate that −5,000 cfs is an inflection point in OMR for fish entrainment. OMR could be more positive than −5,000 cfs if additional real-time OMR restrictions are triggered (described below) or constraints other than OMR control exports. Reclamation and DWR would operate to an OMR index computed using an equation. An OMR index allows for shorter-term operational planning and real-time adjustments. Reclamation and DWR would make a change to exports within 3 days of the trigger when monitoring, modeling, and criteria indicate protection for fish is necessary. The 3-day trigger would allow for efficient power scheduling.

4.3.6.6.1 <u>Onset of OMR Management</u>

Reclamation and DWR would start OMR management when one or more of the following conditions have occurred:

- Integrated Early Winter Pulse Protection (“First Flush” Turbidity Event): To minimize project influence on migration (or dispersal) of Delta Smelt, Reclamation and DWR would reduce exports for 14 consecutive days so that the 14-day averaged OMR index for the period would not be more negative than −2,000 cfs, in response to “First Flush” conditions in the Delta. The population-scale migration of Delta Smelt is believed to occur quickly in response to inflowing freshwater and turbidity (Grimaldo et al. 2009; Sommer et al. 2011). Thereafter, best available scientific information suggests that fish make local movements, but there is no evidence for further population-scale migration (Polanksy et al. 2018). “First flush” may be triggered between December 1 and January 31 and include:
    - Running 3-day average of the daily flows at Freeport is greater than 25,000 cfs and
    - Running 3-day average of the daily turbidity at Freeport is 50 Nephelometric Turbidity Unit (NTU) or greater, or
    - Real-time monitoring indicates a high risk of migration and dispersal into areas at high risk of future entrainment.

This “First Flush” action may only be initiated once during the December through January period and would not be required if:

- Water temperature reaches 12 degrees Celsius based on a three station daily mean at Honker Bay, Antioch, and Rio Vista, and/or
- Ripe or spent Delta Smelt are collected in a monitoring survey.

- Salmonids Presence: After January 1, if more than 5% of any one or more salmonid species (wild young-of-year Winter-Run, wild young-of-year Spring-Run, or wild Central Valley Steelhead) are estimated to be present in the Delta as determined by their appropriate monitoring working group based on available real-time data, historical information, and modeling.

4.3.6.6.2 Additional Real-Time OMR Restrictions and Performance Objectives

Reclamation and DWR would manage to a more positive OMR than −5,000 cfs based on the following conditions:

- Turbidity Bridge Avoidance (“South Delta Turbidity”): After the Integrated Early Winter Pulse Protection or February 1, whichever comes first, and prior to April 1, Reclamation and DWR would manage exports in order to maintain daily average turbidity in Old River at Bacon Island (OBI) at a level of less than 12 NTU. The purpose of this action is to protect Delta Smelt from damaging levels of entrainment after a First Flush and in years when a First Flush does not occur. This action seeks to avoid the formation of a continuous turbidity bridge from the San Joaquin River shipping channel to the fish facilities, which historically has been associated with elevated salvage of pre-spawning adult Delta Smelt. If the daily average turbidity at Bacon Island could not be maintained at less than 12 NTU, Reclamation and DWR would manage exports to achieve an OMR no more negative than −2,000 cfs until the average turbidity at Bacon Island drops below 12 NTU. After 5 days, Reclamation and DWR could determine that real-time OMR restrictions were not required to avoid damaging levels of entrainment based on the distribution of Delta Smelt in real-time monitoring and the absence of detections in salvage (i.e., less than 5% of the population).
- Larval and Juvenile Delta Smelt: When Q-West (net flow on the San Joaquin River at Jersey Point) is negative and larval or juvenile Delta Smelt are within the entrainment zone of the pumps based on real-time sampling, Reclamation and/or DWR would run hydrodynamic models informed by the Enhanced Delta Smelt Monitoring Program (EDSM), 20 mm, or other relevant survey data to estimate the percentage of larval and juvenile Delta Smelt that could be entrained and operated to avoid no greater than 10% loss of modeled larval and juvenile cohort Delta Smelt (typically this would come into effect beginning the middle of March).
- Cumulative Loss Threshold:
  - Reclamation and DWR would avoid exceeding cumulative loss thresholds over the duration of the 2019 Biological Opinions for wild Winter-Run Chinook Salmon, hatchery Winter-Run Chinook Salmon, wild Central Valley Steelhead from December through March, and wild Central Valley Steelhead from April 1 through June 15th. Wild Central Valley Steelhead would be separated into two time periods to protect San Joaquin origin fish that historically appear in the Mossdale trawls later than Sacramento origin fish. The loss threshold and loss tracking for hatchery Winter-Run Chinook Salmon does not include releases into Battle Creek. Loss (for development of thresholds and ongoing tracking) for Chinook salmon are based on length-at-date criteria.
  - The cumulative loss thresholds would be based on cumulative historical loss from 2010 through 2018. Reclamation’s and DWR’s performance objectives would set a trajectory such

that this cumulative loss threshold (measured as the 2010-2018 average cumulative loss multiplied by 10 years) would not be exceeded by 2030.

- If, at any time prior to 2024, Reclamation and DWR would exceed 50% of the cumulative loss threshold, Reclamation and DWR would convene an independent panel to review the actions contributing to this loss trajectory and make recommendations on modifications or additional actions to stay within the cumulative loss threshold, if any.
- In the year 2024, Reclamation and DWR would convene an independent panel to review the first five years of actions and determine whether continuing these actions are likely to reliably maintain the trajectory associated with this performance objective for the duration of the period.
- If, during real-time operations, Reclamation and DWR would exceed the cumulative loss threshold, Reclamation and DWR would immediately seek technical assistance from USFWS and NMFS, as appropriate, on the coordinated operation of the CVP and SWP for the remainder of the OMR management period. In addition, Reclamation and DWR would, prior to the next OMR management season, charter an independent panel to review the OMR Management Action consistent with "Chartering of Independent Panels" under the "Governance" section of Alternative 1. The purpose of the independent review would be to evaluate the efficacy of actions to reduce the adverse effects on listed species under OMR management and the non-flow measures to improve survival in the south Delta and for San Joaquin origin fish.

- Single-Year Salvage Threshold:
  - In each year, Reclamation and DWR would avoid exceeding an annual loss threshold equal to 90% of the greatest annual loss that occurred in the historical record from 20010 through 2018 for each of wild Winter-Run Chinook Salmon, hatchery Winter-Run Chinook Salmon, wild Central Valley Steelhead from December through March, and wild Central Valley Steelhead from April through June 15. Wild Central Valley Steelhead are separated into two time periods to protect San Joaquin Origin fish that historically appear in the Mossdale trawls later than Sacramento origin fish. The loss threshold and loss tracking for hatchery Winter-Run Chinook Salmon does not include releases into Battle Creek. Loss (for development of thresholds and ongoing tracking) for Chinook salmon would be based on length-at-date criteria.
  - During the year, if Reclamation and DWR would exceed the annual loss from 2010 through 2018, Reclamation and DWR would review recent fish distribution information and operations with the fisheries agencies at the Water Operations Management Team (WOMT) and seek technical assistance on future planned operations. Any agency could elevate from WOMT to a Directors discussion, as appropriate.
  - During the year, if Reclamation and DWR would exceed 50% of the annual loss threshold, Reclamation and DWR would restrict OMR to a 14-day moving average OMR index of no more negative than −3,500 cfs, unless Reclamation and DWR determine that further OMR restrictions are not required to benefit fish movement because a risk assessment shows that the risk is no longer present based on real-time information.
  - The −3,500 cfs OMR operational criterion adjusted and informed by this risk assessment would remain in effect for the rest of the season. Reclamation and DWR would seek NMFS technical assistance on the risk assessment and real-time operations.
  - During the year, if Reclamation and DWR exceed 75% of the annual loss threshold, Reclamation and DWR would restrict OMR to a 14-day moving average OMR index of no

more negative than −2,500 cfs, unless Reclamation and DWR determine that further OMR restrictions are not required to benefit fish movement because a risk assessment shows that the risk is no longer present based on real-time information.

- The −2,500 cfs OMR operational criterion adjusted and informed by this risk assessment would remain in effect for the rest of the season. Reclamation and DWR would seek NMFS technical assistance on the risk assessment and real-time operations.
- Risk assessment: Reclamation and DWR would determine and adjust OMR restrictions under this section by preparing a risk assessment that considers several factors including, but not limited to, real-time monitoring detects few fish in the south Delta and few fish are detected in salvage. Reclamation and DWR would share its technical analysis and supporting documentation with USFWS and NMFS, seek their technical assistance, discuss the risk assessment and future operations with WOMT at its next meeting, and elevate to the Directors as appropriate.
- If, during real-time operations, Reclamation and DWR would exceed the single-year loss threshold, Reclamation and DWR would immediately seek technical assistance from USFWS and NMFS, as appropriate, on the coordinated operation of the CVP and SWP for the remainder of the OMR management period. In addition, Reclamation and DWR would, prior to the next OMR management season, charter an independent panel to review the OMR Management Action consistent with “Chartering of Independent Panels” under the “Governance” section of Alternative 1. The purpose of the independent review would be to evaluate the efficacy of actions to reduce the adverse effects on listed species under OMR management and the non-flow measures to improve survival in the south Delta and for San Joaquin origin fish.

- Reclamation and DWR would consider the historical monthly distribution of loss to avoid disproportionately salvaging fish during any single month.

Reclamation and DWR would continue monitoring and reporting the salvage at the Tracy Fish Collection Facility and Skinner Fish Protection Facility. Reclamation and DWR would continue the release and monitoring of yearling Coleman National Fish Hatchery Late-Fall run as yearling Spring-Run Chinook Salmon surrogates.

4.3.6.6.3 Storm-Related OMR Flexibility

Reclamation and DWR could operate to a more negative OMR up to a maximum (otherwise-permitted) export rate at Banks and Jones Pumping Plants of 14,900 cfs (which could result in a range of OMR values) to capture peak flows during storm-related events. Reclamation and DWR would continue to monitor fish in real-time and would operate in accordance with the thresholds in “Additional Real-Time OMR Restrictions” above. Under the following conditions, Reclamation and DWR would not cause OMR to be more negative for capturing peak flows from storm-related events:

- Integrated Early Winter Pulse Protection (above) or Additional Real-Time OMR Restrictions (above) are triggered. Under such conditions, Reclamation and DWR would have already determined that more restrictive OMR is required.
- An evaluation of environmental and biological conditions indicates more negative OMR would likely cause Reclamation and DWR to trigger an Additional Real-Time OMR Restriction (above).
- Salvage of yearling Coleman National Fish Hatchery Late-Fall run (as yearling Spring-Run Chinook Salmon surrogates) exceeds 0.5% within any of the release groups.

- Reclamation and DWR identify changes in spawning, foraging, sheltering, or migration behavior beyond those described in the 2019 Biological Opinion for this project.

Reclamation and DWR would continue to monitor conditions and could resume management of OMR to no more negative than −5,000 cfs if conditions indicate the above offramps are necessary to avoid additional adverse effects. If storm-related flexibility causes the conditions in "Additional Real-Time OMR Restrictions", Reclamation and DWR would implement additional real-time OMR restrictions.

4.3.6.6.4 End of OMR Management

OMR criteria may control operations until June 30 (for Delta Smelt and Chinook salmon), until June 15 (for steelhead/rainbow trout), or when the following species-specific off ramps have occurred, whichever is earlier:

- Delta Smelt: When the daily mean water temperature at CCF reaches 25°C for 3 consecutive days.
- Salmonids:
  - When more than 95% of salmonids have migrated past Chipps Island, as determined by their monitoring working group, or
  - After daily average water temperatures at Mossdale exceed 72°F for 7 days during June (the 7 days do not have to be consecutive).

4.3.6.6.5 Real-Time Decision-Making and Salvage Thresholds

Reclamation and DWR may confer with the Directors of NMFS, USFWS, and CDFW if they desire to operate to a more negative OMR than what is specified in Additional Real-Time OMR Restrictions. Upon mutual agreement, the Directors of NMFS and USFWS may authorize Reclamation to operate to a more negative OMR than the Additional Real-Time OMR Restrictions, but no more negative than −5,000 cfs. The Director of CDFW may authorize DWR to operate to a more negative OMR than the Additional Real-Time OMR Restrictions, but no more negative than -5,000 cfs.

Figure 4.3-5 shows OMR management in a decision tree.

4.3.6.7 *Tracy Fish Collection Facility Carbon Dioxide Injection and Release Sites*

Reclamation would continue to screen fish from Jones Pumping Plant with the TFCF. The TFCF uses behavioral barriers consisting of primary louvers and four rotating traveling screens aligned in a single row 7 degrees to the flow of the water to guide entrained fish into holding tanks before transport by truck to release sites at the confluence of the Delta. The TFCF was designed to handle smaller fish (less than 200 mm) that would have difficulty fighting the strong pumping plant- induced flows, as the intake is essentially open to the Delta and impacted by tidal action. The number of pumps (units) running at the Jones PP dictates the flow and velocity at the TFCF. There are 6 units at Jones PP but a maximum of 5 can used; each unit increases the velocity through the TFCF primary channel by approximately 0.5 ft/sec.

The primary louvers are located in the primary channel just downstream of the trashrack structure. The traveling water screen is located in the secondary channel.

The louvers allow water to pass through onto the pumping plant, but the openings between the slats are tight enough and angled against the flow of water to prevent most fish from passing between them and to enable the fish to enter one of four bypass entrances along the louver arrays. Reclamation would install a carbon dioxide injection device to allow remote controlled anesthetization of predators in the secondary channels of the TFCF.

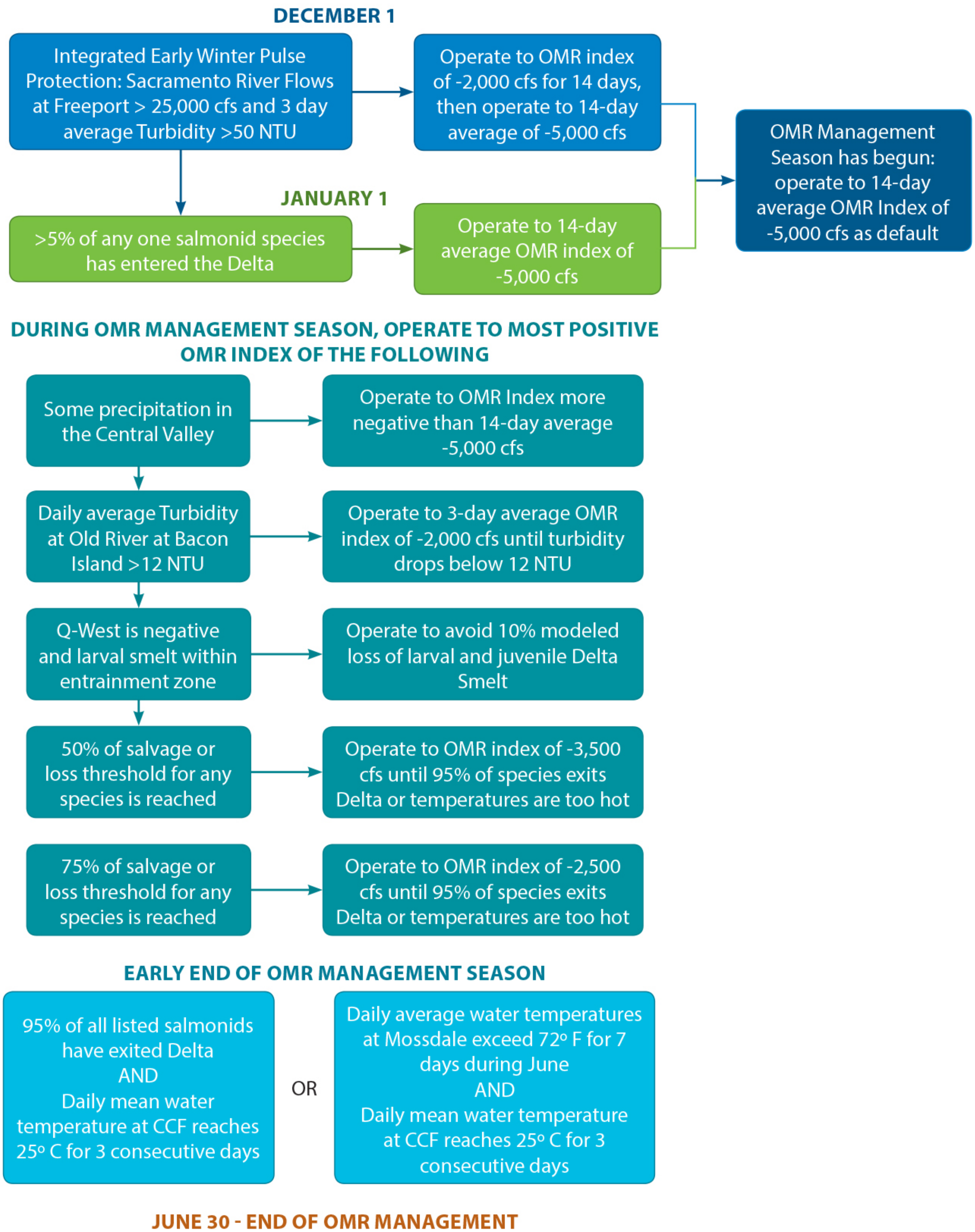

Figure 4.3-5. Decision Tree for Old and Middle River Reverse Flow Management

The current primary louver cleaning procedures and operations would continue. These procedures involve lifting each individual louver panel, 36 total, out of the water in order to spray wash the debris. Generally, each primary louver panel is lifted and lowered back into place three times per day, although frequency of cleaning may be increased or decreased according to pumping rate and debris loads. It takes approximately 3-7 minutes to lift, spray clean, and lower each louver panel back into place. While export pumping may be reduced to address damaged louver panels, issues during cleaning, or other maintenance scenarios where facilities are not capable of effectively salvaging fish, complete shutdown of pumping usually does not occur due to issues related to the primary louvers. At 5 Jones PP units running, louvers would be cleaned before the incoming tide as much as possible. The morning day shift would usually begin cleaning as soon as they start their work, around 6:00 a.m. During high debris periods, operators would monitor differentials and clean before any problems arise. At a minimum, all 36 louver panels would be cleaned 2-3 times a day but during heavy debris loads, operators would clean 3-6 times a day. At 2-4 Jones PP units, operators would determine when to clean and making sure the louvers do not reach 1 foot differential. At 1 Jones PP unit, operators would normally clean periodically during the incoming tide. Generally, less frequent cleaning is required in early summer (low averages of 60 minutes per day) and much higher during the winter months (high averages of 440 minutes per day). This means that there would be a louver panel lifted 1-7.5 hours per day depending on season, pumping rates, and debris loads.

When south Delta hydraulic conditions allow, and conditions are within the original design criteria for the TFCF, the louvers would be operated to achieve water approach velocities for striped bass of approximately 1 foot per second from May 15 through October 31 and for salmon of approximately 3 feet per second from November 1 through May 14.

Fish passing through the facility would be sampled at intervals of 30 minutes every 2 hours year-round. Approximately 52 different species of fish are entrained into the TFCF each year; however, the total numbers are significantly different for the various species salvaged. Fish observed during sampling intervals are identified by species, measured to fork length, examined for marks or tags, and placed in the collection facilities for transport by tanker truck to the release sites in the north Delta away from the pumps. Hauling trucks used to transport salvaged fish to release sites inject oxygen and contain an 8 parts per thousand salt solution to reduce stress. In addition, TFCF personnel monitor for the presence of spent female Delta Smelt in anticipation of expanding the salvage operations to include sub-20 mm larval Delta Smelt detection.

TFCF personnel would monitor for the presence of spent female Delta Smelt by euthanizing all adult Delta Smelt that are collected in the 30-minute fish count, determine the gender and the gonadal or sexual maturation stage of the Delta Smelt, and determine if the eggs have reached Stage IV, the stage when eggs are ready for release (0.9 to 10 mm in diameter and easily stripped). Stages V (i.e., postvitellogenic stage) and VI (i.e., postovulatory, or spent stage) are expected soon after Stage IV observation. Stages would be determined and reported real-time when a biologist is present or the following morning after smelt detection and collection. Stage or gonad maturation is determined using egg stage descriptions from Mager (1996).

Larval smelt sampling at the TFCF would commence once a trigger is met (detection of a spent female at CVP and SWP being one of three triggers). Fish count screen with a 2.4 mm mesh size opening would be replaced with one that has a mesh size of 0.5 mm to retain larval fish. Sampling is done four times a day (4:00 a.m., 10:00 a.m., 4:00 p.m., 10:00 p.m.) and all larval smelt would be identified to species and reported the day after collection.

Salvage of fish would occur at the TFCF 24 hours per day, 365 days per year. Fish would be salvaged in flow-through holding tanks (6.1-m diameter, 4.7-m deep) that provide continuous flows of water (Sutphin and Wu 2008). Fish would be maintained in these holding tanks for 8-24 hours depending on the species of fish that are being salvaged, the number of fish salvaged, and debris load. The number of fish that would be salvaged in TFCF holding tanks would be generally estimated by performing a 30 minute fish-count subsample every 120 minutes (2 hours). The number of each species of fish collected in the subsample would be determined and then multiplied by 4 (120 pumping minutes/30 minute fish-count subsample equals an expansion factor of 4) to estimate the total number of each species of fish, as well as the total number of fish, that were salvaged in TFCF holding tanks during the 120 minute period. Pumping minutes and fish-count minutes could potentially deviate from 120 minutes and 30 minutes, respectively, which would change the expansion factor used to estimate total fish salvage.

If no Chinook Salmon, Steelhead, or Delta Smelt were salvaged, fish could be maintained in TFCF holding tank for up to 24 hours. If a Chinook Salmon or Steelhead were collected during fish-counts, fish could only be maintained in TFCF holding tanks for up to 12 hours. If a Delta Smelt were collected during fish-count, salvaged fish could only be held in TFCF holding tanks for up to 8 hours. When fish could be maintained in TFCF holding tanks for 24 hours, fish transport (fish haul) would generally occur each morning. When 2 fish hauls per day would be necessary, a night fish haul would be added. When 3 fish hauls would be necessary, they would usually be completed at 7 a.m., 3 p.m., and 9:30 p.m. each day. Fish-haul would also be dictated by the Bates Tables which uses size classes, species, and water temperature as indicators for when to conduct a fish haul.

During normal operations, salvaged fish would be transported approximately 49.9 km and released at one of two Reclamation release sites near the confluence of the Sacramento and San Joaquin Rivers (Antioch Fish Release Site and Emmaton Fish Release Site). In general, the Emmaton Fish Release Site would be used for fish hauls performed during daytime hours and the Antioch Fish Release Site would be used for fish hauls performed during nighttime hours. This is done for safety and security reasons as the Antioch Fish Release Site has a gate that can be locked behind the operator after he/she enters the release site area. Upon arrival at release sites, operators would measure certain important water quality parameters (dissolved oxygen, salinity, and temperature) prior to releasing fish. This measurement would verify that water quality parameters remained acceptable during fish transport. In the future, Reclamation would increase the number of release sites to reduce predation.

Reclamation would conduct studies and physical improvements aimed to improve fish survival and improve TFCF efficiency, reducing mortality through the facility, fish hauling and release operations through the Tracy Fish Facility Improvement Program. Activities include louver improvement and replacement, predation studies and piscivorous predator control, improvement of hydrologic monitoring and telemetry systems, holding area improvements including fish count automation and tank aeration and screening, improvement of data management as well as aquaculture facility maintenance, operation and improvements. TFCF studies are established at annual multi-agency meetings of the Tracy Tech Advisory Team. Reclamation would provide written reports of study results on their website.

4.3.6.8 *Delta Smelt Summer-Fall Habitat*

Reclamation and DWR would use structured decision making to implement Delta Smelt habitat actions. In the summer and fall (June through October) of below normal, above normal, and wet years, based on the Sacramento Valley Index, the environmental and biological goals are, to the extent practicable, the following:

- Maintain low salinity habitat in Suisun marsh and Grizzly Bay when water temperatures are suitable;
- Manage the low salinity zone to overlap with turbid water and available food supplies; and
- Establish contiguous low salinity habitat from Cache Slough Complex to the Suisun Marsh.

The Delta Smelt Summer-Fall Habitat action would be incorporated into the “Four Year Review” under the “Governance” section of Alternative 1.

The Delta Smelt Habitat Action described below is intended to improve Delta Smelt food supply and habitat, thereby contributing to the recruitment, growth, and survival of Delta Smelt. The current conceptual model is that Delta Smelt habitat should include low salinity conditions of 0-6 ppt, turbidity of approximately 12 NTU, temperatures below 25°C, food availability, and littoral or open water physical habitats (FLaSH Synthesis, pp. 15-25). The Delta Smelt Habitat Action is being undertaken recognizing that the highest quality habitat in this large geographical region includes areas with complex bathymetry, in deep channels close to shoals and shallows, and in proximity to extensive tidal or freshwater marshlands and other wetlands. The Delta Smelt Habitat Action is to provide these habitat components in the same geographic area through a range of actions to improve water quality and food supplies.

The action may include, but is not limited to the following components:

- SMSCG operations for up to 60 days (not necessarily consecutive) in June through October of below normal, above normal, and wet years;
- Project operations to maintain a monthly average 2 ppt isohaline at 80 km from the Golden Gate Bridge in above normal and wet water years in September and October with offramp criteria when:
    - Sufficient habitat acreages in Suisun Marsh, Grizzly Bay, and other adjacent areas are available to support Delta Smelt recruitment (e.g. 0-6 ppt at Hunter’s Cut, non-lethal temperatures, etc.);
    - Suitable recruitment projections based on Service approved lifecycle modeling and/or monitoring to indicate a positive trend in Delta Smelt and a determination that the Summer-Fall Habitat Action is not necessary to continue that trend; or
    - The absence of Delta Smelt in target areas based on EDSM or similar sampling; or other factors that would limit the benefits of the action (lack of suitable habitat, based on presence/absence modeling such as the Hurdle Model or similar).
- Food enhancement actions, e.g., those included in the Delta Smelt Resiliency Plan to enhance food supply, the North Delta Food Subsidies and Colusa Basin Drain project, Sacramento River Deepwater Ship Channel lock reoperation, and Suisun Marsh Food Subsidies (Roaring River distribution system reoperation). These projects are described below in more detail.

Through collaborative planning (described in Section 4.3.9), Reclamation and DWR would develop a Summer-Fall Habitat Plan to meet the environmental and biological goals in years when summer-fall habitat actions are triggered. In above normal and wet years, operating to a monthly average X2 of 80 km in September and October is an operational back-stop that would be available to provide a specific acreage of low salinity habitat. In every year, Reclamation and DWR would propose, based on discussions with the USFWS, a suite of actions that would meet the action’s environmental and biological goals. If it is determined that any of the off-ramps identified above are applicable, Reclamation and DWR would include a discussion of those off-ramps in the Summer-Fall Habitat Plan.

As part of the Delta Smelt Habitat Action, Reclamation intends to meet Delta outflow augmentation in the fall primarily through export reductions as they are the operational control with the most flexibility in September and October. Storage releases from upstream reservoirs may be used to initiate the action by pushing the salinity out further in August and early September; however, the need for this initial action would depend on the particular hydrologic, tidal, storage, and demand conditions at the time. In addition, storage releases could be made in combination with export reductions during the fall period during high storage scenarios where near-term flood releases to meet flood control limitations are expected. In these scenarios, Reclamation would make releases in a manner that minimizes redd dewatering where possible.

The offramp criteria would be more fully defined and examples of potential implementation developed through the structured decision making or other review process. The review would include selection of appropriate models, sampling programs, and other information to be used. The specific offramp criteria may be modified through the process. The process would be completed prior to implementation and may be improved in subsequent years as additional information is synthesized and reviewed.

Enhancement actions may include:

- *Sacramento River Deepwater Ship Channel:* Reclamation would partner with the City of West Sacramento and West Sacramento Area Flood Control Agency to repair or replace the West Sacramento lock system to hydraulically reconnect the ship channel with the mainstem of the Sacramento River. When combined with an ongoing food web study, the reconnected ship channel has the potential to flush food production into the north Delta. An increase in food supply is likely to benefit Delta Smelt and their habitat.
- *North Delta Food Subsidies and Colusa Basin Drain:* DWR, Reclamation, and water users would increase food entering the north Delta through flushing nutrients from the Colusa Basin into the Yolo Bypass and north Delta. DWR, Reclamation, and water users would work with partners to flush agricultural drainage (i.e., nutrients) from the Colusa Basin Drain through Knight's Landing Ridge Cut and Tule Canal to Cache Slough, improving the aquatic food web in the north Delta for fish species. Reclamation would work with DWR and partners to augment flow in the Yolo Bypass in July and/or September by closing Knights Landing Outfall Gates and routing water from Colusa Basin into Yolo Bypass to promote fish food production.
- *Suisun Marsh Food Subsidies:* Water users would add fish food to Suisun Marsh through coordinating managed wetland flood and drain operations in Suisun Marsh, RRDS food production, and reoperation of the SMSCG. As noted in the Delta Smelt Resiliency Strategy, this management action may attract Delta Smelt into the high-quality Suisun Marsh habitat in greater numbers, reducing use of the less food-rich Suisun Bay habitat (CNRA 2016). Infrastructure in the RRDS may help drain food-rich water from the canal into Grizzly Bay to augment Delta Smelt food supplies in that area. In addition, managed wetland flood and drain operations can promote food export from the managed wetlands to adjacent tidal sloughs and bays.

4.3.6.9 *Additional Operations Components*

In addition to the changes to CVP and SWP export operations, Alternative 1 would include studies to understand how operations interact with fisheries:

- *San Joaquin Basin Steelhead Telemetry Study*: Continuation of the San Joaquin Basin Steelhead Telemetry Study. This is a 6-year study on the migration and survival of San Joaquin Origin Central Valley Steelhead.
- *Steelhead Lifecycle Monitoring Program*: Development of infrastructure that would support a functioning life cycle monitoring program in the Stanislaus River and a Sacramento basin CVP tributary (e.g. Clear Creek, Upper Sacramento, American River) to evaluate how actions related to stream flow enhancement, habitat restoration, and/or water export restrictions affect biological outcomes including population abundance, age structure, growth and smoltification rates, and anadromy and adaptive potential in these two populations. The goal of this monitoring program would be to improve understanding of steelhead demographics and, when combined with other steelhead-focused parts of Alternative 1 (San Joaquin and Delta steelhead telemetry study),

inform actions that would increase steelhead abundance and improve steelhead survival through the Delta.

- *San Joaquin Basin Steelhead Collaborative*: Within 1 year, Reclamation would coordinate with Collaborative Science and Adaptive Management Program (CSAMP) to sponsor a workshop for developing a plan to monitor steelhead populations within the San Joaquin Basin and/or the San Joaquin River downstream of the confluence of the Stanislaus River, including steelhead and rainbow trout on non-project San Joaquin tributaries. The plan would be delivered to the Interagency Ecological Program (IEP) for prioritization and implementation, where feasible, for actions within the responsibility of the CVP and SWP and other members of the IEP. If the IEP is not able to implement the plan, the plan may be raised at the Director Level Collaborative Planning Meeting described under the "Governance" section of Alternative 1 for resolution

4.3.6.10 *Habitat Components*

DWR and Reclamation would continue to implement existing and ongoing restoration efforts that are underway but not complete, including:

- Coordination with water users: Reclamation would coordinate with water users to remove predator hot spots in the Bay-Delta, which includes minimizing lighting at fish screens and bridges and possibly removing abandoned structures; and
- Small Screen Program: Reclamation and DWR continue to work with existing authorities (Anadromous Fish Screen Program) to screen small diversions throughout Central Valley CVP and SWP streams and the Bay-Delta.

4.3.6.11 *Intervention Components*

Reclamation and DWR would continue implementation of the following projects to reduce mortality of ESA-listed fish species:

- Head of Old River: Reclamation and DWR would form a project team to address the scour hole in the San Joaquin River at the Head of Old River. The project team would plan and implement measures to reduce the predation intensity at that site through modifications to the channel geometry and associated habitats.
- Delta Cross-Channel Gate Improvements: The DCC is more than 65 years old and its gates rely on remote operators to travel to the facility to change their position. When the gates are open, they provide a critical diversion structure for freshwater reaching the CVP south Delta pumping station. The gates are closed to prevent scouring (during high flows), reduce salinity intrusion in the western Delta, and protect Sacramento River ESA-listed and nonlisted salmonids. Additional DCC operation would allow for improved exports and water quality without additional adverse effects on salmonids. Reclamation would evaluate improvements to automate and streamline operation of the DCC gates. Reclamation would modernize the DCC gate materials and mechanics to include adding industrial control systems, increasing additional staff time, and improve physical and biological monitoring associated with the DCC daily and/or tidal operations as necessary to maximize water supply deliveries.
- Tracy Fish Collection Facility Improvements: Reclamation would improve the TFCF to reduce loss by (1) incorporating additional fish exclusion barrier technology into the primary fish removal barriers, (2) incorporating additional debris removal systems at each trash removal barrier, screen, and fish barrier, (3) constructing additional channels to distribute the fish collection and debris removal among redundant paths through the facility, (4) constructing additional fish handling systems and holding tanks to improve system reliability; and (5)

incorporating remote operation into the design and construction of the facility. Facility improvements would improve survival of fish salvaged and potentially reduce the loss factors to allow for additional certainty on OMR management with low impacts from salvaging salmonids.

- Skinner Fish Facility Improvements: DWR would continue implementation of projects to reduce mortality of ESA-listed fish species. These measures that would be implemented include (1) electroshocking and relocating predators, (2) controlling aquatic weeds, (3) developing a fishing incentives or reward program for catching predators, and (4) operational changes when listed species are present.
- Release Sites: Reclamation would continue work with DWR to incorporate flexibility in salvage release sites, using DWR's sites, or sites on a barge.
- Conservation and Culture Laboratory: The existing Fish Conservation and Culture Laboratory would be used in the interim to begin supplementation of the wild Delta Smelt population with captively produced Delta Smelt prior to construction of the new conservation hatchery. Supplementation of wild populations would begin within 3-5 years from issuance of the 2019 Biological Opinion. The USFWS would lead development of a supplementation strategy with support from Reclamation. This strategy would include identification of studies to develop necessary information to begin a supplementation program, a focus on capturing and maintaining existing genetic diversity, expansion of the Fish Conservation and Culture Laboratory to produce maximum numbers of Delta Smelt, and identification of and a plan to address necessary regulatory actions. The strategy would have a goal of increasing production to a number and the life stages necessary to effectively augment the population as determined by USFWS. The strategy would be in place 1 year from issuance of the 2019 Biological Opinion. Work done at the Fish Conservation and Culture Laboratory would guide construction and operation of the conservation hatchery.
- Delta Fish Species Conservation Hatchery: Reclamation would partner with DWR to complete construction and operate a conservation hatchery for Delta Smelt, by 2030. The conservation hatchery would breed and propagate a stock of fish with equivalent genetic resources of the native stock and at sufficient quantities to effectively augment the existing wild population, so that they can be returned to the wild to reproduce naturally in their native habitat.

4.3.7 Stanislaus River

As discussed in the No Action Alternative, Reclamation has worked with water users and related agencies to develop an operating plan for New Melones Reservoir to meet the multiple objectives on the system, but a plan is not complete. Alternative 1 includes an operating plan, described below, which is intended to replace often overlapping and conflicting operational components of previous federal and state flow requirements and is representative of Reclamation's contribution to any current or future flow objectives on the lower San Joaquin River at Vernalis.

4.3.7.1 *Seasonal Operations*

Reclamation would meet water rights, contracts, and agreements that are specific to the East Side Division and Stanislaus River. Senior water right holders (OID and SSJID) would receive annual water deliveries consistent with the 1988 Agreement and Stipulation, and water would be made available to CVP contractors in accordance with their contracts and applicable shortage provisions.

In high storage, high inflow conditions, Reclamation would operate for flood control in accordance with the USACE flood control manual. Because New Melones Reservoir is large relative to its annual inflow, flood control is relatively infrequent; however, Tulloch Lake, located downstream of New Melones

Reservoir, is subject to high local inflows, and may be in flood control operations for brief periods when New Melones Reservoir is not. During these periods, releases from Tulloch Lake may be used to meet flow objectives, schedules, or requirements on the lower Stanislaus River below Goodwin Dam.

Reclamation would operate New Melones Reservoir (as measured at Goodwin Dam) in accordance with a Stepped Release Plan (SRP) that varies by hydrologic condition and water year type as shown in Table 4.3-6.

Table 4.3-6. New Melones SRP Annual Releases by Water Year Type

Water Year Type	Annual Release (TAF)
Critical	184.3
Dry	233.3
Below normal	344.6
Above normal	344.6
Wet	476.3

The New Melones SRP would be implemented similarly to the No Action Alternative with a default daily hydrograph and the ability to shape monthly and seasonal flow volumes to meet specific biological objectives. The default daily hydrograph is the same as prescribed under the No Action Alternative for critical, dry, and below-normal water year types. The difference occurs in above-normal and wet years, where the minimum requirement for larger releases is reduced from the No Action Alternative to promote storage for potential future droughts and preserve cold water pool. When compared to minimum daily flows from the No Action Alternative, the daily hydrograph for the New Melones SRP is identical for critical, dry, and below-normal year types; above-normal and wet year types follow daily hydrographs for below-normal and above-normal year types from current operating requirements, respectively.

For the New Melones SRP, Reclamation would classify water year types using the San Joaquin Valley 60-20-20 Water Year Hydrologic Classification (60-20-20) developed for D-1641 implementation. Previous operating plans for New Melones Reservoir relied on the New Melones Index to determine water year type, calculated by summing end-of-February storage and forecasted inflow through September. Because the reservoir can store more than twice its average inflow, the New Melones Index resulted in a water year type determination that was more closely tied to storage rather than hydrology. Changing from the New Melones Index to 60-20-20 is expected to provide operations that better represent current hydrology and correlate more closely to water year types for other nearby tributaries.

Reclamation would convene the Stanislaus Watershed Team (successor to the Stanislaus Operating Group), consisting of agency representatives and local stakeholders having direct interest on the Stanislaus River, at least monthly to share operational information and improve technical dialogue on the implementation of the New Melones SRP. The Stanislaus Watershed Team would provide input on the shaping and timing of monthly or seasonal flow volumes to optimize biological benefits.

During the summer, Reclamation would be required to maintain applicable dissolved oxygen standards on the lower Stanislaus River for species protection. Reclamation currently operates to a 7.0 mg/L dissolved oxygen requirement at Ripon from June 1 to September 30. Reclamation would move the compliance location to Orange Blossom Bridge, where the species are primarily located at that time of year.

4.3.7.2 *Habitat Components*

Alternative 1 includes the following habitat components:

- Spawning Habitat: Under the CVPIA (b)(13) program, Reclamation's annual goal of gravel placement is approximately 4,500 tons in the Stanislaus River. Continued gravel placement sites would include River Mile 58 on the lower Stanislaus River, Goodwin Canyon (at the cable crossing and float tube pool), Honolulu Bar, Buttonbush, and Rodden Road. Reclamation could also work with new sites, including Two Mile Bar, Kerr Park, and Goodwin Canyon.
- Rearing Habitat: Reclamation would construct an additional 50 acres of rearing habitat adjacent to the Stanislaus River by 2030. Reclamation may improve or add to existing projects at Lancaster Road, Honolulu Bar, Buttonbush, or Rodden Road. Reclamation could also work with new sites at Two Mile Bar or Kerr Park.
- Temperature Management: Reclamation would study approaches to improving temperature for listed species on the lower Stanislaus River to include evaluating the utility of conducting temperature measurements or profiles in New Melones Reservoir.

4.3.8 San Joaquin River

Reclamation would continue to implement the SJRRP, as described in the No Action Alternative. Additionally, Reclamation would implement rearing habitat restoration on the lower San Joaquin River. Reclamation would work with private landowners to create a locally driven, regional partnership to define and implement a large-scale floodplain habitat restoration effort in the lower San Joaquin River. This stretch of the San Joaquin River is cut-off from its floodplain due to an extensive levee system, with two notable exceptions at Dos Rios Ranch (1,600 acres) and San Joaquin River National Wildlife Refuge (2,200 acres). In recent years, there has been growing interest in multibenefit floodplain habitat restoration projects in the Central Valley that can provide increased flood protection for urban and agricultural lands, improved riparian corridors for terrestrial plants and wildlife, and enhanced floodplain habitat for fish. The resulting restoration could include thousands of acres of interconnected (or closely spaced) floodplain areas with coordinated and/or collaborative funding and management. Such large-scale effort along this corridor would require significant support from a variety of stakeholders, which could be facilitated through a regional partnership.

4.3.9 Governance

Reclamation would work with DWR, NMFS, USFWS, CDFW, public water agencies, and other participants to manage operations in multiple ways. Key governance functions are described below.

4.3.9.1 *Core Water Operation*

Reclamation and DWR would operate the CVP and SWP, while reducing the stressors on listed species influenced by those ongoing operations. through real-time monitoring. Reclamation would implement activities, monitor performance, and report on compliance with the commitments in Alternative 1. The Real-Time Water Operations Charter (Charter) in the 2019 Biological Opinion establishes how Reclamation and DWR would monitor and report on ESA Section 7 commitments under Alternative 1 and how the five agencies, public water agencies, and other participants would communicate, and coordinate real-time water operations decisions. The Charter also describes the deliverables, schedule, and decision-making processes.

NMFS, USFWS, and CDFW would provide information to Reclamation and DWR on the real-time disposition of species through specific monitoring workgroups. This information would inform the risk analysis performed by Reclamation and DWR.

4.3.9.2 *Scheduling*

Fishery agencies and water users in watershed-based groups would provide scheduling recommendations to Reclamation and DWR on duration, timing, and magnitude of specific blocks of water related to Alternative 1 components that have schedule flexibility. Reclamation and DWR would evaluate and consider the recommendations and operate the CVP and SWP to those schedules as feasible.

4.3.9.3 *Collaborative Planning*

As part of Alternative 1, Reclamation would pursue and implement certain actions through collaborative planning with the goal of continuing to identify and undertake actions that benefit listed species. Collaborative planning would make use of the CSAMP, CVPIA, IEP, and Delta Plan Interagency Implementation Committee (DPIIC), successors to the forums, or complementary forums (e.g. Voluntary Agreement forums). Each of these programs has established governance, work planning, implementation, reporting, and independent review.

Where necessary, Reclamation and DWR would form project teams comprised of fishery agency and water users that assist Reclamation and DWR on the implementation of specific actions. The CVPIA develops priorities across CVPIA fish-related provisions and watersheds in the Central Valley. The process uses an Adaptive Resource Management approach with support from Decision-Support Models to prioritize implementation of management actions that have the highest probability of achieving biological objectives for naturally produced populations of native anadromous fish. The Adaptive Resource Management approach also guides plans for monitoring and research by synthesizing existing monitoring data, annually updating Decision Support Models using new information, and estimating the value of new information to the decision making process. CSAMP and DPIIC have similar tools in various stages of development.

Reclamation would use CSAMP to convene an annual Directors Level Collaborative Planning meeting with NMFS, DWR, DFW and FWS to review collaborative planning actions (including restoration, monitoring, and research actions), discuss the resources each agency can contribute, and discuss strategies for collectively influencing and supporting the likelihood that priority restoration, monitoring, and research actions and their beneficial effects would be implemented.

Reclamation and DWR have a strong record of accomplishment in benefiting species through habitat restoration, facility improvements, monitoring, and science, as documented in work plans and accomplishment reports. Specific examples of recent projects in partnership with stakeholders, but not an exhaustive list, include:

- Shasta Division (Sacramento River)
  - Market Street gravel addition in 2019
  - Reading Island side channel restoration in 2018
  - Lake California side channel restoration in 2018
  - Additional gravel at the Keswick Dam launch site in 2018
- Clear Creek planning and 2019 award of funds for the completion of the Phase 3C

- American River
  - Nimbus side channel restoration in 2014;
  - Sacramento Bar restoration in 2016.
- Stanislaus River
  - Goodwin Canyon gravel addition in 2016;
  - Landcaster Road side channel in 2017.
- Delta and Suisun Marsh
  - McCormack Williamson Tract tidal and floodplain habitat in 2018
  - Yolo Flyway Farms tidal restoration in 2018
  - Decker Island tidal restoration in 2018
  - Tule Red tidal restoration in scheduled for fall of 2019
  - Winter Island tidal restoration scheduled for fall of 2019
  - Dutch Slough tidal and floodplain restoration construction ongoing since 2018
  - Freemont Weir adult fish passage in 2019
  - Knight's Landing Outflow Gates in 2016
  - Wallace Weir barrier and rescue facility in 2019
  - Suisun Marsh Gate Reoperation Pilot in 2018 and planned for 2019
  - Roaring River Drain Gate Installation in 2018
- Fish Passage and Screening
  - Deer Creek Irrigation District Dam in 2017;
  - Mill Creek Fish Passage Assessment and Restoration Project in 2016;
  - Lower Deer Creek Falls Fish Passage Improvement Project in 2018;
  - RD2035 Woodland Davis intake in 2016;
  - Small screen program through the Family Farm Alliance for Locke Ranch on the Mokelumne, Hidden Valley Range on the San Joaquin, Clover Creek/Millville on Clover Creek, and Oswald WD on the Feather River in 2017;
- Science and Monitoring
  - Directed Outflow Project in 2017, 18, and 19
  - Enhanced Delta Smelt Monitoring Program
  - Six-Year Steelhead Telemetry Study
  - Salmon and Sturgeon Assessment of Indicators by Lifestage
  - Salvage Monitoring Studies

The action agencies' collaborative planning programs are robust and account for the technical, social, and economic complexities of implementing large-scale habitat restoration programs. Reclamation has the authority to undertake these actions, subject to appropriations, under Reclamation Law including authorizations for the Central Valley Project, Fish and Wildlife Coordination Act, CVPIA (1992), Calfed

Bay-Delta Authorization Act (2004), and Water Infrastructure Improvements for the Nation (WIIN) Act (2016). Reclamation's historical annual appropriations bills include funding of spawning and rearing habitat, fish screens, fish salvage, hatcheries, and specific restoration programs. Sources include the Bay-Delta Fund, Central Valley Project Restoration Fund, and Water and Related Resources Fund. Future obligations and expenditures are subject to appropriation by Congress.

To fund these actions, DWR has the statutory authority to require the reimbursement in the SWP contracts for water and power for any costs DWR incurs for SWP-relate fish and wildlife preservation (Water Code Sections 11912, 12937 and 12938).

Reclamation and DWR also commit to continue to support collaborative efforts that are underway in other forums that benefit species. Reclamation and/or DWR agree to track, and where appropriate and within the agencies' authority, champion, sponsor, and/or implement projects consistent with applicable laws, similar to the processes described for the projects identified above.

4.3.9.4 *Compliance and Performance Reporting*

Reclamation and DWR would annually report on water operations and fish performance seasonally and in an annual summary. Changes to Alternative 1 would occur based on the reinitiation triggers provided by 50 CFR 402.16. These triggers include:

a) If the amount or extent of taking specified in the incidental take statement is exceeded;

b) If new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered;

c) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion; or

d) If a new species is listed or critical habitat designated that may be affected by the identified action.

Reclamation would monitor take for the purpose of evaluating trigger (a) above; Reclamation would monitor the effects of Alternative 1 for the purpose of evaluating trigger (b) above. If Reclamation decides to modify Alternative 1, Reclamation would evaluate the changes to Alternative 1 based on trigger (c) above. Consistent with 50 CFR 402.16, the USFWS and/or NMFS could also reinitiate formal consultation as appropriate. Reclamation would coordinate with DWR as an "applicant" and support DWR's coordination with CDFW.

4.3.9.5 *Drought and Dry Year Actions*

Within 18 months of executing the Record of Decision, Reclamation would coordinate with DWR to develop a voluntary toolkit to be exercised at the discretion of Reclamation, DWR, other agencies, participating water users, and/or others for the operation of Shasta Reservoir during critical hydrologic year types. The toolkit would include, at a minimum: measures at the Livingston-Stone National Fish Hatchery; the potential for translocation of fish; and facility improvements to reduce the adverse effects of critical and dry years on listed species. Drought and dry year planning would include the measures under Shasta Cold Water Pool Management Dry Years, Drought Years, and Successive Dry Years.

On October 1st, if the prior water year was dry or critical, Reclamation would meet and confer with USFWS, NMFS, DWR, CDFW, and Sacramento River Settlement Contractors on voluntary measures to be considered if drought conditions continue into the following year, including measures that may be beyond Reclamation and DWR's discretion. If dry conditions continue, Reclamation would regularly meet with this group (and potentially other agencies and organizations) to evaluate current hydrologic conditions and the potential for continued dry conditions that may necessitate the need for development of a drought contingency plan (that may include actions from the toolkit) for the water year.

By February of each year following a critical hydrologic year type, Reclamation would report on the measures employed and assess the effectiveness. The toolkit would be revisited at a frequency of not more than 5 years after the Record of Decision.

4.3.9.6 *Chartering of Independent Panels*

Reclamation and DWR would charter independent panels to review particular actions as described in certain components of Alternative 1. Independent panels would review actions consistent with the standards of the Delta Stewardship Council and applicable Reclamation and DWR guidance. Experts on the panel would provide information and recommendations but would not make consensus recommendations to Reclamation. NMFS and FWS could provide technical assistance and input in the development of the charter. Reclamation and DWR would provide the results of the independent review to NMFS and FWS. Reclamation would coordinate with DWR to document a response to the independent review including whether implementation of alternative strategies would require reinitiation consistent with the reinitiation triggers provided by 50 CFR 402.16. Nothing associated with the chartering of and responding to independent panels precludes NMFS nor FWS from exercising its statutory responsibilities under the ESA.

4.3.9.7 *Four Year Reviews*

In January of 2024 and January of 2028, Reclamation and DWR would charter an independent panel to review the following actions:

- Upper Sacramento Performance Metrics
- OMR management and measures to improve survival through the South delta
- Delta Smelt Summer and Fall Habitat Actions

Reclamation and DWR could incorporate additional information into the reviews in coordination with local, state, and federal partners.

4.4 Alternative 2

Alternative 2 reflects a condition where Reclamation would operate the CVP to meet the legal requirements associated with its water rights, but would not release additional flows for fish and wildlife purposes. DWR would continue to operate Lake Oroville according to the most recent FERC license, and Delta operations would be governed by water right requirements. Most of the water right conditions are from D-1641 (SWRCB 2000), which sets forth the water right requirements to meet the objectives in the Bay-Delta WQCP (SWRCB 1995).

Table 4.4-1 shows each of the components of Alternative 2. The table includes a column that considers if a component is covered at a project or program level of analysis in this EIS, but Alternative 2 does not have any components considered at a program level. Unlike Alternative 1, this table does not include a column for construction effects because Alternative 2 does not have any construction components. If not mentioned in the table, the operations of the No Action Alternative remain.

Table 4.4-1. Components of Alternative 2

Title	Project Level Analysis or Program-Level Analysis
Upper Sacramento	
Operations to meet WRO 90-5 downstream temperature targets	Project
Operations to meet Delta standards in D-1641	Project
Trinity	
Whiskeytown Reservoir Operations	Project
Feather River	
FERC Project #2100-134 controls operations; Alt 1 analyzes downstream of the FERC boundary	Project
American River	
2006 Flow Management Standard Releases	Project
Operations to meet Delta standards in D-1641	Project
Stanislaus	
1987 Reclamation, DFG agreement	Project
Bay-Delta	
D-1641 control of exports, DCC operations, and Delta outflow	Project

4.4.1 Upper Sacramento River (Shasta and Sacramento Divisions)

As described under Alternative 1, Reclamation has multiple requirements that govern the operation of Shasta Reservoir. For Alternative 2, Reclamation would continue to operate Shasta Reservoir in accordance with water rights, contracts, and agreements specific to the upper Sacramento River, including 990, 90-5, 91-1, and 1641, settlement contracts, exchange contracts, water service contracts, flood control operations developed by the USACE, and navigation requirements in the Rivers and Harbors Acts.

4.4.2 Trinity River Division

As described in the No Action Alternative and Alternative 1, the Trinity River system would be operated according to the Trinity River ROD with lower Klamath River augmentation flows.

4.4.3 Clear Creek

Under Alternative 2, Clear Creek base flows would be 50 to 100 cfs based on the 2000 agreement between Reclamation, USFWS, and DFG.

4.4.4 Feather River

Alternative 2 would have the same operations as the No Action Alternative and Alternative 1.

4.4.5 American River Division

Alternative 2 would include flow releases to meet D-893 on the American River, the 2006 American River Flow Management Standard, and releases to meet Delta standards, as needed.

4.4.6 Bay-Delta

The requirements in D-1641 address the standards for fish and wildlife protection, water supply water quality, and Suisun Marsh salinity. These objectives include specific Delta outflow requirements throughout the year, specific export limits in the spring, and export limits based on a percentage of estuary inflow throughout the year. The water quality objectives are designed to protect agricultural, M&I, and fishery uses and vary throughout the year and by water year type. One of the requirements is to provide a minimum flow on the Sacramento River at Rio Vista in September through December of 3,000 to 4,500 cfs, depending on the month and water year type, to protect water quality for Delta water users.

D-1641 includes two Delta outflow criteria: a Net Delta Outflow Index is specified for all months in all water year types and a spring X2 Delta outflow is specified from February through June to maintain freshwater and estuarine conditions in the western Delta to protect aquatic life.

During February through June, D-1641 limits CVP and SWP exports at Banks and Jones Pumping Plants as compared to Delta inflows (also known as the E/I Ratio) to reduce potential impacts on migrating salmon and spawning Delta Smelt, Sacramento Splittail, and Striped Bass. Figure 4.4-1 summarizes Delta requirements.

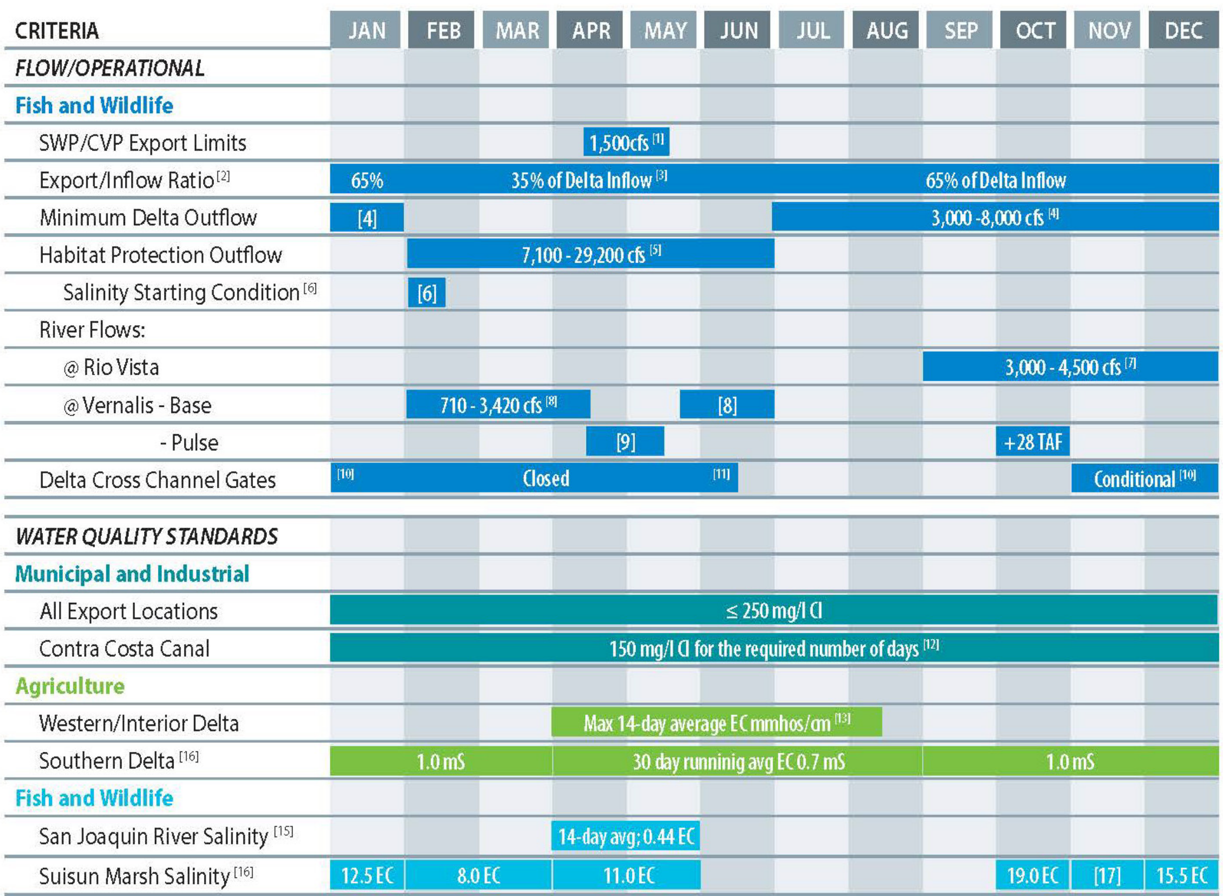

Figure 4.4-1. Delta Requirements in D-1641

FOOTNOTES

[1] Maximum 3-day running average of combined export rate (cfs) which includes Tracy Pumping Plant and Clifton Court Forebay Inflow less Byron-Bethany pumping.

Year Type	All
Apr15 - May15*	The greater of 1,500 or 100% of 3-day avg. Vernalis flow

* This time period may need to be adjusted to coincide with fish migration. Maximum export rate may be varied by CalFed Op's group.

[2]The maximum percentage of average Delta inflow (use 3-day average for balanced conditions with storage withdrawal, otherwise use 14-day average) diverted at Clifton Court Forebay (excluding Byron-Bethany pumping) and Tracy Pumping Plant using a 3-day average. (These percentages may be adjusted upward or downward depending on biological conditions, providing there is no net water cost.)

[3] The maximum percent Delta inflow diverted for Feb may vary depending on the January 8RI.

Jan 8RI	Feb exp. limit
< 1.0 MAF	45%
between 1.0 & 1.5 MAF	35%-45%
> 1.5 MAF	35%

[4] Minimum monthly average Delta outflow (cfs). If monthly standard ≤ 5,000 cfs, then the 7-day average must be within 1,000 cfs of standard; if monthly standard > 5,000 cfs, then the 7-day average must be ≥ 80% of standard.

Year Type	All	W	AN	BN	D	C
Jan	4,500*					
Jul		8,000	8,000	6,500	5,000	4,000
Aug		4,000	4,000	4,000	3,500	3,000
Sep	3,000					
Oct		4,000	4,000	4,000	4,000	3,000
Nov-Dec		4,500	4,500	4,500	4,500	3,500

* Increase to 6,000 if the Dec 8RI is greater than 800 TAF

[5] Minimum 3-day running average of daily Delta outflow of 7,100 cfs OR: either the daily average or 14-day running average EC at Collinsville is less than 2.64 mmhos/cm (This standard for March may be relaxed if the Feb 8RI is less than 500 TAF. The standard does not apply in May and June if the May estimate of the SRI IS < 8.1 MAF at the 90% exceedence level in which case a minimum 14-day running average flow of 4,000 cfs is required.) For additional Delta outflow objectives, see TABLE A.

[6] February starting salinity: If Jan 8RI > 900 TAF, then the daily or 14-day running average EC @ Collinsville must be ≤ 2.64 mmhos/cm for at least one day between Feb 1-14. If Jan 8RI is between 650 TAF and 900 TAF, then the CalFed Op's group will determine if this requirement must be met.

[7] Rio Vista minimum monthly average flow rate in cfs (the 7-day running average shall not be less than 1,000 below the monthly objective).

Year Type	All	W	AN	BN	D	C
Sep	3,000					
Oct		4,000	4,000	4,000	4,000	3,000
Nov-Dec		4,500	4,500	4,500	4,500	3,500

[8] BASE Vernalis minimum monthly average flow rate in cfs (the 7-day running average shall not be less than 20% below the objective). Take the higher objective if X2 is required to be west of Chipps Island.

Year Type	All	W	AN	BN	D	C
Feb-Apr14 and May16-Jun		2,130 or 3,420	2,130 or 3,420	1,420 or 2,280	1,420 or 2,280	710 or 1,140

[9] PULSE Vernalis minimum monthly average flow rate in cfs. Take the higher objective if X2 is required to be at or west of Chipps Island.

Year Type	All	W	AN	BN	D	C
Apr15 - May15		7,330 or 8,620	5,730 or 7,020	4,620 or 5,480	4,020 or 4,880	3,110 or 3,540
Oct	1,000*					

* Up to an additional 28 TAF pulse/attraction flow to bring flows up to a monthly average of 2,000 cfs except for a critical year following a critical year. Time period based on real-time monitoring and determined by CalFed Op's group.

[10] For the Nov-Jan period, Delta Cross Channel gates may be closed for up to a total of 45 days.

[11] For the May 21-June 15 period, close Delta Cross Channel gates for a total of 14 days per CALFED Op's group. During the period the Delta cross channel gates may close 4 consecutive days each week, excluding weekends.

[12] Minimum # of days that the mean daily chlorides ≤ 150 mg/l must be provided in intervals of not less than 2 weeks duration. Standard applies at Contra Costa Canal Intake or Antioch Water Works Intake.

Year Type	W	AN	BN	D	C
# Days	240	190	175	165	155

[13] The maximum14-day running average of mean daily EC (mmhos/cm) depends on water year type.

	WESTERN DELTA				INTERIOR DELTA			
	Sac River @ Emmaton		SJR @ Jersey Point		Mokelumne R @ Terminous		SJR @ San Andreas	
Year Type	0.45 EC from April 1 to date shown	EC value from date shown to Aug15 *	0.45 EC from April 1 to date shown	EC value from date shown to Aug15 *	0.45 EC from April 1 to date shown	EC value from date shown to Aug15 *	0.45 EC from April 1 to date shown	EC value from date shown to Aug15 *
W	Aug 15		Aug 15		Aug 15		Aug 15	
AN	Jul 1	0.63	Aug 15		Aug 15		Aug 15	
BN	Jun 20	1.14	Jun 20	0.74	Aug 15		Aug 15	
D	Jun 15	1.67	Jun 15	1.35	Aug 15		Jun 25	0.58
C		2.78		2.20		0.54		0.87

* When no date is shown, EC limit continues from April 1.

[14] As per D-1641, for San Joaquin River at Vernalis: however, the April through August maximum 30- day running average EC for San Joaquin River at Brandt Bridge,Old River near Middle River, and Old River at Tracy Road Bridge shall be 1.0 EC until April 1, 2005 when the value will be 0.7 EC.

[15] Compliance will be determined between Jersey Point & Prisoners Point. Does not apply in critical years or in May when the May 90% forecast of SRI ≤ 8.1 MAF.

[16] During deficiency period, the maximum monthly average mhtEC at Western Suisun Marsh stations as per SMPA is:

Month	mhtEC
Oct	19.0
Nov	16.5
Dec-Mar	15.6
Apr	14.0
May	12.5

Footnotes continued on following page.

[17] In November, maximum monthly average mhtEC = 16.5 for Western Marsh stations and maximum monthly average mhtEC = 15.5 for Eastern Marsh stations in all periods types.

Table A

Number of Days When Max. Daily Average Electrical Conductivity of 2.64 mmhos/cm must be maintained at Chipps Island and Port Chicago. (This can also be met with a maximum 14-day running average EC of 2.64 mmhos/cm, or 3-day running average Delta outflows of 11,400 cfs and 29,200 cfs, respectively.) Port Chicago Standard is triggered only when the 14-day average EC for the last day of the previous month is 2.64 mmhos/cm or less. PMI is previous month's 8RI. If salinity/flow objectives are met for a greater number of days than required for any month, the excess days shall be applied towards the following month's requirement. The number of day's for values of the PMI between those specified below shall be determined by linear interpolation.

	Chipps Island (Chipps Island Station D10)				
PMI (TAF)	FEB	MAR	APR	MAY	JUN
≤ 500	0	0	0	0	0
750	0	0	0	0	0
1000	28*	12	2	0	0
1250	28	31	6	0	0
1500	28	31	13	0	0
1750	28	31	20	0	0
2000	28	31	25	1	0
2250	28	31	27	3	0
2500	28	31	29	11	1
2750	28	31	29	20	2
3000	28	31	30	27	4
3250	28	31	30	29	8
3500	28	31	30	30	13
3750	28	31	30	31	18
4000	28	31	30	31	23
4250	28	31	30	31	25
4500	28	31	30	31	27
4750	28	31	30	31	28
5000	28	31	30	31	29
5250	28	31	30	31	29
≥ 5500	28	31	30	31	30

	Port Chicago (Continuous recorder at Port Chicago)				
PMI (TAF)	FEB	MAR	APR	MAY	JUN
0	0	0	0	0	0
250	1	0	0	0	0
500	4	1	0	0	0
750	8	2	0	0	0
1000	12	4	0	0	0
1250	15	6	1	0	0
1500	18	9	1	0	0
1750	20	12	2	0	0
2000	21	15	4	0	0
2250	22	17	5	1	0
2500	23	19	8	1	0
2750	24	21	10	2	0
3000	25	23	12	4	0
3250	25	24	14	6	0
3500	25	25	16	9	0
3750	26	26	18	12	0
4000	26	27	20	15	0
4250	26	27	21	18	1
4500	26	28	23	21	2
4750	27	28	24	23	3
5000	27	28	25	25	4
5250	27	29	25	26	6
5500	27	29	26	28	9
5750	27	29	27	28	13
6000	27	29	27	29	16
6250	27	30	27	29	19
6500	27	30	28	30	22
6750	27	30	28	30	24
7000	27	30	28	30	26
7250	27	30	28	30	27
7500	27	30	29	30	28
7750	27	30	29	31	28
8000	27	30	29	31	29
8250	28	30	29	31	29
8500	28	30	29	31	29
8750	28	30	29	31	30
9000	28	30	29	31	30
9250	28	30	29	31	30
9500	28	31	29	31	30
9750	28	31	29	31	30
10000	28	31	30	31	30
> 10000	28	31	30	31	30

4.4.7 Stanislaus River

Under Alternative 2, Reclamation would operate New Melones Reservoir in accordance with the 1987 DFW agreement.

4.4.8 San Joaquin River

Alternative 2 would include implementation of the SJRRP and flows required in D-1641. D-1641 conditioned CVP water rights to meet flow requirements on the San Joaquin River at Vernalis from February to June to the extent possible.

D-1422 required Reclamation to operate New Melones Reservoir to maintain average monthly levels of 500 parts per million total dissolved solids in the San Joaquin River at Vernalis as it enters the Delta. D-1641 modified the water quality objectives at Vernalis to include the irrigation and nonirrigation season objectives contained in the Bay-Delta WQCP: average monthly electric conductivity of 0.7 mS/cm during the months of April through August and 1.0 mS/cm during the months of September through March.

4.5 Alternative 3

Alternative 3 would incorporate the same flow and operations as described in Alternative 2 to meet requirements in D-1641 and other legal requirements, but would also incorporate habitat restoration and intervention measures. Table 4.5-1 shows each of the components of Alternative 3, including whether each component is covered at a project or program level of analysis in this EIS. The table also indicates if a component involves construction. If not mentioned in the table, the operations of the No Action Alternative remain.

Table 4.5-1. Components of Alternative 3

Title	Project Level Analysis or Program-Level Analysis	Construction Effects
Upper Sacramento		
Operations to meet WRO 90-5 downstream temperature targets	Project	–
Operations to meet Delta standards in D-1641	Project	–
Cold Water Management Tools (e.g., Battle Creek Restoration, Intake Lowering near Wilkins Slough, Shasta TCD Improvements)	Program	–
Spawning and Rearing Habitat Restoration	Program	X
Small Screen Program	Program	X
Winter-Run Conservation Hatchery Production	Program	–
Adult Rescue	Program	–
Juvenile Trap and Haul	Program	–
Trinity		
Whiskeytown Reservoir Operations	Project	–
Feather River		
FERC Project #2100-134 controls operations; Alt 1 analyzes downstream of the FERC boundary	Project	–
American River		
2006 Flow Management Standard Releases	Project	–
Spawning and Rearing Habitat Restoration	Program	X
Drought Temperature Facility Improvements	Program	X

Title	Project Level Analysis or Program-Level Analysis	Construction Effects
Stanislaus		
1987 Reclamation, DFG agreement	Project	–
Spawning and Rearing Habitat Restoration	Program	X
Temperature Management Study	Program	–
San Joaquin		
Lower SJR Habitat Restoration	Program	X
Bay-Delta		
D-1641 control of exports, DCC operations, and Delta outflow	Project	–
Barker Slough PP Sediment and Aquatic Weed Removal	Project	-
Clifton Court Aquatic Weed and Algal Bloom Management	Project	–
Tracy Fish Collection Facility Operations CO2 Injection and Release Sites	Project	–
San Joaquin Basin Steelhead Telemetry Study	Project	–
Sacramento Deepwater Ship Channel Food Study	Program	–
North Delta Food Subsidies/Colusa Basin Drain Study	Program	–
Suisun Marsh Roaring River Distribution System Food Subsidies Study	Program	–
Habitat Restoration		
Predator Hot Spot Removal	Program	–
Additional habitat restoration (25,000 acres within the Delta)	Program	X
Facility Improvements		
Delta Cross Channel Gate Improvements	Program	X
Tracy Fish Facility Improvements	Program	X
Skinner Fish Facility Improvements	Program	X
Small Screen Program	Program	X
Fish Intervention		
Reintroduction efforts from Fish Conservation and Culture Laboratory	Project	–
Delta Fish Species Conservation Hatchery	Program	X

4.5.1 Upper Sacramento River

In addition to the operations described for Alternative 2, Alternative 3 would include spawning and rearing habitat restoration within the Sacramento River. These habitat restoration efforts would be the same as described for Alternative 1. Additionally, Alternative 3 would include intervention measures described for Alternative 1 (small screen program, adult rescue, and juvenile trap and haul).

4.5.2 Trinity River Division

As described in the No Action Alternative and Alternative 1, the Trinity River system would be operated according to the Trinity River ROD with lower Klamath River augmentation flows.

4.5.3 Clear Creek

Clear Creek base flows would be 50 to 100 cfs based on the 2000 agreement between Reclamation, USFWS, and DFG.

4.5.4 Feather River

Alternative 3 would be the same as the No Action Alternative and other Action Alternatives for the Feather River.

4.5.5 American River Division

Alternative 3 would follow the operations described for Alternative 2 but would also incorporate spawning and rearing habitat restoration as described for Alternative 1.

4.5.6 Bay-Delta

Alternative 3 would have flows and operations as described for Alternative 2, but would incorporate additional habitat and intervention measures. Alternative 3 would include the habitat restoration measures (food subsidies and tidal habitat restoration) described in Alternative 1. Alternative 3 would also include the intervention measures described in Alternative 1 (Barker Slough PP sediment and aquatic weed removal, Clifton Court aquatic weed removal, fish collection facility improvements, predator hotspot removal). In addition to the measures in Alternative 1, Alternative 3 would include 25,000 acres of habitat restoration within the Delta.

4.5.7 Stanislaus River

Alternative 3 would operate New Melones Reservoir based on the 1987 DFW agreement as described in Alternative 2. In addition, Alternative 3 would include spawning and rearing habitat restoration as described for Alternative 1.

4.5.8 San Joaquin River

Alternative 3 would include SJRRP and D-1641 flows, as described for Alternative 2. Additionally, Alternative 3 would include rearing habitat restoration on the Lower San Joaquin River, as described for Alternative 1.

4.6 Alternative 4

Alternative 4 includes management of storage facilities to preserve coldwater pool and additional instream flows in the Sacramento River and the Delta as proposed during scoping. Alternative 4 strives to meet instream flow targets by balancing instream flows with carryover storage sufficient to protect fish. Overall, this alternative prioritizes and attempts to hold water in storage to maintain the cold water pool while increasing instream flows to the extent possible. It would continue flood management and deliveries to senior water right holders. This alternative also would have the CVP and SWP operate to maintain a positive combined OMR from March through May.

Scoping comments proposed meeting a flow objective of 55% of unimpaired flows year round to mimic the natural hydrograph. However, a 55% requirement following the natural hydrograph results in high releases during winter and spring months, which constrain Reclamation's ability to meet cold water pool storage targets. Therefore, the flow objectives cannot be met in all conditions. For example, a flow action would not be taken in drier years to ensure cold water pool storage in reservoirs. During drier hydrologic conditions when the flow objectives are not met, Reclamation and DWR would operate the CVP and SWP to follow the operational objectives described in Alternative 1 and maintain the positive OMR. This operational regime would last from March through February, and the flow objectives would resume in the following March.

Table 4.6-1 shows each of the components of Alternative 4. The table includes a column that considers if a component is covered at a project or program level of analysis in this EIS and whether it involves construction actions. If not mentioned in the table, the operations of the No Action Alternative remain.

Table 4.6-1. Components of Alternative 4

Title	Project Level Analysis or Program-Level Analysis	Construction Effects
Upper Sacramento		
Operations to meet minimum instream flow requirement of 55% of unimpaired flow (reduced during Shasta Critical years)	Project	–
Trinity		
Whiskeytown Reservoir Operations	Project	–
Operations to meet Clear Creek water rights and agreements, and minimum instream flow requirement of 55% of unimpaired flow	Project	–
Grass Valley Creek Flows from Buckhorn Dam	Project	–
Feather River		
FERC Project #2100-134 controls operations of dam and low flow channel	Project	–
Minimum instream flow requirement of 55% of unimpaired flows (reduced during years with low storage or inflow conditions)	Project	–
American River		
2017 Flow Management Standard Releases and minimum instream flow requirement of 55% of unimpaired flow (reduced during years with low storage or inflow conditions)	Project	–
Stanislaus		
Stanislaus Stepped Release Plan	Project	–
Alteration of Stanislaus DO Requirement	Project	–

Title	Project Level Analysis or Program-Level Analysis	Construction Effects
Bay-Delta		
Export constraints from April through May depending on San Joaquin River flows	Project	–
Bypass of reservoir releases for fish so they become Delta outflows	Project	–
Positive OMR from March through May	Project	–
Tracy Fish Collection Facility Operations	Project	–
Skinner Fish Facility Operations	Project	–
U.C. Davis Fish Culture Center Refugial Population	Project	–
South-of-Delta Water Contractors		
Increased Water Use Efficiency	Program	X

4.6.1 Upper Sacramento River

In the Sacramento River system, balancing instream flow releases with water in storage (to maintain the coldwater pool) is critical for operations. Alternative 4 would increase instream flow releases with a target of 55% of unimpaired flows. Reclamation would release water from Shasta Reservoir to meet this flow target at the Sacramento River above Red Bluff and the confluence with the Feather River.

A "Shasta Critical" year is defined in CVP contracts as a year when forecasted inflow to Shasta Reservoir is less than 3.2 MAF, which represents a very dry year. During Shasta Critical years, Reclamation would reduce instream flow releases to less than the 55% target to maintain water in storage for coldwater pool. Model results show that this occurs in about 10% of years.

4.6.2 Trinity River Division

As described in the No Action Alternative and Alternative 1, the Trinity River system would be operated according to the Trinity River ROD with lower Klamath River augmentation flows. In addition to these operations, Reclamation would modify operations at Buckhorn Dam, as described below.

4.6.2.1 *Grass Valley Creek Flows from Buckhorn Dam*

Reclamation would release water from Buckhorn Dam to Grass Valley Creek in accordance with requirements published in the Buckhorn Dam and Buckhorn Reservoir standard operating procedures manual for water rights permit 18879 issued to DWR, which establishes the timing and magnitude of minimum flows and flushing flows from the dam. Flow from the dam outlet could be as low as 5 cfs in the bypass channel or as high as 100 cfs from spill during March or April, both of which are dependent on season and the hydrologic conditions. Additional flushing of the channel can occur during the winter months when the reservoir fills and spills water at a natural inflow rate, which may exceed 100 cfs.

In addition, Reclamation would increase flow from the dam outlet works for maintenance of the outlet channel and to cue juvenile salmonids in the reach to begin their downstream migration to the Trinity River. Reclamation would release pulse flows when the reservoir water elevation exceeds 2,803.13 feet above sea level between March 1 and April 15 to the extent feasible. Flow increases could range from 5 cfs to 100 cfs.

Reclamation would increase flow to the extent feasible in the outlet channel when necessary in October and November to provide adult Coho Salmon sufficient flow for upstream migration and spawning.

4.6.3 Clear Creek

Reclamation would release water from Whiskeytown Reservoir into Clear Creek to maintain flows at Igo that are 55% of unimpaired flows.

4.6.4 Feather River

Under Alternative 4, DWR would continue to operate Oroville Dam under the terms of its FERC license. The FERC license includes flow requirements in the Low Flow Channel just downstream from the dam that would govern these operations in Alternative 4. The FERC license also includes requirements downstream from the Thermalito outlet, but Alternative 4 would include additional flow targets. Under Alternative 4, DWR would operate Lake Oroville to maintain flows below the Thermalito outlet that are 55% of unimpaired flows. To balance these flow targets with water in storage, DWR would release less flow during years with low storage or forecasted inflow conditions. Model results show that this occurs in about 35% of years.

4.6.5 American River Division

Reclamation would operate the American River system consistent with the American River 2017 Flow Management Standard, with an additional target to have 55% unimpaired flow below Nimbus Dam. To balance these flow targets with water in storage, Reclamation would release less flow during years with low storage or forecasted inflow conditions. Model results show that this occurs in about 60% of years.

4.6.6 Bay-Delta

Releases from CVP and SWP reservoirs to meet the upstream flow targets would pass through the Delta and become Delta outflow. Additionally, Alternative 4 would include a positive combined OMR from March through May, subject to minimum health and safety pumping of 1,500 cfs.

4.6.7 Stanislaus River

Alternative 4 would include the Stepped Release Plan described in Alternative 1.

4.6.8 San Joaquin River

Alternative 4 would include SJRRP flows.

4.6.9 South-of-Delta Water Contractors

Alternative 4 includes increased water use efficiency for CVP and SWP contractors.

4.6.9.1 *Agricultural Water Use Efficiency*

Under Alternative 4, agricultural water users would increase irrigation efficiency by implementing additional efficient water management practices (EWMPs). A substantial amount of water use efficiency already occurs under the No Action Alternative, which would limit the opportunity for additional water made available through efficient practices. Under the No Action Alternative, Reclamation already requires CVP contractors to implement cost-effective BMPs to manage water use, based on CVPIA Section 3405(e). The CVPIA and Section 210(b) of the Reclamation Reform Act of 1982 require the preparation and submittal of a Water Management Plan. Additionally, the state of California requires development of Agricultural Water Management Plans for agricultural water suppliers that supply water to more than 25,000 acres and provides grant funding related to these plans for water suppliers to 10,000 to 25,000 acres. These plans need to include drought management plans and report on the status of EWMPs. EWMPs are required where they are technically feasible and locally cost-effective.

Alternative 4 would increase water use efficiency above current and proposed practices. Water suppliers and growers would need to identify and invest in additional district-level or on-farm practices to improve irrigation efficiency. The California Water Code (Section 10608.48) defines conditional EWMPs, and the practices that are feasible and cost-effective have already been implemented. This component could involve some of these conditional practices from the Water Code that have not yet been implemented:

- Alter land use for lands with exceptionally high water use or whose irrigation contributes to significant problems, including problem drainage
- Use available recycled water that otherwise would not be used beneficially, meets health and safety criteria, and does not harm crops or soils
- Install more efficient on-farm irrigation systems or technology to better manage existing systems
- Line canals in distribution systems or replace canals with pipes to reduce water losses
- Construct and operate supplier spill and tailwater systems
- Automate canal control devices to reduce losses
- Improve pump efficiencies in distribution systems

Some of these measures would involve construction of new facilities, such as new on-farm irrigation systems or distribution canal improvements.

4.6.9.2 *Municipal and Industrial Water Use Efficiency*

Similar to agricultural water use efficiency measures, a substantial amount of M&I water use efficiency has already been implemented or is planned for implementation under the No Action Alternative. In 2015, because of the prolonged drought conditions, Governor Brown called for a reduction in urban water use of 25% through improved water use efficiency. Urban water users were successful in reducing water use by 24% (DWR 2017). Governor Brown then issued Executive Order B-37-16 to extend these efforts with improved long-term urban water use efficiency. This Executive Order indicated a need for more local specificity in the target set in the Water Conservation Act of 2009 (SB X7-7), which mandated a 20 percent reduction in urban per capita use by 2020. The Executive Order established provisions for water agencies to develop targets based on individual information.

The Executive Order and SB X7-7 have pushed M&I water providers to implement cost-effective measures to increase water use efficiency. Under Alternative 4, this component would implement additional water use efficiency measures beyond what is already implemented or planned for implementation. Additional measures may include distribution system improvements, in-home modifications (plumbing and public outreach), landscape transformation, and commercial/industrial process improvements. Some of these measures would involve construction, such as distribution system improvements or landscape changes.

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Appendix D - Attachment 1

Appendix D1 Components for the Reinitiation of Consultation on Long-Term Operations

D1.1 Introduction

This appendix contains the components used for alternative formulation along with supporting performance analysis. Monitoring and the organization structure to accomplish reporting and adaptive management are described independent of the potential actions in a specific component. The implementation aspects are organized by:

- Watershed
  - Central Valley Wide
  - Upper Sacramento (Shasta and Sacramento Divisions)
  - Trinity River
  - Feather River
  - American River
  - Bay-Delta
  - Stanislaus River
  - San Joaquin River
  - Friant Division
- Category
  - Water Operation
  - Temperature Facility Improvements
  - Habitat
  - Flow Routing
  - Salvage Efficiency
  - Conservation Hatchery
  - Production Hatchery
  - Passage and Reintroduction
  - Diversion Screening

Component documentation includes:

- Title
- Summary

- Description
- Objectives
- Conceptual Model (CM) (Each Species and Life Stage)
- Current Condition
- Background
- Current Science
- Justification
- References

D1.2 Site-Specific Proposed Action

D1.2.1 Central Valley Wide

D1.2.1.1 *Water Operations*

D1.2.1.1.1 Coordinated Operation Agreement

Summary

United States Department of the Interior, Bureau of Reclamation and California Department of Water Resources (DWR) have agreed to revisions to the 1986 Coordinated Operations Agreement (COA) (Reclamation and DWR 1986), which establishes the mechanisms for coordinating operations of the Central Valley Project (CVP) and State Water Project (SWP). The California State Water Resources Control Board (SWRCB) conditioned Reclamation's and DWR's water rights individually to protect the beneficial uses of water within the CVP and SWP and jointly for the protection of beneficial uses in the Sacramento Valley and the Sacramento-San Joaquin Delta Estuary. Reclamation and DWR coordinate and operate the CVP and SWP to meet these requirements.

Description

The COA was signed by both Reclamation and DWR and authorized by Congress in 1986. It defines the project facilities and their water supplies, sets forth procedures for coordination of operations, and identifies formulas for sharing joint responsibilities for meeting Delta standards and other legal uses of water. It also identifies how unstored flow will be shared, sets up a framework for exchange of water and services between CVP and SWP, and provides for periodic review of the agreement.

Through the COA, Reclamation and DWR share the obligation for meeting in-basin uses. In-basin uses are defined in the COA as legal uses of water in the Sacramento Basin, including the water required for SWRCB Delta standards. Each project is obligated to ensure water is available for these uses. The respective degree of obligation depends on whether the Delta is in balanced or excess conditions.

Balanced water conditions are defined in the COA as periods when it is mutually agreed that releases from upstream reservoirs plus unregulated flows approximately equal the water supply needed to meet Sacramento Valley in-basin uses plus exports. During excess water conditions, sufficient water is available to meet all beneficial needs, and the CVP and SWP are not required to supplement the supply with water from reservoir storage. Under COA Article 6(g), Reclamation and DWR have the responsibility (during excess water conditions) to store and export as much water as possible within physical, legal, and contractual limits. In excess water conditions, water accounting is not required. However, during balanced water conditions, CVP and SWP share the responsibility in meeting in-basin uses.

Reclamation and DWR have agreed to modify four key elements of the COA to address changes since COA was originally signed: (1) in-basin uses; (2) export restrictions; (3) CVP's use of Harvey O Banks Pumping Plant (Banks Pumping Plant); and (4) periodic review. These elements are proposed to be updated as follows:

- In-basin use (COA Article 6(c)) – Sharing of Responsibility for Meeting Sacramento Valley In-basin Use with Storage Withdrawals During Balanced Water Conditions

  Each party's responsibility for making available storage withdrawals to meet Sacramento Valley in-basin use of storage withdrawals must be determined by multiplying the total Sacramento Valley in-basin use of storage withdrawals by the percentages in Table D1.2-1 (changed from 75% United States and 25% State of California).

  Table D1.2-1. Sharing of Requirements for Storage Withdrawals for In-basin Use.

Water Year Type*	United States	State of California
Wet	80%	20%
Above Normal	80%	20%
Below Normal	75%	25%
Dry	65%	35%
Critical	60%	40%

  *Water year types will be determined by the Sacramento Valley 40-30-30 index.

  The water year classifications described in Article 6(c) must be based on the Sacramento Valley 40-30-30 index as most recently published through DWR Bulletin 120. In a dry or critical year following two dry or critical years, the United States and the State will meet to discuss additional changes to the percentage sharing of responsibility to meet in-basin use.

- Sharing of Applicable Export Capacity When Exports Are Constrained

  During periods when exports are constrained by nondiscretionary requirements imposed on the CVP and SWP South Delta exports by any federal or state agency and the Delta is in balanced water conditions, CVP and SWP will share the total export capacity with Reclamation pumping up to 65% of the allowable total exports and DWR pumping the remaining capacity, no less than 35%.

  When restrictions are in place and the Delta has excess water conditions, CVP and SWP will share the available capacity with Reclamation pumping 60% and DWR pumping 40% of available water.

- CVP Use of Banks Pumping Plant

  DWR will transport up to 195,000 acre-feet (AF) of CVP water through the California Aqueduct Reaches 1, 2A, and 2B no later than November 30 of each year by direct diversion or by rediversion of stored CVP water at times those diversions do not adversely affect SWP purposes or do not conflict with SWP contract provisions. The State will provide available capacity to the CVP from the Banks Pumping Plant to divert or redivert 195,000 AF when the diversion capacity at the South Delta intake to Clifton Court Forebay exceeds 7,180 cubic feet per second (cfs) during July 1 through September 30. When the Delta has excess water conditions during July 1 through September 30, the diversion capacity at the South Delta intake to Clifton Court Forebay that exceeds 7,180 cfs will be shared equally by the State and the United States. Article 6(c) does not alter the Cross-Valley Canal contractors' priority to pump at the Banks Pumping Plant, as stated in Revised Water Rights Decision 1641 (March 15, 2000).

- Periodic Review (Article 14(b)(2): 24)

  Prior to December 31 of the fifth full year following execution of the revised COA and before December 31 of each fifth year thereafter or within 365 days of the implementation of new or revised requirements imposed jointly on CVP and SWP operations by any federal or state agency or prior to initiation of operation of a new or significantly modified facility of the United States or the State or more frequently if so requested by either party, the United States and the State jointly will review the operations of both the CVP and the SWP. The parties will (1) compare the relative success with which each party has had in meeting its objectives; (2) review operation studies supporting this agreement, including the assumptions contained therein; and (3) assess the influence of the factors and procedures of Article 6 in meeting each party's future objectives.

Objectives

Fisheries: juveniles at Chipps Island per Adult Return, Abundance

Conceptual Model (Each Species and Life stage)

Increased water in storage in Shasta reservoir could be used for multiple purposes to benefit fish. It could remain in storage as part of the cold water pool or be released at times that downstream flows would help fish. The Salmon and Sturgeon Assessment of Indicators by Life Stage (SAIL) CM indicated "Water temperature affects the rate of development of embryos and alevins" for Winter-Run Chinook Salmon. Increased flows could also help eggs survive by reducing stranding and dewatering. Regarding fry survival, the SAIL CM found "The foremost factor affecting migration, growth, and survival of SRWRC fry is habitat…" and "[i]ncreased instream flow affects many of these factors through dilution (e.g., toxicity and contaminants), reduction in water temperatures (which also affects DO, food availability, predation, pathogens, and disease) and entrainment and stranding risk." While this CM is specific to Winter-Run Chinook Salmon, the benefits of increased flow and decreased temperatures are similar for Spring-Run Chinook Salmon.

Flexibility on the American River system could help CV Steelhead and Fall-Run Chinook Salmon that reside in the Lower American River. There is no CM specific to steelhead and salmon on the American River, but the stressors are generally similar to Winter-Run Chinook Salmon. Decreased temperatures during the steelhead spawning and incubation period (roughly March and April) could extend the period with suitable conditions and benefit fish (Hannon and Deason 2005). Additionally, increased flows could reduce stranding or dewatering of redds.

Current Condition

Water is released from Shasta and Folsom Reservoirs to meet in-delta standards. Reclamation provides 75% of the water needed to meet these standards, and DWR provides 25% from Oroville Reservoir releases.

Background

Reclamation and DWR agreed to COA in 1986, when regulations governing operations were different. As water quality and flow requirements have increased, the agreement has become less applicable to current conditions.

Current Science

For Shasta Reservoir, Reclamation submits a Sacramento River Temperature Management Plan each spring to the SWRCB to comply with Water Rights Order 90-5. In 2014 and 2015, drought conditions resulted in limited supplies available to meet flow targets and to maintain temperatures within the Sacramento River. Warmer fall water temperatures resulted in Winter-Run Chinook Salmon mortality, but these effects were reduced in 2016 (NMFS 2018).

Drought conditions for the American River were similarly hard on steelhead and Fall-Run Chinook Salmon during 2014 and 2015. Monitoring in 2014 found that populations of both fish decreased substantially compared to 2013 (PSMFC 2014). Temperatures in 2014 and 2015 were warm enough that the Nimbus Fish Hatchery had to be evacuated (CDFW 2015).

Justification

Different sharing agreements between the CVP and SWP could result in more operational flexibility for fish and water supply.

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D1.2.2 Upper Sacramento River Basin (Shasta and Sacramento Divisions)

D1.2.2.1 *Water Operations*

D1.2.2.1.1 Shasta Temperature Management

Summary

Starting at a biologically relevant date in the spring, Reclamation would manage the available volume of cold water in Shasta Reservoir to meet or exceed a minimum level of Winter-Run Chinook Salmon egg incubation and emergence requirements for redds on the Sacramento River above Clear Creek (CCR). In years when Reclamation determines that temperature criteria would restrict water supply operations, Reclamation would optimize use of cold water by varying water temperatures based on stage-specific temperature-dependent mortality models, e.g., Anderson (2017) at CCR. In years when Reclamation determines that insufficient cold water is available to meet stage-specific requirements, Reclamation would manage release temperature at Keswick Dam to maximize Winter-Run Chinook Salmon survival based on available cold water and real-time monitoring of redd location.

Description

Spring Pulse Flows

In spring, Keswick Dam releases are gradually increased as flows are needed to support instream demands on the mainstem Sacramento River and Delta requirements. As a standard practice, Reclamation operates Shasta Reservoir in the spring to have storage in the reservoir high enough to use the Shasta Dam temperature control device (TCD) upper shutters by the end of May to maximize the cold water pool potential for Winter-Run Chinook Salmon egg incubation management.

Under the Core Water Operation, Reclamation would not release spring pulse flows unless the projected May 1 Shasta Reservoir storage is greater than 4 million acre-feet (MAF). If Shasta Reservoir total storage on May 1 is projected to be greater than 4 MAF, Reclamation would make a spring pulse release as long as the release would not cause Reclamation to drop into a lower tier of the Shasta Reservoir summer temperature management.

Spring Management of Spawning Locations

Reclamation and NMFS may agree as part of the Adaptive Management Implementation Plan to run experiments in individual years to determine if keeping water colder earlier induces earlier spawning or if keeping April and May Sacramento River temperatures warmer induces later spawning.

Temperature Management

The closer Shasta Reservoir is to full by the end of May, the greater the likelihood of being able to meet the Winter-Run Chinook Salmon temperature control criteria throughout the entire temperature control season. If Shasta Reservoir storage is high enough to use the Shasta Dam TCD upper shutters by the end of May, Reclamation can maximize the cold water pool potential. Storage of 3.66 MAF allows water to pass through the upper gates of the Shasta Dam TCD, but historical relationships suggest that a storage of 4 MAF on May 1 generally provides enough storage to continue operating through the upper gates and develop a sufficient cold water pool to meet 53.5 degrees Fahrenheit (°F) on the Sacramento River above Clear Creek (at the CCR gaging station) for Winter-Run Chinook Salmon. Figure D1.2-1 provides an approximate rule of thumb for the relationship between temperature compliance, total storage in Shasta Reservoir, and cold water pool in Shasta Reservoir.

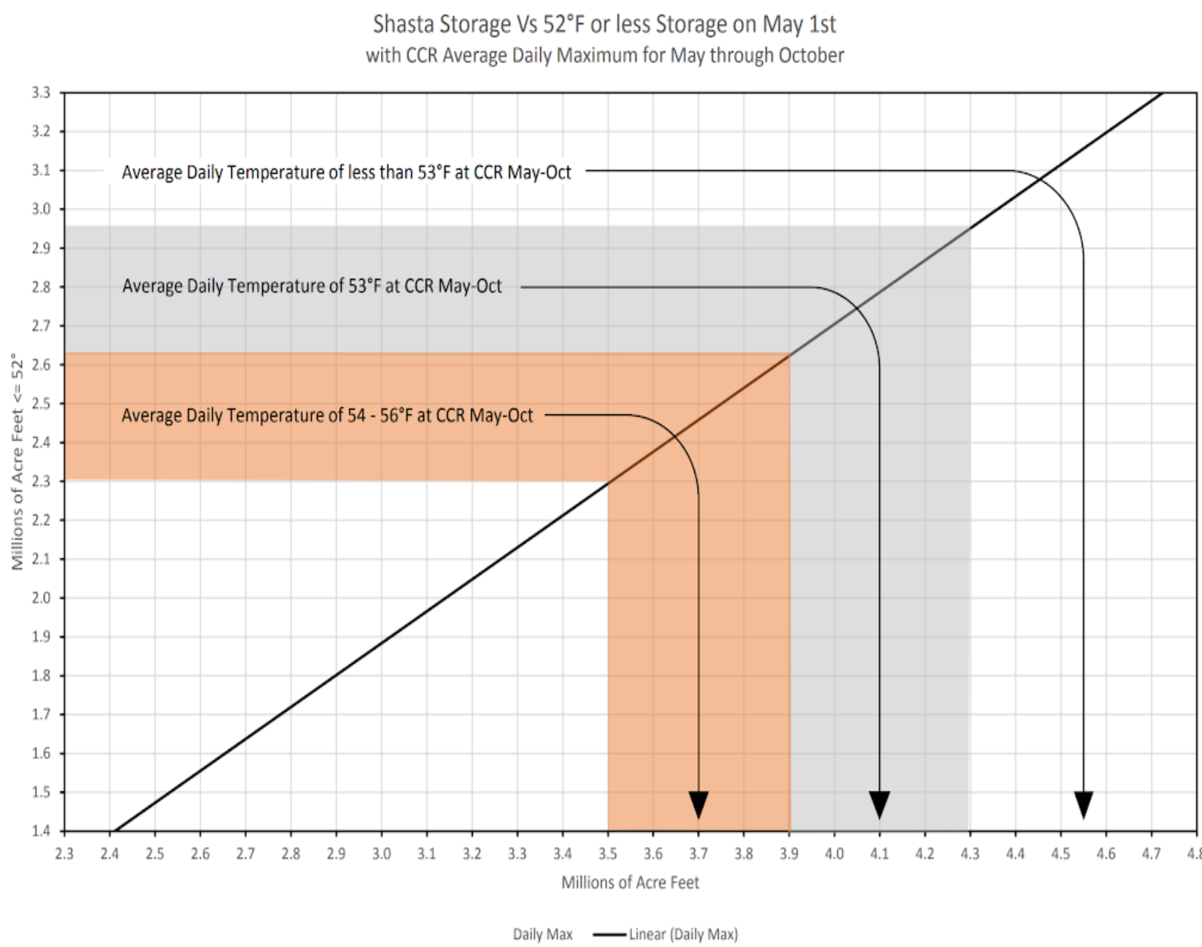

Figure D1.2-1. Relationship between Temperature, Shasta Storage, and Cold Water Pool

Summer Temperature Management

Reclamation proposes to operate the TCD at Shasta Dam to continue providing temperature management in accordance with the Central Valley Project Improvement Act (CVPIA) 3406(b)(6) while minimizing impacts to power generation. Reclamation proposes to address cold water management using a tiered strategy that allows for strategically selected temperature objectives based on projected total storage and cold water pool, meteorology, Delta conditions, and habitat suitability for incoming fish population size and location. The proposed tiers (Tiers 1 through 4) are described below.

In any given year, cold water pool and storage could result in Reclamation switching between tiers within the year if needed to optimally use the cold water pool. Cold water pool is defined as the volume of water in Shasta Lake that is less than 52°F, which Reclamation would determine based on monthly (or more frequently) reservoir temperature profiles. Reclamation will use the most recent reservoir temperature profile to develop the May temperature management plan and any necessary updates. The Sacramento River at CCR is a surrogate for the downstream most redd. Temperature management would start after May 15 or when the Winter-Run Chinook Salmon monitoring team determines, based on real-time monitoring, that Winter-Run Chinook Salmon have spawned, whichever is later. Temperature management ends October 31 or when the Winter-Run Chinook Salmon monitoring team determines, based on real-time monitoring, that 95% of Winter-Run Chinook Salmon redds' eggs have emerged, whichever is earlier.

Tier 1

Temperature management would start after May 15 or when the Winter-Run Chinook Salmon monitoring team determines, based on real-time monitoring, that Winter-Run Chinook Salmon have spawned, whichever is later. In years when Reclamation determines that cold water pool is sufficient (more than 2.8 MAF of cold water pool in Shasta Reservoir at the beginning of May or modeling suggests that a daily average temperature of 53.5°F at CCR can be maintained from May 15 to October 31), Reclamation proposes to operate to a daily average temperature of 53.5°F at the Sacramento River above CCR to avoid temperature-dependent mortality based on the latest egg mortality models. Reclamation proposes to operate to this temperature until the Winter-Run Chinook Salmon monitoring team determines, based on real-time monitoring, that 95% of the Winter-Run Chinook Salmon redds' eggs have emerged or October 31, whichever is earlier.

Tier 2

In years when cold water pool is insufficient to allow Tier 1 or above (less than 2.8 MAF of cold water pool in Shasta Reservoir at the beginning of May or modeling suggests the 53.5°F at CCR cannot be maintained from May 15 to October 31), Reclamation would optimize use of cold water for Winter-Run Chinook Salmon eggs based on life stage specific requirements, reducing the duration of time that ideal water temperature targets are met. Water temperatures at CCR would vary based on real-time monitoring of redd timing and life stage-specific temperature-dependent mortality models, e.g., Anderson (2017). The period of 53.5°F at CCR would be centered around the projected period when the Winter-Run Chinook Salmon eggs have the highest dissolved oxygen requirement (37 to 67 days post-fertilization). At 2.79 MAF of cold water pool, Reclamation would operate to 53.5°F from 37 days after the first observed redd to 67 days after the last observed redd, as long as it is earlier than October 31. The duration of the 53.5°F protection will decrease in proportion to the available cold water pool on May 1. Reclamation will determine this period by running different temperature scenarios through the latest egg mortality model(s) and real-time monitoring of redds. Daily average temperatures at CCR during the temperature management season outside of the stage-specific critical window would not exceed 56°F without prior coordination with NMFS and U.S. Fish and Wildlife Service (USFWS).

Tier 3

When Reclamation determines that life stage-specific temperature targets cannot be met per Tier 2 above (less than 2.3 MAF of cold water pool in Shasta Reservoir at the beginning of May), Reclamation proposes to use cold water pool releases to maximize Winter-Run Chinook Salmon redd survival by increasing the coldest water temperature target (see Figure D1.2-2 below). At the highest storage levels in Tier 3, the targeted temperature at CCR will be a daily average of 53.5°F and, as storage decreases, would warm in the life stage-specific critical period up to 56°F. Reclamation would increase the temperature while minimizing adverse effects to the greatest extent possible, as determined by the latest egg mortality models, real-time monitoring, and expected and current water availability. This tier would be in effect until Reclamation could no longer meet 56°F at CCR.

Tier 4

If there is less than 2.5 MAF of total storage (note the use of "total" storage as opposed to the "cold water pool" used in the previous criteria) in Shasta Reservoir at the beginning of May, Reclamation will attempt to operate to a less than optimal temperature target and period that is determined in real-time with technical assistance from NMFS and USFWS. Reclamation proposes to implement intervention measures (such as increasing hatchery intake, as described below).

Figure D1.2-2 shows potential examples of the four different methods.

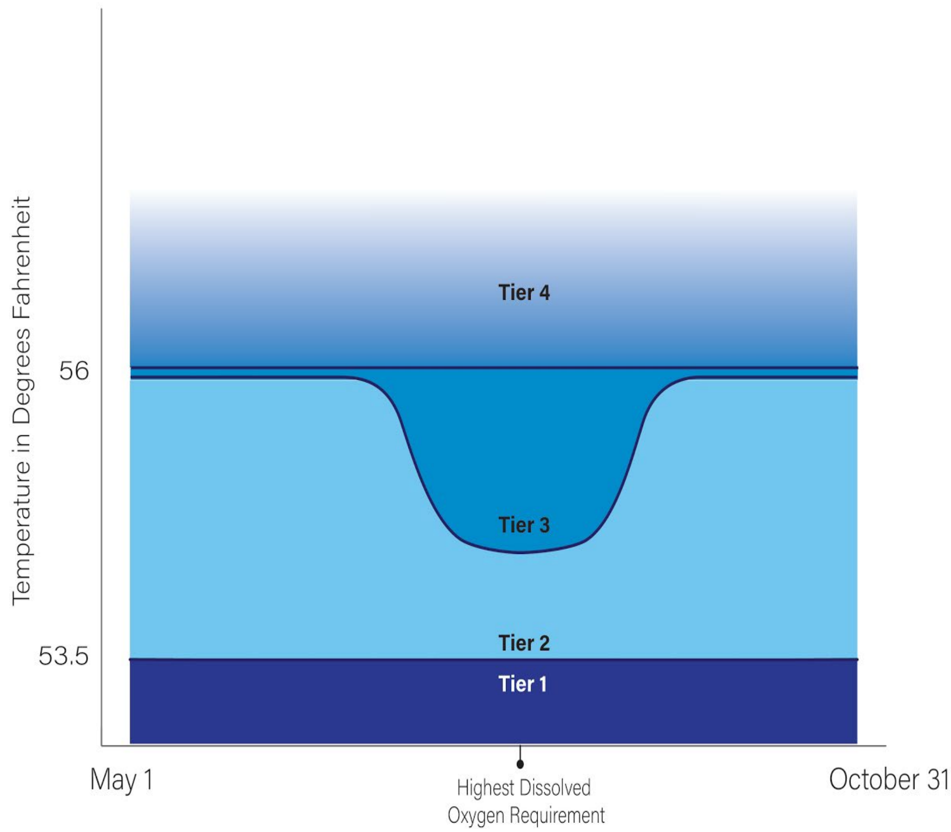

Figure D1.2-2. Tiers for Shasta Temperature Management

Figure D1.2-3 provides a decision tree explaining the decision points for Shasta Reservoir temperature management.

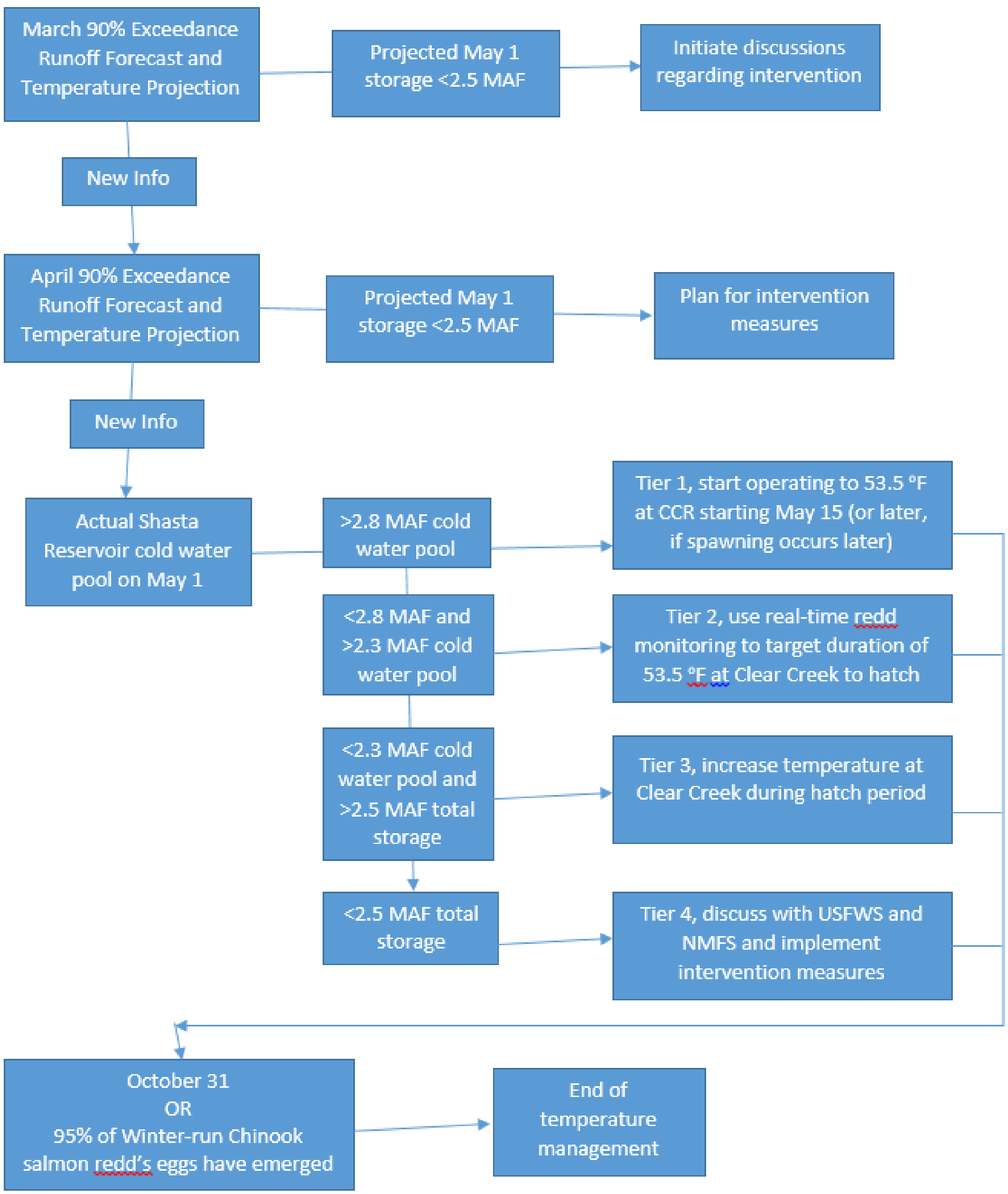

Figure D1.2-3. Shasta Temperature Management Decision Tree

At the March forecast (mid-March), if the forecasted Shasta Lake total storage is projected to be below 2.5 MAF at the end of May, Reclamation would initiate discussions with USFWS and NMFS on potential intervention measures, if the low storage condition continues into April and May, as described in Tier 4.

Reclamation proposes to perform the first temperature model run in April after DWR Bulletin 120 has been received and the operations forecast completed. This is the first month that a temperature model run is feasible based on temperature profiles. Prior to April, there is insufficient stratification in Shasta Lake to allow a temperature model to provide meaningful results. The April temperature model scenario is used to develop an initial temperature plan for submittal to the SWRCB under WRO 90-5. This temperature plan may be updated as Reclamation has improved data on reservoir storage and cold water pool via the reservoir profiles at the end of May and throughout the temperature control season.

Reclamation intends to provide temperature profile measurements for Shasta, Whiskeytown, and Trinity Reservoirs in Water Year 2019 as shown in Table D1.2-2.

Table D1.2-2. Temperature Profile Measurements for Shasta, Whiskeytown, and Trinity Reservoirs

Reservoir	Every Month	Every Two Weeks	Every Week	Comment
Shasta	01/01–03/01 12/1–12/31	03/01–05/01 11/15–12/01	05/01–11/15	25-foot intervals for “every month,” otherwise 5-foot intervals
Whiskeytown	01/01–12/31			25-foot intervals
Trinity	01/01–12/31			25-foot intervals

Reclamation proposes to provide a draft temperature management plan to the Sacramento River Temperature Task Group in April for its review and comment per WRO 90-5. Reclamation’s proposed April temperature management plan will describe the four tiers below Reclamation projects for that year’s summer temperature management season along with a temperature modeling scenario and operations forecast. SWRCB has overall authority to determine if the plan is sufficient to meet water right permit requirements.

Reclamation proposes to incorporate drought protection into water supply allocations and to implement CVPIA 3406(b)(19).

<u>Fall and Winter Refill and Redd Dewatering</u>

Reclamation proposes to rebuild storage and the cold water pool for the subsequent year. Maintaining releases to keep late spawning Winter-Run Chinook Salmon redds underwater may decrease storage necessary for temperature management in a subsequent year. Reclamation will minimize effects with a risk analysis of the remaining Winter-Run Chinook Salmon redds, the probability of sufficient cold water in the subsequent year, and conservative distribution and timing of subsequent Winter-Run Chinook Salmon redds. If maintaining flows puts the subsequent Winter-Run Chinook Salmon year class at a 10% temperature-dependent egg mortality risk, Reclamation will reduce releases to rebuild storage.

Demands by the national wildlife refuges, upstream CVP contractors, and Sacramento River Settlement Contractors in October result in Keswick releases that are generally not maintained throughout the winter due to needs to store water for beneficial uses the following year. These releases result in some early fall Chinook redds being dewatered at winter base flows.

Following the emergence of Winter-Run Chinook Salmon and prior to the majority of Fall-Run Chinook Salmon spawning, upstream Sacramento Valley CVP contractors and Sacramento River Settlement Contractors propose to work to synchronize their diversions to lower peak rice decomposition demand. With lower late October and early November flows, Fall-Run Chinook Salmon are less likely to spawn in shallow areas that would be subject to dewatering during winter base flows. Reductions would balance the potential for dewatering late spawning Winter-Run Chinook Salmon redds.

Targets for winter base flows (December 1 through end of February) from Keswick would be set in October and would be based on Shasta Reservoir end-of-September storage. These targets would be set based on end-of-September storage and current hydrology. These base flows would be set based on historical performance to accomplish improved refill capabilities for Shasta Reservoir to build cold water pool for the following year.

Table D1.2-3 shows examples of possible Keswick releases based on Shasta storage condition; these would be refined through modeling efforts.

Table D1.2-3. Keswick Release Schedule for End-of-September Storage

Keswick Release (cfs)	Shasta End-of-September Storage
3,250 cfs	< 2.2 MAF
4,000 cfs	< 2.8 MAF
5,000 cfs	> 3.2 MAF

Objectives

- Fundamental objectives: Increase juveniles at Chipps Island per adult return.
- Means objectives: Productivity.

Conceptual Model

The SAIL report for Winter-Run Chinook Salmon states,

> "Water temperature affects the rate of development of embryos and alevins (H7; Beachum and Murray 1990; Rombough 1988). It is recommended that temperature does not exceed 56°F to avoid egg mortality (Slater 1963; Myrick and Cech 2004). The amount of cold water available to achieve optimal temperature for this life stage varies as a function of the amount of cumulative precipitation, reservoir stratification, and previous water operations. Water temperature also affects the saturation concentration of dissolved oxygen within the stream. Dissolved oxygen has been positively correlated with Chinook larval growth up to a concentration of ~ 11 mg O2/L, however the concentration within the Central Valley is typically less, resulting in embryo and alevin development to potentially be stunted (H5; Mesick 2001). Pathogens, disease, and contaminants affect the survival of eggs and the condition of emerging fry and can be exacerbated by increased water temperature and reductions in flow (H9, H2; McCullough 1999; Scholz et al. 2000). Water temperature can also impact the predation rate on eggs, embryos, and fry as predator metabolic demands increase with temperature (H9)."

For fry the SAIL report states, "[a]ll historical SRWRC rearing habitat has been blocked since the construction of Shasta Dam, confining fry to the low elevation habitats on the Sacramento River. Remaining rearing areas are dependent on cold water releases from Shasta Dam in order to sustain the remnant population (H7)."

Current Condition

The 2009 NMFS Biological Opinion (BO) Reasonable and Prudent Alternative (RPA) Action I.2.4 requires, in part,

> "daily average water temperatures not in excess of 56 degrees Fahrenheit at compliance locations between Balls Ferry and Bend Bridge from May 15 through September 30 for protection of winter-run, and the same requirement in the same area through October 31 for protection of mainstem spring-run."

Background

Prior to the passage of the CVPIA in 1992, Reclamation was able to function as a multiyear project. This means that end of year reservoir storages were higher to allow for carryover storage into the next year to help protect against a drought. However, since the passage of CVPIA, the projects have come under increasing pressure to provide water for environmental protections, which has resulted in decreased ability to allocate water to CVP contractors that then has resulted in additional pressure being applied to Reclamation from contractors to allocate additional water. As a result, the reservoirs are drawn down lower more frequently to meet the additional demands. The combined effect of these actions is that the CVP now operates primarily as an annual project. Only in the wettest years is Reclamation able to carry over supplies into the following year for drought protection.

If releases are reduced during some time frames to maintain higher storage levels in reservoirs, they have a corresponding effect in reducing inflows to the Delta, which then reduces Delta outflows. Reduced Delta outflows may have a negative impact on Delta fisheries. The benefit of increased reservoir storage has to be weighed against the potential negative downstream impacts to fisheries. In addition, maintaining a higher carryover storage increases the risk of having to make flood control releases early in the season to draw down to the required maximum flood conservation space. Making flood control releases in October and November to draw down to the required maximum storage conflicts with Winter-Run Chinook Salmon needs, for which Reclamation reduces flows rapidly during the fall to encourage development of the cold water pool for the following year.

Inflow to Shasta Reservoir, while not absent during summer, is mostly from winter rain and spring snowmelt between November and May. By April the reservoir has received almost all expected inflows. Therefore, Shasta Reservoir operations for the Sacramento River between April and October are working with a mostly known volume of water. April and May is when the reservoir begins to warm, stratify, and form a warm pool layer. Between May and October is when the Winter-Run Chinook Salmon spawn; with the majority spawning in June and July (WRC 2018). Between May and October is the only time when temperature management occurs because it is the only time that has a warm pool and that Winter-Run Chinook Salmon eggs are temperature sensitive. Temperature management during this period includes the concept of "hedging," a small certain loss now to reduce larger future risks. Hedging for temperature starts in May at the beginning of the temperature planning season. Between May and October the system must meet specific downstream temperature targets, which require optimal combinations of warm and cold pool storage during the stratified May through October period and optimal volumes of cold storage during the mixed November through April time. When operating with full delivery allocations and temperature requirements, the reservoir always empties by the second year, independently of whether hedging or a static Sacramento River temperature target is used.

On January 19, 2017, NMFS transmitted a proposed amendment to the 2011 amended RPA for Shasta Reservoir operations (RPA Action Suite I.2). The amendment included minimum storage targets between April 1 and May 31 between 3.5 MAF and 4.2 MAF, depending on water year type, and end of season storage between 1.9 MAF and 3.2 MAF, depending on water year type. Reclamation implemented a pilot program in 2017 for the draft amendment and modeled the draft amendment. The amendment's storage targets resulted in hundreds of thousands of acre-feet reduction in CVP water user deliveries.

Described below are water years, which showcase the difficulty of meeting temperature targets with a limited cold water pool and conflicting objectives during period of drought and the resulting redd counts from those years.

During water year 2013, 23 redds were counted in July near Keswick Dam in temperatures between 54 to 55°F. The weighted average mortality was 14% overall. On March 8, Keswick Dam releases were increased to support D-1641 flow requirements. By April 12, Keswick Dam releases increased to 5,700 cfs and as high as 13,00 cfs by mid-May due to Wilkins Slough flow objectives and Delta requirements. By June, depletions in the Sacramento River were the highest on record. Due to low storage and elevation in the Shasta Reservoir, the middle shutters on the TCD were required to be open sooner than desired to meet hydraulic operational criteria. Opening the middle shutters sooner than projected depleted the cold water pool earlier than expected. Reclamation continued to meet temperature compliance at Airport Road from May to August.

During water year 2014, 20 redds were surveyed in temperatures of at least 54 to 55°F with half of those surveyed in 55 to 56°F between June to late July. The weighted average observed mortality of all the redds for water year 2014 was 79.1%. Water year 2014 was a critically dry year and initial carryover storage in Shasta Reservoir was 1.9 MAF. In late April, the temperature target at CCR was changed to 56°F based on late April temperature analysis. Due to a calibration error, the temperature modeling showed trending Keswick Dam temperature to be 1°F lower than the actual trend. This likely further depleted the cold water pool sooner than necessary.

During water year 2015, 27 redds were surveyed. Nineteen redds were surveyed in temperatures between 56 to 57°F, seven were surveyed in temperatures of 55 to 56°F,and one was surveyed in temperatures of 54 to 55°F. For all Redds surveyed during water year 2015, there was a weighted average observed mortality of 88.9%. Water year 2015 was a critically dry year and initial carryover storage in Shasta Reservoir was 1.15 MAF. A target of 57°F, not to exceed 58°F, was conducted for CCR compliance location in mid-April and this extended the cold water pool.

Current Science

According to a recent paper, approximately 53.6°F) is the critical temperature for Winter-Run Chinook Salmon egg incubation (Martin et al. 2017).

> "Hatching is an important transition in the incubation because eggs obtain oxygen by diffusive flux across the egg membrane while alevin obtain oxygen by pumping water through their gills (Wells and Pinder 1996). This switch from diffusive to pump transport, greatly increases the fish's ability to tolerate low oxygen after hatching. The critical oxygen level below which routine metabolism becomes dependent on the ambient oxygen rises steadily during egg development and then drops about 50% after hatching (Rombough 2007). Additionally, the post-hatching oxygen sensitivity is essentially independent of incubation temperature (Rombough 1986). Thus, sensitivity to low oxygen increases steadily during egg development and then drops rapidly and stabilizes in the alevin stage." (Anderson 2018, pre-print)

Anderson (2018, pre-print) compared the Martin egg mortality model (Martin et al. 2017), which is the NMFS-SWFSC temperature-dependent mortality model, with several expanded models. Model I, developed by Martin et al. (2017), expresses thermal mortality independent of the stage or age of incubation and background mortality independent of redd location. Model II extends Model I with age-dependent thermal mortality and Model III adds river reach-specific background mortality. According to Anderson, the models with the finer spatial and temporal resolution (Models II and III) predict reservoir operations that require less flow and better protect fish. Thus, there could be benefits to Reclamation to use Model II and/or III instead of the Martin model for Sacramento River temperature management.

Reclamation's proposed action incorporates the concept of risk management, or what some refer to as "hedging": a small certain loss now to reduce larger future risks. Examples of this include intentionally releasing small floods to avoid large ones, or conserving some storage and causing some immediate shortage to avoid deeper drought. For reservoirs for which cold water limits meeting downstream temperature and flow goals, there is a set of months, seasons and years for which expected and available water supply render meeting downstream targets unachievable, another set for which meeting temperature targets requires careful planning, and another set for which incoming fish population size is too small to warrant water use for temperature management under extreme drought conditions (Adams, 2017).

Justification

The proposed action includes operating to 53.5 degrees at Clear Creek (Tier 1) when May 1 Shasta cold water pool is more than 2.8 MAF, which occurs 47% of the time. In a Tier 1 year, Reclamation would operate to a temperature which is colder than recommended by the CM and operate to this temperature from May 15 to October 31 (or a shorter window, based on real-time monitoring of the Winter-Run Chinook Salmon). Tier 1 should have limited if any mortality of Winter-Run Chinook Salmon eggs, as it provides colder than the ideal temperature of 53.7 degrees Fahrenheit per Martin, 2017. Occasional redds emerge downstream of Clear Creek, and these redds (depending on the distance downstream and the warming) could experience warmer temperatures than ideal, and should be the only sources of mortality in Tier 1.

In Tier 2, Reclamation operates to 53.5 degrees Fahrenheit at Clear Creek for the critical period based on Anderson, 2017, which is tied to the maximum dissolved oxygen requirement right before hatch. Under the Jim Anderson Model (II / III), the duration of temperature control would be shorter. In essence, incorporating age and reach-specific dissolved oxygen requirements might provide the same thermal protection as the current RPA or NMFS' amendment, but use less water in normal years. It may also provide better protection of Winter-Run Chinook Salmon eggs in dry and critical dry years (Anderson, 2018).

The strategy proposed by NMFS in the draft Shasta RPA amendment process maintains the duration and raises the compliance temperature in drier years. Reclamation takes a similar approach in Tier 3 of the Shasta temperature action, keeping the duration of the critical dissolved oxygen requirement cold water temperature time period, but increasing the temperature due to drier hydrology with a smaller cold water pool.

Between 2003 and 2018, Winter-Run Chinook Salmon fish count surveys only found an expected three spawning fish in April below Shasta Dam (wrc, 2018). Thus, Reclamation's proposed action starts temperature management on May 15 or later, depending on Winter-Run Chinook Salmon spawning. However, statistical analysis indicates a correlation between warmer April temperatures and later Winter-Run Chinook Salmon spawning (Hendrix 2017).

Movement of the compliance location to the CCR gaging station provides for targeting consistent temperatures closer to the location of actual anticipated spawning. Table D1.2-4 shows the percentage of aerial redds located between Airport Road Bridge and Keswick Dam on the Sacramento River for all salmonid runs from 2001 to 2018. The area between Airport Road Bridge and Keswick Dam is located upstream from the current compliance location. High percentages of redds from Winter-Run and Late-Fall-Run Chinook Salmon are consistently spawned in this area. Focusing on the location of anticipated spawning area may benefit cold water pool storage in the fall months.

Table D1.2-4. Percentage of Aerial Redds between Airport Road Bridge and Keswick Dam on the Sacramento River

Year	Late-Fall	Winter	Spring	Fall
2001	68.1%	94.8%	24.1%	22.4%
2002	66.8%	98.2%	45.7%	25.7%
2003	85.3%	99.3%	59.1%	12.6%
2004	93.4%	99.7%	95.5%	19.9%
2005	52.1%	99.8%	69.5%	39.3%
2006	38.0%	99.7%	83.9%	30.7%
2007	61.9%	94.1%	63.3%	36.6%
2008	66.5%	99.8%	78.3%	25.6%
2009	85.4%	100%	N/S	42.0%
2010	73.1%	100%	33.3%	40.0%
2011	97.6%	100%	N/A	36.7%
2012	86.1%	100%	N/A	43.9%
2013	N/A	99.8%	100%	42.4%
2014	67.0%	100%	N/A	38.5%
2015	N/A	100%	N/A	32.9%
2016	100%	100%	100%	62.3%
2017	89.7%	100%	100%	70.6%
2018	87.8%	100%	N/S	N/S

N/S indicates not surveyed
N/A indicates no redds observed

As discussed above, Reclamation has incorporated “hedging” into its proposed action. Reclamation is willing to accept a certain reduction in this year’s juvenile outmigration (lack of spring pulse flows) if the anticipated impacts of reduced cold water pool on next year’s eggs are greater. If Shasta total storage on May 1 is projected to be greater than 4 MAF, Reclamation would make a Spring pulse release as long as the release would not cause Reclamation to drop into a lower Tier of the Shasta summer temperature management. 4 MAF of storage on May 1 is a Tier 1 year. Dropping from Tier 1 to 2 or especially from Tier 2 to 3, is anticipated to have a larger effect on next year’s temperature-dependent egg mortality than the benefit of spring pulses on this year’s juvenile outmigration. The March and April time period during juvenile outmigration is critical due to the in-progress stratification of Shasta Reservoir, and therefore uncertain volume of cold water pool.

Similarly, Reclamation has incorporated hedging into fall baseflow releases. Reclamation will minimize effects with a risk analysis of the remaining Winter-Run Chinook Salmon redds, the probability of sufficient cold water in the subsequent year, and conservative distribution and timing of subsequent Winter-Run Chinook Salmon redds. If maintaining fall / winter baseflows flows puts the subsequent Winter-Run Chinook Salmon year class at a 10% temperature-dependent egg mortality risk, Reclamation will reduce releases to rebuild storage. The certain risk of dewatering a small percentage (<10%) of this year’s Winter-Run Chinook Salmon redds is less than the uncertain risk of impacting 10% of next year’s Winter-Run Chinook Salmon eggs.

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D1.2.2.1.2 <u>Operation of a Shasta Dam Raise</u>

Summary

In the long-term, Reclamation proposes to enlarge Shasta Dam and Reservoir by raising the dam crest 18.5 feet. The additional storage created by the 18.5-foot dam raise would be used to improve the ability to meet water temperature objectives and habitat requirements for salmonids during drought years and increase water supply reliability.

Description

Reclamation would operate a raised Shasta Dam consistent with scenario CP4A in the 2015 Shasta Lake Water Resources Investigation Feasibility Report, for CVP operation only. CP4A focuses on increasing anadromous fish survival, while also increasing water supply reliability. An 18.5 foot raise would increase storage by approximately 634 TAF. Operation under scenario CP4A would include a dedicated cold water storage of 191 TAF, that acts as a thermal cap to chill the rest of the stored water. Operations for the remaining portion of increased storage (approximately 443 TAF) would be 120 TAF reserved in dry years and 60 TAF reserved in critical years to focus on CVP deliveries. Reclamation conducted modeling for CP4A that looked at CVP only, as described in Table D1.2-5.

Table D1.2-5. Increases in CVP and SWP Deliveries (average all years).

	CP4A (acre-feet)	CP4A CVP Only (acre-feet) (approximate)
Agriculture	31,700	65,500
M&I	19,900	4,700

Objectives

- Fundamental objectives: Increase juveniles at Chipps Island per adult return and maintain minimum population during drought.
- Means objectives: Abundance and productivity.

Conceptual Model (Each Species and Life Stage)

Winter-Run Chinook Salmon spawn in the upper Sacramento River, extending from just below Keswick Dam to approximately 60 miles downstream to Red Bluff Diversion Dam, though most spawning occurs within the first 10 miles below Keswick Dam (Windell 2017). Water temperature affects the rate of development of embryos and alevins (Rombough 1988, Beacham and Murray 1990) and temperature should not exceed 56 °F (13.3 °C) to avoid egg mortality (Myrick and Cech 2004). The amount of cold water available to achieve optimal temperature for this life stage varies as a function of the amount of cumulative precipitation, reservoir stratification, and previous Shasta Reservoir water operations.

Winter-Run Chinook Salmon fry begin to emerge from the gravel and start exogenous feeding from July–October (Fisher 1994). Optimal water temperatures for juvenile Chinook Salmon rearing range from 53.6–57.2°F (12–14°C). A daily average water temperature of 60°F (15.5°C) is considered the upper temperature limit for juvenile Chinook Salmon growth and rearing (NMFS 1997). Inhibition of Chinook Salmon smolt development in the Sacramento River may occur at water temperatures above 63°F (17.2°C; Marine and Cech 2004).

Current Condition

Reclamation, in coordination with NMFS, USFWS, DWR, CDFW, and the State Water Resources Control Board (State Water Board), developed a Shasta Temperature Management Plan to develop temperature management criteria and related operations that reduce the risk to Winter-Run Chinook Salmon and maintain water supply operations and deliveries. The biological objectives include the following:

- Target 57°F at CCR, not to exceed 58°F unless going above is needed to conserve cold water pool based on real-time temperature management team guidance.
- Develop a base operation that meets this temperature objective and delays last TCD side gate operation until mid-October (target October 15th).
- Develop a rigorous real-time management process that carefully tracks river temperatures, air temperatures, and biological metrics to ensure that water releases are made for the sole purpose of optimizing limited cold water pool resources throughout the season.
- Minimize the potential for Fall-Run Chinook Salmon redd dewatering in October and November.
- Retain wildlife refuge water supply planning objectives to the maximum extent feasible, consistent with previous considerations.

Base operations are set at the following:

- Establish 7,250 cfs as a base flow from Keswick Dam in June and July.
- Modeled Keswick releases in other months that achieve the above objectives are August 7,250 cfs; September 6,500 cfs; October 5,000 cfs. These are subject to adjustment by the real-time monitoring and decision making group based on performance of the plan in June and July.

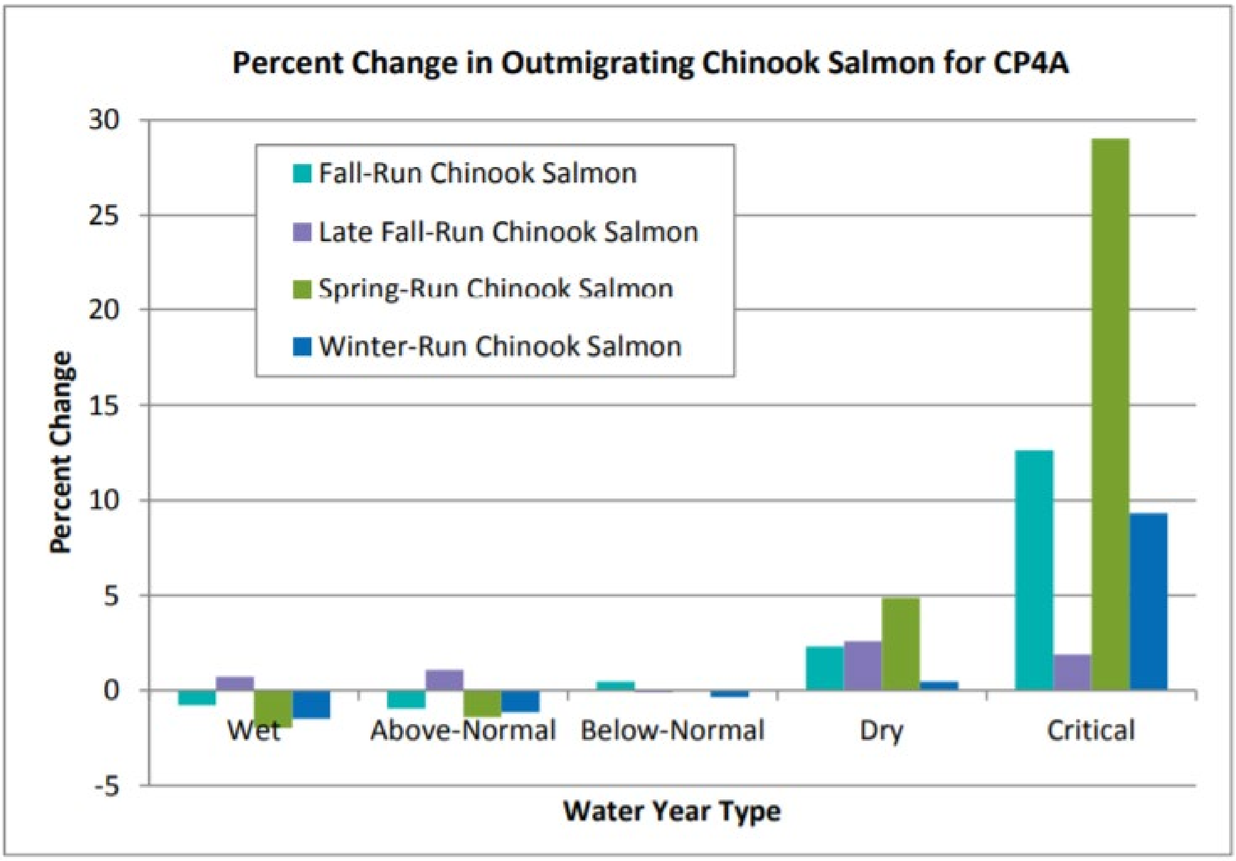
Actual operations will be decided using a real-time monitoring and decision making process that includes representatives from the relevant Federal and State agencies. This decision making process may yield adjustments to base operations depending on real-time conditions on the ground (e.g., real-time water temperatures and resulting cold water pool volume). Reclamation will convene the real-time monitoring and decision making group at least weekly, and more frequently if necessary to inform decisions about temperature operations. The agencies also acknowledge the expertise of water districts and irrigation districts to operate their systems in partnership with the agencies to optimize results and minimize impacts. The agencies expect to work closely during real-time operations with such districts.

Background

Despite projections and modeling efforts in 2014, Shasta Reservoir ran out of sufficiently cold water in September 2014. After this point, there was insufficient cold water available for release to the Sacramento River to manage temperatures. This lack of ability to regulate temperature was a primary factor contributing to the loss of 95% of the previous year class of wild Sacramento River Winter-Run Chinook Salmon.

Current Science

Reclamation would manage the cold-water pool each year based on recommendations from Sacramento River Temperature Task Group. The adaptive management plan may include operational changes to the timing and magnitude of releases from Shasta Dam for the benefit of anadromous fish, as long as there are no conflicts with current operational guidelines or adverse impacts to water supply reliability. To assess the effects of operations on Chinook Salmon in the upper Sacramento River, the computer model SALMOD would evaluate changes in Chinook Salmon population between Keswick Dam and the Red Bluff Pumping Plant. In response to changes in Shasta Reservoir operations under CP4A during dry and critical water years – the years targeted for improving water reliability for both users and fish – modeling with SALMOD showed increases in production of Chinook Salmon populations, especially Winter-Run and Spring-Run Chinook Salmon (see Figure D1.2-4).



Note: Simulated Using SALMOD; Water Year Types Based on the Sacramento Valley Water Year Hydrologic Classification

Figure D1.2-4. Percent Change in Outmigrating Chinook Salmon for CP4A (Source: Reclamation 2015)

CP4A would increase water supply reliability by increasing water supplies for CVP and SWP irrigation and M&I deliveries primarily during drought periods. This action would contribute to replacement of supplies redirected to other purposes in the CVPIA. The component would help reduce future water shortages by increasing the reliability of dry and critical year water supplies for agricultural and M&I deliveries by at least 77.8 TAF per year and average annual deliveries by about 51.3 TAF per year. In addition, water use efficiency would reduce current and future water shortages (Reclamation 2015).

Justification

The Shasta Dam Raise would increase the depth and volume of the cold-water pool in Shasta Reservoir. This would increase the ability of Reclamation to make cold-water releases and to regulate water temperatures for fish in the upper Sacramento River, particularly in dry and critical years. The component includes dedicating 191 TAF of the increased storage to increasing the cold-water pool in Shasta Reservoir, which may be managed under an adaptive management plan. Improved water temperature and flow conditions are expected to increase the salmon population by about 710,000 outmigrating juvenile salmon per year on average.

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D1.2.2.2 *Habitat*

D1.2.2.2.1 Spawning Habitat

Summary

Reclamation proposes to place 40-55 tons of gravel in the upper Sacramento River to enhance spawning opportunities.

Description

Reclamation proposes to place gravel in the Sacramento River between Keswick Dam and Red Bluff Diversion Dam (RBDD) to increase spawning habitat for salmonids and sturgeon. In addition, The gravel placements would benefit egg and larval salmonids and sturgeon, as well as invertebrate prey species of rearing juveniles. Restoration actions would occur through the year 2030. A total of 40-55 tons of gravel would be placed to create spawning habitat at the project sites listed below.

The following are spawning project sites that are to be completed in the future;

- Salt Creek Gravel Injection Site (River Mile [RM] 300.7)
- Keswick Dam Gravel Injection Site (RM 302)
- South Shea Levee (RM 289)
- Shea Levee (RM 290)
- Tobiasson Island Side Channel (RM 292)

Spawning projects could include these sites or other sites, but would include at least three sites upstream of Bonnyview Bridge.

The gravel placed would be uncrushed, rounded "natural river rock" with no sharp edges. The gravel would be free of oils, clay, debris, and organic materials. Three different gravel augmentation methods could be applied:

- Lateral Berm: A recruitment pile of gravel is placed as a steeply sloping bar parallel to the channel to provide a long-term supply of spawning gravel and is mobilized into the river channel during high flows
- Riffle Supplementation: Gravel is placed, contoured within the channel (partial or entire channel width), and graded to appropriate depths to provide immediate spawning habitat
- End Dump Talus Cone: A large pile of gravel is placed on the riverbank for recruitment into the river during high flows

Current plans indicate that Salt Creek would be a lateral berm placement; Keswick would be an end dump talus cone, and South Shea Levee, Shea Levee, and Tobiasson Island would be a riffle supplementation (Reclamation 2015).

Objectives

- Fundamental objective: Increase juveniles at Chipps Island per adult return
- Means objective: Abundance

Conceptual Model (Each Species and Life Stage)

The salmonid life stages most affected by spawning habitat enhancements are the eggs and alevins in the spawning redds and the spawning adults. These life stages are addressed by the SAIL CM1 and CM7 for Winter-Run Chinook Salmon (Windell et al. 2017). CM1 conceptualizes upper Sacramento River the life stage periods from egg spawning and incubation to fry emergence from the redds, which can be used to conceptualize potential effects of spawning gravel augmentation on these life stages of Winter-Run Chinook Salmon, as well as on spawning success in the upper Sacramento River for Spring-Run, Fall-Run, and Late Fall-Run Chinook Salmon and Steelhead. Per the CM1 framework diagram (Windell et al. 2017, Figure D1.2-3), erodible sediment supply, which includes gravel augmentation, is linked to substrate size and related to hypothesis $\mathbf{H_8}$, "sedimentation and gravel quantity." Per the narrative (page 7), "Since 1997, a total of 213,000 tons of gravel have been placed from 300 yards to 1.5 miles downstream of Keswick Dam to increase the availability of suitable spawning habitat ($\mathbf{H_8}$)."

The SAIL CM7 conceptualizes the adult life stage period from holding in the upper Sacramento River to spawning. Per the CM7 framework diagram (Windell et al. 2017, Figure 34), erodible sediment supply, including gravel augmentation, is linked to the environmental driver, gravel quality and distribution/augmentation, which in turn is linked to the habitat attribute, spawning habitat.

Green sturgeon spawn in gravel substrates, so gravel augmentation in the upper Sacramento River would potentially enhance habitat for green sturgeon egg incubation and larval development (Heublein et al. 2017). The potential importance of spawning habitat for green sturgeon is addressed in hypothesis H_4 (Table 1, page 5) of the CM for green and white sturgeon in the San Francisco Estuary watershed produced by the Southwest Fishery Science Center (Heublein et al. 2017), which proposes that incubation habitat availability and quality influences relative embryo abundance and distribution. The egg sub-model (page 15) links the environmental driver, Channel Morphology & Substrate, to the habitat attribute, Incubation Habitat. The larvae sub-model (page 18) similarly links the environmental driver, Channel

Morphology & Substrate, to the habitat attribute, Rearing Habitat. In the case of the larvae, the gravel substrate provides rearing habitat for only the first part of the larval life stage because the larvae leave the hatching area well before they metamorphose into the juvenile stage.

Current Condition

Coarse sediment from the upper watershed is prevented from being transported downstream by Shasta and Keswick dams, resulting in an alluvial sediment deficit and reduction in fish habitat quality within the upper Sacramento River. From 1964 to 1980, there appears to have been a significant loss in spawning area in portions of the upper Sacramento River (Stillwater 2007). By 2005, extensive new spawning areas had developed upstream of the Anderson Cottonwood Irrigation District Dam, presumably in response to gravel injections at Keswick Dam and Salt Creek that helped locally offset losses due to the deficit in coarse sediment supply occurring as a result of blockage by Shasta Dam (Stillwater 2007).

Significant efforts have been made to increase the quantity and quality of spawning habitats below the dams. Many habitat restoration projects have been recently implemented in the upper Sacramento River. The following are spawning and rearing habitat projects that were recently completed but will require annual maintenance: Kutras Lake Rearing Structures (RM 296), North Cypress (RM 295), North Tobiasson Side Rearing Structures (RM 292), Kapusta 1-A Side Channel (RM 288), and Lake California Side Channel (RM 270).

Between 2002 and 2013, gravel was placed on two sites in the upper Sacramento River. The Keswick and Salt Creek gravel placement sites listed above have received approximately 220,000 tons of gravel since 1997. CDFW aerial redd surveys and instream gravel locations show that Chinook Salmon are preferentially using gravel that was placed at the Keswick Dam and Salt Creek sites (Reclamation 2016).

Background

CVPIA Section 3406 (b)(13) directs Reclamation to develop and implement a continuing program for the purpose of restoring and replenishing, as needed, salmonid spawning gravel lost due to the construction and operation of CVP dams and other actions that have reduced the availability of spawning gravel and rearing habitat in the Sacramento River from Keswick Dam to RBDD. The CVPIA Programmatic Environmental Impact Statement included habitat restoration projects between Keswick Dam and RBDD (Reclamation 2016).

In 2014, NMFS released the Central Valley Salmon and Steelhead Recovery Plan, which identifies two salmonid conservation principles: (1) recovery cannot be achieved without sufficient habitat and (2) species with restricted spatial distribution are at a higher risk of extinction from catastrophic environmental events. The plan identifies lack of spawning gravel as one of the key threats below Keswick Dam and outlines a recovery action to develop a long-term gravel augmentation plan to increase and maintain spawning habitat.

Current Science

Recent research using physical modeling experiments to guide river restoration projects yielded three restoration manuals (Stillwater Sciences et al. 2008). The purpose of the research project was to build state-of-the-art flumes and conduct a series of physical modeling experiments to address some of the fundamental and unresolved scientific questions underlying the river restoration strategies of gravel augmentation, dam removal, and channel-floodplain redesign. Three manuals (one for each of the three restoration practices) integrate results from laboratory experiments from this study with theoretical analysis, numerical modeling, and field case studies to produce scientifically based guidelines for assessing, implementing, and predicting the in-channel response of these common restoration strategies. The manuals are intended for use by restoration practitioners and managers.

A research effort entailing over a decade of river restoration field research on the Sacramento River has yielded new understanding of many river processes and new numerical models and decision analysis tools (TNC et al. 2008).

Justification

Gravel augmentation provides a source of appropriately sized gravels to restore spawning habitats once gravels are mobilized and redeposited downstream by high flows. Riffle supplementation will create instantly available spawning habitat up to 15 acres per year (NMFS 2015).

The need for the action derives from the declines of naturally spawned salmonid stocks due in part to loss of spawning habitat through curtailment of gravel recruitment due to blockage of the river channel by dams and the alteration in flow patterns.

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D1.2.2.3 *Passage and Reintroduction*

D1.2.2.3.1 Adult Rescue

Summary

Reclamation proposes to trap and haul adult salmonids and sturgeon from Yolo and Sutter bypasses during droughts and after periods of bypass flooding, when flows from the bypasses are most likely to attract upstream migrating adults, and move them up the Sacramento River to spawning grounds. This would improve survival of the adults, leading to increased juvenile production in the following year and, therefore, corresponding flexibility at salvage.

Description

This action requires Reclamation to provide rescues of adult salmonids and sturgeon trapped at barriers in the Yolo and Sutter bypasses. Fish rescues are often needed when Sacramento River flows overtop the Fremont and/or Tisdale Weirs. At such times, flows within the bypasses are typically much greater than flows within the Sacramento River, attracting adult salmonids and sturgeon migrating up the Sacramento River into the Yolo Bypass at the Cache Slough complex and into the Sutter Bypass at the Feather River confluence. Adult fish may also by attracted into the bypasses during drought periods, when flow exiting the bypasses may be higher relative to Sacramento River flow than during other periods. For the Yolo Bypass, west side tributary and drainage canal flows can attract anadromous fish into the bypass at the Cache Slough complex, particularly during periods of high tides and low Sacramento River flows. Fish attracted by west side stream and drainage canal flows migrate upstream through the Toe Drain, Tule Canal, Knights Landing Ridge Cut, and Colusa Basin Drain Canal. Similar to fish stranded during weir spill events, fish attracted into the Yolo Bypass by west side tributary and drainage canal flows are unable to return to the Sacramento River. CDFW initiated fish trapping and rescue efforts in the Colusa Basin Drain in 2013 and at the Wallace Weir in the Knights Landing Ridge Cut in 2014 to return anadromous fish to the Sacramento River (CDFW 2016).

Fish rescue efforts should be viewed as a last resort in terms of fisheries conservation measures within the Yolo and Sutter bypasses, but some level of fish rescue will likely always be needed. Many improvements for fish passage in the Yolo Bypass are currently under construction or in planning (Reclamation and DWR 2017). Plans include actions to improve passage at road crossings and other barriers, fish rescue at the Knights Landing Ridge Cut (to prevent fish from migrating upstream into the Colusa Basin Drain), and a new fish passage structure at Fremont Weir. The new Fremont Weir structure, scheduled for completion in 2019, is designed to allow passage of adult salmonids and sturgeon from the weir to the Sacramento River during periods when Sacramento River flow overtops the weir and for a period afterwards as the floodwater recedes (DWR and Reclamation 2017). It is expected that this structure will greatly reduce the number of adult salmonids and sturgeon that become trapped behind the weir. The old fish passage structure at Fremont Weir did not perform well, but the new structure is expected to correct most of the problems identified with the old structure (DWR and Reclamation 2017). Reclamation and DWR are planning to construct a new gated notch in Fremont Weir to increase inundation of the Yolo Bypass for floodplain rearing habitat, and this gated structure would further improve fish passage. Nonetheless, some continued stranding of fish should be expected, and fish rescues will continue to be needed.

Following periods of Yolo Bypass flooding, some of the fish attracted into the bypass are stranded in the western section of Fremont Weir, which currently has no access to the fish passage structure, and at road crossings, ponds, canals and weirs. The many improvements for fish passage in the Yolo Bypass are expected to reduce these strandings, but not to eliminate them. As noted above, the potential to strand fish may also be high during drought periods, when water levels in the bypass are relatively low, but the number of adult fish attracted into the bypass are also likely to be lower than during period of bypass flooding. There are numerous isolation and stranding areas within the Sutter Bypass, and until fish passage improvements are implemented in the Sutter Bypass, fish rescue operations will continue to be needed to prevent the loss of threatened and endangered fish species in this bypass (CDFW 2017; Reclamation and DWR 2017).

Fish rescues are currently conducted primarily by the CDFW. The timing of fish rescue operations is dependent on factors such as water depth temperature, inundation area, species composition, and potential safety issues. All fish captured are identified to species, enumerated, assessed for condition, and measured. Adult salmonids and sturgeon are tagged before release and subsequently monitored to determine post-release survival, spawning success, and behavior (CDFW 2016). These procedures would be continued under this proposed fish rescue component, but rather than returning the fish to a nearby portion of the Sacramento River, as is currently done, the rescued fish would be transported upriver, if feasible, to suitable spawning areas of the fish.

Objectives

- Fundamental objective: Increase juveniles at Chipps Island per adult return
- Means objective: Abundance

Conceptual Model (Each Species and Life stage)

The SAIL CM included for the Winter-Run Chinook Salmon addresses stranding and rescue of adult salmonids is CM6, Adult Migration from Ocean to Upper Sacramento River (Windell et al. 2017). Per the CM6 framework diagram (Windell et al. 2017, Figure 8), the landscape attribute, Flood Bypass Weirs, is linked to the habitat attribute, Stranding Risk, and the environmental driver, Colusa Basin Releases, is also linked to Stranding Risk. Per the narrative (page 30):

> Water operations can influence the routing of Upper Sacramento River-origin water through agricultural fields into drainage canals and can create false attraction cues that cause salmon to deviate from the mainstem Sacramento River migration corridor and become stranded in agricultural fields behind flood bypass weirs (H3).

The CM6 narrative also discusses several linkages addressed in the model hypotheses and other effects of stranding:

> …stranding in bypasses can expose SRWRC [Sacramento River Winter-Run Chinook Salmon] to elevated and lethal water temperatures (H6) and poor water quality factors such as low DO (H4), which can compromise fish condition and the ultimate success of fish rescues into the mainstem Sacramento River. Stranding also increases the exposure of adults to poaching (H2).

The potential importance of passage impediments for green sturgeon is addressed in hypothesis H_{33} (Table 1, page 5) of the CM for green and white sturgeon in the San Francisco Estuary watershed produced by the Southwest Fishery Science Center (Heublein et al. 2017), which proposes that run-size and distribution are influenced by migration barriers. The spawning adult sub-model (page 27) links the environmental driver, Proximity to Barriers & Diversions, to the habitat attributes, Barriers and Harvest.

Current Condition

The Yolo Bypass and Fremont Weir and the Sutter Bypass and Tisdale Weir are sources of migratory delay and loss of adult Chinook Salmon, steelhead, and sturgeon (NMFS 2009). The Yolo Bypass conveys up to 80% of the system's floodwaters for a distance of approximately 31 miles before discharging back into the Sacramento River upstream of Rio Vista. Yolo Bypass flows attract upstream migrating fish from the Sacramento River into the Yolo Bypass at the mouth of the Cache Slough complex. Among these are several Federal- and State-listed species, including Winter-Run Chinook Salmon, Spring-Run Chinook Salmon, Central Valley Steelhead, and Green Sturgeon. These fish continue migrating up the Yolo Bypass and may be able to return to the Sacramento River via the Fremont Weir (or the Tisdale Weir in the Sutter Bypass) as long as a sufficient volume of water flows over the weirs. However, when floodwaters recede, fish can be trapped in the weir splash basins and downstream scour ponds, pools, and swales. The original fish passage structure at Fremont Weir was inadequate to allow fish passage at most flows. As a result, adult salmonids and sturgeon migrating upstream through the Yolo Bypass were unable to reach upstream spawning habitat in the Sacramento River and its tributaries (https://www.calfish.org/ProgramsData/ConservationandManagement/CentralValleyMonitoring/SacramentoValleyTributaryMonitoring/YoloandSutterBypasses-Monitoring.aspx).

Even when floodwaters do not overtop flood control weirs, flows entering the Yolo Bypass from the west side (streams and agricultural drains) are oftentimes sufficient to attract fish. These fish continue their upstream migration through a series of perennial flowing agricultural drains such as Toe Drain, Tule Canal, and Knights Landing Ridge Cut. However, greater numbers of adult fish, particularly salmonids and sturgeon enter the Yolo Bypass during overtopping of the Fremont Weir and subsequent inundation of the Yolo Bypass (https://www.calfish.org/ProgramsData/ConservationandManagement/CentralValleyMonitoring/SacramentoValleyTributaryMonitoring/YoloandSutterBypasses-Monitoring.aspx).

Flow conditions in the bypass often allow adult salmonids and sturgeon to enter the Colusa Basin Drain, where they become stranded. There are three routes to enter the Colusa Basin Drain: (1) Yolo Bypass via the Knights Landing Ridge Cut, (2) Knights Landing Outfall Gates, and 3) hydrologic connection between the Colusa Basin and the Sacramento River (Windell et al. 2017). To hold back drainage water, an earthen Wallace Weir was manually constructed annually at the terminus of Knights Landing Ridge Cut in the Yolo Bypass for many years. Winter storms often broke the weir, allowing adult salmonids to stray into the Colusa Basin where they cannot reenter the Sacramento River. A permanent structure, including a fish rescue facility, was recently completed that remains operational under all flows (DWR and Reclamation 2017).

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 2016). Over 10,000 fish, comprising 19 species, including four listed species (Winter-Run and Spring-Run Chinook Salmon, Central Valley Steelhead, and Green Southern Sturgeon DPS), have been captured and relocated during these rescue efforts. Without these efforts, many of these fish would die from poor water quality, predation, or poaching. (Reclamation and

DWR 2017). The ultimate reproductive success of fish intercepted at the bypass weirs and returned to the Sacramento River is unknown (Windell 2017).

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. Adult salmon, steelhead, and white sturgeon 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. Various ponds, scour pools, drainages, and swales within the Tisdale and Sutter bypasses also can strand fish. 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 DWR 2017). Butte Creek also drains through the Sutter Bypass prior to its confluence with the Sacramento River, which can result in salmonids returning to Butte Creek or emigrating from Butte Creek to the Sacramento River becoming isolated in the Sutter or Tisdale bypasses (CDFW 2016).

Background

CDFW staff has conducted numerous fish rescues at the Fremont and Tisdale weirs for over 60 years, saving tens of thousands of fish, including listed species. The Draft Environmental Impact Statement/Environmental Impact Report for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project addresses alternatives to modify the Fremont Weir to increase volitional fish passage back to the Sacramento River. However, the project is not scheduled for construction until 2021. Although project completion is expected to enhance fish passage and reduce stranding in the Yolo Bypass, CDFW will continue to monitor the Yolo Bypass for fish stranding and conduct rescues as necessary. Plans to modify the Tisdale Weir for structural improvements and fish passage are moving forward, but some fish rescue will still be necessary at this facility.
https://www.calfish.org/ProgramsData/ConservationandManagement/CentralValleyMonitoring/SacramentoValleyTributaryMonitoring/YoloandSutterBypasses-Monitoring.aspx

Current Science

A number of modeling and research tools have recently been developed to assist in creating facilities to reduce stranding of fish in the bypasses. These include the following (Reclamation and DWR 2017, DWR 2017):

- Yolo Bypass Passage for Adult Salmonid and Sturgeon (YBPASS) tool combined with and U.S. Army Corps of Engineers Hydrologic Engineering Center River Analysis System (HEC-RAS) modeling to compare modeled water depths and velocities in the alternative-specific intake structures and transport channels to against adult Chinook Salmon and sturgeon fish passage criteria.
- Sedimentation and river hydraulics two-dimensional (SRH-2D) modeling along the Fremont Weir section of the Sacramento River to predict the hydrodynamics under the influence of various Fremont Weir notch configurations.
- Daily hydrodynamic two-dimensional unsteady flow (TUFLOW) modeling 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.

Justification

The need to modify existing flood bypass weirs to reduce migration delays, mortality, and stranding risks has been identified by several agency efforts (CALFED 2000, USFWS 2001, Reclamation and DWR 2012, cited in Windell et al. 2017). In some years, flows through the bypasses likely result in false migration cues and large numbers of adult salmonids and sturgeon swim upstream in the bypasses and associated drains before being blocked at weirs and other impediments preventing successful migration. It is not possible to monitor and rescue all adults that become stranded and therefore the loss of adults prior to spawning can be demographically costly to the population (Windell 2017).

Design and construction of fish passage improvement measures at the Fremont Weir and within the Yolo Bypass have begun and are scheduled to continue through 2021. While some of the proposed fish passage designs will likely increase fish passage through the Yolo and Sutter bypasses and back to the Sacramento River, sturgeon in particular may still be susceptible to isolation and stranding due to increased duration of flows through the bypass, as some planned modifications are intended to increase floodplain inundation for salmonid rearing (CDFW 2016). Monitoring for isolation and stranding of fish within the Yolo and Sutter bypasses should continue even after completion of fish passage improvement measures to determine if the measures are successful. Fish rescue efforts should be conducted as necessary to reduce lethal take of listed species (CDFW 2016)

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D1.2.3 Trinity Division

D1.2.3.1 *Water Operations*

D1.2.3.1.1 <u>Clear Creek</u>

Summary

Reclamation would release pulse flows from Whiskeytown Reservoir for habitat needs and channel maintenance on Clear Creek.

Description

Reclamation proposes to create pulse flows for channel maintenance by releasing up to 7,000 AF through the regular outlet once every three years to increase the flood magnitudes in Clear Creek. In addition, Reclamation will continue to release 7,000 AF for attraction flows in the spring. For the channel maintenance flows, Reclamation will release flows up to 900 cfs timed to coincide with high flows downstream of Whiskeytown Dam. This revised action will include mechanical side channel restoration when flow actions have not adequately addressed the rearing habitat needs. In addition, other mechanical methods may be used to improve habitat quantity and quality downstream of Whiskeytown Dam. If flows are sufficient downstream of the dam, the channel maintenance flows could reactivate fluvial geomorphic processes to re-create and maintain diverse instream and floodplain habitat required to support and recover aquatic and riparian habitat.

Objectives

- Fundamental objective: Increase juveniles at Chipps Island per adult return
- Means objectives: Spatial structure, productivity, diversity

Conceptual Model (Each Species and Life stage)

Increased flow releases would improve Spring-Run Chinook Salmon spawning habitat quantity and quality and rearing habitat diversity in Clear Creek by increasing the frequency and magnitude of flows sufficient to transport gravel and erode the banks. In combination with gravel augmentation, the high flows would allow for regular gravel transport and floodplain inundation throughout the river, and limit sand deposition on the bed. This component addresses SAIL CM upper river hypothesis sedimentation and gravel quantity (H8) and redd quality (H3) (Windell et al. 2017). Alluvial bank erosion and bar construction associated with the high flows would increase juvenile rearing habitat in Clear Creek.

Current Condition

Currently, flow in Clear Creek is primarily controlled through releases from Whiskeytown Dam, which is located 17 miles upstream from the confluence with the Sacramento River. The reservoir can release flows up to 1,200 cfs for a reservoir elevation of 1,209 feet (ft) (just below the Glory Hole elevation). Under current conditions, flood flows can be released through the Glory Hole Spillway, but the magnitude of these flows cannot be controlled, which may lead to safety issues and potentially fish stranding as the reservoir elevation drops below the lip of the Glory Hole.

Background

Restoration projects on Clear Creek include the removal of Saeltzer Dam, spawning gravel augmentation, riparian habitat restoration, and channel reconstruction. Minimum flow releases from the reservoir are 50 cfs from January to October and 100 cfs from November to December. In addition, flows are released through the existing infrastructure from June 1 to October 31 to maintain sufficiently low temperatures for incubating eggs in summer. The flows to maintain temperature can be much higher than the minimum flows. For example, for October 1-15, 2018, 200 cfs were released from Whiskeytown to Clear Creek (Reclamation 2018), 150 cfs more than the required minimum flow.

Current Science

Modeling and monitoring of sediment transport on Clear Creek suggest that gravel transport initiates between 3,000 and 3,500 cfs (McBain and Trush 2001, Pittman and Matthews 2004). Daily average flow at the United States Geological Survey (USGS) gage at Igo exceeded 3,000 cfs on only five days (in two years) from WY 1998-2018, although annual peak flows exceeded 3,000 cfs 9 out of 20 years from 1998-2017. This suggests that peaks have a short duration that limits their geomorphic effectiveness.

In 2018, the Carr Fire burned much of the Clear Creek watershed below Whiskeytown Dam. This fire is likely to increase the sediment supply to Clear Creek in the near-term, and its potential effects will need to be assessed in tandem with flow release investigations.

Justification

Maintaining high spawning gravel quality and quantity requires relatively frequent sediment transport, a common attribute of alluvial rivers (e.g., Trush et al. 2000). Monitoring of sediment mobility in Clear Creek has shown that sediment transport thresholds differ throughout the river length. In general, sediment transport thresholds appear to occur between 3,000 and 3,500 cfs for most of the river (McBain and Trush 2001).

Over 190,000 tons of gravel have been augmented in Clear Creek (TNC 2017), but Pittman and Matthews (2007) estimated that 560,000 tons of sediment may be required to resupply gravel to the entire length of Clear Creek below Whiskeytown Dam. As of 2007, this sediment was slowly moving downstream (Pittman and Matthews 2007). Maintaining spawning habitats requires relatively frequent gravel transport (every one to three years) to limit gravel embeddedness. The flows will provide some bank erosion in alluvial sections of the river and remove fine sediment from the bed (and deposit in the floodplain). All the responses to increased flows will increase spawning and rearing habitat quality and quantity in Clear Creek. Increases in flow will likely require an increase in the volume of augmented spawning gravel to match the increased sediment transport rate associated with higher flows. Moreover, these flow increases will require additional monitoring to ensure that gravel supply is similar to gravel transport.

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D1.2.3.1.2 Grass Valley Creek Flows

Summary

Reclamation would increase flow from the Buckhorn Dam outlet works to Grass Valley Creek for maintenance of the outlet channel and improve juvenile and adult migration.

Description

Reclamation proposes to release flow from Buckhorn Dam to Grass Valley Creek in accordance with requirements published in the Buckhorn dam and reservoir standard operating procedures manual for water rights permit 18879 issued to the California Department of Water Resources, which establishes the timing and magnitude of minimum flows and flushing flows from the dam.

In addition, Reclamation proposes to increase flow from the dam outlet works for maintenance of the outlet channel and to cue juvenile salmonids in the reach to begin their downstream migration to the Trinity River. Pulse flows will occur when the reservoir water elevation exceeds 2,803.13 ft above sea level between March 1 and April 15. Pulse discharge magnitudes will be up to 100 cfs, sufficient to mobilize gravel in the outlet channel upstream of where the spillway outlet. The pulse discharge may occur in a discrete event or by accumulation of multiple events lasting 5 to 7 days.

Reclamation also proposes to increase flow in the outlet channel when necessary in October and November to provide adult Coho Salmon sufficient flow for upstream migration and spawning. For this purpose, flow released from the outlet works will be increased to provide flow depths that are ≥0.60 ft on riffle crests within a downstream distance of 600 ft from the upstream extent of the run-of-river channel and increases discharge at the USGS stream gage near Lewiston to ≥10 cfs.

Objectives

- Fundamental objective: Increase juveniles at Chipps Island per adult return
- Means objectives: Spatial structure, productivity, diversity

Conceptual Model (Each Species and Life stage)

Increased flow releases would improve spawning habitat quantity and quality and rearing habitat diversity in Grass Valley Creek by increasing the frequency and magnitude of flows sufficient to transport gravel. This component addresses SAIL CM upper river hypothesis sedimentation and gravel quantity (H8) and redd quality (H3) (Windell et al. 2017).

The juvenile life stage for Coho Salmon is the most limited and quality summer and winter rearing habitat is lacking for the population. NMFS 2014 states the current high stressors for juvenile Coho Salmon to include:

- Rearing opportunities and capacity are low due to a reduced and dampened flow regime. Loss of flow variability and reduced rearing habitat during the fall and winter months as a result of water storage and regulation is expected to reduce the ability of the habitat in the Upper Trinity River to support winter rearing of juvenile Coho Salmon.
- Trinity River Hatchery plays a role in limiting the productivity (recruits produced per spawner) of the Upper Trinity River population through negative genetic and ecological interactions. Competition with hatchery fish released from Trinity River Hatchery limits rearing and spawning capacity in the Upper Trinity River.
- Floodplain and channel structure is a high stress for the population and particularly affects fry, juveniles, and adults. Poor floodplain and channel structure is attributed to changes in the hydrology of the sub-basin. Changes in sediment supply, storage, and transport, in combination with altered mainstem flow following construction of the Trinity River Division, altered the channel geomorphology.

Current Condition

Gauge records at the mouth of Grass Valley Creek indicate a variable hydrology with a mean average flow of approximately 20 cfs. Discharge fluctuations range from the low end of 6 cfs which is controlled by the Buckhorn Dam outlet works and winter-spring runoff events that can reach up to 1,000 cfs for a short multiple hour duration. Approximately 600 feet downstream of the outlet works there is an exposed bedrock outcrop that is causing a natural hydraulic control resulting in raised surface water elevations.

Construction of Buckhorn Debris Dam and the operation of the Hamilton sediment ponds have prevented a considerable amount of fine sediment from entering the mainstem via Grass Valley Creek. Other mechanical efforts to remove sediment and improve habitat conditions in the river have included cleansing of spawning riffles, dredging of sand from mainstem pools, side channel construction, and a pilot bank rehabilitation program to improve mainstem channel morphology.

Background

For 1.2 miles above the reservoir and from the dam to the mouth, Grass Valley Creek is a fish bearing Class I waterbody, supporting Chinook and Coho Salmon, steelhead, rainbow and brown trout, Klamath small-scale sucker, and lamprey. Steelhead trout are found as far as the dam and Chinook Salmon are found 7.5 miles up from the mouth of the dam. Surveys conducted by TRRPO and NMFS on June 23, 2011 observed Coho Salmon in the outlet channel, although no Coho Salmon were observed above an exposed bedrock outcrop located approximately 600 feet downstream of the outlet works (Reclamation 2012). Grass Valley Creek is being used by Coho Salmon throughout most its 10.8 miles of stream length between the dam and confluence with the Trinity River.

NMFS 2014 states for Coho Salmon population: “The Upper Trinity River population is at moderate risk of extinction because NMFS estimates the ratio of the three consecutive years of lowest abundance within the last twelve years to the amount of IP-km in a watershed is greater than one, but the ratio is less than the minimum required spawner density.”

Buckhorn Dam was built to trap fine sediment eroding from the upper Grass Valley Creek watershed in order to reduce fine sediment input into the Trinity River. It has an uncontrolled/un-gated “run of the river” concrete spillway on the north end of the dam that spills during the winter-spring runoff period or storm events. The dam also has a buried 800-foot long gated-conduit system as the main outlet works. Buckhorn Dam completely blocks upstream fish migration.

Current Science

As part of an ongoing study for the Trinity River Restoration Program (TRRP), Reclamation conducts bedload and suspended sediment sampling at four monitoring locations on the mainstem Trinity River: at Lewiston (TRAL), near Grass Valley Creek (TRGV), at Limekiln Gulch (TRLG), and near Douglas City (TRDC). TRLG is downstream of the mouth of Grass Valley Creek. TRRP’s restoration strategy involves a combination of Spring Flow Releases, fine and coarse sediment management, and mechanical channel rehabilitation. Annual studies are conducted as part a sediment budget approach to understanding sediment-related habitat issues. The sediment load estimates inform gravel injection strategies (locations and volumes) and hydrograph development for Spring Flow Releases.

The Final Recovery Plan for the Southern Oregon/Northern California Coast Coho Recovery Plan (2014) lists recovery actions for the Upper Trinity River Coho Salmon population. The following are applicable to Grass Valley Creek.

- Improve flow timing or volume: Increase instream flows.
- Improve flow timing or volume: Secure and maintain sufficient instream flows.
- Increase channel complexity: Increase large woody debris, boulders, and other stream structures.
- Reduce water temperature, increase dissolved oxygen: Increase flow.
- Reconnect the channel to the floodplain: Increase beaver abundance.

Justification

Maintaining high spawning gravel quality and quantity requires relatively frequent sediment transport, a common attribute of alluvial rivers (e.g., Trush et al. 2000). NMFS 2014 states: “Recovery activities in the watershed should promote increased spatial distribution as well as increased productivity and abundance. Curtailing the effects of hatchery fish on this population is of utmost importance. Activities that increase streamflows, reduce summertime stream temperatures, increase fish distribution through barrier removal, promote increased floodplain and channel structure and improve long-term prospects for large woody debris recruitment, should be a priority in the watershed."

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D1.2.4 Feather River Basin

D1.2.4.1 *Water Operations*

D1.2.4.1.1 Core Water Operations

Summary

DWR would adjust Lake Oroville releases to result in more favorable flow and temperature conditions for salmonids.

Description

DWR would adjust river flow and temperature in the Feather River, as provided under the Federal Energy Regulatory Commission (FERC) Settlement Agreement for the Licensing of Oroville Facilities, to create additional spawning and rearing habitat by increasing useable area for adult and juvenile salmonids. Table D1.2-6 shows the new flow and temperature targets. These targets are within the Feather River Low Flow Channel (LFC), which is the reach between the fish barrier dam and the Thermalito Afterbay Outlet (where the flows through the powerplant are discharged).

Table D1.2-6. Feather River Flow and Temperature Adjustments.

Flow	
Flow Velocity (cfs)	*Implementation Date*
700	April 1 – September 8
800	September 9 – March 31
Temperature	
Target (F, mean daily)	*Compliance Point*
56 – 63	Robinson Riffle

The temperature target would be 56 degrees from October through April, then have a transition period through May 15. The temperature target would shift to 63 degrees through August, with a transition period to September 8. For the rest of the month of September, the temperature target would be 58 degrees.

DWR would also provide for re-operation of the Oroville facilities to maximize spawning and rearing in the Feather River for salmonids. Instead of routing flows through Thermalito Forebay and the power generation facilities at Oroville, a pulse flow would instead be routed directly through the low-flow channel to create optimal conditions for fish in the upper Feather River. This pulse flow would be 2,000 cfs for 14 or more continuous days between January 1 and April 15. DWR would make this release in dry, below normal, or above normal years, and it would result in a release of 43 TAF on an average annual basis.

Objectives

- Fundamental objective: Increase juveniles at Chipps Island per adult return
- Means objectives: Abundance and productivity

Conceptual Model (Each Species and Life stage)

Increased flows and decreased temperatures in the LFC would benefit Spring-Run and Fall-Run Chinook Salmon in the Lower Feather River, particularly the spawning and rearing periods. The biggest stressor is high water temperature during the spawning periods, when the air temperature is warm.

Aspects of the SAIL CM for Winter-Run Chinook Salmon on the Sacramento River can be linked to Spring-Run and Fall-Run Chinook Salmon on the Feather River. The SAIL CM identifies the impacts of high water temperatures as a stressor for spawning and rearing for salmonids. The SAIL CM states:

> In recent years, water temperatures suitable for critical SRWRC life stages (spawning, egg incubation, and fry emergence) appear to have confined successful reproduction to the upper 10 to 15 river miles below Keswick Dam. Adult Chinook Salmon held at temperatures greater than 60°F have exhibited poor survival and reduced egg viability (DWR 1988). Laboratory and field studies have shown that when adult fish are exposed to constant or average temperatures above 55.4–60°F (13–15.6°C) during holding prior to spawning, there is a detrimental effect on the size, number, or fertility of eggs held in vivo (EPA 2001). Thus, adult holding and spawning distribution may be limited by the temperature controlled stretch of the Sacramento River.

For rearing to outmigrating juveniles, the SAIL CM states:

> The foremost factor affecting migration, growth, and survival of SRWRC fry is habitat (e.g., substrate, water quality, water temperature, water velocity, shelter, and food; Williams 2006,

Williams 2010). Additional factors include disease, predation, and climate variability (NMFS 1997, Williams 2010). Increased instream flow affects many of these factors through dilution (e.g., toxicity and contaminants), reduction in water temperatures (which also affects DO, food availability, predation, pathogens, and disease) and entrainment and stranding risk, and potentially increases in cues to stimulate outmigration.

Current Condition

The Thermalito Diversion Dam and Powerplant is four miles downstream from the Oroville Dam/Hyatt Powerplant. The dam diverts water to the Thermalito Power Canal, which bypasses water from the Feather River into the Thermalito Forebay, Thermalito Pumping-Generating Plant, and Thermalito Afterbay. This water re-enters the Feather River at the Thermalito Afterbay Outlet.

Just downstream from the Thermalito Diversion Dam is the Fish Barrier Dam, which is impassible to fish that diverts fish into the ladder into the Feather River Fish Hatchery. The Feather River LFC is the reach from the Fish Barrier Dam downstream to the Thermalito Afterbay Outlet. Currently, DWR releases 600 cfs into this reach to maintain conditions for fish (NMFS 2016).

Background

The lower Feather River (downstream of Oroville Dam) supports Spring-Run and Fall-Run Chinook Salmon. Adult Fall-Run Chinook Salmon typically migrate upstream to spawn from September through December, and spring-run typically move upstream from March through June to spawn the following fall. Before development of water and power facilities on the Feather River system, Fall-Run Chinook Salmon spawned in the mainsteam river downstream of the current Oroville Dam site. Spring-Run Chinook spawned upstream of the current Oroville Dam site in the three branches of the Feather River (Sommer, et al. 2001).

Construction of the Oroville water and power facilities has changed the flows and temperatures within the LFC. Mean monthly flows through the LFC are now 5 to 38 percent of pre-dam levels. Mean monthly temperatures are 2 to 14 degrees cooler during May through October and 2 to 7 degrees warmer during November through April (Sommer, et al. 2001).

Current Science

Currently, the Feather River LFC presents the primary area of interest for salmon spawning (Sommer, et al. 2001). There is little or no spawning downstream of Honcut Creek (downstream from the LFC).

In support of the FERC relicensing effort, DWR studied water temperatures and the relationships to Spring-Run Chinook salmon immigration and holding in the lower Feather River. The study established index values to indicate suitable temperatures, and found that these index values were exceeded in some pools during the holding period. The conclusion indicated that "increased incidence of disease, developmental abnormalities, increased in-vivo egg mortality, and temporary cessation of migration could occur due to elevated water temperatures in some areas of the lower Feather River" (DWR 2004).

Justification

The flow and temperature targets would maintain suitable conditions for Spring-Run and Fall-Run Chinook Salmon during the periods that they are migrating upstream, holding, spawning, and rearing in the Lower Feather River.

References

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D1.2.5 American River Basin

D1.2.5.1 *Water Operations*

D1.2.5.1.1 2017 Flow Management Standard Releases and "Planning Minimum"

Summary

Reclamation proposes to implement a version of the Flow Management Standard (FMS) proposed by the Water Forum in 2017 that incorporates a multiyear sustainable management approach.

Description

Reclamation proposes to meet water rights, contracts and agreements that are both specific to the American River Division as well as those that apply to the entire CVP, including the Delta Division. For lower American River flows (below Nimbus Dam), Reclamation proposes to adopt the minimum flow schedule and approach proposed by the Water Forum in 2017. Flows range from 500 to 2000 cfs based on time of year and annual hydrology. The flow schedule is intended to improve cold-water pool and habitat conditions for steelhead and Fall-Run Chinook Salmon. Minimum releases into the lower American River are determined based on multiple formulas established through a cooperative effort with stakeholders (American River Water Agencies 2017).

Reclamation proposes to work together with the American River Stakeholders (CDFW and DWR, American River Water Agencies) to define an appropriate amount of storage in Folsom Reservoir that represents the lower bound for typical forecasting processes at the end of calendar year (the "planning minimum") (DWR and CDFW 2018). The objective of the planning minimum is to preserve storage to protect against future drought conditions and to facilitate the development of the cold water pool when possible. This planning minimum will be a single value (or potentially a series of values for different hydrologic year types) to be used for each year's forecasting process into the future. The objective of incorporating the planning minimum into the forecasting process is to provide releases of salmonid-suitable temperatures to the lower American River and reliable deliveries (using the existing water supply intakes and conveyance systems) to American River water agencies that are dependent on deliveries or releases from Folsom Reservoir. To meet this objective, Reclamation proposes to work together with the American River parties to determine the draft value(s) that are appropriate. If there is a change circumstances that may necessitate adjustments to the value(s) for the planning minimum, any American River Stakeholder may request that the technical group reconvene and that Reclamation re-evaluate its preferred value(s) based on the changed circumstances.

Reclamation would then determine preferred value(s) for use in its forecasting process for guiding seasonal operations, however, the forecasted storage may fall below the "planning minimum" due to a variety of circumstances and causes. In those instances, Reclamation and the American River stakeholders will develop a list of potential off-ramp actions that may be taken to either improve forecasted storage or decrease demand on Folsom. In its forecasting process for guiding seasonal operations, Reclamation will plan to maintain or exceed the planning minimum at the end of the calendar year. When Reclamation estimates, using the forecasting process, that it would not be able to maintain Folsom Reservoir storage at the end-of-December "planning minimum" for that year type (such as in extreme hydrologic conditions) or unexpected events cause the storage level to be at risk, American River Division contractors would coordinate with Reclamation to identify and implement appropriate actions to improve forecasted storage conditions, and the American River stakeholders would work together to educate the public on the actions that have been agreed upon and implemented and the reasons and basis for them. If potential changes to Folsom operations would have impacts on other divisions of the CVP/SWP or the entire integrated system, Reclamation will meet and discuss with Water Contractors. Reclamation would ramp down to the revised minimum flows from Folsom Reservoir as soon as possible in the fall and maintain these flows, where possible.

Objectives

- Fundamental objective: maintain minimum fish population during drought
- Means objective: spatial structure

Conceptual Model (Each Species and Life stage)

The FMS would benefit steelhead and Fall-Run Chinook Salmon in the Lower American River, particularly the spawning and rearing periods. Steelhead spawn during winter, and juvenile steelhead generally rear over summer before emigrating to the ocean following winter or spring. Therefore, their biggest stressor is high water temperature during the summer, when the air temperature is hot. Fall-Run Chinook Salmon spawn during the fall, and the juveniles emigrate from the river before summer. Their biggest stressor is warm water temperatures and inadequate spawning flows during October and November.

Aspects of the SAIL CM for Winter-Run Chinook Salmon on the Sacramento River can be linked to Fall-Run Chinook Salmon and steelhead on the American River. The SAIL CM identifies the impacts of high water temperatures as a stressor for spawning and rearing for salmonids. The SAIL CM states:

> In recent years, water temperatures suitable for critical SRWRC life stages (spawning, egg incubation, and fry emergence) appear to have confined successful reproduction to the upper 10 to 15 river miles below Keswick Dam. Adult Chinook Salmon held at temperatures greater than 60°F have exhibited poor survival and reduced egg viability (DWR 1988). Laboratory and field studies have shown that when adult fish are exposed to constant or average temperatures above 55.4–60°F (13–15.6°C) during holding prior to spawning, there is a detrimental effect on the size, number, or fertility of eggs held in vivo (EPA 2001). Thus, adult holding and spawning distribution may be limited by the temperature controlled stretch of the Sacramento River.

For rearing to outmigrating juveniles, the SAIL CM states:

> The foremost factor affecting migration, growth, and survival of SRWRC fry is habitat (e.g., substrate, water quality, water temperature, water velocity, shelter, and food; Williams 2006, Williams 2010). Additional factors include disease, predation, and climate variability (NMFS 1997, Williams 2010). Increased instream flow affects many of these factors through dilution (e.g., toxicity and contaminants), reduction in water temperatures (which also affects DO, food availability, predation, pathogens, and disease) and entrainment and stranding risk, and potentially increases in cues to stimulate outmigration.

Current Condition

The current operations at Folsom Dam are guided by the NMFS BO RPA Action II.1, Lower American River Flow Management, which requires Reclamation to implement the flow schedule specified by the 2006 FMS. Folsom Dam is operated to meet the State Water Rights permits and requirements adopted by the State Water Resources Control Board (SWRCB) in 1958 though Decision 893.

Background

The 2006 FMS is a set of measures that includes minimum release requirements and water temperature objectives, oversight by an interagency workgroup (American River Group), and monitoring and evaluation. The 2006 FMS uses a sliding scale for minimum flow releases, and water temperature targets that balance available water supplies with achievable objectives to preserve wildlife and biological functions within the river.

Current Science

The Sacramento Water Forum has been working on options to modify the FMS, and the process is ongoing.

Justification

Recent drought conditions have demonstrated the need for reliable water storage in Folsom Reservoir and a modification to the current flow requirements of the lower American River. Modification of the FMS could allow Reclamation to maintain reliable water supplies within the Folsom Reservoir and improve habitat conditions for steelhead and Fall-Run Chinook Salmon in the lower American River.

References

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D1.2.5.2 *Habitat*

D1.2.5.2.1 Spawning and Rearing Named Projects

Summary

This component includes spawning and rearing projects to improve conditions for Chinook Salmon in the Lower American River system.

Description

These projects would increase spawning and rearing opportunities in the Lower American River (Reclamation 2016):

- Paradise Beach: this site includes a large floodplain area along the left bank of the river upstream of Paradise Beach. Side channel habitat would be created and the floodplain habitat modified so that it becomes inundated over a range of flows. Woody material would be included in the side channel habitat.
- Howe to Watt: The site includes the low elevation area along the south side of the river between the Watt and Howe boat ramps. It includes existing side channel and backwater habitat that becomes disconnected from the river at lower flow levels. Work at this site would increase the connectivity between the backwater habitat and the river channel so that juvenile rearing can occur at most flows.
- Upper River Bend: The site includes a one mile reach of the river between the upstream part of River Bend Park and the downstream end of Ancil Hoffman golf course. The reach includes floodplain area along both sides of the channel. The riffles in this area include low density spawning. Much of the existing habitat is armored with material too large for spawning. Side channel habitat would be created and floodplain habitat modified in the low elevation areas on both sides of the river.
- Ancil Hoffman: The site includes floodplain area along the right bank of the river. The main channel includes riffle habitat where spawning occurs, mostly along the left bank and adjacent to the island at the upstream end of the site. The project would include side channel creation and floodplain modification along the right bank and gravel placement in the main river channel. The short side channel at the upstream end of the site includes good depths and velocities for spawning but the substrate is mostly too large. The oversized material would be pushed to deeper water or onto the island and replaced with spawning sized material from the floodplain area. The finished side channel would be slightly deeper than the existing channel which is dry at low flows. Woody material would be added to the side channel areas.
- Sacramento Bar – North and South: The site includes Sacramento Bar and the reach of river adjacent to Sacramento Bar. Sacramento Bar is a slightly perched floodplain where both gravel mining and dredging occurred in the past. The mining left a pond disconnected from the river at all times except for high flows. The river channel at the upstream end of the site receives

spawning use, predominantly along the edges of the channel. The spawning habitat consists of predominantly oversized material with most usable sized material along the banks. The project would create side channel and modify floodplain habitat on Sacramento Bar. Gravel from the bar would be sorted and placed in the river channel along the east side of the bar to improve the size distribution of the spawning habitat.

- El Manto: The site includes low elevation floodplain habitat along the left bank of the river and the main channel of the river upstream and downstream of San Juan Rapids. Spawning occurs on the riffles through this reach. The habitat in the center of the channel is armored with material too large for spawning. The project would include side channel creation and floodplain modification along the left bank of the river.
- Sunrise: The site includes the reach of the river between the Sunrise Boulevard Bridge and the old Fair Oaks Bridge. The area consists of a riffle where heavy salmonid spawning occurs, pool habitat upstream of the riffle, and some low elevation floodplain on the south side of the river. However, a juvenile isolation area is currently within the floodplain. Work at this site would include side channel creation, floodplain modification, and woody material placement along the south side of the river.
- Upper Sunrise (Lower Sailor Bar): This site includes a ¾ mile reach of the river between the upper Sunrise side channel and the 2012 gravel placement and side channel creation project and includes the adjacent floodplain along the south side of the river. Previous projects occurred in this reach in 2010 – 2012. The past work included riffle and island creation midway through the reach, side channel reconnection at the downstream end of the reach and gravel placement and side channel creation at the upstream end of the reach. Woody material was placed in the main channel adjacent to the created islands and within the created side channel at the upstream end of the reach. The reach includes a low elevation area along the south side of the river where additional side channel and floodplain habitat could be created. Additional gravel placement could occur at the 2010 – 2011 placement sites to enlarge the site to create a channel spanning riffle.

Objectives

- Fundamental objective: Increase juveniles at Chipps Island per adult return
- Means objective: Abundance and productivity

Conceptual Model (Each Species and Life stage)

Spawning habitat restoration is primarily focused on gravel augmentation, which can benefit multiple Chinook Salmon life stages. Provided that gravel augmentation creates suitable depth, velocity, and substrate conditions, these rehabilitation actions can increase adult spawning activity (Merz and Setka 2004, Zeug et al. 2012) and provide high quality incubation habitat for embryos and yolk sac fry (Merz et al. 2004). Gravel augmentation can also improve juvenile rearing habitat by increasing local water surface elevation, resulting in more frequent and extensive inundation of edge habitat and floodplains (Sellheim et al. 2015). However, if spawning substrate is too large, it may not be used by smaller-bodied species or individuals within a species (Zeug et al. 2012); in contrast, if substrate is too small it may result in poor embryo survival, even if spawning occurs (Merz et al., in press). The projects also include rearing habitat improvements by increasing the opportunities to activate floodplains, creation of secondary channels to access floodplain, and improvement of floodplain rearing habitat quality.

Current Condition

Historic gold and gravel mining have greatly altered geomorphic and hydraulic conditions of the American River, with adverse impacts to salmonid populations (Williams 2001, Yoshiyama et al. 2001). Extensive alterations to the American River streambeds deeply incised the main channel, disconnected side channels and floodplains, and altered riparian vegetation (James 1997). Regulated flows compounded incision, further eroded beds and banks, coarsened bed material, and inhibited the flushing of fine particles from the gravel (Kondolf 1997, Kondolf et al. 2001).

Background

Gravel augmentation is a widely accepted technique for rehabilitating anadromous salmonid spawning habitats within regulated streams of the California Central Valley (Wheaton et al. 2004a, 2004b). Several studies have demonstrated that gravel augmentation can increase Chinook Salmon spawning activity (Merz and Setka 2004, Palm et al. 2007, Zeug et al. 2012). Physical and biological effects of gravel augmentation projects are influenced by a suite of intermediate mechanisms and external factors related to hydrodynamics, geomorphology, and ecology (Downs and Kondolf 2002). Therefore, the overall effects of restoration projects on river ecosystems and specified life stages of target species, and secondary influences on non-target organisms, are highly variable both within and among ecosystems. In addition, because even heavily regulated rivers are dynamic and both flow and physical engineering of spawning beds by salmon cause downstream sediment transport, a gravel augmentation project is not expected to function indefinitely and will be reduced as sediment is carried downstream (Merz et al. 2006, Humphries et al. 2012).

In the past two decades, several rehabilitation efforts have been undertaken on the American River to improve the quality and quantity of salmonid spawning habitat. Table D1.2-7 summarizes the amounts of gravel added to the river during each year in which a gravel augmentation project was implemented.

Table D1.2-7. CVPIA gravel augmentation in the American River from 1999 to present.

Year	Gravel augmentation (tons)
1999	6,000
2008	7,000
2009	10,600
2010	16,000
2011	20,770
2012	24,510
2013	6,000
2014	10,000
2016	30,000
TOTAL	130,880

Current Science

Multiple effectiveness monitoring studies have been implemented on the American River to test the effects of gravel augmentation on salmon adults, embryos, and juveniles. Zeug et al. (2012) found that gravel augmentation increased site utilization, but the degree to which a particular augmentation action was effective depended upon the species (Chinook salmon or steelhead) and substrate size. Cramer Fish Sciences (2017a) found that substrate size impacts benthic invertebrate prey production, with lower prey density in smaller gravels. Merz et al. (in press) also observed conflicting optimal gravel sizes between adult spawners and salmon embryos, with higher spawning activity in small gravel and higher embryo survival in large gravel. Sellheim et al. (2015) found that gravel augmentation improved juvenile rearing habitat by reconnecting remnant floodplains under lower streamflow conditions. Cramer Fish Sciences (2017b) assessed gravel augmentation site longevity and that the positive effects of gravel augmentation (i.e., increased habitat utilization) declined to pre-project levels within 5 to 6 years after implementation.

Justification

In response to continued anadromous salmonid stock declines, Public Law 102-575 was passed by Congress in 1992 and, under Title 34, established the CVPIA (1992). With the goal of protecting, restoring, and enhancing fish, wildlife, and associated habitats in the Central Valley, this legislation granted authority to Reclamation and USFWS to co-lead anadromous fish restoration efforts for the United States Department of the Interior (Interior). The resulting CVPIA Fisheries Program was directed to make "…all reasonable efforts…" to double natural production of anadromous fish [Section 3406(b)(1)]. Section 3406(b)(1)(A) gives "…first priority to measures which protect and restore natural channel and riparian habitat values through habitat restoration actions" (CVPIA 1992). Additionally, to compensate for actions that reduced the availability of spawning and rearing habitat, CVPIA Section 3406(b)(13) authorizes and directs Reclamation and USFWS, along with other Federal and State agencies, to create a program to continue restoration and replenishment of spawning gravel in Central Valley rivers, including the American River below Nimbus Dam (hereafter referred to as the lower American River).

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D1.2.6 Bay-Delta

D1.2.6.1 *Water Operations*

D1.2.6.1.1 OMR Management

Summary

OMR reverse flow provides a surrogate indicator for how export pumping, inflow and the spring-neap tidal cycle influence hydrodynamics in the south Delta. Reverse OMR flow (negative values of OMR) indicates a net flow from the Sacramento River toward the export pumps. The RPAs in 2008/2009 BOs added OMR reverse flow criteria to protect listed fish species in the Delta from entrainment into channels that lead to the export pumps. Reclamation would proposed Real-Time OMR Protections for Delta Smelt and salmonids, including modifications to FWS BO Actions 2 and 3 along with NMFS BO IV.2.3 to incorporate real-time monitoring of fish distribution, hydrodynamic models, and entrainment models into the decision support for the management of OMR, as follows:

The Smelt Working Group (SWG) and Delta Operations for Salmon and Sturgeon (DOSS) would inform Reclamation when fish species have entered the portion of the Delta that is within the influence of the Pumping Plants.

1. At that time, Reclamation would conduct a risk assessment based on hydrodynamic models, entrainment models, and the monitoring of fish distribution to determine whether the pumps were at risk of entraining fish over the incidental take limit.
2. If Reclamation's risk assessment indicates low risk to the species, pumping would continue. If the risk assessment indicates high risk of exceeding the take limit, pumping would be reduced until the risk lowers.
3. Once 50% loss has been reached in a given year/season, Reclamation would begin operating to the density dependent triggers as identified in the 2009 NMFS BO, as amended.

Storm event OMR management during storm-related events, consistent with the Water Infrastructure Improvements for the Nation Act (WIIN) Act, Section 4003, to continue to occur through the duration of the BO. Reclamation would propose to operate to the Index Based OMR that utilizes an equation for measuring compliance.

Description

Reclamation and DWR propose to operate the CVP and SWP in a manner that maximizes exports while minimizing entrainment of fish and protecting critical habitat. OMR reverse flows provide a surrogate indicator for how export pumping, inflow, and the spring-neap tidal cycle influence hydrodynamics in the south Delta. The management of OMR, in combination with other environmental variables, can minimize or avoid the entrainment of fish in the South Delta and at CVP and SWP salvage facilities. Reclamation and DWR propose to maximize exports by incorporating real-time monitoring of fish distribution, turbidity, temperature, hydrodynamic models, and entrainment models into the decision support for the management of OMR to focus protections for fish when necessary and provide flexibility where possible, consistent with the WIIN Act Sections 4002 and 4003, as described below. Estimates of species distribution will be described by multi-agency Delta-focused technical teams. Reclamation and DWR will make a change to exports within 3 days when monitoring, modeling, and criteria indicate protection for fish is necessary.

- Reclamation and DWR propose to operate to an index equation for OMR. An OMR index allows for short-term operational planning and real-time adjustments.

- OMR Management: From the onset of OMR management to the end, Reclamation and DWR will operate to an OMR index no more negative than a 14-day moving average of −5,000 cfs unless a storm event occurs. Grimaldo et al (2017) indicate that negative 5,000 cfs is a key OMR threshold for fish entrainment. OMR could be more positive than negative 5000 cfs if additional real-time OMR restrictions are triggered as described below.
- Onset of OMR Management: Reclamation and DWR shall start OMR management when one or more of the following conditions have occurred:
  - Integrated Early Winter Pulse Protection - After December 1, when the 3-day average turbidity is 12 Nephelometric Turbidity Units (NTU) or greater at Old River at Bacon Island (OBI), Prisoner's Point (PPT), and Victoria Canal (VCU) in December, Reclamation and DWR propose to operate to -2,000 cfs of the 14-day average OMR index for 14 days.
  - Salmonids - After January 1, if more than 5% of any one or more salmonid species (wild young-of-year Winter-Run Chinook Salmon, wild young-of-year Spring-Run Chinook Salmon, or steelhead) are estimated to be present in the Delta as determined by their appropriate Monitoring Team based on available real-time data, historical information and modeling.
- Additional Real-Time OMR Restrictions: Reclamation and DWR shall manage to a more positive OMR based on the following conditions:
  - Turbidity Bridge Avoidance: Reclamation and DWR propose to operate to avoid a turbidity bridge (defined as 3-day average turbidity of 12 NTU at OBI). If a turbidity bridge occurs (3-day average turbidity is 12 NTU or greater at OBI and VCU and/or other predictors of a turbidity bridge), Reclamation and DWR propose to operate to a 5-day average OMR index of -2000 cfs for at least 5 days until 24 hours after the turbidity bridge dissipates (drops below 12 NTU at any of the southernmost stations). If turbidity is triggered by a wind event in Franks Tract and the channels immediately adjacent to Franks Tract, Reclamation would not modify the controlling OMR. When water temperature reaches 12 degrees Celsius based on a three station daily mean at Mossdale, Antioch, and Rio Vista, or when Delta Smelt spawning starts (indicated by spent females in the Spring Kodiak Trawl (SKT), Enhanced Delta Smelt Monitoring (EDSM) Program, or at Jones or Banks), this action terminates.
  - Wild Central Valley Steelhead Protection: Reclamation and DWR would operate to OMR of -2,500 cfs for 5 days whenever natural-origin steelhead loss trigger between the onset of OMR management for steelhead and May 31 exceeds 10 steelhead per TAF. The timing of this action is intended to provide protections to San Joaquin origin Central Valley steelhead, but the loss-density trigger is based on loss of all steelhead since there is currently no protocol to distinguish San Joaquin-basin and Sacramento-basin steelhead in salvage. Reclamation would use the current loss equation for steelhead or surrogate.
  - Salvage or Loss Thresholds: To backstop real-time operations, Reclamation and DWR propose a cumulative loss threshold of 90% of the take limit for Chinook Salmon, a cumulative loss threshold of 90% of the take limit for steelhead, a cumulative expanded salvage threshold of 90% of the take limit for Green Sturgeon, 1% of the abundance estimate based on EDSM for adult Delta Smelt, and 5% of the abundance estimate based on EDSM for juvenile Delta Smelt. Reclamation and DWR propose to operate as follows:
    - Reclamation and DWR may operate to a more positive OMR when the daily salvage loss indicates that continued OMR of negative 5,000 cfs may exceed cumulative salvage loss thresholds.

- When Q-West is negative and larval or juvenile smelt are within the entrainment zone of the pumps based on real-time sampling, Reclamation and/or DWR propose to run hydrodynamic models informed by the EDSM, 20 mm or other relevant survey data to estimate the percentage of larval and juvenile smelt that could be entrained, and operate to avoid no greater than 10% loss of modeled larval and juvenile cohort Delta Smelt. (Typically, this would come into effect no earlier than the middle of March.)
- Restrict OMR to a 14-day moving average OMR index of -3,500 cfs when a species-specific cumulative salvage or loss threshold exceeds 50 percent of the threshold. The OMR restriction to -3,500 cfs will persist until the species-specific off ramp is met.
- Restrict OMR to a 14-day moving average OMR index of -2,500 cfs (or more positive if determined by Reclamation) when cumulative salvage or loss threshold for any of the above species exceeds 75 percent of the threshold. The OMR restriction to -2,500 cfs will persist until the species-specific off ramp is met.
- Species-specific off ramp: Species-specific OMR restrictions will end when the individual species-specific "End of OMR management criteria" are met. For instance, if a Winter-Run Chinook Salmon cumulative salvage loss exceed 50% of the criteria during the season, operations would be limit to -3,500 OMR until it is estimated 95% of Winter-Run Chinook Salmon have migrated past Chipps Island.

The Secretaries of Interior and Commerce will comply with Section 4002 of the WIIN Act while the WIIN Act is in effect for OMR more positive than negative 5,000 cfs.

If Reclamation determines that a more negative OMR than the thresholds is warranted, Reclamation shall seek technical assistance from USFWS and NMFS, and support DWR in seeking California Endangered Species Act compliance.

- Storm-Related OMR Flexibility: If Reclamation and DWR are not implementing additional real-time OMR restrictions, consistent with other applicable legal requirements, Reclamation and DWR may operate to a more negative OMR up to a maximum (otherwise-permitted) export rate of 14,900 cfs (which could result in a range of OMR values) to capture peak flows during storm-related events. Reclamation and DWR will continue to monitor fish in real-time and will operate in accordance with "Additional Real-time OMR Restrictions," above.
- End of OMR Management: OMR criteria may control operations until June 30, or when both of the following have occurred, whichever is earlier:
  - Delta Smelt - when the daily mean water temperature at Clifton Court Forebay reaches 25° C for 3 consecutive days.
  - Salmonids - When more than 95 percent of salmonids have migrated past Chipps Island, as determined by their Monitoring Team, OR after daily average water temperatures at Mossdale exceed 72 degrees Fahrenheit for 7 days during June.

Figure D1.2-5 shows OMR management in a decision tree.

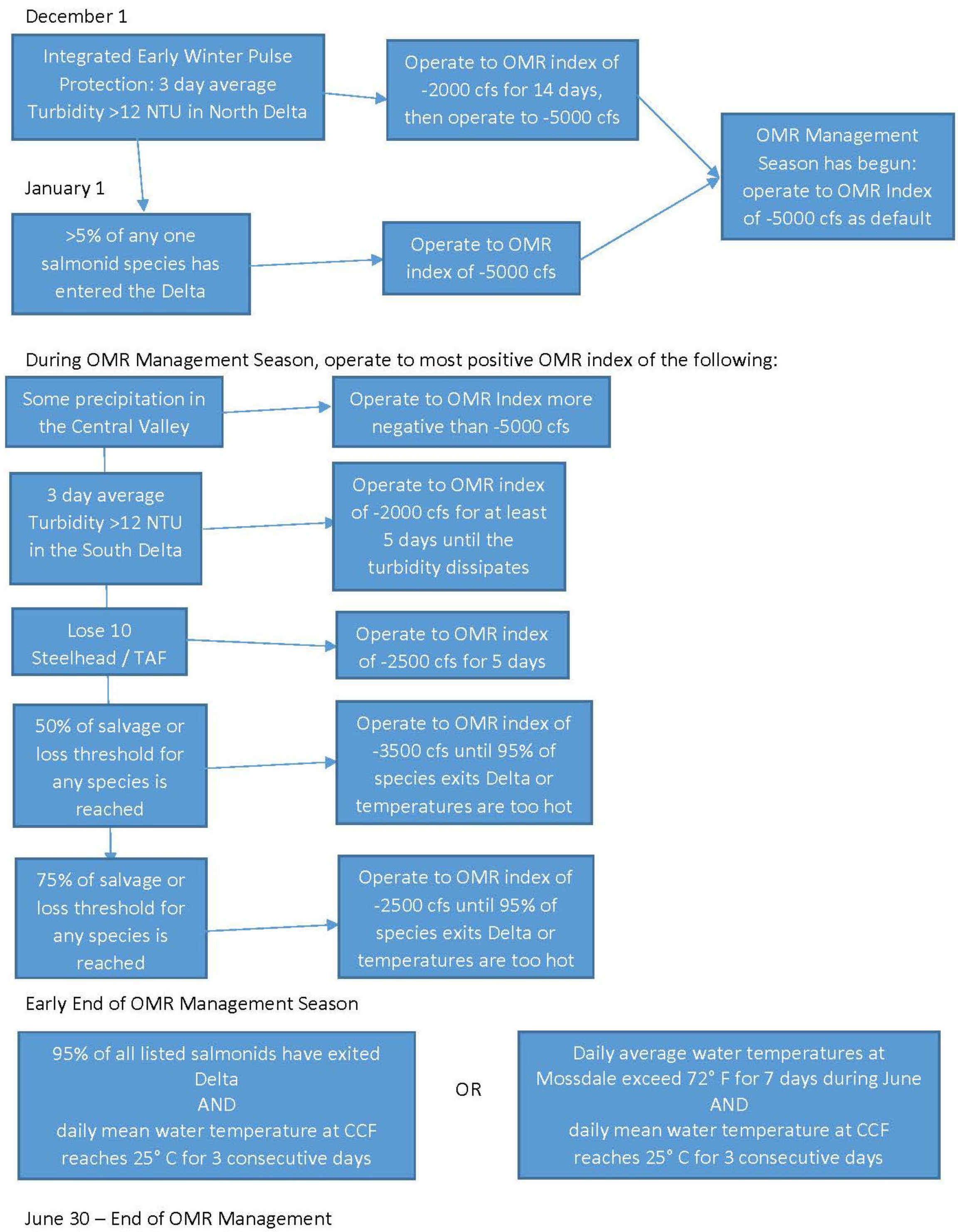

Figure D1.2-5. OMR Decision Tree

Objectives

- Fundamental objective: Increase juvenile salmon at Chipps Island per adult return
- Means objective: Adult Delta Smelt abundance

Conceptual Model (Each Species and Life stage)

This action affects CM4: Rearing to Migrating Juvenile in Tidal Delta, Estuary, and Bays for Winter-Run Chinook Salmon, and similar CMs for other salmonids. Habitat attribute H9 in this life stage is the effect of Jones and Banks Pumping Plants on entrainment risk for salmonids, which affects survival, timing and growth. The SAIL CM states,

> "Migration corridors and rearing habitats near water diversions increase the risk of entrainment-related mortality (H9). Juvenile salmon arriving in the South Delta are at risk of entrainment in the CVP and SWP water intakes. Each of these pumping plants has a fish salvage facility, and recent research suggests that once juvenile salmon enter the South Delta survival can be higher for fish captured in the CVP salvage facility and re-released more seaward (Buchanan et al., 2013). This reflects the extremely poor survival rate in the south Delta, which is hypothesized to result from poor rearing conditions such as low refuge habitat and food availability, and high predation risk. In addition, juvenile salmon may experience a diminished ability to navigate out of the south Delta toward the ocean due to confusion of navigational cues such as altered hydrology, channel network configuration, water quality gradients, and further navigational impairments from contaminants."

It further states,

> "In the interior Delta longer travel times and lower survival have been documented (Brandes and McLain 2001; Newman and Brandes 2010; Perry et al. 2010). In one study, survival probabilities were negatively associated with water exports, suggesting that water exports affect migration by increasing the risk of entrainment (Newman and Brandes 2010)."

In the SAIL CM, water diversions also affect the fish assemblage, which affects predation and competition, which affects the survival, timing, and growth of salmonid juveniles.

For Delta Smelt, relevant linkages from the CM (IEP MAST 2015) are:

- Proximity to water diversion sites can affect entrainment risk for multiple life stages of Delta Smelt (H1 from adult to larvae CM, H4 from larvae to juvenile CM).
- Exports (Brown et al. 2016) can also affect autochthonous and allochthonous food production and retention, which affects food availability and visibility, which affects multiple life stages of Delta Smelt (H2 from larvae to juvenile CM, H3, H4b from juvenile to subadult CM, subadult to adult CM).

Current Condition

2008 USFWS Biological Opinion (2008 BO) – RPA Actions 1, 2, and 3

- Action 1- To protect pre-spawning adult Delta Smelt from entrainment during the first flush and to provide advantageous hydrodynamic conditions early in the migration period. Action 1 Limits exports so that the average daily OMR flow is no more negative than -2000 cfs for a total duration of 14 days, with a 5-day running average no more negative than -2500 cfs (within 25 percent). From December 1-December 20, the action may be required based upon an examination of turbidity data from PPT, Holland Cut, and VCU and salvage data from CVP and SWP, and other parameters for protection. After December 20th the action will begin if the 3-day average at all three stations exceeds 12 NTU or if three days of Delta Smelt salvage after December 20 at either facility or cumulative daily salvage count that is above a risk threshold based upon the daily salvage index greater than or equal to 0.5.

- Action 2 – To protect pre-spawning adults from entrainment and adverse hydrodynamic conditions. Action 2 limits the range of net daily OMR flows to no more negative than -1,250 to -5000 cfs. Action 2 will begin immediately after Action 1 or as recommended by the SWG if Action 1 Is not implemented.
- Action 3- To minimize the number of larval Delta Smelt entrained at the facilities by managing the hydrodynamic in the Central Delta flow levels pumping rates spawning a time sufficient for protection of Delta Smelt. Action 3 limits OMR daily flow to no more negative than -1,250 to -5000 cfs, based on a 14-day running average with a simultaneous 5-day running average within the 25 percent of the applicable requirement for OMR. Action 3 is required when temperatures reaches 12C base on a three station average at Mossdale, Antioch and Rio Vista or at the onset of spawning (presence of spent females in SKT or at either facility.

2009 NMFS 2009 Biological Opinion (2009 BO) – RPA Action IV.2.3

The 2009 BO RPA Action IV.2.3 was intended to reduce the vulnerability of emigrating juvenile Winter-Run Chinook Salmon, Yearling Spring-Run Chinook Salmon, and CV Steelhead within the lower Sacramento and San Joaquin rivers to entrainment into the channels of the South Delta and at the pumps due to the diversion of water by the export facilities in the South Delta. This action is also intended to enhance the likelihood of salmonids successfully exiting the Delta at Chipps Island by creating more suitable hydraulic conditions in the mainstem of the San Joaquin River for emigrating fish, including greater net downstream flows. These actions require CVP and SWP to reduce exports, as necessary, to limit negative flows to negative 2,500 to negative 5,000 cfs in the OMR, depending on the presence of salmonids, from January 1 through June 15.

Background

Historically, the OMR was part of the tidal distributary channel network of the San Joaquin River (Whipple et al. 2012). Today, they are a central component of the CVP and SWP water conveyance system through the Delta. Water from the Sacramento River in the north now flows through the northern Delta (down Georgiana Slough, through Three-Mile Slough and around Sherman Island) and eastern Delta (via the artificial “Delta cross-channel” and down the forks of the Mokelumne River) to OMR in the central Delta, then to the SWP and CVP. The SWP and CVP pumps are capable of pumping water at rates sufficient to cause the loss of ebb tide flows and to cause negative net flows through OMR toward the pumps (Grimaldo et al. 2009), thus greatly altering regional hydrodynamics and water quality (Monsen et al. 2007). Fish and other aquatic species in the Delta may be transported toward the pumps (Arthur et al 1996, Brown et al. 1996, Moyle et al. 2010), may swim toward the pumps if they are behaviorally inclined to follow net flow (Grimaldo et al. 2009), or may move toward the pumps if they are employing tidal surfing behavior (Sommer et al. 2011).

The use of OMR management was introduced by the USFWS and the NMFS in their 2008/09 BOs on the LTO of the CVP and SWP. These BOs imposed additional constraints on the Projects’ exports during December to June by requiring RPA OMR operation for protected fish species such as Delta Smelt, steelhead, and Winter-Run Chinook Salmon. In general, Delta Smelt salvage increases with increasing net OMR flow reversal (i.e., more negative net OMR flows) and when turbidity exceeds 10-12 NTU (USFWS 2008, Grimaldo et al. 2009). OMR flows represent the direction and magnitude of flows in the South Delta between the Projects’ export facilities and the lower San Joaquin River. The flows are dependent on factors such as flow into the Delta from tributaries and flows exported from the Delta by the Projects, but are also influenced by atmospheric pressure, spring-neap tidal cycles, diversions by local users of water, and the wind. Actual measurements on the OMR corridors are made through acoustic velocity meters maintained by the USGS and located near Bacon Island for both river corridors. Since 2014, Reclamation and DWR has managed OMR flows through an OMR Index Demonstration Project.

Management of OMR flow criteria through an index (estimate) using numerical model output or using data-based regression relationships, rather than actual USGS tidally filtered measurements. The index eliminated the 5-day running average requirement and allows operators to "ride out" daily OMR flow fluctuations without having to continuously adjust exports.

Past Implementation

Since 2009, net OMR flows during periods of increased fish entrainment risk can be less negative than they were in years prior to the BiOps (see Figure D1.2-6). Prior to 2008, net OMR flows often reached −8,000 to −10,000 cfs (Kimmerer 2008, Grimaldo et al. 2009), when outflow was low. An exception to these strongly negative flows occurred during April-May export curtailments associated with the Vernalis Adaptive Management Program 2000–2012.

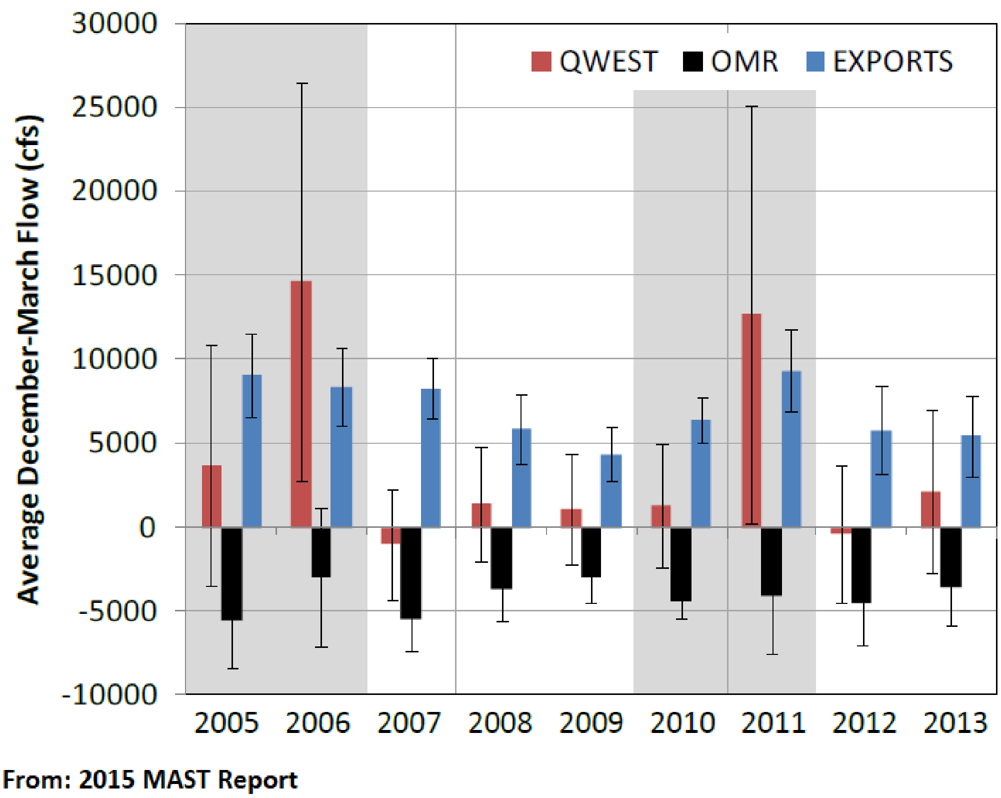

Figure D1.2-6. Annual average daily net flows for December through March in cfs in the OMR, past Jersey Point on the lower San Joaquin River (QWEST) and total exports in millions of acre-feet (MAR), 2005-2013. Error bars are 1 standard deviation.

For complete more details concerning OMR implementation, see DOSS Technical Advisory Team annual reports from 2010 to 2018. These reports are available at: https://www.westcoast.fisheries.noaa.gov/central_valley/water_operations/doss.html

Current Science

Salmonids

For salmon released in the Sacramento River, Perry et al. (2010) found, "survival of juvenile salmon migrating through the interior Delta, where water pumping stations are located, was consistently less than for fish that migrated via the Sacramento River". He also states that "survival is low when fish migrate via a route in which more water can flow inland than towards the ocean". Perry et al. (2010) noted that "travel times for fish migrating through the interior Delta were longer than alternative routes, possibly contributing to lower survival through the interior Delta." Reclamation infers from this study, as well as others, that Jones and Banks pumping plants do reduce juvenile salmon survival in an area around them, and that the export facilities do not just directly salvage fish but move them into areas where they may be more exposed to other mortality factors (e.g., predation, water quality). Releases of coded wire tag Fall-Run Chinook Salmon between 1993 and 2003 in the Sacramento and San Joaquin Rivers were analyzed by Zeug and Cavallo (2013). This study found that tributary conditions (temperature, water quality) and fish size may be more important than exports, and the authors state there "was little evidence that large-scale water exports or inflows influenced recovery rates in the ocean during this time period". The authors note that the use of ocean recovery data also may have influenced the lack of a detectable flow effect. The authors also state that "assumed relationships and CMs should be quantitatively evaluated before implementing management actions" (Zeug and Cavallo 2013). Reclamation infers from this study that tributary conditions may be more important than exports in affecting salmonid survival.

Michel et al. (2012) found that water velocity was negatively correlated with movement rates for late-fall run yearling Chinook Salmon from the Sacramento River. Reclamation infers from this study that additional factors are at play in addition to water velocity (which exports affects in an area around the Jones and Banks Pumping Plants). Cavallo et al, 2015 found that both inflows and diversions had relatively small effects on the predicted routing of fish into the interior Delta at tidally dominated junctions. The authors concluded that the proportion of flow entering a distributary channel was selected as the best metric to explain route selection of juvenile Chinook Salmon at junctions in the Delta. The linear model explained a significant fraction of the total variation in observed routing; however, fish were less likely to enter distributary routes relative to total flow proportion. These results suggest that total flow proportion at each junction can be used in conjunction with the linear model to predict fish routing. This will be an effective tool for evaluating water management actions on fish routing; especially where little or no observed fish routing data are available. For example, if managers propose to keep more fish in the main stem by increasing inflows or reducing diversion, they can use the model to determine how much flow proportions would need to be altered to achieve a measurable effect on observed routing. However, because the authors did not examine the effects of flow and exports on fish that have already been entrained into the interior Delta these conclusions may not be applicable to proposed changes to OMR management or capable of assessing the impacts of exports on interior Delta entrainment and survival within the interior Delta. These results are in contrast to a multi-year analysis of flow-survival relationships in the North Delta which did use a substantially more robust set of observed fish routing data and revealed that flow effects were only significant in reaches that switch from bidirectional to unidirectional as flow increases (transitional reaches), whereas flow has no detectable effect where flow is always bidirectional (Perry et al., 2018). This emerging science indicates to Reclamation that exports do not affect the routing of salmon in the Delta once they reach its strongly tidal interior; specifically, once they pass Georgiana Slough on the Sacramento River or the head of Old River on the San Joaquin River.

On the San Joaquin River, Holbrook et al (2009) found the highest survival of San Joaquin River Fall-Run Chinook Salmon through the San Joaquin River and stated that "once tagged fish entered Old River, only fish collected at two large water conveyance projects and transported through the Delta by truck were detected exiting the Delta, suggesting that this route was the only successful migration pathway for fish that entered Old River". San Joaquin River salmon survival has been declining over time, (https://www.fws.gov/lodi/juvenile_fish_monitoring_program/docs/PSP_CalFed_FWS_salmon_studies_final_033108.pdf), and thus research has found poor survival regardless of route. DWR's stipulation study found that for the "OMR flow treatments tested in this study, there appeared to be little influence of OMR flows tested on steelhead tag travel times on the route-level and steelhead tag movement at the junctions and routes examined in this study" (DWR 2014). The junctions and routes examined in the study were relatively far from Jones and Banks Pumping Plants. In addition, this was a one year study under which two OMR flows were evaluated -2500 and -5000. As such, it compares poor outmigration conditions to poor outmigration conditions for San Joaquin origin steelhead and by proxy Chinook Salmon from both the Sacramento and San Joaquin River systems and is limited in its interpolation. In the San Joaquin Basin, habitat conditions may be so poor that even positive OMR flows do not have an effect on survival, which remains low (SJRG 2011, SJRG 2013). Tag results from the six-year acoustic study suggest Vernalis flows accounted for more of the variation in steelhead survival than: exports, inflow/export ratio, flow at the head of Old River, or OMR flows (Reclamation 2018a, b, c). "Exports did not appear to have an effect on route entrainment at the head of Old River, but flows, or rather, flow and stage did" (Reclamation 2018c).

The Salmonid Scoping Team (SST) issued a two-volume report in 2017 that looked at hydrodynamics, juvenile migration behavior of salmon and steelhead, and survival of juvenile salmon and steelhead in the San Joaquin River and central Delta. Neither coded wire tag nor acoustic tag data show a strong and consistent relationship between survival and exports (SST 2017). However, prior to this statement, the SST report identifies that the "basis of knowledge is considered to be low because information on the relationships between water project operations and South Delta hydrodynamics among different migration routes and drivers such as exports, barriers or Clifton Court radial gate operations, and migration route velocity is based primarily on non-peer-reviewed agency reports, and because of limitations of the models and lack of calibration and validation in the south Delta channels as presented in this report." The authors also state that "outside of the north Delta, it is not currently possible to predict how specific changes in flow and velocity impact migration rates. Acoustic tag studies have not shown strong relationships between exports and migration rate under the conditions tested, but few analyses have focused on the relationship between exports and migration rate. Also, exports, velocities, and flows may be linked in some locations such that determining relative effects among these variables will be difficult." For hydrodynamic effects, the Salmonid Scoping Team (2017) stated that "the effects of SWP and CVP exports on hydrodynamics is greatest in channels located in close proximity to the export facilities and decreases as a function of distance both upstream and downstream of the facilities." SST (2017) also stated that, "Water export operations contribute to salmonid mortality in the Delta via direct mortality at the facilities, but direct mortality does not account for the majority of the mortality experienced in the Delta; the mechanism and magnitude of indirect effects of water project operations on Delta mortality outside the facilities is uncertain." SST (2017) also recommends that further focused investigation into the links to water project operations underlying salmonid mortality due to hypothesized indirect mortality factors including, "increased metabolic rate of predatory fish such as striped bass and largemouth bass in the Delta, water project operations affecting the magnitude and timing of flow resulting in increased juvenile salmonid predation mortality, changes in Delta habitat, including expansion of non-native submerged aquatic vegetation, increased water clarity, potential exposure to contaminants, and other factors." "Further, there is also currently no broad scientific agreement on threshold changes in flows or velocities that influence salmonid migration behavior or survival within a channel or at a channel junction."

Some of the SST members felt that any change in velocity or flow resulting from water project operations could be biologically significant, while others felt that only changes above some threshold that has yet to be defined should be considered to have potential biological significance. For example, would a change in velocity at a specific location in the Delta as a result of a change in exports of 0.01 ft/sec, 0.1 ft/sec, or 1.0 ft/sec be expected to affect route selection, migration rate, or survival?" (SST, 2017). The SST 2017 also recommends conducting further focused investigation into the links between water project operations and salmonid mortality due to hypothesized indirect mortality factors including increased metabolic rate of predatory fish, water project operations affecting the magnitude and timing of flow resulting in increased juvenile salmonid predation and expansion of non-native submerged aquatic vegetation, increased water clarity, potential exposure to contaminants, and other factors

Independent review panels have found that "…simple flow metrics like OMR may have too much uncertainty to be an appropriate basis for setting standards," (Monismith et al., 2014) and "…the lack of relationships between OMR inflows/exports and smolt movement/survival suggest that these were insensitive indicators for evaluating effectiveness of Delta operations on salmonids" (Anderson et al. 2012, p. 31).

Appendix A – Juvenile Chinook Salmon Distribution and Timing draws upon data from the SacPAS website on the historical migration and timing of Winter-Run Chinook Salmon. As stated by Rosario et al (2013), "Winter-run appear to be present in the Sacramento River system or Delta nearly year round—they are first detected emigrating from their natal grounds at Red Bluff in July, and last detected leaving the Delta at Chipps Island as smolts as late as May." The CM Reclamation presents in Appendix A shows that rearing fish are less vulnerable to the effects of exports as they are in slower moving or shallower areas less likely to be drawn towards the facilities. The presence of one of these rearing salmonids in the Jones or Banks Pumping Plants may not indicate a population level effect, as the rearing salmonids are at a different timing than migratory smolts and may be in smaller groups. However, significant numbers of Winter-Run Chinook Salmon passing Chipps Island may indicate that fish are beginning their emigration phase and may be vulnerable to adverse effects due to exports.

Delta Smelt

In evaluating historical data for the influence of OMR on Delta Smelt salvage Grimaldo et al (2017) found that "during first flush periods, salvage at each facility was best explained by water exports (sampling effort), precipitation (recently linked to movement and vulnerability to offshore trawling gear), abundance and Yolo Bypass flow. During the entire adult salvage season, SWP salvage was best explained by SWP exports, Yolo Bypass flow, and abundance whereas CVP salvage was best explained by abundance, OMR flows, and turbidity. This study suggests that adult Delta Smelt salvage is influenced by hydrodynamics, water quality, and population abundance." The authors go on to state,

> "CVP exports actually played a minor influence in directly affecting CVP salvage and that it had no detectable influence on SWP salvage. OMR flows had a higher influence on CVP salvage, more so than even CVP exports, suggesting an indirect influence of SWP and CVP exports as they both contribute to net reverse flows in the south Delta (Monsen et al. 2007). But the influence of OMR flow could also be related to San Joaquin River flow dynamics, especially for Delta Smelt that may take multiple routes to the salvage facilities."

Reclamation adds that SWP will export water for the CVP due to capacity constraints or other issues which would otherwise prevent the CVP from exporting all the water it possibly could. The authors state, "in some years, adult Delta Smelt move into the south Delta where they become more vulnerable to water exports because they become distributed within the hydrodynamic "footprint" of the Projects where the net movement of water is toward the pumping plants."

Grimaldo et al (2017) further found,

> "OMR flows have been used as metric for management of adult entrainment risk, because the magnitude of salvage observations was related to OMR in the US Fish and Wildlife's 2008 Biological Opinion (FWS 2008). Confirming those findings, BRT models of both CVP and SWP expected salvage increased at OMR < -5,000 cfs, when all other variables were held at their averages. While OMR flow was the second most important predictor of CVP salvage, more important than even CVP exports, the OMR threshold of -5,000 cfs was most notable in SWP salvage."

Based on this paper (among others), Reclamation infers that CVP and SWP exports affect the local hydrodynamics of the south Delta, creating negative OMR flows at times, which can entrain Delta Smelt. Reclamation also infers that OMR is a relevant physical parameter for protecting Delta Smelt, and specifically that an OMR of -5,000 cfs is a relevant threshold for predicting salvage.

In addition to salvage, entrainment into the South Delta is an effect of CVP and SWP operations on Delta Smelt identified in the 2008 USFWS BO. Swanson et al. 1998 defined the critical swimming velocity (Ucrit) for Delta Smelt to be 24 to 32 centimeters per second. The paper states, "the relatively poor swimming ability of these Delta Smelt suggests that…this species would be at greater risk from entrainment." From this paper, Reclamation infers that any Delta Smelt entering the south Delta will be unable to outswim strongly negative OMR flows irrespective of San Joaquin River flow dynamics.

In addition to the Fall Mid-water Trawl (FMWT) and SKT, the EDSM Program provides information to inform entrainment risk by dynamic sampling of Delta sub-regions, improving the reliability estimates of distribution and abundance. However, it has been recognized that "abundances near the detection threshold of the sampling techniques makes it very difficult to draw reliable inferences about how many Delta Smelt there are, and where they are located" (2008 USFWS BO). Delta Smelt populations have reduced further since 2008. EDSM and all Delta Smelt monitoring programs are limited due to the low abundance of the species and therefore limited in their ability to support real-time decision making.

Justification

The justification for the action is to provide the maximum quantity of water supplies practicable to Central Valley Project contractors, and State Water Project contractors, through real-time OMR management while not jeopardizing federally listed fish species or adversely modifying their designated critical habitat. Reclamation would manage OMR flows for species protection while increasing water supply, by considering relevant factors such as the distribution of the listed species throughout the Delta, and the potential effects of high entrainment risk on subsequent species abundance, the water temperature and turbidity.

Figure D1.2-7 shows Sacramento Beach seine raw catch from 2003-2016. Beach seining is used to monitor and assess the effects of water operations on the inter- and intra-annual abundance and distribution of juvenile Chinook Salmon occurring in mostly unobstructed nearshore habitats (for example beaches and boat ramps; Kjelson et al, 1982). Beach seine and trawl data results indicate that fry and smolt sized individuals occupy both open water mid-channel and near shore littoral habitats (Speegle et al, 2013). Delta beach seine data and other investigations (e.g., Kjelson et al. 1982) imply that fry may prefer near-shore littoral habitat and that smolts may prefer to occupy open water mid-channel habitat during the day (Speegle et al, 2013). While beach seine data is used to assist in estimating abundance of out-migrating juvenile Chinook Salmon, it may be representative of Winter-Run Chinook Salmon fry rearing, as beach seines sample from the littoral zone at the edges of the channel.

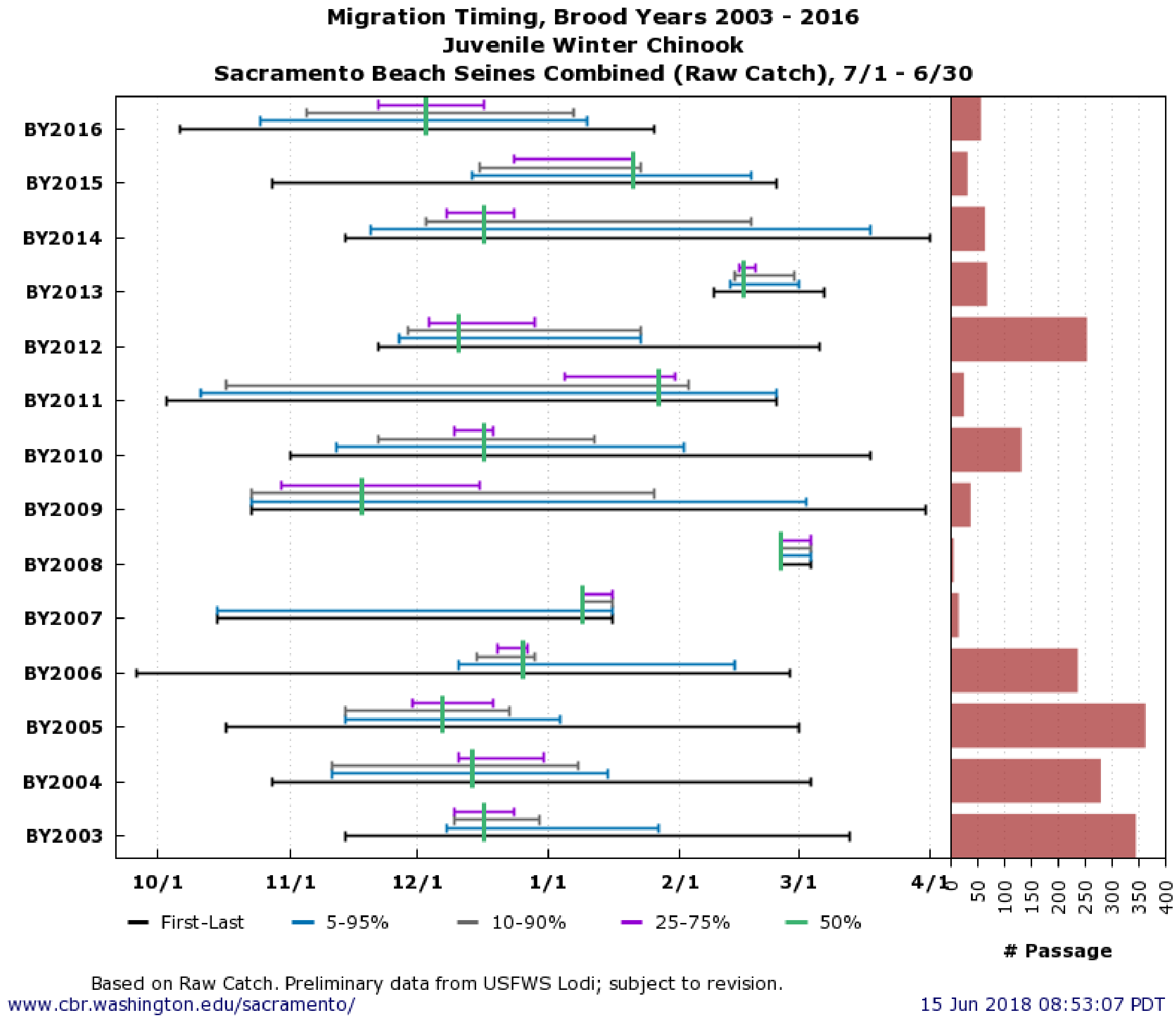

Figure D1.2-7. Winter-Run Juvenile Chinook Salmon Sacramento Beach Seines. Figures from SacPAS.

Figure D1.2-8 below shows the emigration timing of juvenile Winter-Run Chinook Salmon from brood years 2008 through 2016 from SacPAS, based on raw catch data at the Chipps Island trawl from the USFWS in Lodi. As can be seen on the figure, the first fish may begin emigrating out of the Delta as early as December, but in years like 2011, this first fish is not indicative of the whole population. This figure also shows that migration timing is highly variable. In 2015, the majority of the population migrated out of the Delta in early April, but in 2013, the majority migrated out in early March.

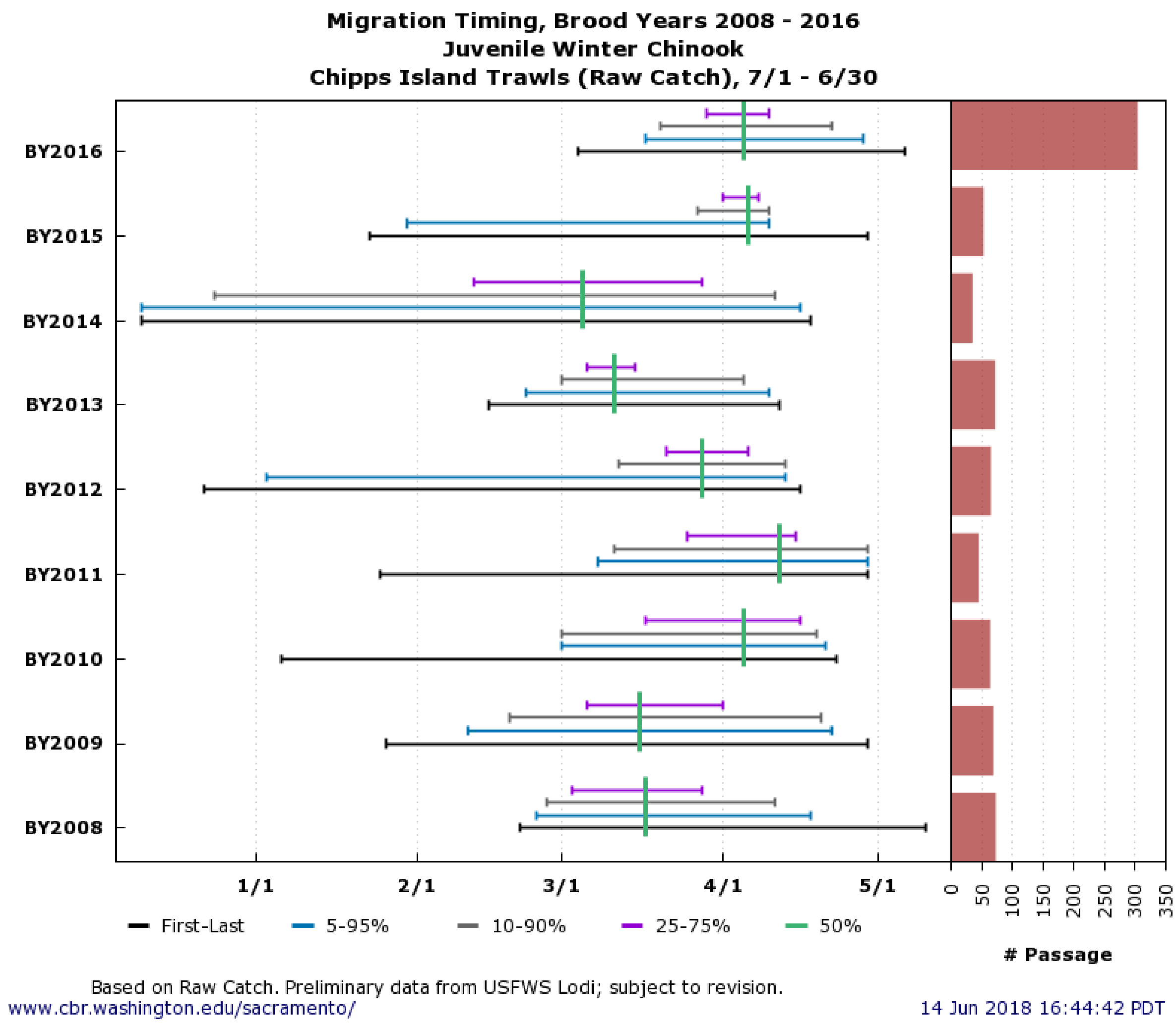

Figure D1.2-8. Juvenile Winter-Run Chinook Salmon Migration Timing. Figures from SacPAS: http://www.cbr.washington.edu/sacramento/data/query_hrt.html

Comparing Figure D1.2-7 to Figure D1.2-8, juvenile Winter-Run Chinook Salmon are in the littoral zone at a different timing than they are migrating past Chipps Island. This behavior, possible fry rearing, happens earlier in the year.

Relatively limited study has been done of rearing salmonids in the Delta. Erkkila et al (1950) stated that "the population of juvenile fish in the Delta from February to June is composed entirely of seaward migrant king salmon". While current populations and species assemblage are certainly much different than those observed in 1950, it appears that some juvenile Chinook Salmon may rear in the Delta before migrating out. Kjelson et al. (1982) demonstrated that coded wire tag fry (<70 mm FL) reared in the Estuary for up to two months, primarily in the upper freshwater portion of the Delta. The relative contribution of delta-reared fry to adult production is unknown but may have been substantial under natural conditions (Brown 2003). High fry densities were found in Steamboat Slough by McLain and Castillo (2009).

Based on the trawl and seine data presented above as well as the studies showing some rearing of salmon in the Delta, Reclamation's CM is that Chinook Salmon migrate downstream to the Delta during the fall and winter, rear (and continue smoltification) in the Delta during the winter and spring and complete the emigration process by leaving the Delta in the spring. Reclamation believes that the purpose of OMR triggers are to identify when a population level effect is about to occur and avoid it before occurrence. Reclamation conceptualizes that rearing in the Delta is done in small groups of juvenile fish, and that these rearing fish are less vulnerable to the effects of exports as they are in slower moving or shallower areas less likely to be drawn towards the facilities. Reclamation conceptualizes that if one of these rearing salmonids is entrained into Jones or Banks Pumping Plants, this entrainment may not indicate a population level effect is imminent, as the rearing salmonids are at a different timing than migratory smolts and may be in smaller groups.

Therefore, Reclamation and DWR propose using 5% of the Winter-Run Chinook Salmon population passing Chipps Island as an alert to Reclamation and DWR that fish are beginning their emigration phase and may be vulnerable to adverse effects due to exports. At this point, Reclamation and DWR would begin the OMR salmonid action with OMR flows no more −5000 cfs.

Reclamation and DWR propose using the fish distribution estimates produced by DOSS to inform Reclamation and DWR when fish are exhibiting the migratory behavior, and therefore, are at greater risk of adverse effects due to exports. As shown by Figure D1.2-9 from the 2015 DOSS report, DOSS fairly accurately predicts on a weekly basis when fish are yet to enter the Delta, in the Delta, and have exited the Delta. The distribution estimates produced by DOSS are based on all relevant monitoring conducted in the region and represent use of the best available scientific data. DOSS' estimate of fish passing Chipps Island exceeding 5% of the Winter-Run Chinook Salmon population will be used as an alert to Reclamation and DWR that fish are beginning their emigration phase and may be vulnerable to adverse effects due to exports. Reclamation and DWR would then use this alert to evaluate initiating the OMR action and likely limit OMR flows to no more negative than -5000 cfs (with the exceptions noted below) until DOSS estimates 95% or more of the Winter-Run Chinook Salmon have passed Chipps Island.

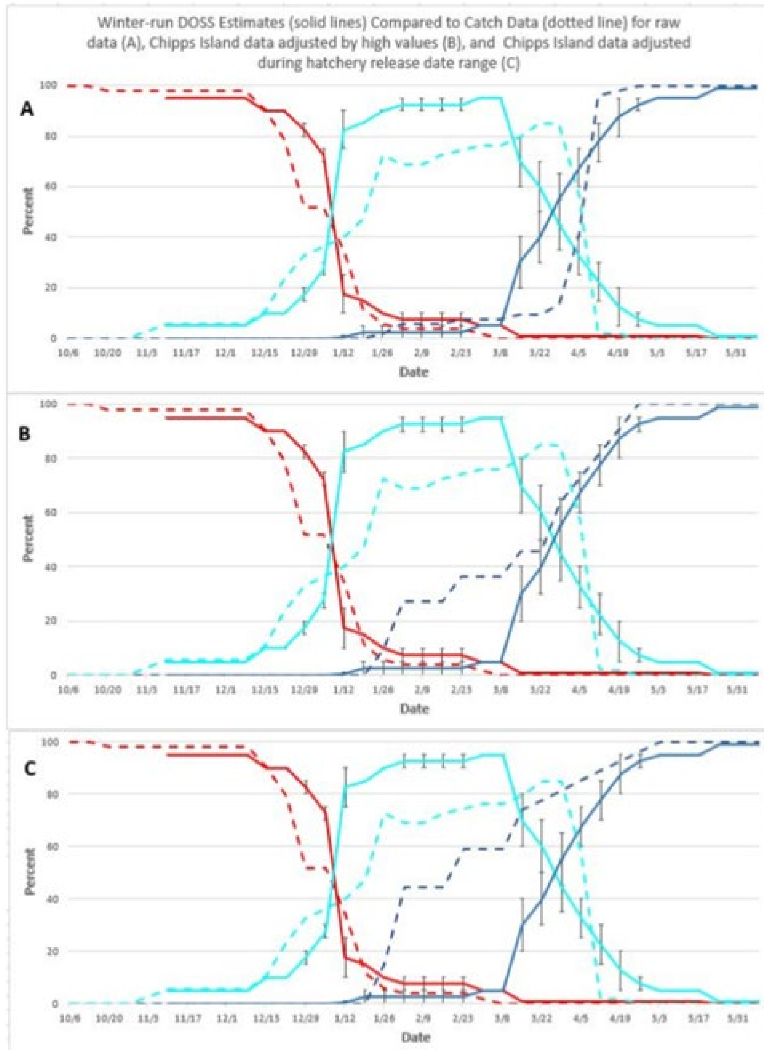

Figure D1.2-9. Winter-Run Chinook Salmon weekly DOSS estimates compared to raw data (A), adjusted high values only (B), and adjusted hatchery release date range (C). Red lines indicate "Yet to Enter the Delta," turquoise lines indicate "In Delta," and dark blue lines indicate "Exited the Delta." Solid lines are weekly DOSS estimates and dashed lines are catch data.

<u>Delta Smelt</u>

As stated in the 2008 BO, there are three major factors related to operations of the CVP/SWP affecting Delta Smelt population resilience and long-term viability. It is also recognized that the hydrologic changes from the CVP/SWP result in ecological conditions that influence Delta Smelt interactions with other stressors within the Delta. For purposes of the OMR, these factors are (1) direct mortality associated with entrainment of pre-spawning adult Delta Smelt by CVP/SWP operations and (2) direct mortality of larval and early juvenile Delta Smelt associated with entrainment by CVP/SWP operations. The combination of tidal cycles, hydrologic and meteorological events, and CVP/SWP operations can draw Delta Smelt into the South and Central Delta where they are more susceptible to entrainment by the facilities prior to any observed Delta Smelt salvage. This necessitates an anticipatory strategy in order to sufficiently protect Delta Smelt from entrainment.

Grimaldo et al (2017) find that "during first flush periods, salvage at each facility was best explained by water exports (sampling effort), precipitation (recently linked to movement and vulnerability to offshore trawling gear), abundance and Yolo Bypass flow. During the entire adult salvage season, SWP salvage was best explained by SWP exports, Yolo Bypass flow, and abundance whereas CVP salvage was best explained by abundance, OMR flows, and turbidity. This study suggests that adult Delta Smelt salvage is influenced by hydrodynamics, water quality, and population abundance." The authors go on to state,

> "CVP exports actually played a minor influence in directly affecting CVP salvage and that it had no detectable influence on SWP salvage. OMR flows had a higher influence on CVP salvage, more so than even CVP exports, suggesting an indirect influence of SWP and CVP efforts as they both contribute to net reverse flows in the south Delta (Monsen et al. 2007). But the influence of OMR flow could also be related to San Joaquin River flow dynamics, especially for Delta Smelt that may take multiple routes to the salvage facilities."

According to Grimaldo et al. (2017),

"OMR flows have been used as metric for management of adult entrainment risk, because the magnitude of salvage observations was related to OMR in the US Fish and Wildlife's 2008 Biological Opinion (FWS 2008). Confirming those findings, BRT models of both CVP and SWP expected salvage increased at OMR < -5,000 cfs, when all other variables were held at their averages. While OMR flow was the second most important predictor of CVP salvage, more important than even CVP exports, the OMR threshold of -5,000 cfs was most notable in SWP salvage."

The 2008 Service BO uses information from the FMWT, SKT, and Delta Smelt salvage at the Jones and Banks pumping plants to inform OMR action implementation, but available physical and biological monitoring data other than these are also used. Recent Enhanced Delta Smelt Monitoring (EDSM) may provide information to inform entrainment risk. EDSM also provides dynamic sampling of sub-regions by water year, retains samples for future research, and improves representation of near shore occupancy and abundance. Additionally, Delta Smelt abundance may have declined to levels near the detection threshold of EDSM. As indicated in the 2008 Service BO, "abundances near the detection threshold of the sampling techniques makes it very difficult to draw reliable inferences about how many delta smelt there are, and where they are located".

In addition to enhanced monitoring, there are currently under development or available several Delta Smelt Particle Tracking models. These include several based on DWR's one-dimensional DSM2 model with particle tracking, such as those used by Rose (2013), Wilbur (2000), Miller (2002), and Kimmerer and Nobriga (2008).

For questions involving multiple dimensions (such as salinity in the Delta), Gross et al (2010, 2018) has developed a three-dimensional Particle Tracking Model (FISH PTM) using the Bay-Delta UnTRIM model (MacWilliams et al., 2008) for the hydrodynamics. The Flexible Integration of Staggered-grid Hydrodynamics Particle Tracking Model (FISH PTM) was developed to represent particle transport processes for a class of hydrodynamic models. The FISH-PTM represents horizontal and vertical transport processes, has flexible particle release capabilities, has representation of movement of particles through structures including culverts and weirs, has representation of particle losses at exports and agricultural diversions, and incorporates vertical swimming behavior. There is ongoing effort to develop swimming behaviors, including that by Korman et al (2018), who statistically evaluated the Particle-tracking models with swimming behavior to determine which swimming behaviors best fit proportional entrainment loss.

In addition to the particle tracking models, organizations (such as ICF) are developing statistical models to predict entrainment. Machine learning approaches trained on historical data could, based on current and forecasted environmental conditions and water operations, predict a distribution of potential take for smelt.

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D1.2.6.2 *Habitat*

D1.2.6.2.1 Low Salinity Zone – X2 Isohaline for Low Salinity Zone from D-1641 to Fall X2 (No Fall X2)

Summary

Reclamation proposes to operate the Suisun Marsh Salinity Control Gates (SMSCG), in coordination with the Roaring River Distribution System (RRDS) west-side drain, during September and October following above normal and wet water years to achieve a target low salinity zone (LSZ) areal extent. This would replace the existing USFWS (2008) RPA Action 4 for fall X2 and outflow.

Description

In place of the USFWS (2008) RPA Action 4 for fall X2 and outflow, Reclamation proposes to operate the SMSCG in coordination with the RRDS west-side drain in September and October following above normal and wet water years. The initial proposal is that operations will be done to achieve a target LSZ areal extent consistent with the existing USFWS (2008) RPA Action 4. Based on modeling, this would require 5,313 hectares of LSZ (i.e., salinity of 1-6) in September and October following above normal years, and 8,380 hectares following wet years (IEP MAST 2015, p.79). Achievement of these targets would be assessed using the UnTRIM Bay-Delta Model (DMA 2014), applying the observed outflow, SMSCG, and RRDS operations, in addition to other necessary inputs to be developed by Reclamation and DWR. The specific target habitat areal extent will be refined from the initial proposal in consultation with USFWS.

Reclamation also proposes to coordinate with USFWS to potentially supplement or replace the LSZ areal extent target approach with an index-based approach. The existing method of Feyrer et al. (2011) gives predictions of an abiotic habitat index as a function of X2, with the index essentially being the area of habitat (hectares) weighted by its suitability for Delta Smelt as a function of Secchi depth, specific conductance, and temperature. From this method, target habitat indices can be developed for fall following above normal (index = 4,835) and wet (index = 7,261) water years (IEP MAST 2015, p.83). With optimal conditions (i.e., habitat suitability = 1 for Secchi depth, specific conductance, and temperature), the habitat indices would be interpreted as 4,835 hectares of optimal habitat following above normal years and 7,261 hectares of optimal habitat following wet years. Use of a habitat index offers the benefit of incorporating the effects of other proposed actions (e.g., the Sediment Augmentation Program for Turbidity) that could influence variables other than just salinity (specific conductance). Reclamation would coordinate with USFWS to assess the potential for updating the habitat index to incorporate biotic elements, in particular food (zooplankton prey density), in order to better capture the potential benefits from actions such as operation of the RRDS west-side drain.

Objectives

- Fundamental objective: Increase abundance of Delta Smelt
- Means objective: Abundance

Conceptual Model (Each Species and Life stage)

The IEP MAST CM for the transition between the sub-adult and adult Delta Smelt life stages posits that hydrology (fall outflow) as an environmental driver acts with wind and winter floods to influence turbidity and therefore the predation risk habitat attribute and influence food availability through action of food production and retention. Fall outflow also interacts with bathymetry to affect the size and location of the LSZ habitat attribute (IEP MAST 2015, p.89-91).

Current Condition

The current USFWS (2008) RPA Action 4 is described as follows:

> Subject to adaptive management…, provide sufficient Delta outflow to maintain average X2 for September and October no greater (more eastward) than 74 km in the fall following wet years and 81km in the fall following above normal years. The monthly average X2 must be maintained at or seaward of these values for each individual month and not averaged over the two month period. In November, the inflow to CVP/SWP reservoirs in the Sacramento Basin will be added to reservoir releases to provide an added increment of Delta inflow and to augment Delta outflow up to the fall target. The action will be evaluated and may be modified or terminated as determined by [USFWS].

Details of current operations of the SMSCG are provided in the description of the Suisun Marsh Salinity Control Gates proposed action, which note that currently the SMSCG are operated between October and May when needed to meet Suisun Marsh salinity standards.

Background

The background and justification for the fall X2 RPA action is provided by USFWS (2008: p.372-375). In summary, the action was aimed to address the USFWS conclusion that after 1998, fall outflows were similar to historic droughts regardless of water year type. Fall habitat was noted to shift in abundance and distribution largely due to fluctuations in salinity (Feyrer et al. 2007), with more upstream X2 confining the Delta Smelt population in upstream areas of narrow channels, where there may be more exposure to stressors such as agricultural diversions and predation (USFWS 2008, p.372). Exposure of Delta Smelt in the fall to such adverse effects was suggested by USFWS (2008, p.372) to possibly be part of the reason that Feyrer et al. (2007) found a statistical association between fall X2 and the production of young Delta Smelt the following year following 1987 (i.e., an additive model predicting the summer townet index of one year as a function of the previous fall midwater trawl index, specific conductance, and Secchi depth). Other factors noted to be associated with lower flow conditions by USFWS (2008, p.372) include Microcystis. The fall X2 action was focused on wet and above normal years because USFWS (2008, p.373) felt that these were the year types in which project operations most significantly adversely affected fall conditions and therefore, actions in these year types would be more likely to benefit Delta Smelt.

Since issuance of the USFWS (2008) BO, the fall X2 action was triggered twice, in 2011 and 2017, which were both classified as wet years. In both years, the specific requirements of the RPA were modified: in 2011 as a result of legal action, and in 2017 as a result of a temporary modification of the October requirements in response to low reservoir storage caused by damage to the Oroville Dam spillway. Estimates for daily X2 are available from the California Data Exchange Center (CDEC, http://cdec.water.ca.gov/dynamicapp/staMeta?station_id=CX2) and DAYFLOW (https://water.ca.gov/Programs/Environmental-Services/Compliance-Monitoring-And-Assessment/Dayflow-Data). The former is based on linear interpolation of the 2.64 µS/cm electrical conductivity location among four electrical conductivity monitoring stations at Martinez (MRZ, 56 km), Port Chicago (PCT, 64 km), Chipps Island (74 km) and Collinsville (CLL, 81 km), as such, there are no estimates produced for X2 < 56 km and X2 > 81 km. The DAYFLOW estimate is based on an equation predicting daily X2 from Delta outflow and the previous day's X2. Mean September X2 was estimated to be 73.8 km (CDEC) and 75.3 km (DAYFLOW) in 2011, and 74.4 km (CDEC) and 74.5 km (DAYFLOW) in 2017. Mean October X2 was estimated to be 73.3 km (CDEC; note that one day had X2 > 81 km and was not included in the calculation) and 74.0 km (DAYFLOW) in 2011, and 77.4 km in 2017 (only CDEC data were available; note that four days had X2 > 81 km and were not included in the calculation).

A summary of past implementation of SMSCG operations is provided in the *Suisun Marsh Salinity Control Gates* component.

Current Science

The IEP MAST CM was applied to address several hypotheses to address why Delta Smelt abundance increased in the wet year of 2011. First, the hypothesis that food availability affects Delta Smelt abundance and survival was generally supported (IEP MAST 2015, p.140). There was some limited support for the hypothesis that high Microcystis levels may have a negative effect on sub-adult to adult survival, although the lower survival in 2011 compared to 2010 was suggested to potentially have been the result of greater outflow causing Microcystis to be displaced downstream to the LSZ in September (IEP MAST 2015, p.141). IEP MAST (2015) concluded that there was some evidence in support of the hypothesis that the size and position of the low salinity zone during fall affects abundance, survival, and growth of Delta Smelt but cautioned that additional years of data and investigations are needed. A multiplicative stock-recruitment model assessing Delta Smelt survival from fall to summer as a function of September and October X2 and fall stock size (i.e., the fall midwater trawl index) did not find evidence that X2 was an important predictor of survival (Reclamation 2017, Appendix A). In contrast to 2011, the Delta Smelt fall midwater trawl index did not increase in 2017, despite low fall X2 (see previous section); studies are underway to assess the possible reasons for this difference.

Justification

The habitat-based LSZ management action is proposed in order to specifically accommodate hypothesized Delta Smelt habitat requirements in terms of extent of the LSZ, while reducing the water cost associated with the existing X2-based requirements.

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D1.2.6.2.2 Suisun Marsh Salinity Control Gates

Summary

Reclamation would increase operations of the SMSCG to direct more fresh water into Suisun Marsh, which will reduce salinity in order to improve habitat conditions for Delta Smelt in the region.

Description

Reclamation in partnership with DWR would increase operations of the SMSCG to direct more fresh water into Suisun Marsh by closing the gates on flood tides and opening the gates on ebb tides. This will reduce salinity. As noted in the Delta Smelt Resiliency Strategy, this management action may attract Delta Smelt into the high-quality Suisun Marsh habitat in greater numbers, reducing use of the less food-rich Suisun Bay habitat (CNRA 2016). The timing of the action could be in late spring/summer of drier water years, depending on salinity conditions. Monitoring would be undertaken to ensure that water operations are undertaken as necessary to minimize the potential for unintended salinity changes in the Suisun Bay and the Sacramento-San Joaquin River confluence area. The SMSCG could be potentially operated in coordination with the Roaring River Distribution System action from the Delta Smelt Resiliency Strategy (CNRA 2016).

Objectives

- Fundamental objective: Increase abundance of Delta Smelt
- Means objective: Abundance

Conceptual Model (Each Species and Life stage)

The SMSCG action would primarily influence Delta Smelt; the basic action was originally proposed as part of the Delta Smelt Resiliency Strategy (CNRA 2016). As described in the Resiliency Strategy, the action is intended to benefit the transition between the juvenile and sub-adult life stages during late spring/summer and was originally proposed as an alternative to outflow augmentation. The primary environmental driver relates to food production, as noted in the MAST CM: "Juvenile growth and survival is hypothesized to depend on availability and quantity of food. Food production during this summer period is hypothesized to involve complex interactions of clam grazing, nutrients, hydrology and harmful algal blooms" (IEP MAST 2015, p.90). Reducing salinity in Suisun Marsh through operation of the SMSCG would make conditions more suitable for Delta Smelt (Hasenbein et al. 2013) and therefore facilitate access to habitat with greater food density and opportunity for growth (Hammock et al. 2015).

Current Condition

Operation of the SMSCG began in October 1988 as Phase II of the Plan of Protection for the Suisun Marsh (ICF International 2016, p.3-122). The objective of SMSCG operation is to decrease the salinity of the water in Montezuma Slough. Currently, the US Army Corps of Engineers permit requires the SMSCG to be operated between October and May only when needed to meet Suisun Marsh salinity standards (ICF International 2016, p.3-122). When Delta outflow is low to moderate and the gates are not operating, tidal flow past the gate is approximately 5,000 to 6,000 cfs while the net flow is near zero. When operated, flood tide flows are arrested while ebb tide flows remain in the range of 5,000 to 6,000 cfs. The net flow in Montezuma Slough becomes approximately 2,500 to 2,800 cfs (ICF International 2016, p.3-122).

Background

Historically, the SMSCG have been operated as early as October 1, while in some years (e.g., 1996) the gates were not operated at all (ICF International 2016, p.3-122). When the channel water salinity decreases sufficiently below the salinity standards or at the end of the control season, the removable flashboards are removed and the gates raised to allow unrestricted movement through Montezuma Slough. Other than the pilot study undertaken in August 2018 as part of the Delta Smelt Resiliency Strategy, operation has not occurred outside of the October–May required operating period.

Current Science

Hammock et al. (2015) demonstrated that several indicators of Delta Smelt growth, nutritional status, and health (stomach fullness, liver glycogen depletion, RNA/DNA ratio, hepatosomatic index, condition factor, and lesion score) generally are significantly better in Suisun Marsh than in Suisun Bay and other areas of Delta. Low abundance of Delta Smelt food in Suisun Bay is largely the result of grazing by the invasive clam *P. amurensis* (Kimmerer and Thompson 2014; Kimmerer and Lougee 2015) that may have resulted in earlier peaks in some important zooplankton prey species and therefore affected Delta Smelt (Merz et al. 2016). The abundance of *P. amurensis* in Suisun Marsh is spatially limited, possibly as a result of limited connectivity with Suisun Bay, high detritus loads, and high predation pressure from fish and avian species (Baumsteiger et al. 2017); this presumably results in less grazing pressure than in Suisun Bay. Operation of the SMSCG to be closed on flood tides and open on ebb tides can shift the salinity distribution further upstream in Suisun Bay and the Delta. Modeling undertaken in support of the 2018 pilot SMSCG effort suggested that the typical water cost for this action would be in the low tens of thousands of acre-feet to maintain D-1641 criteria (Zhou 2018). Installation of drain gates on the western end of the Roaring River Distribution System, as being undertaken as part of the Delta Smelt Resiliency Strategy, is intended to allow draining of food-rich water from flooded duck ponds to Suisun Bay (Hobbs et al. 2017) and could be done in association with the SMSCG action.

Justification

Operation of the SMSCG would facilitate lower salinity conditions to occur in Suisun Marsh, particularly in drier years, while allowing Delta outflow to be less than otherwise would be necessary to achieve low salinity in Suisun Marsh. This would provide greater habitat suitability for Delta Smelt in an area that has shown to have good growth and would increase flexibility in water supply management in the Delta.

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D1.2.6.2.3 Barker Slough Pumping Plant Sediment and Aquatic Weed Removal

Summary

Remove sediment and aquatic weeds to maintain pump operation, flows, and fish screen performance at Barker Slough Pumping Plant (BSPP).

Description

Sediment accumulates in the concrete apron sediment trap in front of the BSPP fish screens and within the pump wells behind the fish screens. Sediment removal from the sediment trap and the pump wells would be removed as needed.

Aquatic weeds would be removed, as needed, from in front of the fish screens at BSPP. Aquatic weeds accumulate on the fish screens, blocking water flow, and causing water levels to drop behind the screens in the pump wells. The low water level inside of the pump wells causes the pumps to automatically shut off to protect the pumps from cavitation. Aquatic weed removal system consists of grappling hooks attached by chains to an aluminum frame. A boom truck, staged on the platform in front of the BSPP pumps, will lower the grappling system into the water to retrieve the accumulated aquatic vegetation. The removed aquatic weeds will be transported to two aggregate base spoil sites located near the pumping plant.

Objectives

- Fundamental objective: Maintain minimum population during drought
- Means objective: Abundance

Conceptual Model

The CMs are not directly applicable.

Current Conditions

Sediment accumulates in the concrete apron sediment trap in front of the BSPP fish screens and within the pump wells behind the fish screens. Aquatic weeds accumulate on the fish screens, blocking water flow, and causing water levels to drop behind the screens in the pump wells. The low water level inside of the pump wells causes the pumps to automatically shut off to protect the pumps from cavitation.

Each of the pumps are individually screened with a positive barrier fish screen consisting of a series of flat, stainless steel, wedge-wire panels with a slot width of 3/32 inches. The screen is designed to prevent entrainment of fish larger than 25 millimeters (mm). The screens in front of each bay are entirely submerged and are more than 23 feet below the top of the concrete platform (Figure 2). Each fish screen is 7 feet wide by 10 feet long. The screens are cleaned once a month using a high-pressure hose from the back side of the screens. A truck mounted crane is used to lift the screens up for cleaning and then each screen is lowered back into position along vertical metal slots anchored to the façade of the intake structure.

Background

Sediment and aquatic weeds accumulate in front of the fish screens and pumps. Sediment routinely accumulates in front of and behind the fish screens. Aquatic weed loads have increased in recent years necessitating manual removal from the fish screens.

Current Science

DWR conducted evaluations of the fish screens at BSPP and found that after 2 and 1/3 years of gathering entrainment data, only one larval Delta Smelt was caught (out of more than 8,000 larval fish caught) (DWR 2019).

At the request of DWR, California Department of Boating and Waterways conducts herbicide treatments in Barker Slough, Lindsay Slough, and Liberty Island to manage nuisance aquatic weeds and reduce the accumulation of weed mats in Barker Slough.

Justification

Removal of sediment and aquatic weeds is necessary to maintain flow and pump operations and prevent blockage of fish screens at BSPP.

References

DWR. 2019. Fish Screen Evaluation Report Barker Slough Pumping Plant North Bay Aqueduct 2015 – 2016, Volume 2, DWR Bay-Delta Office.

D1.2.6.2.4 <u>Clifton Court Forebay Aquatic Weed and Algal Bloom Management</u>

Summary

DWR would expand the existing aquatic weed removal and harmful algal bloom (HAB) control activities in Clifton Court Forebay to include the use of the herbicide Aquathol K and peroxygen-based algaecides and to expand the treatment period beyond the current July 1 to August 31 permissible treatment period. DWR would retain the use of currently approved copper-based herbicides and the approved use of mechanical weed harvesters.

Description

To reduce aquatic weed growth and control HABs, DWR would apply Aquathol K, copper-based herbicides and algaecides, and peroxide-base algaecides to targeted areas within CCF on an as-needed basis. The selected herbicide or algaecide would be dependent upon the aquatic weed species or algal species present. Treatments with Aquathol K and copper-based herbicides would occur as needed from June 28 to August 31; treatments needed outside of the June 28 to August 31 window would only occur under certain conditions and with agreement from NMFS and USFWS. Treatments with peroxygen-based algaecides would occur year-round, as needed.

The target concentration of Aquathol®K treatments would be 2-3 ppm. Applications of copper herbicides would be applied at a concentration of 1 ppm with an expected dilution to 0.75 ppm upon dispersal in the water column. Applications copper-based algaecides would be applied at a concentration of 0.2 to 1 ppm with expected dilution within the water column. PAK®27 algaecide treatments are proposed to occur, as needed, year-round. PAK®27 would be applied in the range of 0.3 to 10.2 ppm hydrogen peroxide. No more than 50% of the forebay would be treated at any one time. DWR would apply herbicides by aircraft or by boat to the areas with high weed growth or high algal bloom concentration.

Protective measures would be implemented to prevent or minimize adverse effects from herbicide applications. Applications of aquatic herbicides and algaecides would be contained within CCF by closing the radial intake gates to CCF prior to, during, and following the application. The radial gates would remain closed during the recommended minimum contact time based on herbicide type, application rate, and aquatic weed or algae assemblage.

Objectives

- Fundamental objective: Maintain minimum population during drought
- Means objective: Abundance

Conceptual Model (Each Species and Life stage)

The IEP MAST CM for Delta Smelt posits that predation may be increased by invasive species such that it is an environmental driver for declining trends in populations (IEP MAST 2015).

The SAIL report for Winter-Run Chinook Salmon posits that predation affects salmonids both directly and indirectly (by limiting food sources and available habitat) (Windell et al. 2017).

Current Condition

Excessive aquatic weed growth in CCF results in significant clogging of the trashracks and vertical louver array, creates an impediment to fish passage into Skinner Fish Facility, and provides cover for predatory fish species. Control of aquatic weeds through the application of herbicides is one of the four interim measures to reduce salmonid predation in the CCF.

Aquatic weed assemblages change from year to year in the CCF from predominantly Egeria (*Egeria densa)* to one dominated by sago pondweed (*Potamogeton pectinalus*), Eurasian watermilfoil (*Myriophyllum spicatum*), coontail (*Cerataphyllum demersum*), American pondweed (*Potamogeton nodosus*), and curly-leaf pondweed (*Potamogeton crispus*). Depending upon the aquatic weed assemblage, DWR annually applies either copper-based herbicides to control Egeria or Aquathol®K to control pondweed species. Egeria is effectively controlled by copper-based herbicides, and pondweed species are effectively controlled by endothall-based herbicides such as Aquathol®K. Therefore, both copper and Aquathol K herbicides are essential to effectively control excessive aquatic weed growth in CCF.

While aquatic weeds begin to grow in April to early June, herbicide treatment is currently restricted to July 1 to August 31. In recent years, DWR has completed annual environmental compliance to allow application of herbicides 48 hours prior to July 1 and the utilization of Aquathol K. Aquathol K is applied at the target concentration of 2-3 ppm. Copper herbicides are applied at a concentration of 1 ppm with an expected dilution to 0.75 ppm upon dispersal in the water column. Treatment areas are typically about 900 acres but no more than 50% of the 2,180 total surface acres. Mechanical harvesters are used to remove floating mats and water hyacinth as needed, but they are inadequate to control the aquatic weeds without the additional use of aquatic herbicides.

DWR monitors taste and odor compounds and cyanotoxin concentrations in CCF. Monitoring locations include CCF inlet and Banks PP. Copper sulfate may be applied to areas of CCF when monitoring results indicate production is occurring within CCF and that the water quality may be significantly degraded for use by downstream municipal users. Applications of copper sulfate for algal control are applied at a concentration of 0.2 to 1 ppm with expected dilution within the water column. No more than 50% of the surface area of CCF is treated at one time.

The current permissible treatment period for herbicide applications is July 1 to August 31. This period coincides with the highest water demand period resulting in a loss of water delivery. It also occurs after the onset of SAV growth and after salmonid smolt outmigration. Herbicide treatment protective measures include full closure of the CCF radial intake gates for 24 hours prior to, during, and after the herbicide application, resulting in limitations to pumping at Banks PP for about 60 hours (48 hours for pre- and post-treatment gate closure plus herbicide contact time).

Background

Excessive growth of submerged aquatic weeds in CCF can cause severe head loss and pump cavitation at Banks Pumping Plant when the stems of rooted plants break free, combine into “mats,” and accumulate on the primary trashracks and secondary louvers. This mass of uprooted and fragmented vegetation essentially forms a watertight plug at the trashracks and vertical louver array. The resulting blockage necessitates a reduction in the water pumping rate to prevent potential equipment damage through pump cavitation and excessive weight on louver array causing collapsed structure. Cavitation creates excessive wear and deterioration of the pump impeller blades.

To avoid the unscheduled shutdowns caused by aquatic weeds (Egeria) and to prevent water quality degradation caused by harmful algal blooms, DWR started applying herbicides in May 1995. From 1995 to 2006, DWR applied complex copper herbicides (Komeen® or Nautique®) once or twice per year, typically during May or June (DWR 2015). DWR temporarily stopped applying copper-based herbicides in 2006 because the North American green sturgeon was listed as a threatened species and began using mechanical harvesting (DWR 2015). The mechanical harvesters were inadequate to control the aquatic weeds resulting in significant clogging of the trashracks and vertical louver array, culminating in collapse of the louver structure. DWR resumed copper applications in 2015. However, due to the change in aquatic weed species composition between 2006 and 2014, from an Egeria-dominated community to a mixed pondweed species community, copper-based treatments were no longer effective. Pondweed species are not controlled or killed by copper herbicides. In 2016, DWR received permission to conduct a pilot study to assess the effectiveness of Aquathol K, an endothall-based herbicide, to control the pondweed assemblage. Following a successful treatment resulting in a significant reduction in pondweed biomass, Aquathol K was applied again in 2017 and 2018.

Aquatic weed control has been identified as one of four interim measures to increase salmonid survival in CCF. Dense stands of aquatic weeds provide cover for unwanted predators that may prey on salmonid smolts within CCF. Salmonid smolts are present in CCF during Spring months and during the onset of aquatic weed growth. However, as currently permitted, aquatic weed controlled does not occur until after conditions in CCF are no longer suitable for salmonids (water temperature >25°F). As such, the current aquatic weed control efforts do not benefit salmonid smolts traversing the CCF. Application of Aquathol®K or copper herbicide during Spring months may benefit smolt survival in CCF by reducing predatory fish habitat.

Attached benthic cyanobacteria blooms have occurred in CCF that produce compounds that cause unpleasant tastes and odors to finished drinking water. The highest biomass of taste- and odor-producing cyanobacteria was present in the nearshore areas but not limited to shallow benthic zone. Geosmin and 2-methylisoborneol (MIB) are natural byproducts of algal chlorophyll production. The finished drinking water secondary maximum contaminant level (MCL) for taste and odor compounds is 10 ng/L of geosmin and 5 ng/L of MIB. Historically, copper sulfate was applied to the nearshore areas of CCF when results of solid phase microextraction analysis exceed the control tolerances (MIB < 5 ng/L and geosmin < 10 ng/L) (DWR 2013). Application areas varied considerably in past years based on the distribution of the benthic algal bloom in CCF. Treatments for benthic blooms have not occurred in recent years and are expected to be infrequent in the future.

Harmful algal blooms (HAB) in CCF are of concern as they may produce cyanotoxins which degrade drinking water quality. As part of an early warning system to SWCs, DWR first began monitoring for cyanotoxins in the SWP in 2006. Cyanotoxins can cause skin rashes, gastrointestinal distress, liver failure, and even death in humans, dogs and wildlife. The frequency of occurrence of HAB's is increasing world-wide, including in the Sacramento-San Joaquin Delta. Since its initial observation in 1999 in the San Francisco Estuary, Microcystis blooms have occurred every year in the Delta, typically starting in July and ending in October (Lehman et al. 2013). Recent drought conditions caused enhanced Microcystis blooms in Delta waterways that lasted into December (Lehman et al. 2017). In 2015, the U.S. Environmental Protection Agency (EPA) published non-regulatory 10-day finished drinking water advisory levels for microcystins and cylindrospermopsin. These are established health-based advisory levels for concentrations at or below which adverse human health effects are not anticipated to occur over a 10-day exposure period (EPA 2015). In addition, EPA listed cyanotoxins including microcystin-LR, cylindrospermopsin, and anatoxin–a on the Contaminant Candidate Lists (CCL), which identify contaminants that may need regulation under the Safe Drinking Water Act.

A HAB within CCF may necessitate the application of an algaecide to halt the production of cyanotoxins and protect downstream drinking water. As outlined above, HABs have typically occurred July through October but as late as December in the Delta. The current permissible application period of June 29 to August 31 overlaps with only a portion of the expected bloom period. Treatment of HABs in CCF has not occurred to date, but treatments in upcoming years may be warranted. Depending upon the dominate species, HABs can be effectively controlled with a surface application (treatment of the upper 3 feet of the water column) of either copper sulfate or a peroxide algaecide (e.g., PAK®27). Peroxide-based algaecide treatment are proposed to occur, as needed, year-round. There are no anticipated impacts on fish with the use of peroxide-based aquatic algaecides in CCF during treatment. The oxidation reaction occurs immediately upon contact with the water destroying algal cell membranes and chlorophyll, and the byproducts are hydrogen peroxide and oxygen.

Current Science

Use of Aquathol®K

Aquathol®K (liquid formulation) is a widely used contact herbicide that controls submerged weeds in lakes and ponds, and the short residual contact time (12-48 hours) makes it effective in both still and slow-moving water. Aquathol®K is effective on many weeds, including hydrilla, milfoil, and curly-leaf pondweed, and begins working on contact to break down cell structure and inhibit protein synthesis. Without the ability to grow, the weed dies. Full kill takes place in 1 to 2 weeks. As weeds die, they sink to the bottom and decompose. Aquathol®K is not effective at controlling *E. densa*. With the changing aquatic weed assemblage in CCF, Aquathol®K is an essential tool, alongside of copper herbicides, for aquatic weed management. Aquathol®K is registered for use in California and has effectively controlled pondweeds and southern naiad in CCF and in other lakes.

Endothall has low acute and chronic toxicity effects to fish. The LC_{50} for salmonids is 20-40 times greater than the maximum concentration allowed to treat aquatic weeds. The EPA maximum concentration allowed for Aquathol®K is 5 parts per million (ppm). A recent study (Courter *et al.* 2012) of the effect of *Cascade*® (same endothall formulation as Aquathol®K) on salmon and steelhead smolts showed no sublethal effects until exposed to 9-12 ppm, that is, 2-3 times greater than the 5 ppm maximum concentration allowed by the EPA and about 4-6 times greater than the 2-3 ppm applied in past CCF treatments. In the study, steelhead and salmon smolts showed no statistical difference in mean survival between the control group and treatment groups, however, steelhead showed slightly lower survival after 9 days at 9-12 ppm. Based on the studies with salmonids, Aquathol®K applied at or below the EPA maximum allowable concentration of 5 ppm poses a low to no toxicity risk to salmon, steelhead and other fish. No studies have assessed the exposure risk to green sturgeon or Delta smelt.

When aquatic plant survey results indicate that pondweeds are the dominant species in CCF, Aquathol®K will be selected due to its effectiveness in controlling these species. Aquathol®K will be applied according to the label instructions, with a target concentration dependent upon plant biomass, water volume, and forebay depth. The target concentration of treatments will be 2-3 ppm, which is well below the concentration of 9-12 ppm where sublethal effects have been observed (Courter *et al.* 2012). DWR will monitor herbicide concentration levels during and after treatment to ensure levels do not exceed the Aquathol®K application limit of 5 ppm. Additional water quality testing may occur following treatment for drinking water intake purposes. Samples will be submitted to a laboratory for analysis. There is no "real time" field test for endothall. No more than 50% of the surface area of CCF will be treated at one time. A minimum contact time of 12 hours is needed for biological uptake and treatment effectiveness, but the contact time may be extended up to 24 hours to reduce the residual endothall concentration for NPDES compliance purposes.

Continuation of Use of Copper-based Aquatic Herbicides and Algaecides

Copper herbicides and algaecides include chelated copper products and copper sulfate pentahydrate crystals. When aquatic plant survey results indicate that *E. densa* is the dominant species, copper-based compounds will be selected due to their effectiveness in controlling this species. *E. densa* is not affected by application of Aquathol®K. Copper-based algaecides are effective at controlling algal blooms (cyanobacteria) that produce cyanotoxins or taste and odor compounds.

Copper herbicides and algaecides will be applied in a manner consistent with the label instructions, with a target concentration dependent upon target species and biomass, water volume and the depth of the forebay. Applications of copper herbicides will be applied at a concentration of 1 ppm with an expected dilution to 0.75 ppm upon dispersal in the water column. Applications for algal control will be applied at a concentration of 0.2 to 1 ppm with expected dilution within the water column. DWR will monitor dissolved copper concentration levels during and after treatment to ensure levels do not exceed the application limit of 1 ppm, per NPDES permit required procedures. Treatment contact time will be up to 24 hours. If the dissolved copper concentration falls below 0.25 ppm during an aquatic weed treatment, DWR may opt to open the radial gates after 12 hours but before 24 hours to resume operations. Opening the radial gates prior to 24 hours would enable the rapid dilution of residual copper and thereby shorten the exposure duration of ESA-listed fish to the treatment. No more than 50% of the surface area of CCF will be treated at one time.

Use of Peroxygen-Based Algaecides

Harmful algal blooms (HAB) in CCF are of concern as they degrade drinking water quality through the production of cyanotoxins that can cause skin rashes, gastrointestinal distress, liver failure, and even death in humans, dogs and wildlife. Microcystis blooms occur annually in the Delta, typically starting in July and ending in October. Recent drought conditions caused enhanced Microcystis blooms in Delta waterways that lasted into December (Lehman et al. 2017). In 2015, the U.S. Environmental Protection Agency (EPA) published non-regulatory 10-day finished drinking water advisory levels for microcystins and cylindrospermopsin. These are established health-based advisory levels for concentrations at or below which adverse human health effects are not anticipated to occur over a 10-day exposure period (EPA 2015). In addition, EPA listed cyanotoxins including microcystin-LR, cylindrospermopsin, and anatoxin–a on the Contaminant Candidate Lists (CCL), which identify contaminants that may need regulation under the Safe Drinking Water Act. DWR first began monitoring for cyanotoxins in the SWP in 2006. A HAB within CCF may necessitate the application of an algaecide to halt the production of cyanotoxins and protect downstream drinking water sourcewaters.

Peroxygen-based algaecides, such as PAK®27, are effective at controlling cyanobacteria. PAK®27 algaecide active ingredient is sodium carbonate peroxyhydrate. An oxidation reaction occurs immediately upon contact with the water destroying algal cell membranes and chlorophyll. There is no contact or holding time requirement, as the oxidation reaction occurs immediately, and the byproducts are hydrogen peroxide and oxygen. There are no fishing, drinking, swimming, or irrigation restrictions following the use of this product. PAK®27 has NSF/ANSI Standard 60 Certification for use in drinking water supplies at maximum-labeled rates and is certified for organic use by the Organic Materials Reviews Institute (OMRI).

PAK®27 will be applied in a manner consistent with the label instructions, with permissible concentrations in the range of 0.3 to 10.2 ppm hydrogen peroxide. No more than 50% of the surface area of CCF will be treated at one time.

Expansion of the Herbicide and Algaecide Use Period

Aquatic weed control has been identified as one of four interim measures to increase salmonid survival in CCF. Dense stands of aquatic weeds provide cover for unwanted predators that may prey on salmonid smolts within CCF. Salmonid smolts are present in CCF during Spring months and during the onset of aquatic weed growth. However, as currently permitted, aquatic weed controlled does not occur until after conditions in CCF are no longer suitable for salmonids (water temperature >25°F). As such, the current aquatic weed control efforts do not benefit salmonid smolts traversing the CCF. Application of Aquathol®K or copper herbicide during Spring months may benefit smolt survival in CCF by reducing predatory fish habitat. The proposed target concentration for Aquathol®K is 2-3 ppm, which is well below the concentration of 9-12 ppm where sublethal effects have been observed (Courter *et al.* 2012). While an application of copper herbicide may affect salmonid smolts present in CCF during the time of treatment, the reduction in SAV will results in a reduction in predator habitat and may result in an overall greater increase in smolt survival. Additional precautionary measures to protect ESA listed species include meeting with NMFS and USFWS prior to treatment and the closure of the radial gates prior to treatment for a specified time of 24 hours or until the expected Delta smelt and salmonid smolt survival period with CCF has been exceeded.

Additional protective measures will be implemented to prevent or minimize adverse effects from herbicide applications. As described above, applications of aquatic herbicides and algaecides will be contained within CCF. The radial intake gates to CCF will be closed prior to, during, and following the application. The radial gates will remain closed during the recommended minimum contact time based on herbicide type, application rate, and aquatic weed or algae assemblage. Additionally, following the gate closure and prior to aquatic herbicide the applications of Aquathol®K and copper-based pesticides following gate closures, the water is drawn down in the CCF via the Banks Pumping Plant. This drawdown helps facilitate the movement of fish in the CCF toward the fish diversion screens and into the fish protection facility, and it lowers the water level in the CCF to decrease the total amount of herbicide that would needed to be applied, per volume of water, and aides in the dilution of any residual pesticide post-treatment. Following reopening of the gates and refilling of CCF, the rapid dilution of any residual pesticide and the downstream dispersal of the treated water into the California Aqueduct via Banks PP will reduce the exposure time of any ESA-listed fish species present in CCF.

Peroxide-based algaecide treatment are proposed to occur, as needed, year-round. There are no anticipated impacts on fish with the use of peroxide-based aquatic algaecides in CCF during treatment. The reduction in cyanotoxin production following treatment may benefit fish. The oxidation reaction occurs immediately upon contact with the water destroying algal cell membranes and chlorophyll. There is no contact or holding time proposed as the oxidation reaction occurs immediately and the byproducts are hydrogen peroxide and oxygen.

DWR has worked with NMFS and USFWS to develop a set of operational procedures to minimize the potential effects on listed species during aquatic herbicide treatment. These procedures limit the time of year (and temperatures of Clifton Court Forebay) when DWR could apply herbicides; close the forebay before and after application, monitor potential effects; and monitor conditions before, during, and after applications.

Justification

<u>Use of New Herbicides</u>

With the changing aquatic weed assemblage in CCF, Aquathol K is an essential tool, alongside of copper herbicides, for aquatic weed management. Aquathol K is a widely used contact herbicide that is effective on many weeds, including hydrilla, milfoil, and curly-leaf pondweed. Aquathol®K is not effective at controlling *E. densa*. Endothall has low acute and chronic toxicity effects to fish. Based on the studies with salmonids, Aquathol K applied at or below the EPA maximum allowable concentration of 5 ppm poses a low to no toxicity risk to salmon and steelhead. The target concentration of treatments will be 2-3 ppm, which is well below the concentration of 9-12 ppm where sublethal effects have been observed (Courter *et al.* 2012).

When aquatic plant survey results indicate that *E. densa* is the dominant species, copper-based compounds will be selected due to their effectiveness in controlling this species. Copper-based algaecides are effective at controlling algal blooms (cyanobacteria) that produce cyanotoxins or taste and odor compounds.

Harmful algal blooms (HAB) in CCF are of concern as they degrade drinking water quality through the production of cyanotoxins. A HAB within CCF may necessitate the application of an algaecide to halt the production of cyanotoxins and protect downstream drinking water sourcewaters. Peroxygen-based algaecides are effective at controlling cyanobacteria. There is no contact or holding time requirement, as the oxidation reaction occurs immediately, and the byproducts are hydrogen peroxide and oxygen. There are no fishing, drinking, swimming, or irrigation restrictions following the use of this product.

Expansion of the Herbicide and Algaecide Use Period

Aquatic weed control has been identified as one of four interim measures to increase salmonid survival in CCF. Dense stands of aquatic weeds provide cover for unwanted predators that may prey on salmonid smolts within CCF. Salmonid smolts are present in CCF during Spring months and during the onset of aquatic weed growth. However, as currently permitted, aquatic weed controlled does not occur until after conditions in CCF are no longer suitable for salmonids (water temperature >25°F). As such, the current aquatic weed control efforts do not benefit salmonid smolts traversing the CCF. Application of herbicide during Spring months may benefit smolt survival in CCF by reducing predatory fish habitat. The proposed target concentration for Aquathol®K is 2-3 ppm, which is well below the concentration of 9-12 ppm where sublethal effects have been observed (Courter *et al.* 2012). While an application of copper herbicide may affect salmonid smolts present in CCF during the time of treatment, the reduction in SAV will results in a reduction in predator habitat and may result in an overall greater increase in smolt survival. Additional precautionary measures to protect ESA listed species include meeting with NMFS and USFWS prior to treatment and the closure of the radial gates prior to treatment for a specified time of 24 hours or until the expected Delta smelt and salmonid smolt survival period with CCF has been exceeded.

Additional protective measures will be implemented to prevent or minimize adverse effects from herbicide applications, as described above.

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D1.2.6.2.5 Tidal and Channel Margin Restoration

Summary

Reclamation and DWR propose to work with partners to restore 8,000 acres of tidal marsh in the Sacramento-San Joaquin Delta. This includes any actions needed to complete the restoration in areas that have been identified as part of the 2008 USFWS BO requirements, California EcoRestore goals, and restoration pursuant to California WaterFix Proposed Action, as well as selecting new areas for restoration. The Delta has lost a diversity of ecosystem services benefits over the last 150 years as much of the land was 'reclaimed' for agriculture resulting in channelization of the waterways and an extensive system of levees. Along with these changes came invasive plants and animals that now make up the majority of the Delta's total biomass. Restoration of tidal habitats will reverse some of these changes and benefit multiple species of native fish and wildlife, especially listed salmonids and smelt. Tidal habitats provide multiple benefits including increased food availability and refuge from predators.

Description

Multiple planning efforts and management directives have identified various potential habitat restoration actions in the Delta. Such actions are being considered to fulfill tidal habitat restoration requirements of the BOs and Incidental Take Permit. A number of tidal habitat restoration projects are currently underway or planned under California EcoRestore and the Fish Restoration Program (FRP). The FRP projects currently being planned or implemented are part of the larger effort to meet the following goals (DWR and CDFW 2016):

- Restore 8,000 acres of intertidal and associated sub-tidal habitat in the Delta and Suisun Marsh, including 800 acres of mesohaline habitat to benefit longfin smelt, to enhance food production and availability for native Delta fishes;
- Restore processes that will promote primary and secondary productivity and tidal transport of resources to enhance the pelagic food web in the Delta;
- Increase the amount and quality of salmonid rearing and other habitat;
- Increase through-Delta survival of juvenile salmonids by potentially enhancing beneficial migratory pathways.

Objectives

- Fundamental objectives: Increase juveniles at Chipps Island per adult return and maintain minimum population during drought

- Means objectives: Abundance, productivity, spatial structure, and diversity

Conceptual Model (Each Species and Life stage)

Tidal habitat restoration at appropriate sites within the Delta, such as in the North Delta Arc region, would be expected to increase food availability and enhance habitat for smelt and salmonids. This relates specifically to several of the MAST hypotheses for Delta Smelt, including:

- **Adult hypothesis:** Variability in prey availability during winter and spring affects growth and fecundity (eggs per clutch and number of clutches) of female Delta Smelt
- **Larval hypothesis 2:** Increased food availability results in increased larval abundance and survival.
- **Juvenile hypothesis 3:** Juvenile Delta Smelt growth and survival is affected by food availability.
- **Sub-adult hypothesis 1:** Sub-adult Delta Smelt abundance, growth, and survival is affected by food availability.

In addition, restored habitat may affect smelt predation risk by altering interactions among hydrology, turbidity, temperature, and predators (which are covered by various MAST hypotheses).

Habitat restoration in the Delta is also expected to diversify salmonid rearing habitat, which could increase variation in out-migrant timing and population stability (Windell et al. 2017). In particular, this relates to hypotheses in the SAIL CM4 for Winter-Run Chinook Salmon that covers rearing to outmigrating juveniles in the Bay-Delta. Habitat restoration can increase habitat capacity by affecting interactions with predators and competitors, refuge habitat, food availability and quality, and temperature (**H2, H3, H4, H7**). Restoration may also affect stranding risk (**H6**), either positively or negatively depending on design and construction parameters that affect floodwater recession.

The various IEP CMs described by Sherman et al. (2017) were specifically designed to address potential effects of tidal wetland restoration on fish and, therefore, are applicable to this action.

Current Conditions

A wide variety of past planning efforts, state and federal agencies, academic experts, and other stakeholders have recognized the value of habitat restoration in the Delta. Aside from the immediate localized benefits to native species, restoration would also contribute to creating an interconnected series of tidal and other habitats in key portions of the Delta to benefit native fish species. For example, habitat restoration in the North and West Delta could contribute to creating an enhanced series of interconnected habitats running from Yolo Bypass through the Cache-Lindsey Slough-Liberty Island region, down the Sacramento River including Twitchell and Sherman islands, to Suisun Marsh, now commonly referred to as the North Delta Habitat Arc (Moyle et al. 2016).

A number of restoration planning and implementation efforts are in various stages of completion throughout the Delta, with approximately 30 projects currently being tracked under EcoRestore. However, none of the projects to date have yet received official credit under the USFWS 2008 BO.

Background

The Delta Plan, EcoRestore, and various other prior planning efforts such as Delta Vision, Bay Delta Conservation Plan (BDCP), and CALFED planning documents from the 1990s, have identified various strategies and potential locations for restoration based on factors such as current habitat for a wide variety of special-status species, relative ease of restoration, and ability to accommodate sea level rise. Tidal marsh restoration in the Delta is RPA Component 4 of the USFWS 2008 BO.

Current Science

Aside from the MAST and SAIL syntheses and CMs, there are several other efforts that have attempted to summarize our understanding of the key drivers affecting listed species and their habitats in the Delta in the form of various CMs. Two primary efforts include (1) CMs developed under the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) that cover a broad range of ecosystem processes and stressors (e.g., such as delta food webs (Durand 2008) and mercury (Alpers et al. 2008) and (2) recently published CMs developed by the IEP to guide tidal wetland restoration and monitoring of restoration sites in the Sacramento-San Joaquin Delta and Suisun Marsh (Sherman et al. 2017). The MAST, SAIL, and IEP CMs represent the current best understanding of ecological functions and the influences of landscape patterns and scales on native species life history behaviors.

Our understanding of the Delta ecosystem has increased substantially in recent years, but much uncertainty remains. Monitoring and adaptive management, including use of structured decision making, have been widely discussed as tools for dealing with existing uncertainty related to key management actions in the Delta. For example, monitoring of FRP restoration projects and other areas in the CSC area is being planned by the IEP Tidal Wetlands Project Workgroup to help improve our understanding of how tidal restoration will help Delta Smelt and other native fishes.

Justification

Restored habitat would have long-term benefits of increased physical habitat for Delta Smelt and salmonids, and improve ecosystem functions (i.e., greater food production). Converting agricultural areas to tidal wetlands will provide a net increase in zooplankton and benthic invertebrates (primary food source for smelt and salmon). By establishing open water habitats at intertidal and shallow sub-tidal elevations, habitat restoration could also increase turbidity due to wind-wave resuspension of sediments, a process common to Suisun Bay and important for smelt feeding success (IEP-MAST 2015). This type of restoration fulfills numerous multispecies recovery strategies. However, many projects are only beginning; costs are high and could increase.

This action is consistent with RPA Component 4 of the USFWS 2008 BO, also part of the Sacramento Valley Salmon Resiliency Strategy, California EcoRestore, and the Delta Smelt Resiliency Strategy.

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D1.2.6.3 *Flow Routing*

D1.2.6.3.1 Delta Cross Channel Operational Changes

Summary

Reclamation proposes to conduct October and November Delta Cross Channel (DCC) operations to meet the existing triggers from the NMFS (2009) BO Action IV.1.2 related to the DCC, but to act in advance of projected water quality standard violations, as modeled with DSM2 and in consideration of other data, such as tidal and barometric conditions.

Description

Currently, DCC operations in October and November are governed by D-1641 and the NMFS (2009) BO Action IV.1.2 (see further description below in *Current Conditions (RPA, WQCP, Facility*). Reclamation proposes to conduct October-November DCC operations to meet the existing triggers from the NMFS (2009) BO Action IV.1.2 related to the DCC, but to act in advance of projected water quality standard violations. Reclamation, at its discretion, may close the gates for up to 10 days during the first half of October to reduce the straying of returning adult Fall-Run Chinook Salmon to the Mokelumne River (Reclamation 2012).

The actual timing and duration of the DCC gate closure will be based on DSM2 modeling as well as other data. The DSM2-QUAL model uses Delta inflow, south Delta exports, barrier operations, tide forecasts, in-Delta water use, and initial Delta water quality conditions to model salinity conditions at multiple locations. The primary water quality sampling locations used for decisions regarding DCC management are Jersey Point, Bethel Island, Holland Cut, and Bacon Island, which are monitored and used for modeling electrical conductivity. In addition to DSM2 modeling data, DCC closure considerations will include available data for tides, wind, barometric pressure, and existing water quality.

Modeling results and other data will be reviewed by Reclamation with the CALFED Operations Team and the NMFS-required DOSS Group, and the proposed action will be coordinated through the Water Operations Management Team. These teams will review Delta Smelt and longfin smelt distributional information and coordinate with CDFW and USFWS to determine if the proposed action may cause changes in hydrodynamics resulting in increased entrainment of these species into the lower San Joaquin River. Using these various real-time data sources, annual DCC closures in October and November would be scheduled between 0 and 10 days in accordance with proposed water quality concern level targets (Table D1.2-8).

Table D1.2-8. Proposed Water Quality Concern Level Targets for Informing Delta Cross Channel Closure Requirements (Source: Reclamation 2012).

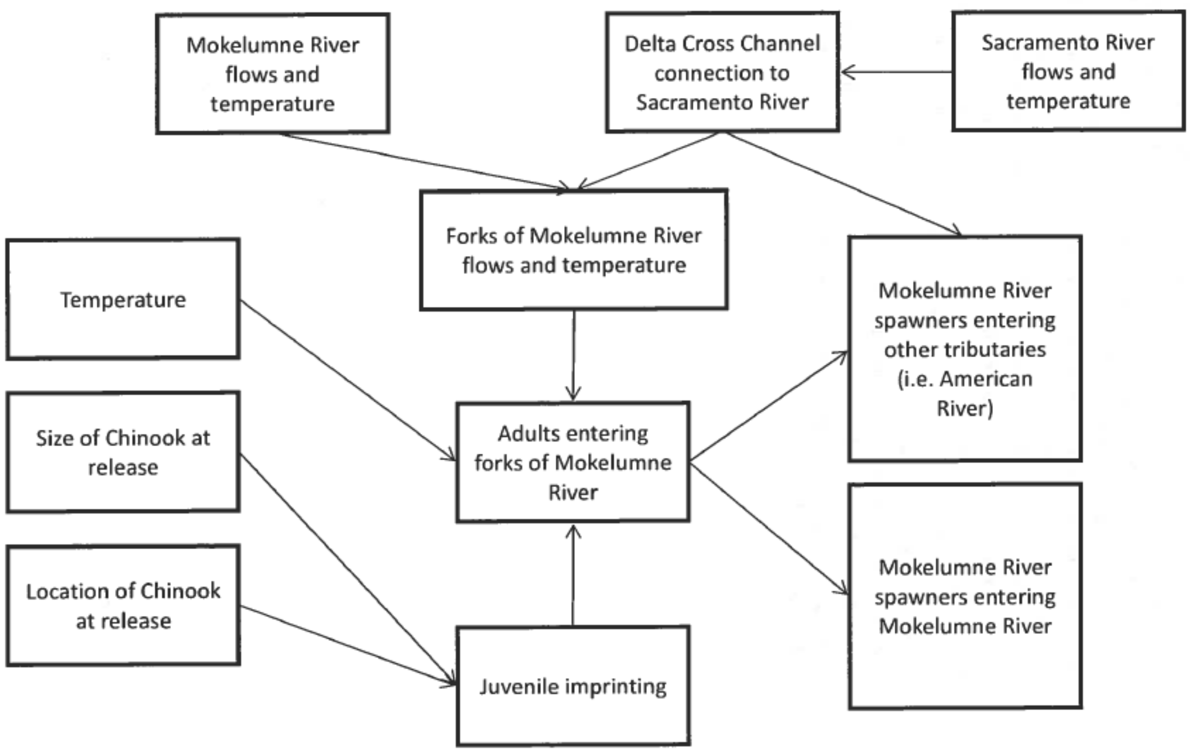
Water Quality Concern Level Targets (DSM2-Simulated Electrical Conductivity)	
Jersey Point	1,700 µmhos/cm
Bethel Island	1,000 µmhos/cm
Holland Cut	1,000 µmhos/cm
Bacon Island	800 µmhos/cm

Objectives

- Fundamental objective: Increase juveniles at Chipps Island for adult returns
- Means objective: Abundance

Conceptual Model (Each Species and Life stage)

As described further in *Delta Cross Channel Improvements*, the SAIL CM4 for Winter-Run Chinook Salmon (Windell et al. 2017) pertains to rearing to outmigrating juveniles in the Bay-Delta and is also pertinent to steelhead and Spring-Run Chinook Salmon from the Sacramento River Basin. Per the SAIL CM (Windell et al. 2017, p.23), "Human modification of the Delta has resulted in a channel network that no longer operates across predictable gradients for native fish and provides unnatural cues and routes for migration... In the interior Delta, longer travel times and lower survival have been documented." Closure of the DCC reduces juvenile salmonid entry into the interior Delta, thereby potentially reducing the risk of longer travel time and lower survival. In addition, the SAIL CM6 for Winter-Run Chinook Salmon describes potential effects on adult migration from the ocean to the upper Sacramento River, noting that "Natural and artificial barriers can delay the upstream passage and increase energetic costs to migration for salmon" and that "Water operations can influence the routing of Upper Sacramento River-origin water…and can create false attraction cues that cause salmon to deviate from the mainstem Sacramento River migration corridor" (Windell et al. 2017, p.30). These considerations are relevant in consideration of the DCC, for fish returning to the Sacramento River as well as to the San Joaquin River and Mokelumne River basins, for example. From the perspective of Mokelumne River salmonids (Fall-Run Chinook Salmon and steelhead), the Reclamation (2012) CM of processes influencing adult escapement to the Mokelumne River illustrates the potential importance of the DCC in influencing straying to other basins (e.g., the American River) (Figure D1.2-10).



Source: Reclamation (2012)

Figure D1.2-10. CM of Biological and Physical Processes that May Influence Adult Fall-Run Chinook Salmon Escapement to the Mokelumne River.

Current Conditions

As described further in *Delta Cross Channel Improvements*, DCC gate operations are primarily governed by NMFS (2009) RPA Action IV.1.2 and by D-1641. From October 1 to November 30, the DCC gates may be closed based on exceedance of salmon monitoring density triggers and in consideration of meeting water quality criteria (Table D1.2-7). In addition to management as a result of the NMFS RPA and D-1641, whenever flows in the Sacramento River at Sacramento reach 20,000 to 25,000 cfs (on a sustained basis) the DCC gates are closed to reduce potential scouring and flooding that might occur in the channels on the downstream side of the gates (USFWS 2008). The WIIN Act requires implementation by Reclamation and DWR of a pilot project to test and evaluate the ability to operate the Delta cross-channel gates daily or as otherwise may be appropriate to keep them open to the greatest extent practicable to protect out-migrating salmonids, manage salinities in the interior Delta and any other water quality issues, and maximize CVP and SWP pumping, subject to the condition that the pilot project shall be designed and implemented consistent with operational criteria and monitoring criteria required by the California State Water Resources Control Board (Public Law 114–322 130 stat. 1851).

Table D1.2-9. Operation of the Delta Cross Channel under State Water Board Decision 1641 and the National Marine Fisheries Service (2009) Biological Opinion during October and November (Source: Reclamation 2012).

D-1641	
Date	Action
November 1-January 30	DCC gates may be closed for up to a total of 45 days.

NMFS BiOp		
Date	VI. Action Triggers	Action Responses
October 1-November 30	Water quality criteria per D-1641 are met and either the the KLCI or SCI is greater than 5 fish per day	Within 24 hours, close the DCC gates and keep closed until the catch index is less than 3 fish per day at both the Knights Landing and Sacramento monitoring sites.
	Water quality criteria per D-1641 are met, niether Knights Landing Catch Index or the Sacramento Catch Index are greater than 3 fish per day but less than or equal to 5 fish per day	Within 24 hours of trigger, DCC gates are closed. Gates will remain closed for 3 days
	The KLCI or SCI triggers are met but water quality critera are not met per D-1641 crtieria	DOSS reviews monitoring data and makes recommendation to NMFS and WOMT per procedutes in Action IV.5

Background

As described further in *Delta Cross Channel Improvements*, the basis for DCC operations is largely from studies showing that survival of Sacramento River basin juvenile salmonids through the Delta generally is greater when the DCC is closed (e.g., Newman 2003, Perry et al. 2010, Perry et al. 2012). Since water year 2010, the DCC has been closed for 0 to 18 days in October and November (see Table 3 in *Delta Cross Channel Improvements*). As noted by USFWS (2008, p.174), larval and juvenile Delta Smelt are probably not strongly affected by DCC operations, based on previous studies (Kimmerer and Nobriga 2008), although there could be times when DCC closure affects Delta Smelt by generating flows that draw them into the South Delta.

Current Science

Further studies on the migration success of juvenile salmonids through the Delta have continued to suggest that the interior Delta migration route via the DCC and Georgiana Slough results in lower survival migration through the north Delta and main stem Sacramento River (Singer et al. 2013). Although the number of years for assessment is limited, there is evidence that temporary closure of the DCC in fall reduces the straying rate of adult Fall-Run Chinook Salmon returning to the Mokelumne River (Setka 2017).

Justification

Opening the DCC gates in advance of projected water quality standard exceedances will allow better compliance with water quality standards and increased operational flexibility, potentially decreasing salinity at Jones Pumping plant and reducing the amount of Delta outflow necessary to meet D-161 salinity requirements.

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D1.2.6.4 *Salvage Efficiency*

D1.2.6.4.1 Salvage Release Sites

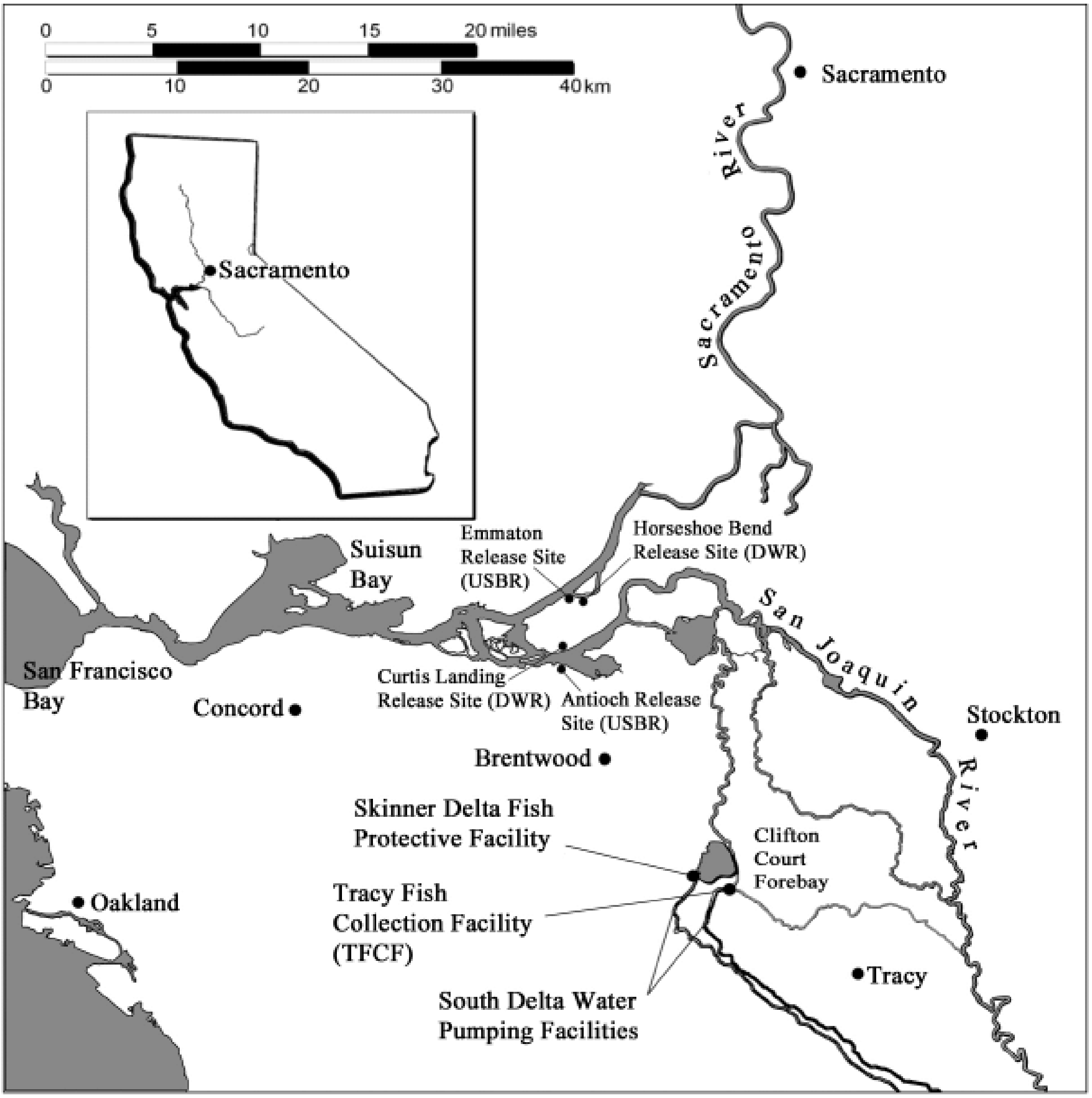
Summary

Reclamation proposes to improve salvage operations at the Tracy Fish Collection Facility (TFCF) by partnering with DWR to reduce predation of salvaged fish during release by varying the release locations used and considering mobile release from barges.

Description

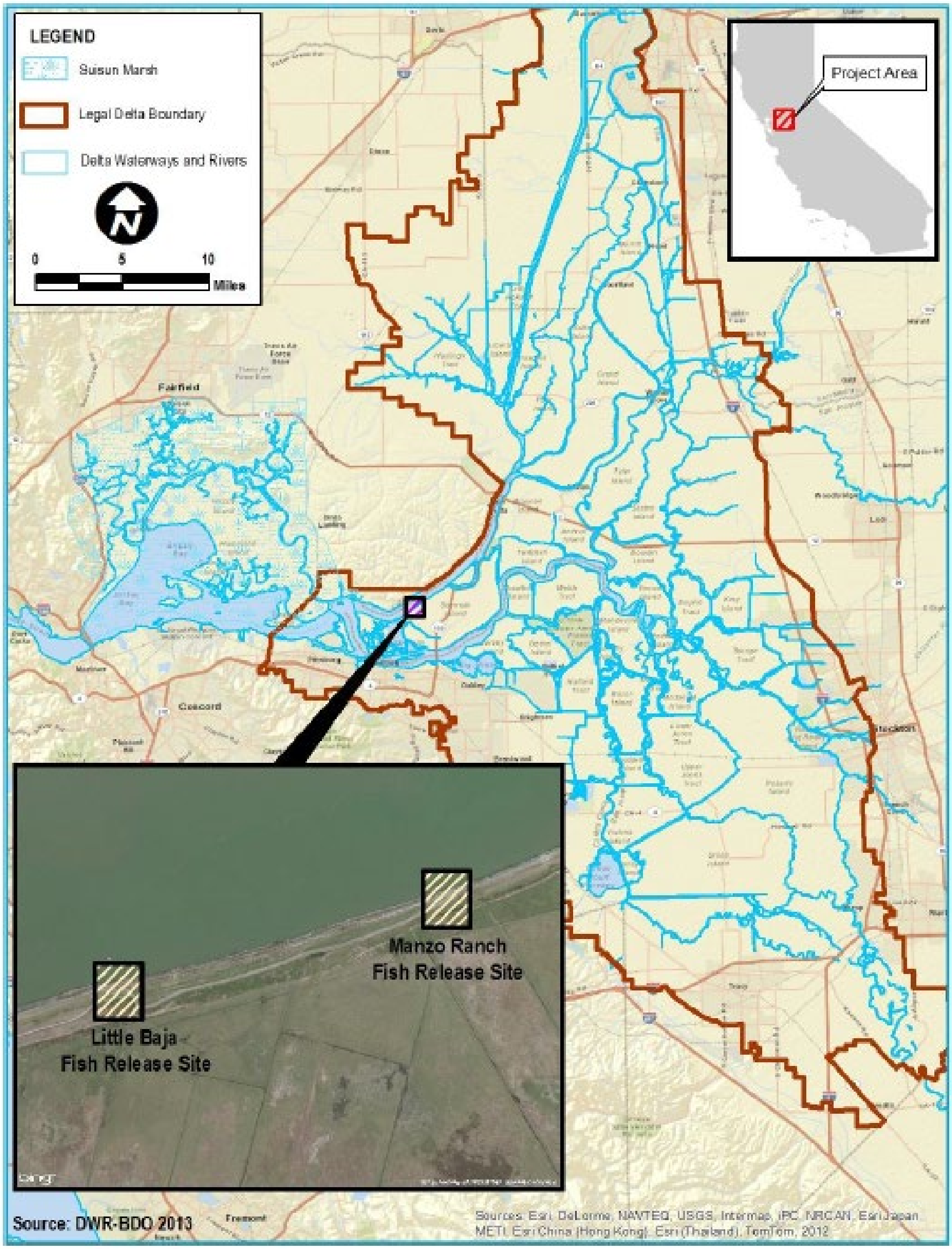
Reclamation would partner with DWR to reduce predation of salvaged fish during release in the west Delta. There are currently six salvage release sites in the west Delta: four of these sites (Curtis Landing, Antioch, Emmaton, and Horseshoe Bend; Figure D1.2-11) have had long-term use, whereas two sites (Little Baja and Manzo Ranch; Figure D1.2-12) were only recently completed. This element will involve use of the six release locations by Reclamation and DWR. As noted by Karp and Bridges (2016), historical operations of the release sites focused on fairly regular schedules, with DWR and Reclamation exclusively using their own release sites except in emergencies. The predictability in release schedules is hypothesized to increase risk of predation for salvaged fish. The proposed action will aim to reduce release site predation through changes to the historical operational scheme based on studies evaluating recommendations by Karp and Bridges (2016). These recommendations included altering the frequency of salvaged fish releases either by reducing the number of releases each day or by using one site every few days. Determining the optimum number of release sites would be based on gradually increasing the number of release sites being used and monitoring changes in predator density over time.

The salvage release action will also consider the use of other release strategies, in particular the use of barges. As summarized by Karp and Bridges (2016), barge releases of salvaged fish could provide several benefits, including allowing: salvaged fish to acclimate to Delta water conditions before release, allowing salvaged fish to recover from transport/handling-induced stress, accommodating a large number of salvaged fish at one time, moving fish away to offshore areas where it is hypothesized that there is less predation, and accommodating night releases when predation by visual predators should be lower. Compared to another potential release method, i.e., the use of net pens, barging allows very large numbers of salvaged fish to be moved long distances because a barge can move fish faster than towing a net pen and requires fewer operators. Barging could be used nearly every day of the year and would not be as limited by weather or fog as is the use of net pens. For feasible implementation, it is likely that barging would involve use of trucks to deliver salvaged fish from the TFCF to barges moored in the west Delta (e.g., Antioch or Rio Vista; Karp and Bridges 2016).



Source: Karp and Bridges (2016).

Figure D1.2-11. Location of The Four Long-Term Fish Salvage Release Locations in the Delta.



Source: DWR (2014).

Figure D1.2-12. Location of the Recently Completed Fish Salvage Release Locations in the Delta.

Objectives

- Fundamental objective: Increase juveniles at Chipps Island per adult return
- Means objective: Abundance

Conceptual Model (Each Species and Life stage)

As previously noted for other proposed actions, per the SAIL CM4 for Winter-Run Chinook Salmon rearing to outmigrating juveniles in the Bay-Delta (Windell et al. 2017, p.22), "Juvenile salmon arriving in the southern end of the Delta are at risk of entrainment in the Central Valley Project and State Water Project water intakes." The green sturgeon SAIL CM for the transition from juvenile to adult/sub-adult notes "both juvenile green sturgeon distribution and behavior suggest that entrainment and impingement in diversions affect survival" (Heublein et al. 2017, p.22).

Current Conditions

The NMFS (2009) RPA Action IV.4.3 requires implementation of state-of-the-art salvage release procedures to improve overall survival of listed species. This involves conducting release site studies to develop methods to reduce predation at the "end of the pipe" following release of salvaged fish. Studies are required to examine but not be limited to a) potential use of barges to release the fish in different locations within the western Delta, with slow dispersion of fish from barge holding tanks to Delta waters; b) multiple release points (up to six) in western Delta with randomized release schedule; and c) conducting a benefit to cost analysis to maximize this ratio while reducing predation at release site to 50% of the current rate. Based on these studies, predation reduction methods are to be implemented that reduce release site predation to 50% of the current rate.

Background

Analysis in the NMFS (2009, p.352) BO identifies prescreen loss (15%), louver efficiency loss (53.2%), collection/handling/transport/release loss (2%), and post-release loss (10%) as the various elements contributing to approximately 35% survival of fish salvaged at the TFCF. Hydroacoustic studies have provided evidence that predators can be abundant at the release sites (Miranda et al. 2010).

Current Science

Studies are underway to determine release site strategies in order to optimize release schedules at the multiple SWP/CVP release sites (Fullard et al. 2017, 2018).

Justification

Changes in salvage release sites could help minimize the effects of the salvage process on listed fishes, in particular juvenile salmonids and Green Sturgeon.

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D1.2.6.5 *Conservation Hatchery*

D1.2.6.5.1 <u>Delta Smelt Conservation Hatchery</u>

Summary

Reclamation would partner with IEP to develop a conservation hatchery for Delta Smelt, which is a rearing facility to breed and propagate a stock of fish with equivalent genetic resources of the native stock, so that they can be returned to the wild to reproduce naturally in their native habitat.

Description

An extreme decline in Delta Smelt abundance has led to a number of management actions to support this endangered species, including the development and refinement of culture techniques and the creation of a Delta Smelt refuge population. Delta Smelt have been cultured since the mid-1990s (Lindberg et al. 2013) and are now held in a refuge population at the UC Davis Fish Culture and Conservation Laboratory (FCCL), with a portion of these fish also held at the Livingston Stone National Fish Hatchery. The goal of the Delta Smelt captive breeding program at the FCCL is to "create a genetically and demographically robust captive population that will act as a genetic bank in the event this species becomes extinct in the wild, as well as potentially serve as a source for supporting wild populations if such a need arises" (Fisch et al. 2012). The captive breeding program operates under a rigorous genetic management plan jointly managed by the FCCL and the Genomic Variation Laboratory (GVL) at UC Davis to maintain genetic diversity and minimize kinship among captive fish (Fisch et al. 2012).

As a result of the recent extreme population declines, interest in the development of a full-scale Conservation Hatchery, and accompanying Hatchery Genetic Management Plan and Supplementation Program, have increased. Towards this goal, the USFWS in collaboration with DWR and Reclamation have been considering the construction of a regional Fish Technology Center to be co-located at the Rio Vista Army Base, Redevelopment Area. This Center's purpose will be to support an expanded refuge population and research toward the development of a full-scale Conservation Hatchery for species supplementation (USFWS 2016). Here supplementation is defined as the intentional movement and release of an organism inside its indigenous range (if the species has disappeared this same action would be considered reintroduction) (IUCN SSC 2013).

Objectives

- Fundamental objective: Maintain minimum population during drought.
- Means objective: Productivity

Conceptual Model (Each Species and Life stage)

The CMs are not directly applicable.

Current Condition

The maximum adult capacity of the FCCL facility is currently only 53,500 adult fish, thus large numbers of cultured animals are culled from the population due to space limitations. If a species supplementation program were to be considered necessary, the FCCL would not be able to accommodate the level of production needed for such a program. As such, a facility dedicated to a full-scale Conservation Hatchery, managed under a Hatchery Genetic Management Plan, is needed. The FTC at Rio Vista is currently in the design and planning stages, and a conservation hatchery is included in the building plans; however, the funding and agreements for the running of the facility has not been defined. This facility will require Congressional approval for funding.

While the FCCL has been successful in refining captive propagation techniques and establishing a refugial population of Delta Smelt that is genetically indistinguishable from the wild using neutral loci (Fisch et al. 2013), there is recent evidence for domestication selection. Finger et al. (in press, *Journal of Heredity*) found that the relative reproductive success (RRS) of pair crosses with one wild and one cultured parent was lower than that of pair crosses with two cultured parents. This trend has continued across a period of nine years, since the inception of the Delta Smelt captive breeding program at the FCCL. Additionally, the RRS of pair crosses with two cultured parents has increased continually over generations, indicating that adaptation to captivity is likely occurring but cannot be detected with the existing panel of microsatellite markers.

The most direct way to minimize hatchery domestication selection is to reduce the amount of time that Delta Smelt spend in the hatchery. This aim could be accomplished by using fish with minimal hatchery ancestry (e.g., pair crosses with one or two wild parents) for population reinforcement or reintroduction and/or by releasing Delta Smelt at the fertilized egg stage. Numerous studies have shown that cultured fish do not perform as well (e.g., survival, growth, behavior, and reproductive success) under natural conditions as wild fish (McGinnity et al. 2003, Berejikian and Ford 2004, Araki et al. 2007, 2008). To minimize the risk of hatchery effects, cultured Delta Smelt could be released at the fertilized egg stage using techniques that have been developed in Japan for a related species, Wakasagi (*Hypomesus nipponensis*).

Background

Delta Smelt is a small (maximum length ~120 mm FL) estuarine fish endemic to the upper reaches of the San Francisco Estuary (SFE) (Moyle 2002; Bennett 2005; IEP-MAST 2015). Once very abundant, Delta Smelt are now rare and are protected under the federal (ESA; threatened) and California Endangered Species Act (CESA; endangered). The species currently consists of a single remnant population (Moyle and Herbold 1992, Fisch et al. 2011) that completes its entire life cycle in the upper SFE. Delta Smelt live one to two years and historically demonstrated high variability in spatial distribution and annual abundance, generally responding better to wetter conditions, high turbidity, moderate temperatures, and improved food availability (Moyle et al. 2016). The decline of this species began during the early 1980s, which ultimately led to its federal listing in 1993 (USFWS 1993). Population abundance decreased further around 2002, which included declines of several other pelagic fishes of the upper SFE, a phenomenon known as the “Pelagic Organism Decline” (POD) (Sommer et al. 2007, Thomson et al. 2010, IEP-MAST 2015).

Current Science

FCCL facility consists of several buildings located at the Skinner Fish Facility adjacent to Clifton Court Forebay. Wild Delta Smelt were captured and first brought to the FCCL for the purpose of establishing a refugial population in 2006 (Fisch et al. 2013). Captive spawning was initiated in 2008, accompanied by an intensive genetic management strategy that involves controlled mate selection to minimize kinship and preserve genetic diversity (Ballou and Lacy 1995, Lindberg et al. 2013); the introduction of wild Delta Smelt into the refugial population each year is also an important factor that retards genetic variation loss. Details of the genetic management plan for Delta Smelt reared at the FCCL are presented in Finger and May (2015).

Approximately 100 wild Delta Smelt are collected from the Delta annually and housed at the FCCL in preparation for spawning. At the beginning of every spawning season, ripe individuals are tagged and fin clips are sent to the Genomic Variation Laboratory (GVL) at UC Davis for genotyping at 12 microsatellite loci (Fisch et al. 2009). The genotype data is used for pedigree reconstruction to identify the family of the tagged fish; wild fish are assumed to be unrelated. The GVL then makes recommendations about which individuals should be crossed to represent the greatest number of pair crosses from the previous year and to maximize the genetic input of wild fish.

Justification

Hatchery production and supplementation using cultured Delta Smelt may be the only viable, short-term means to prevent species extinction. Further declines in wild broodstock availability will reduce successful natural production as well as reduce levels of genetic diversity available for conservation aquaculture, making species recovery that much harder. Given the precarious demographic status of Delta Smelt and the severely degraded conditions of its habitat, the benefits of developing a conservation hatchery and supplementation program now outweigh the risks of such experiments (Anders 1998, Bohling 2016, Hobbs et al. 2017, Lessard et al. 2018).

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D1.2.7 Stanislaus River Basin

D1.2.7.1 *Water Operations*

D1.2.7.1.1 New Melones Revised Plan of Operations

Summary

Reclamation would implement the New Melones Revised Plan of Operation to create a sustainable operation on the Stanislaus River.

Description

Reclamation would operate New Melones Reservoir (as measured at Goodwin Dam) in accordance with a Stepped Release Plan (SRP) that varies by hydrologic condition and water year type as shown in Table D1.2-10.

Table D1.2-10. New Melones SRP Annual Releases by Water Year Typ

Water Year Type	Annual Release (TAF)
Critical	184.3
Dry	233.3
Below Normal	344.6
Above Normal	344.6
Wet	476.3

The New Melones SRP would be implemented similarly to the No Action Alternative with a default daily hydrograph and the ability to shape monthly and seasonal flow volumes to meet specific biological objectives. The default daily hydrograph is the same as prescribed under the No Action Alternative for critical, dry, and below-normal water year types. The difference occurs in above-normal and wet years, where the minimum requirement for larger releases is reduced from the No Action Alternative to promote storage for potential future droughts and preserve cold water pool. When compared to minimum daily flows from the No Action Alternative, the daily hydrograph for the New Melones SRP is identical for critical, dry, and below-normal year types; above-normal and wet year types follow daily hydrographs for below-normal and above-normal year types from current operating requirements, respectively.

For the New Melones SRP, Reclamation would classify water year types using the San Joaquin Valley 60-20-20 Water Year Hydrologic Classification (60-20-20) developed for D-1641 implementation. Previous operating plans for New Melones Reservoir relied on the New Melones Index to determine water year type, calculated by summing end-of-February storage and forecasted inflow through September. Because the reservoir can store more than twice its average inflow, the New Melones Index resulted in a water year type determination that was more closely tied to storage rather than hydrology. Changing from the New Melones Index to 60-20-20 is expected to provide operations that better represent current hydrology and correlate more closely to water year types for other nearby tributaries.

Reclamation would convene the Stanislaus Watershed Team (successor to the Stanislaus Operating Group), consisting of agency representatives and local stakeholders having direct interest on the Stanislaus River, at least monthly to share operational information and improve technical dialogue on the implementation of the New Melones SRP. The Stanislaus Watershed Team would provide input on the shaping and timing of monthly or seasonal flow volumes to optimize biological benefits.

During the summer, Reclamation would be required to maintain applicable dissolved oxygen standards on the lower Stanislaus River for species protection. Reclamation currently operates to a 7.0 mg/L dissolved oxygen requirement at Ripon from June 1 to September 30. Reclamation would move the compliance location to Orange Blossom Bridge, where the species are primarily located at that time of year.

Objectives

- Fundamental objectives: Increase juveniles at Chipps Island per adult return and maintain minimum population during drought
- Means objectives: Abundance and productivity

Conceptual Model (Each Species and Life stage)

While steelhead, Spring-Run Chinook salmon, and Fall-Run Chinook Salmon on the Stanislaus River are not specifically included in the available CMs, this component also relates to the ability to meet flow and water quality requirements at Vernalis. Flow and water quality entering the Delta are key for species residing in, or migrating through, the Delta.

Current Condition

New Melones has been operated under an Interim Plan of Operations since 1997. The IPO was developed prior to completion of current tools to understand hydrology in the basin, and the water releases for different purposes were overallocated in many years. The Interim Plan of Operations requires releases early in the season that have resulted in inadequate water available later in the season to meet requirements. Table D1.2-11 shows the Interim Plan of Operations.

Table D1.2-11. New Melones Interim Plan of Operation Allocations (TAF)

New Melones Storage Plus Inflow		Fishery		Vernalis Water Quality		Bay-Delta		CVP Contractors	
From	To	From	To	From	To	From	To	From	To
0	1,400	0	98	0	70	0	0	0	0
1,400	2,000	98	125	70	80	0	0	0	0
2,000	2,500	125	345	80	175	0	0	0	59
2,500	3,000	345	467	175	250	75	75	90	90
3,000	6,000	467	467	250	250	75	75	90	90

Background

Reclamation has been working with water rights holders and CVP contractors on the Stanislaus system to develop the Revised Plan of Operations. This plan strives to meet requirements for fish flows, temperature, water quality, dissolved oxygen, and water deliveries.

Current Science

NMFS' *Recovery Plan for Central Valley Chinook Salmon and Steelhead* (NMFS 2014) identifies recovery actions on the Stanislaus River. These actions include managing flow releases to provide suitable water temperatures and flows for all steelhead life stages, and the Revised Plan of Operation would improve the ability to manage temperatures under multiple hydrologic conditions. The plan also identifies the need to evaluate whether pulse flows are beneficial to adult steelhead immigration and juvenile steelhead emigration. The Revised Plan of Operation identifies blocks of water that could be used for pulse flows or sustained flows over a longer period.

Justification

The *Recovery Plan for Central Valley Chinook Salmon and Steelhead* (NMFS 2014) identifies the steelhead population on the Stanislaus River below Goodwin as a Core 2 population. The Interim Plan of Operations is not able to maintain temperatures throughout the year under some hydrologic conditions, and the Revised Plan of Operations has addressed several of the issues that lead to the problems experienced in recent years.

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D1.2.7.1.2 Relaxation of Stanislaus River Dissolved Oxygen Requirement

Summary

Reclamation would petition the SWRCB to alter the requirement for DO at Ripon to be 7 milligrams per liter (mg/L) from June through November of dry years.

Description

SWRCB D-1422 requires that water be released from New Melones Reservoir to maintain a DO concentration in the Stanislaus River as specified in the Water Quality Control Plan (WQCP) for the Sacramento and San Joaquin river basins. The 1995 revision to the WQCP established a minimum DO concentration of 7 milligrams per liter (mg/l), as measured on the Stanislaus River near Ripon. In coordination with Reclamation's plan of operation for New Melones Reservoir, Reclamation will petition the SWRCB to modify this requirement to maintain a minimum DO concentration of 5 mg/l at Ripon during dry years. In these years, New Melones Reservoir does not have sufficient inflow to meet all requirements on the lower San Joaquin River. Relaxing the standard would allow an improved ability to maintain temperatures throughout the season.

Objectives

- Fundamental objectives: Increase juveniles at Chipps Island per adult return and maintain minimum population during drought
- Means objectives: Abundance and productivity

Conceptual Model (Each Species and Life stage)

While Fall-Run Chinook Salmon and steelhead on the Stanislaus River are not specifically included in the available CMs, sufficient dissolved oxygen is recognized as a requirement for anadromous fish within the Stanislaus system. Additionally, water quality entering the Delta is key for species residing in, or migrating through, the Delta.

Current Condition

Reclamation is required to meet the existing DO standard at Ripon unless the SWRCB approves a temporary relaxation.

Background

In 2015, Reclamation submitted a Temporary Urgency Change Petition to the SWRCB because drought conditions prevented Reclamation from meeting all WQCP standards. The SWRCB approved the petition, which included a provision to reduce the DO standard for the Stanislaus River at Ripon from a minimum of 7 mg/L to 5 mg/L.

Current Science

CDFW studied DO concentrations in the Stanislaus River at Ripon and the lower San Joaquin River (at five locations) during 2011 and 2015 to compare non-drought and drought conditions, respectively. Generally, they found that DO concentrations in the summer were lower during 2015 in both the Stanislaus and San Joaquin rivers and fell below 7 mg/L on the Stanislaus River at Ripon (CDFW undated). Dissolved oxygen concentrations have been found to be a migration barrier for adult salmon if they are lower than 4.2 mg/L (Hallock et al. 1970), but the 2015 DO concentrations were consistently above this level (CDFW undated).

Juvenile steelhead may be rearing in the uppermost reaches of the river during June through November and adult steelhead may begin entering the river as early as October. Few Spring-Run Chinook Salmon typically enter the river during the spring period. Based on past multi-year observations (Kennedy and Cannon 2005, Kennedy 2008), oversummering juvenile salmonids are primarily found upstream of

Orange Blossom Bridge, which is 31 miles upstream from Ripon. DO monitoring at the Stanislaus River Weir (about 15 miles upstream from Ripon) indicates that DO concentrations can be 0.5-1 mg/L higher at this location than Ripon (Cramer Fish Sciences 2006a-d). Because the fish are primarily at least twice this distance upstream from Ripon, the DO is likely to be at this level or higher.

Justification

Maintaining DO concentrations above 7 mg/L in the Stanislaus River at Ripon is challenging during drought conditions, and is not necessary for steelhead, Spring-run Chinook Salmon, or Fall-Run Chinook Salmon.

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D1.3 Program-Level Components

D1.3.1 Central Valley Wide

D1.3.1.1 *Small Screen Program*

D1.3.1.1.1 Summary

Operating water divisions without screening can result in the entrainment of juvenile fish into the diversions and impact listed and special fish populations in these river systems. Most of the larger diversions in the Central Valley have been screened or are currently proposed for screening. Reclamation and DWR propose to screen remaining small unscreened diversions to reduce entrainment of salmonids.

D1.3.1.1.2 Description

Reclamation and DWR propose implementation the Reclamation Small Screen Program (RSSP) to provide fish screens on small water diversions (less than 150 cfs) to reduce the take of listed fish species. The RSSP would provide additional funding, technical services, and in-kind support for existing screening programs in California to further encourage the conversion of unscreened to screened diversions that meets CDFW and NMFS criteria. This program would leverage existing programs and the collaborative partnerships already established with diversion stakeholders and other State and federal agencies. This program would be administered through 2030 to support efforts to provide fish screens for unscreened diversions with maximum instantaneous flow demands less than 150 cfs. Reclamation and DWR would partner with agencies/groups to address diversions without screening and to perform or supplement the following activities as outlined by existing programs.

The RSSP would provide technical services and/or additional funding to achieve the following tasks:

- Identification, evaluation, and prioritization of unscreened diversions to refine current data sets,
- Promote public education through distribution of educational materials and public outreach,
- Consult with current water right holders to help identify appropriate technical solutions and funding pathways, and
- Offer additional grant funding to be administered through existing screening programs.

Projects seeking funding will be evaluated and prioritized based on biological benefits, the size and location of the diversion, project costs, and the availability of cost-share funding partners. The types of projects eligible for funds under the program include:

- Construction of fish screens on unscreened diversions,
- Rehabilitating existing fish screens,
- Replace/improve existing nonfunctioning fish screens, and
- Relocating water diversion to less fishery-sensitive areas.

D1.3.1.1.3 Objectives

- Fundamental objectives: Increase juveniles at Chipps Island per adult return and maintain minimum population during drought
- Means objective: Abundance

D1.3.1.1.4 Conceptual Model (Each Species and Life stage)

Juvenile Chinook Salmon and steelhead migrating down the river systems encounter numerous water/irrigation diversions. The entrainment risk associated with unscreened or poorly screened water diversions leads to direct entrainment and mortality and is classified as a Tier 3 driver (habitat attribute) in the SAIL CM for the Rearing Juvenile to Outmigrating Juvenile life stage of Sacramento River Winter-Run Chinook Salmon, affecting smolts migrating in the Upper River (Keswick Dam to RBDD), Middle River (RBDD to Sacramento), and the Bay-Delta reaches (Windell et al. 2017). The construction of screens under the small screen program would improve the migratory conditions and survival of outmigrating juvenile salmonids, and thus, provide immediate and long-term improvement of the resiliency of Sacramento Valley salmon and steelhead (CNRA 2017). Although the SAIL CM has not been developed for Sacramento River Spring-Run Chinook Salmon and steelhead, the SAIL CM applies to these species due to the close life cycle similarity and habitat attributes that affect survival. Therefore, the benefits of screening water diversions directly apply to these populations.

The SAIL CM for North American green sturgeon and the Sacramento-San Joaquin River white sturgeon classifies the key factors influencing their populations in the San Francisco Estuary watershed (Heublein et al. 2017a). Entrainment in diversions is identified as a Tier 3 habitat attribute affecting sturgeon abundance for the for two juvenile life history stages: the hatch to metamorphosis and metamorphosis stage and the metamorphosis to ocean migration or 75 cm fork length life stage. Larval sturgeon are present in areas where substantial water volumes are diverted, and, due to small size and relatively poor swimming performance of larvae, it is almost certain that entrainment effects larval survival influences larval and juvenile survival. Although some diversion facilities include modern fish screens to reduce entrainment of juvenile salmonids, the effectiveness of screens and facility operations in reducing larval green sturgeon entrainment is poorly understood, and the distribution and behavior of juvenile green sturgeon suggest that entrainment and impingement in diversions affect survival (Heublein et al. 2017b). Furthermore, many small-scale unscreened diversions are present throughout larval habitat of both species in the mainstem Sacramento River likely directly affect juvenile white sturgeon survival. The construction and improvement of fish screens under the proposed small screen program, as well as further study of screen effectiveness for sturgeon, would improve survival of juvenile sturgeon in the Sacramento River and Delta.

D1.3.1.1.5 Current Condition

Query results for unscreened and unassessed diversions were obtained on October 18, 2018, using the CDFW Passage Assessment Database.

- Sacramento River: The database identified 691 unscreened diversions on the Sacramento River, located in 10 different counties (Butte, Colusa, Glenn, Sacramento, Shasta, Solano, Sutter, Tehama, Yolo, and Yuba) between approximately River Mile (RM) 3 and RM 300. In addition to these unscreened diversions, there are 16 unassessed diversions (CDFG 2018).
- American River: The database identified 5 unscreened diversions currently on the American River, all located in the same county (Sacramento), approximately between RM 0 and RM 24. In addition to these five unscreened diversions, three have been identified as unassessed (CDFW 2018).
- Delta: According to the California State Water Resources Control Board (SWRCB) report, there are more than 3,000 known in-Delta water rights and claims. (California State Water Resources Control Board 2014). Fish loss due to entrainment is well documented (Kimmerer 2008; Mussen et al. 2013) and screening of these diversions is a component of recovery of fish in the Bay-Delta (USFWS 1996).

D1.3.1.1.6 Background

The entrainment and loss of fish at unscreened diversions in the Sacramento River basin and Sacramento-San Joaquin River Delta negatively affects the populations of listed species and other special status fish (NMFS 2014). The loss of juvenile salmonids at unscreened water diversions in the Sacramento River and Delta has been identified as a reason for the listing of Winter- and Spring-Run Chinook Salmon and steelhead. While many of the large water diversions (greater than 150 cfs) on the Sacramento River are screened or are currently proposed for screening, most of the over 3,700 water diversions on the Sacramento River and San Joaquin River watersheds and in the Sacramento-San Joaquin River Delta remain unscreened (Mussen et al. 2013).

Existing Programs

Fish screen programs have been established in the Central Valley to prevent entrainment of fish into water diversions and reduce impacts to the species that inhabit the Sacramento-San Joaquin River Delta and its tributaries. Major restoration efforts that impact salmon and steelhead recovery in the Central Valley have resulted in the establishment of Reclamation's Anadromous Fish Screen Program (AFSP) in the mid-1990s and the CALFED Sacramento Valley/Delta Fish Screen Program (DFSP). In addition, the Sacramento-Central Valley Fish Screen Program was created by the FWA in 1996 to screen additional diversions that do fit into the scope of work DFSP.

Reclamation's AFSP was initiated to screen irrigation diversions, with primary funding provided through the CVPIA restoration fund, and augmented on occasion by other Reclamation and CALFED Ecosystem Restoration Program (ERP) funds. The AFSP and the DFSP are operated jointly, with the participation of Reclamation, USFWS, CDFW, NMFS, and DWR. Shared purposes of the AFRP and the ERP are to protect and restore diversity within and among the various naturally-producing populations of Chinook Salmon and steelhead in the Central Valley, and to restore the habitats upon which the populations depend. These programs have supported over 30 projects addressing unscreened diversions throughout the Central Valley, with the majority of projects implemented on relatively large diversions along the mainstem Sacramento River.

<u>Anadromous Fish Screen Program (Reclamation)</u>

The AFSP was established in 1994 to carry out CVPIA Section 3406(b)(21). The CVPIA (Title 34 of Public Law 102-575) required implementation of measures to protect, restore, and enhance fish and wildlife affected by operations of the federal CVP, and directed the Interior to assist the State of California in efforts to implement measures to avoid losses of juvenile anadromous fish from diversions in Sacramento and San Joaquin watersheds and the Delta. The AFSP was specifically developed to help meet the fish restoration objectives of CVPIA and protects juvenile anadromous fish from entrainment in water diversions in California on the Sacramento and San Joaquin rivers, their tributaries, and the Sacramento-San Joaquin Delta. The AFSP is an incentive-based program that encourages the construction of fish screens at water diversions by providing technical assistance and cost-share funding. Fish protected through this program include Chinook Salmon, steelhead trout, and Green and White Sturgeon.

<u>Ecosystem Restoration Program – Sacramento Valley/Delta Fish Screen Program.</u>

The ERP is CDFW's principal program designed to restore the ecological health of the Bay-Delta ecosystem. The ERP includes actions throughout the Bay-Delta watershed and focuses on the restoration of ecological processes and important habitats. The DFSP is a component of the comprehensive ERP; a multiagency effort aimed at improving and increasing aquatic and terrestrial habitats and ecological function in the Delta and its tributaries. The ERP Focus Area includes the Sacramento-San Joaquin Delta, Suisun Bay, the Sacramento River below Shasta Dam, the San Joaquin River below the confluence with the Merced River, and their major tributary watersheds directly connected to the Bay-Delta system below major dams and reservoirs. The vast majority of these projects focus on fish passage issues, species assessment, ecological processes, environmental water quality, or habitat restoration.

Sacramento-Central Valley Fish Screen Valley Fish Screen Program

The Sacramento-Central Valley Fish Screen Program is managed by the FWA, a 501(c)(3) nonprofit corporation that administers the grant-funded program to install fish screens in the Sacramento River. The program's goal is to benefit threatened and endangered anadromous fish species by screening multiple sites that do not currently fit into the scope of work for the current Sacramento Valley/Delta Fish Screen Program. Since 1996, FWA has been the program manager in cooperation with several State and Federal agencies and private contributors in spearheading research and developing and installing fish screens on small agricultural diversions.

California Department of Fish and Game Watershed Restoration Grants Branch

CDFW provides grant programs for the installation or improvement of fish screens. These grant programs include:

- Proposition 68 Restoration Grant Programs
- Proposition 1 Restoration Grant Programs
- Fisheries Habitat Restoration Grant Program

D1.3.1.1.7 Current Science

Fish exclusion screens and protection devices are a common strategy for reducing entrainment risk of a threatened juvenile fish species while maintaining water-diversion activities. The design and success of a fish screen facility is dependent on a number of factors, such as fish species, swimming ability, and hydraulic conditions. Guidance documents for the placement and design of fish screens are provided below.

- Designing Fish Screens for Fish Protection at Water Diversions (NMFS)
- Fish Screening Passage for Anadromous Salmonids (NMFS)
- Fish Protection at Water Diversions: A guide for planning and designing fish exclusion facilities. (Reclamation)
- California Department of Fish and Wildlife Fish Screening Criteria (CDFW)

D1.3.1.1.8 Justification

Fish screen programs have been established in the Central Valley to reduce entrainment of fish into water diversions and reduce impacts to the species that inhabit the Sacramento-San Joaquin River Delta and its tributaries. The implementation of a fish screen program would offer a variety of benefits for both fish and landowners. The addition of fish screens to a previously unscreened diversion allow for more reliable water flow, prevent system clogging (in turn reducing maintenance), protecting fish from diversions, and meeting state and federal laws.

D1.3.1.1.9 References

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D1.3.2 Upper Sacramento River Basin (Shasta and Sacramento Divisions)

D1.3.2.1 *Temperature Facility Improvements*

D1.3.2.1.1 Shasta Temperature Control Device Improvements

Summary

The current Shasta TCD leaks, and when reservoir levels are below the shutters does not allow for selective withdrawal from the reservoir. Additional flexibility to meet temperature control could be provided with structural modifications. Implementation of the Shasta Dam Raise project would replace or modify the TCD.

Description

Depending upon the type of dam raise proposed, the TCD would be either modified or replaced by Reclamation. For relatively small raises of Shasta Dam, the existing TCD structure would be retrofitted to account for additional dam height, and to reduce leakage of warm water into the structure, but no new structure would be needed. However, modifications to, or replacement of, the existing structure are more likely to be necessary for increasingly higher dam raises. TCD modifications would support the objective of increasing the survival of anadromous fish populations by:

1. Increasing the ability of operators at Shasta Dam to meet downstream temperature requirements for anadromous fish,
2. Providing more flexibility in achieving desirable water temperatures during critical spawning, rearing, and out-migration, and
3. Extending the area of suitable spawning habitat farther downstream in the Sacramento River.

Objectives

- Fundamental objectives: Increase juveniles at Chipps Island per adult return and maintain minimum population during drought.
- Means objectives: Abundance and productivity

Conceptual Model (Each Species and Life stage)

Within the Sacramento River Winter-Run Chinook Salmon functions as a single population across (1) the river below Shasta Dam, (2) areas above Shasta Dam, and (3) within the Livingston Stone National Fish Hatchery (NMFS 2009).

Winter-Run Chinook Salmon spawn in the upper Sacramento River, extending from just below Keswick Dam to approximately 60 miles downstream to RBDD, though most spawning occurs within the first 10 miles below Keswick Dam (NMFS 2017).

Water temperature affects the rate of development of embryos and alevins (Rombough 1988, Beacham and Murray 1990) and temperature should not exceed 56 °F (13.3 °C) to avoid egg mortality (Myrick and Cech 2004). The amount of cold water available to achieve optimal temperature for this life stage varies as a function of the amount of cumulative precipitation, reservoir stratification, and previous Shasta Reservoir water operations.

Winter-Run Chinook Salmon fry begin to emerge from the gravel and start exogenous feeding from July–October (Fisher 1994). Optimal water temperatures for juvenile Chinook Salmon rearing range from 53.6–57.2°F (12–14°C). A daily average water temperature of 60°F (15.5°C) is considered the upper temperature limit for juvenile Chinook Salmon growth and rearing (NMFS 1997). Inhibition of Chinook Salmon smolt development in the Sacramento River may occur at water temperatures above 63°F (17.2°C; Marine and Cech 2004).

Current Condition

The seasonal operation of the TCD is generally as follows: during mid-winter and early spring the highest elevation gates possible are used to draw from the upper portions of the lake to conserve deeper colder resources. During late spring and summer, the operators begin the seasonal progression of opening deeper gates as Shasta Lake elevation decreases and cold water resources are utilized. In late summer and fall, the TCD side gates are opened to utilize the remaining cold water resource below the Shasta Powerplant elevation in Shasta Lake.

The seasonal progression of the Shasta TCD operation is designed to maximize the conservation of cold water resources deep in Shasta Lake, until the time the resource is of greatest management value to fishery management purposes.

The TCD can be used to selectively draw water from different depths within the lake, including the deepest, to help maintain river water temperatures beneficial to salmon. The TCD is effective in helping to reduce Winter-Run Chinook Salmon mortality in some critical years and for Fall- and Spring-Run Chinook Salmon in below normal water years (Reclamation 2015b). However, despite projections and modeling efforts in 2014, Shasta Reservoir ran out of sufficiently cold water in September 2014. After this point, insufficient cold water was available for release to the Sacramento River to manage temperatures. This lack of ability to regulate temperature was a primary factor contributing to the loss of 95% of the 2014 year class of wild Sacramento River Winter-Run Chinook Salmon (Reclamation 2015a).

Background

Construction of the TCD at Shasta Dam was completed in 1997. This device is designed to provide for greater flexibility in managing the cold water reserves in Shasta Lake while enabling hydroelectric power generation to occur and to improve salmon habitat conditions in the upper Sacramento River. The TCD is also designed to enable selective release of water from varying lake levels through the power plant to manage and maintain adequate water temperatures in the Sacramento River downstream of Keswick Dam (Reclamation, 2015b).

Current Science

Currently, the Shasta TCD does not function adequately when reservoir levels are below the TCD shutters. A hindcast report issued in March 2015 by Reclamation (Reclamation 2015a) found that the Sacramento River temperature model used to model temperatures and operate the TCD slide gate to manage the cold water pool adequately represented the performance of the Shasta TCD before the side-gate was operational. However, it did a poor job at characterizing the TCD performance once the TCD side gate operation went into real-time effect. These model errors led to an excess expenditure of Shasta cold water pool in the summer of 2014, resulting in early depletion of cold water reserves and loss of temperature control in the river in September 2014. The condition still exists and is proposed to be addressed during the Shasta Dam Raise project (Reclamation 2015a).

Justification

Improving management of the cold water pool in Shasta Reservoir would help Reclamation maintain lower water temperatures into the fall, when they are needed for Winter-Run Chinook Salmon.

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D1.3.2.1.2 Lower Intakes near Wilkins Slough (Meridian Fish Screen)

Summary

Reclamation proposes to provide grants to water users to enable them to install new diversions that would be able to divert at lower flows. This would eliminate a significant restriction to Reclamation's ability to lower flows in the fall time frame to save cold water for the next year, and fix part of a problem that occurred in 2015.

Description

Due to temperature requirements, Sacramento River flows at or near Wilkins Slough can drop below the 5,000 cfs minimum navigational flow set by Congress. As many of the fish screens at diversions in this region were designed to meet the 5,000 cfs minimum, they may not function properly at the lower flows and as a result, not meet state and federal fish screening requirements during the lower flows (NCWA 2014). This could result in take of state and federally protected species that use this section of the river. This action would provide grants to water users within this area to install new diversions and screens that would operate at lower flows, which would allow Reclamation to have greater flexibility in managing Sacramento River flows and temperatures for both water users and wildlife, including listed salmonids (NCWA 2014).

Objectives

- Fundamental objectives: Increase juveniles at Chipps Island per adult return and maintain minimum population during drought.
- Means objective: Abundance

Conceptual Model (Each Species and Life stage)

Juvenile Sacramento River Winter-Run Chinook Salmon spend a varying duration of time rearing in the upper Sacramento River following emergence and before migrating past RBDD into the middle Sacramento River. Juveniles use the middle Sacramento River as a rearing habitat and a migratory corridor to the tidal Delta. The majority of Winter-Run Chinook Salmon juveniles migrate past RBDD from August to December (Poytress et al. 2014) and past Knights Landing at the downstream end of the middle Sacramento River between October and April (del Rosario et al. 2013). Entrainment at unscreened or ineffectively screened water diversions influences salmon survival through this reach.

Current Condition

The NMFS 2009 BO states that flows could be reduced to 3,250 cfs, which is lower than the Wilkins Slough flow requirement. If Reclamation reduced flows below the Wilkins Slough control point requirement and depending on the diversion rate, some screens may not meet the velocity criteria as designed and fish could become entrained, including state and federally listed species such as all life stages of Winter-Run Chinook Salmon.

Due to drought conditions in 2015, Reclamation relaxed the navigational flow requirement at Wilkins Slough to 3,800 cfs in February based on unprecedented warmer temperature within Shasta Reservoir and May 2015 modeling runs that indicated Shasta Reservoir would run out of cold water in mid-August. The resulting reduction in flow at Wilkins Slough potentially subjected fish to velocity criteria at the intake screens that did not meet the state and federal criteria of 0.33 feet per second (ft/s) (NCWA 2014).

Background

When Congress reauthorized the Central Valley Project (CVP) under the Rivers and Harbors Act of 1937, it incorporated by reference and expressly required the implementation of a minimum flow of 5,000 cfs within the Sacramento River between Chico Landing and Sacramento. Congress has taken no subsequent action that has "discontinued" or otherwise changed this minimum navigation flow requirement.

The 1937 act also mandates that CVP "dams and reservoirs shall be used, first, for river regulation, improvement of navigation, and flood control; second, for irrigation and domestic uses; and, third, for power." (50 Stat. 844, 850.) In 1992, Congress explicitly amended this hierarchy of use by enacting CVPIA Sections 3406(a) and (b), which make protection of non-Endangered Species Act (ESA) listed fish and wildlife coequal priorities with irrigation. Even with this amendment, Reclamation's first priority remains river regulation, navigation and flood control.

On the Sacramento River, all major diversions have positive barrier flat-plate fish screens installed that provide protection to listed fishery species. These screens have been designed with an approach velocity of 0.33 ft/s as required by the NMFS and the CDFW.

During design, the screens, velocities, and diversion rates were based upon the Wilkins Slough navigational flow requirement of 5,000 cfs, as this requirement was under federal law.

Current Science

For California, the *Fish Screening for Anadromous Salmonids* (NMFS 1997) states:

- Approach velocity (velocity component perpendicular to the screen face) shall not exceed 0.33 ft/s for on-river screens and 0.4 ft/s for canals. Approach velocity shall be measured approximately three inches in front of the screen surface.
- Screen design must provide for uniform flow distribution over the surface of the screen, thereby minimizing approach velocity. This may be accomplished by providing adjustable porosity control on the downstream side of the screens.
- Sweeping velocity (velocity component parallel to the screen face) shall be greater than approach velocity

Justification

Improved diversion facilities would reduce take of endangered fish in the Sacramento River.

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D1.3.2.2 *Habitat*

D1.3.2.2.1 Rearing Habitat

Summary

Reclamation proposes to create approximately 40 to 60 acres of side channel habitat at no fewer than 10 sites in the upper Sacramento River.

Description

Reclamation proposes to create new side channels, modify existing side channels, and add instream habitat structure to increase rearing habitat for juvenile salmonids in the Sacramento. Habitat structure such as woody material and boulders would be incorporated into restoration designs. A total of 40 to 60 acres of spawning and rearing habitat would be created. The potential sites include Salt Creek, Turtle Bay Island, Kutras Lake Rearing Structures, Painter's Riffle maintenance, North Cypress maintenance, Cypress South, North Tobiasson Rearing Structures maintenance, Tobiasson Side Channel, Shea Side Channel, Kapusta Side Channel, Kapusta 1-A Side Channel maintenance, Kapusta 1-B Side Channel, Anderson River Park Side Channels, Cow Creek Side Channel, I-5 Side Channel, China Gardens, Rancheria Island Side Channel, Rancho Breisgau, Lake California Side Channel maintenance, Rio Vista Side Channel, East Sand Slough Side Channel, La Barranca Side Channel, Woodson Bridge Bank Rearing Improvement, Jellys Ferry, Dog Island, Altube Island, Blackberry Island, Oklahoma Avenue, Mooney Island, McClure Creek, Blethen Island, Wilsons Landing, McIntosh Island, Shaw, Larkins, Reilly Island, Hanson Island, and Broderick.

Floodplain and side channel habitat enhancements may consist of new or reconnected side channels and floodplain modifications that are designed to function under flows within the main channel ranging between 3,250 cfs to 7,000 cfs. Floodplain and side channel habitats will be created, reconnected, or modified by excavation using heavy equipment (i.e., bulldozer, front end loader, excavator). Where the excavated material is of the appropriate size distribution it would be sorted and placed into side channel or main channel areas to enhance habitat features. The fines would be distributed over the floodplain to assist in vegetating the area. Instream habitat structure (e.g., woody material such as, trees, trunks, rootwads, and willows; and variable sized large rocks) would be incorporated into the side channels to enhance habitat quality. The woody material would be held in place by partially burying it in the existing substrate or banks or keying into existing material to provide some stability under higher flows (Reclamation 2015)

Objectives

- Fundamental objective: Increase juveniles at Chipps Island per adult return
- Means objective: Abundance

Conceptual Model (Each Species and Life stage)

The salmonid life stage most affected by rearing habitat enhancements is the rearing and outmigrating juveniles. This life stage is addressed by the SAIL CM2 for Winter-Run Chinook Salmon (Windell et al. 2017). CM2 conceptualizes upper Sacramento River from fry rearing to outmigration of juveniles. Per the CM2 framework diagram (Figure 4 in Windell et al. 2017), geomorphology and bathymetry, which are greatly affected by side channel enhancements, is linked to the following environmental drivers for rearing and outmigration of juveniles: shallow water habitat and food production and retention. These drivers, in turn, are linked to the habitat attributes refuge habitat and food availability and quality. Note that refuge habitat provides protection from piscivorous fish. Per the narrative (page 10), "the channelized, leveed, and riprapped reaches of the Upper Sacramento River typically have low habitat complexity and low abundance of food organisms, and offer little protection from predators. Juvenile SRWRC are dependent on the function of … [high quality rearing] habitat for growth and … survival."

Current Condition

Recruitment of large woody material to the river channel and floodplain has declined due to a reduction in bank erosion and blockage of wood transport by Shasta Dam. The upper Sacramento River has poor rearing habitat. The channelized, leveed, and riprapped river reaches and sloughs that are common in the Sacramento River system typically have low habitat complexity, have low abundance of food organisms, and offer little protection from either fish or avian predators. Juvenile life stages of salmonids are dependent on the function of this habitat for successful survival and recruitment. Some complex, productive habitats with floodplains remain in the system and flood bypasses (i.e., Yolo and Sutter bypasses), but the overall condition of riparian habitat for rearing juvenile salmonid is degraded (NMFS 2009).

Although significant efforts have been made to increase the quantity and quality of spawning habitats below the dams, minimal progress has occurred on rearing habitats. In the upper Sacramento River, the reach of the river in which most salmonids spawn, many of the ideal habitat characteristics for rearing are lacking (e.g., appropriate velocities and cover). Fry emerging from redds in the mainstem riverbed encounter a paucity of velocity and predator refugia (Vogel 2011).

Many habitat restoration projects have been recently implemented in the upper Sacramento River. The following are spawning and rearing habitat projects that were recently completed but will require annual maintenance: Kutras Lake Rearing Structures (RM 296), North Cypress (RM 295), North Tobiasson Side Rearing Structures (RM 292), Kapusta 1-A Side Channel (RM 288), and Lake California Side Channel (RM 270).

Background

Large amounts of rearing habitats for young salmon were lost in the upper Sacramento Valley basin when Shasta and Keswick Dams were built. Loss of this rearing habitat (located in smaller, shallower river channels upstream of the dams, such as the McCloud River) was considered one of the many reasons for the endangered listing of the Winter-Run Chinook Salmon. Since dam construction, young salmon emerging from mainstem spawning areas downstream of the dams must now contend with the severe rigors of a large, deep river channel. It is generally acknowledged that the quality of rearing habitats in those upstream areas was superior to habitats below the dams (Vogel 2011).

In 2014, the NMFS released the Central Valley Salmon and Steelhead Recovery Plan, which identifies two salmonid conservation principles: (1) recovery cannot be achieved without sufficient habitat and (2) species with restricted spatial distribution are at a higher risk of extinction from catastrophic environmental events. The plan identifies loss of riparian habitat, instream cover, and floodplain habitat affecting juvenile rearing and outmigration and places priority on restoring and maintaining riparian and floodplain ecosystems along both banks of the Sacramento River to provide a diversity of habitat types.

Current Science

Recent research using physical modeling experiments to guide river restoration projects yielded three restoration manuals (Stillwater Sciences et al. 2008). The purpose of the research project was to build state-of-the-art flumes and conduct a series of physical modeling experiments to address some of the fundamental and unresolved scientific questions underlying the river restoration strategies of gravel augmentation, dam removal, and channel-floodplain redesign. Three manuals (one for each of the three restoration practices) integrate results from laboratory experiments from this study with theoretical analysis, numerical modeling, and field case studies to produce scientifically based guidelines for assessing, implementing, and predicting the in-channel response of these common restoration strategies. The manuals are intended for use by restoration practitioners and managers.

A research effort entailing over a decade of river restoration field research on the Sacramento River has yielded new understanding of many river processes and new numerical models and decision analysis tools (TNC et al. 2008).

Justification

Floodplain and side channel habitats serve as important refuge and rearing areas for salmonids. Excavation and contouring activities to enhance floodplain and side channel habitats will create instantly available habitat for rearing by up to 15 acres per year (NMFS 2015).

Instream habitat structures such as woody material and boulders contribute to habitat diversity and create and maintain foraging, cover, and resting habitat for both adult and juvenile anadromous fish. Placement of instream woody material on the banks of the active channel will create instantly available habitat by creating diverse cover for juvenile rearing, and possibly for holding adults, by up to four acres each year (NMFS 2015).

The need for the action derives from the declines of naturally spawned salmonid stocks due in part to loss of spawning and rearing habitat through curtailment of gravel recruitment due to blockage of the river channel by dams and the alteration in flow patterns.

References

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D1.3.2.2.2 Sutter Bypass

Summary

Increasing inundation of the Sutter Bypass can increase food and floodplain habitat for listed salmonids, particularly Spring-Run Chinook Salmon. This component includes Tisdale Weir modifications to address fish passage deficiencies.

Description

Sutter Bypass is a floodplain off the east side of the Sacramento River between the Colusa and Verona area. Tisdale Weir releases overflow waters of the Sacramento River into the Sutter Bypass. The weir is fixed crest reinforced concrete and 1,150 feet long. A four-mile leveed bypass channel (Tisdale Bypass) connects the river to the Sutter Bypass. Typically, the Tisdale Weir is the first of the five weirs in the Sacramento River Flood Control System to overtop and continues to spill for the longest duration. Tisdale Weir is 30 years past its engineered life and in need of rehabilitation. As part of the Sacramento River Flood Control Project, the California Department of Water Resources (DWR) is investigating options for rehabilitation of the weir. The project also includes a fish passage facility. Options under consideration currently include an operable gate or a notch that would allow flow and fish to enter and leave the Sutter Bypass at lower Sacramento River elevations.

The Sutter Bypass provides valuable habitat for migrating adult salmon, particularly Spring-Run Chinook Salmon, to Butte Creek. Providing fish passage at Tisdale Weir would facilitate adult migration and increasing inundation of the Sutter Bypass would increase rearing habitat for juveniles.

Objectives

- Fundamental objectives: Increase juveniles at Chipps Island per adult return and maintain minimum population during drought
- Means objectives: Abundance and productivity

Conceptual Model (Each Species and Life stage)

There is a linkage to the Winter-Run Chinook Salmon CM for Spring-Run Chinook Salmon in the Sutter Bypass and Butte Creek. The Sacramento Valley Salmon Resiliency Strategy states the following links to the SAIL CM:

> Winter-run conceptual model of drivers affecting the transition from juvenile rearing in the Upper Sacramento River to migrating into the Middle River (CM2). Reduced access to and quality of non-natal rearing habitats limit food availability and production and lead to reduced fish growth and subsequent survival (H4).
>
> Winter-run conceptual model of drivers affecting the transition from migrating adults to holding adults (CM6). Insufficient adult fish passage at flood bypass weirs combined with attraction flows leads to stranding risk and reduced fish survival, timing, and condition (H3). Winter-run conceptual model of drivers affecting the transition from juvenile rearing in the middle Sacramento River to migrating into the Bay-Delta (CM3). Lack of floodplain connectivity limits food availability and production and leads to reduced fish growth and subsequent survival (H4). (CNRA 2017)

Current Condition

Tisdale Weir is 30 years past its engineered life and in need of rehabilitation. It currently does not have upstream fish passage for fish to pass into the Sacramento River after overtopping events.

Background

Many projects have been implemented by Federal, State, and local stakeholders to make structural improvements to Butte Creek that improve the numbers of Spring-Run Chinook Salmon returning to the creek to spawn. Improving habitat within the Sutter Bypass has been part of these efforts. In addition to upstream projects on Butte Creek, fish food production and holding habitat provided in the Sutter Bypass have addressed salmon needs for all lifecycle stages that occur in the creek. The result has been positive and returning adult numbers are now measured in the thousands (NCWA 2017).

Current Science

The 2017 Sacramento Valley Salmon Resiliency Strategy concludes that improvements to the fish passage and habitat in the Sutter Bypass would address the SAIL CM6 of drivers affecting the transition from migrating adults to holding adults and CM3 of drivers affecting the transition from juvenile rearing in the middle Sacramento River to migrating into the Bay-Delta (CNRA 2017).

Justification

Butte Creek provides spawning habitat for adult Spring-Run Chinook Salmon and the Sutter Bypass provides food supply and rearing and holding habitats for adult and juvenile salmon migration conditions to and from Butte Creek. The project is being funded by DWR, CDFW, and local agencies and is estimated to be complete by 2022 (CNRA 2017).

References

Northern California Water Association (NCWA). 2017. Celebrating the Recovery of Spring-run Salmon on Butte Creek. http://www.norcalwater.org/2017/06/15/celebrating-the-recovery-of-spring-run-salmon-on-butte-creek/

CNRA. 2017. Sacramento Valley Salmon Resiliency Strategy. http://resources.ca.gov/docs/Salmon-Resiliency-Strategy.pdf

D1.3.2.2.3 Putah Creek

Summary

Reclamation and DWR would work to realign the portion of Putah Creek within the Yolo Bypass to improve floodplain habitat and fish passage.

Description

Reclamation and DWR would complete stream realignment and floodplain restoration along the lower Putah Creek that also increases the available floodplain rearing habitat for juveniles. The realignment could include multiple channels in the Yolo Bypass Wildlife Area that would allow for increased rearing habitat on public land and reduce inundation of private lands to the south. The new alignment would connect to the Yolo Bypass Toe Drain (on the east side of the bypass) on the south side of Lisbon Weir (ESA 2016).

The proposal would differ from existing designs by increasing the channel size and number to allow for increased inundation in specific areas after overtopping events or through operation of the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project notch

Objectives

- Fundamental objective: Increase juveniles at Chipps Island per adult return
- Means objective: Abundance

Conceptual Model (Each Species and Life stage)

The objectives of the project target Fall-Run Chinook Salmon; however, Winter-Run Chinook Salmon, Spring-Run Chinook Salmon, and steelhead would benefit from the restoration actions through increased freshwater tidal habitat and food web support.

Current Condition

NMFS RPA Action I.6.3 (Lower Putah Creek Enhancements) states that Reclamation and DWR shall complete stream realignment and floodplain restoration along the lower Putah Creek.

Background

Putah Creek restoration planning by the Yolo Basin Foundation (YBF) in close coordination with the CDFW was ongoing between 2012 and 2016. The current project description would create a new creek channel, restore tidal freshwater wetlands, provide a new water control structure to improve anadromous fish access, and restore in-stream habitat. Connectivity created between these habitats would improve migration and spawning opportunities for adult salmon, as well as rearing and outmigration conditions for smolts.

Current Science

In 2016, YBF completed the design of the new creek channel, the tidal wetland, two channel crossings, and alterations to the agricultural water supply infrastructure, and provided 30% design of a new water control structure. YBF previously identified the need for relocation of three petroleum product pipelines that intersect the proposed alignment of the new Putah Creek channel and held preliminary discussions with the respective pipeline owners regarding those relocations.

Justification

The Putah Creek realignment project would improve access for Fall-Run Chinook Salmon to spawning grounds, increase freshwater tidal habitat for salmonids, and improve rearing habitat in the Yolo Bypass through floodplain restoration.

References

ESA. 2016. Draft Basis of Design Report, Lower Putah Creek Restoration Project, YBWA Reach. Prepared for Yolo Basin Foundation.

Salamunovich, T. 2017. Results of October 2016 lower Putah Creek fish surveys. 30 January 2017.

Solano County Water Agency. 2016. Draft Program Environmental Impact Report for the Lower Putah Creek Restoration Project – Upper Reach Program. May 2016.

D1.3.2.3 *Conservation Hatchery*

D1.3.2.3.1 <u>Conservation Hatchery</u>

Summary

Reclamation proposes to expand the Livingston-Stone National Fish Hatchery to increase Winter-Run Chinook Salmon production during drought years.

Description

Reclamation would expand the Livingston-Stone National Fish Hatchery, on the upper Sacramento River (at the foot of Shasta Dam). The expanded size would allow increased operation to sustain Winter-Run Chinook Salmon, particularly during drought years. Increased production during drought could help populations persist over multiple years.

Objectives

- Fundamental objective: Maintain minimum population during drought
- Means objective: Abundance

Conceptual Model (Each Species and Life stage)

Hatcheries provide artificial rearing and spawning habitat, and therefore, mitigate for losses at both adult and sub-adult life stages. Consequently, expanded hatchery production during drought could mitigate for losses across nearly all SAIL CM components. Nevertheless, specific effects of hatchery production on specific components will depend on potentially complex interactions among hatchery- and natural-origin fish and the environment. For example, if hatchery production effectively mitigates for lost rearing habitat but fails to mitigate for poor downstream migration (e.g., from elevated temperatures and dewatering associated with the drought) then the overall effect of hatchery production may not be effective. If released hatchery fish are clearly marked, however, the newly proposed monitoring framework described in Johnson et al. (2017) will generally allow for diagnosis of when (life stage) and where (geographic domain) expanded hatchery production provides (or fails to provide) a demographic boost to the population.

Current Condition

Current hatchery operations at LSNFH attempt to produce approximately 200,000 pre-smolts from at least 60 females of entirely natural origin. During extreme drought conditions, however, more juveniles (i.e., greater than 200,000) may need to be produced by fewer females that include hatchery-origin fish.

Background

The Sacramento River Winter-Run Chinook Salmon Evolutionarily Significant Unit (ESU) is listed as endangered under the ESA and currently includes only one naturally spawning population limited to the upper Sacramento River (below Keswick Dam). In 1997, Reclamation constructed the Livingston-Stone National Fish Hatchery to propagate ESA-listed Sacramento River Winter-Run Chinook Salmon to partially mitigate for construction of Shasta Dam. Livingston-Stone National Fish Hatchery operates an “integrated” hatchery program, as opposed to a “segregated” program (NMFS 2017). The intention of integrated programs is to minimize genetic divergence between hatchery and natural components of the population by exchanging spawners between them (Paquet et al. 2011). The overall influence of the natural component on the entire population (i.e., the combined natural and hatchery components) depends on the proportion of hatchery-origin fish on the spawning grounds (pHOS) and the proportion of natural-origin fish in the broodstock (pNOB). The goal of LSNFH is to use entirely natural-origin adults for spawning (i.e., pNOB=1.00) and obtain at least 60 females and 120 males (NMFS 2017). These criteria may need to be adjusted to include hatchery-origin spawners and variable numbers of males and females under drought conditions.

Current Science

Because of increased hatchery production and poor in-river spawning success during 2014 and 2015, the spawning escapement for 2018 (the source of spawners for the hatchery) will likely contain mostly hatchery-origin fish. This will likely influence the pNOB objective of 1.00 (NMFS 2017).

Justification

Human-caused climate change has substantially increased the overall likelihood of extreme droughts in California (Williams et al. 2015). As water availability continues to decrease, it is likely that expanded hatchery production will be needed to mitigate for overall Winter-Run Chinook Salmon declines.

References

Johnson, R. C., Windell, S., Brandes, P. L., Conrad, J. L., Ferguson, J., Goertler, P. A. L., Harvey, B.N., Heublein, J., Israel, J.A., Kratville, D.W., Kirsch, J.E., Perry, R.W., Pisciooto, J., Poytress, W.R., Reece, K., Swart, B. G. 2017. Science Advancements Key to Increasing Management Value of Life Stage Monitoring Networks for Endangered Sacramento River Winter-Run Chinook Salmon in California. San Francisco Estuary & Watershed Science, 15(3), 1546-2366. doi: https://doi.org/10.15447/sfews.2017v15iss3art1

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D1.3.2.4 *Passage and Reintroduction*

D1.3.2.4.1 <u>Sacramento Weir Fish Passage</u>

Summary

Reclamation and DWR, in coordination with the USACE, would provide fish passage at Sacramento Weir.

Description

Sacramento Weir routes high flows from the Sacramento, Feather, and American rivers into the Yolo Bypass. The fish passage structure would allow adults to pass the Sacramento Weir into the Sacramento River, focusing on periods when conditions are not amenable for passage at Fremont Weir. This action would be done in coordination with the Lower Elkhorn Levee Setback project, which would widen and expand the Sacramento Bypass by moving the northern levee of the Sacramento Bypass Wildlife Area and a portion of the eastern levee of the Yolo Bypass

A structure at an expanded section of Sacramento Weir has the potential for a wider window of fish passage than at the Fremont Weir. Fish passage at Sacramento Weir could be amenable during additional months, lower flows, and when the river is at lower water surface elevations than existing conditions.

Objectives

- Fundamental objective: Increase juveniles at Chipps Island per adult return and maintain minimum population during drought
- Means objective: Abundance

Conceptual Model (Each Species and Life stage)

The action focuses on adult fish passage improvements in the Yolo Bypass for four federally listed anadromous species: the Sacramento River Winter-Run Chinook Salmon (*Oncorhynchus tshawytscha*); Central Valley Spring-Run Chinook Salmon (*Oncorhynchus tshawytscha*); and California Central Valley steelhead (*Oncorhynchus mykiss*), which are collectively referred to as salmonids; and the Southern Distinct Population Segment (Southern DPS) of North American green sturgeon (*Acipenser medirostris*).

Current Condition

NMFS RPA Action I.7 states the need to reduce migratory delays and mortalities of federally listed fish species within the Yolo Bypass. Current proposals to replace Agricultural Road Crossing #4 at or near its current location to allow for improved fish passage while maintaining water impoundment for adjacent landowners.

Background

In 2018, Reclamation and DWR implemented the Fremont Weir Adult Fish Passage Modification Project, which replaced the existing fish ladder at Fremont Weir, removed an agricultural road crossing in the Tule Canal and replaced another crossing. These actions were taken to improve connectivity within the Yolo Bypass and between the Yolo Bypass and the Sacramento River.

Reclamation and DWR are also working on the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project which will add two additional passage structures at Fremont Weir and replace an agricultural road crossing.

Current Science

A number of modeling and research tools have recently been developed to assist in creating facilities to reduce stranding of fish in the bypasses. These include the following (Reclamation and DWR 2017; DWR 2017):

- YBPASS Tool combined with and HEC-RAS modeling to compare modeled water depths and velocities in the alternative-specific intake structures and transport channels to against adult Chinook Salmon and sturgeon fish passage criteria.
- Sedimentation and River Hydraulics – SRH-2D modeling along the Fremont Weir section of the Sacramento River to predict the hydrodynamics under the influence of various Fremont Weir notch configurations.

- Daily hydrodynamic TUFLOW modeling 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.

Justification

This project would allow for fish passage at Sacramento Weir, which has a potential wider window of amenable fish passage than the Fremont Weir.

References

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D1.3.2.4.2 Juvenile Trap and Haul

Summary

During drought, Reclamation proposes to create juvenile collection weirs at key feasible locations after the spawning area on the Sacramento River and collect Winter-Run Chinook Salmon juveniles that were naturally spawned and trap and haul them down to the Delta to improve returns and maintain the population during severe droughts.

Description

Reclamation proposes implementation of a downstream trap and haul strategy for the capture and transport of juvenile Chinook Salmon and steelhead in the Sacramento River watershed in drought years when low flows and resulting high water temperatures are unsuitable for volitional downstream migration and survival. Temporary juvenile collection weirs will be placed at key feasible locations, downstream of spawning areas in the Sacramento River. Collected fish will be transported to a safe release location in the Delta.

Juvenile trap and haul activities would occur from December 1 through May 31, consistent with the migration period for juvenile Chinook Salmon and steelhead (NMFS 2014), depending on hydrologic conditions. In the event of high river flows or potential flooding, the fish weirs would be removed.

Objectives

- Fundamental objectives: Increase juveniles at Chipps Island per adult return and maintain minimum population during drought
- Means objective: Abundance

Conceptual Model (Each Species and Life stage)

The SAIL CM for the Rearing Juvenile to Outmigrating Juvenile life stage of Sacramento River Winter-Run Chinook Salmon identified water temperature as a Tier 3 Habitat Attribute affecting survival, residence time and migration, and condition of juvenile salmon in for the Upper River, Middle River, and Bay-Delta Reaches (Windell et al. 2017). Winter-Run Chinook Salmon juveniles begin to emigrate from the Upper Sacramento River (past RBDD) as early as mid-July, with peak abundance occurring in September and extending through November; although emigration can continue through May of the next year in dry water years. Since salmon experience high water temperatures in low water-type years, lethal water temperatures identified as a factor affecting survival through the Sacramento River in the SAIL CM. In addition, the presence or lack of accessible refugia from extreme temperatures, predators, and anthropogenic structures and diversions can decrease or increase risk of thermal stress, predation, stranding, and entrainment, thereby providing or depriving juvenile Chinook Salmon an opportunity to use and benefit from rearing and migratory habitats within the Sacramento River and Bay-Delta. Implementation of the proposed wild fish trap and haul program is anticipated to reduce the risk to salmon populations by high temperatures in the Sacramento River and tributaries. Although the SAIL CM has not been developed for Sacramento River Spring-Run Chinook Salmon and steelhead, the SAIL CM applies to these species due to the close life cycle similarity and habitat attributes that affect survival; therefore, the benefits of the proposed wild fish trap and haul Program also directly applies to these populations as well.

Current Condition

Water delivery and hydroelectric operations on the Sacramento River and the resulting reduction or elimination of in-stream flows during migration periods has been identified as one of the threats to for Chinook Salmon and steelhead habitat (NMFS 2014). Factors determining successful outmigration of Chinook Salmon and steelhead include suitable water temperatures, adequate and timely flow for downstream movement, and a passable watercourse, none of which are available in low water years. The successful outmigration of juvenile salmon is critical for survival to adulthood and to support the restoration goals.

Background

During low hydrologic water-year types, low water conditions and high water temperatures exceeding salmon thermal tolerance limits will cause physical and environmental barriers to downstream migration and result in lower salmon survival. Under these conditions, instream flows are not sufficient to support juvenile salmon and steelhead downstream migration, impeding volitional for fish emigrate and survival. River conditions remain largely impassable downstream and are not conducive to juvenile salmon survival. Thus, the CDFW currently transports juvenile hatchery Chinook Salmon downstream to release in areas in Sacramento River where conditions are suitable, in order to improve survival in draught years. Similar actions such as the trap and haul effort to transport fish downstream of these obstacles could improve survival of wild Chinook Salmon and steelhead in the Sacramento River basin during draught years

Current Science

Trap and haul is a common strategy to manage Pacific coast salmonids, has been a solution to move fish around obstacles or in suitable habitat for decades, and has been studied extensively in the Columbia River basin (Lusardi and Moyle 2017). Recently, the success of downstream trap and transport of juvenile salmonids using temporary weir has been studied in the San Joaquin River as a feasible option to improve survival in low flow years (San Joaquin River Restoration Program 2016).

Justification

Outmigration of juvenile salmon is critical for survival to adulthood. During low water years, river conditions are largely impassable downstream and are not conducive to juvenile salmon survival. Therefore, the implementation of a juvenile trap and haul strategy is a prudent action to improve survival in drought years.

References

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D1.3.2.5 *Diversion Screening*

D1.3.2.5.1 Sacramento River Man Made Structures – Keswick to Verona

Summary

This component would implement projects for structural habitat improvements from Keswick to Verona.

Description

Reclamation and the Sacramento River Settlement Contractors (SRSC) propose to complete remaining high-priority fish screen projects in this reach of the Sacramento River. Reclamation and the SRSC propose to reduce lighting to 3 lux or less at fish screens and bridges within 5 years. The SRSC propose to incorporate ongoing redd dewatering coordination with Anderson Cottonwood Irrigation District. The SRSC also propose to address fish passage issues at Weir 1 and Weir 2 in the Sutter Bypass within 5 years.

Specific projects may include: reduced lighting at Sacramento River fish screens, reduced lighting at Sacramento River bridges; Sutter Bypass Weir 1 - Rehabilitation of weir structure and fish ladder (Coupled with new Lower Butte / Sutter Bypass water management plan); Sutter Bypass Weir 2 Multi Benefit Project; Screen Meridian Farms Water Company; Screen Natomas Mutual Water Company; and, Anderson Cottonwood Irrigation District Dam operations to protect salmon redds.

Objectives

- Fundamental objective: Increase juveniles at Chipps Island per adult return
- Means objectives: Abundance and productivity

Conceptual Model (Each Species and Life stage)

Stable and continuous river flows are important to the early life history (egg incubation to emergence from the gravel) of salmonids. If redds are dewatered or exposed to warm, deoxygenated water, incubating eggs/larval fish may not survive. After emergence from their redd, juvenile salmon can become stranded in shallow isolated water and be exposed to poor environmental conditions as well as increased predation.

Fish screens focus on protecting juvenile fish from entrainment during out migration. Juvenile Sacramento River Winter-Run Chinook Salmon spend a varying duration of time rearing in the upper Sacramento River following emergence and before migrating past RBDD into the middle Sacramento River. Juveniles use the middle Sacramento River as a rearing habitat and a migratory corridor to the tidal Delta. The majority of Winter-Run Chinook Salmon juveniles migrate past RBDD from August to December (Poytress et al. 2014) and past Knights Landing at the downstream end of the middle Sacramento River between October and April (del Rosario et al. 2013). Entrainment at unscreened or ineffectively screened water diversions influences salmon survival through this reach.

Current Condition

The Sacramento Valley Salmon Recovery Program includes high priority fish screens on the Sacramento River, including the Meridian Mutual Water Company and Natomas Mutual Water Company screens. Both projects had finished design and environmental documentation and were waiting for funding. With the completion of these projects, all of the original high-priority diversions in the region will be screened.

Anderson Cottonwood Irrigation District Dam creates a deep water pool in the Sacramento River in Redding (RM 298). An additional management action taken to protect these upstream Winter-Run Chinook Salmon redds was to request that the dam be kept in place until November 2, to prevent dewatering of those redds above the dam. The seasonal flashboard dam is normally taken out in October but by keeping the dam in place through November redds upstream remained flooded, allowing Winter-Run Chinook Salmon juveniles the opportunity to emerge without difficulties.

Background

CDFW, DWR, and other Settling Parties developed an Agreement Framework for analysis, adoption and implementation of voluntary agreements to support amendments to the Bay-Delta Water Quality Control Plan for protection of fish and wildlife beneficial uses (CDFW and DWR 2018). The agreement includes habitat improvement and other non-flow measures.

Current Science

Fish exclusion screens and protection devices are a common strategy for reducing entrainment risk of a threatened juvenile fish species while maintaining water-diversion activities. The design and success of a fish screen facility is dependent on a number of factors, such as fish species, swimming ability, and hydraulic conditions. Guidance documents for the placement and design of fish screens are provided below.

- Designing Fish Screens for Fish Protection at Water Diversions (NMFS)

- Fish Screening Passage for Anadromous Salmonids (NMFS)
- Fish Protection at Water Diversions: A guide for planning and designing fish exclusion facilities. (Reclamation)
- California Department of Fish and Wildlife Fish Screening Criteria (CDFW)

Observations for the Sacramento River below Keswick during the 2016-2017 and prior years indicate that oscillating river flows have the potential to dewater redds and strand juvenile salmonids repeatedly in the same locations. Juvenile salmon move between shallow, slow moving waters to rest between venturing into swifter food carrying waters. This tendency makes them particularly susceptible to stranding as flows recede isolating the shallow river margin areas. During typical winter dry periods with steady or decreasing tributary inputs, small flow changes (up or down) from Keswick Dam can result in repeated flooding and dewatering of pool and side channels throughout the upper Sacramento River. The 2016-2017 season experienced significant winter rain events that resulted in flooding and major tributary stream influences. Although the increased tributary inputs substantially reduced redd dewatering below Clear Creek, many stranding sites became inundated then swiftly isolated as floods receded. These flood events combined with decreased Keswick flow releases resulted in the bulk of observed stranded juvenile salmonids (Revnek, et. al. 2017).

Justification

The actions within this component would reduce stranding, entrainment, and predation of juvenile salmonids.

References

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D1.3.3 American River Basin

D1.3.3.1 *Water Operations*

D1.3.3.2 *Temperature Facility Improvements*

D1.3.3.2.1 Drought Temperature Management

Summary

In severe or worse droughts, Reclamation proposes to modify the TCD shutters so that they are automatic to operate and fix the leaks on the existing Folsom TCD by installing seals, such as vertical rubber J-seals or bulb-seals, that close the interface between the panel sides and panel guides. Horizontal seals are also required, consisting of J-seals or bulb-seals that close the interface between the lowest panel and the sill and between contiguous panels.

Description

Water temperature conditions in the lower American River are often sub-optimal for recovery and enhancement of native salmonid species. Folsom Dam operations, coupled with the existing Folsom TCD are used during the spring, summer, and autumn to selectively withdraw stratified cold water impounded by Folsom Dam for the benefit of these salmonid species. However, the current TCD is not adequate to provide optimal thermal conditions (TCI 2014). Modifications of the TCD at Folsom Dam would improve lower American River thermal conditions and help meet temperature requirements in the lower American River.

Objectives

- Fundamental objective: Increase juveniles at Chipps Island per adult return
- Means objectives: Abundance and productivity

Conceptual Model (Each Species and Life stage)

The SAIL CM considers different factors that affect salmonids. Within the LAR, the amount of cold water available to achieve optimal temperature for each life stage varies as a function of the amount of cumulative precipitation, reservoir stratification, and previous Folsom Reservoir water operations. Maintaining adequate maximum river temperatures is key to sustained immigration, spawning, and incubation of Fall-Run Chinook Salmon and steelhead within the LAR (Bratovich et al. 2012).

Current Condition

Folsom Dam was designed to be able to release water from various elevations within the reservoir simultaneously. Dam operators modify TCD shutters on each of the three powerhouse generation penstocks to take water from different depths in the reservoir and blend outflows in order to meet downstream regulatory temperature requirements/targets. Operators also adjust the elevation of the Municipal Water Supply Intake and operate the low-level outlets on the dam to modify outflow water temperatures and preserve cold water resources in the reservoir.

The existing shutter system leaks through gaps between the shutter guides and the superstructure, gaps in the superstructure itself, gaps between contiguous shutter gangs, and gaps between the lowest shutter and the sill. The leakage has been estimated to range from 20% to 40% of the flow through the TCD, which reduces the effectiveness in thermal management (TCI 2014). Additionally, the current shutter lifting system of the TCD would be modified to operate mechanically so that shutter locations can be modified in minutes without shutting down the Folsom power plant.

Background

The repair of the Folsom TCD is in part an extension of the requirements contained in the NMFS 2009 BO (Reasonable and Prudent Alternative) that require Reclamation to identify and evaluate structural solutions to the cold water pool issues in the lower American River.

Later in 2007, there were more studies that focused on modeling efforts (four models: Nimbus Tail water, Lake Natoma/Nimbus Dam, Nimbus Dam forebay and Folsom Lake) that recommended potential structural and operations changes that could lead to a temperature benefit (i.e., cooling of Folsom Dam releases, cooling of Nimbus Dam releases, or a reduction in Folsom Dam releases resulting from an increased cold water balance in the system).

Current Science

A 2014 value planning study (TCI 2014) analyzed potential temperature solutions at Folsom Dam and Reservoir. The purpose of the study was to identify, preliminarily evaluate and develop infrastructure-related alternatives, or a combination of infrastructure-related alternatives at Folsom Dam and Reservoir, that will best improve water temperature management capabilities in the lower American River. There was also an emphasis in trying to tie into efforts already underway under U.S. Army Corps of Engineers authority (the ecosystem restoration component of the Folsom Dam Raise authority) which directs the U.S. Army Corps of Engineers to mechanize and reconfigure the Folsom Dam temperature shutters. This project is a combination of 2 Alternatives (Leak Reduction and TCD mechanization) analyzed within the study.

Justification

Improving the TCD would improve Reclamation's ability to manage temperatures in the Lower American River for Central Valley Steelhead (summer rearing) and Fall-Run Chinook Salmon (fall spawning).

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D1.3.3.3 *Habitat*

D1.3.3.3.1 Rearing Habitat

Summary

Reclamation proposes to conduct a restoration project at William Pond Outlet to create rearing habitat.

Description

The lower American River currently provides rearing habitat for Fall-Run Chinook Salmon and steelhead. Recent evidence suggests the lower American River may also be used for rearing by juvenile Winter-Run Chinook Salmon that spawn in other nearby rivers (Phillis et al. 2018). This component focuses on restoring rearing habitat William Pond Outlet, where the bed is too fine for spawning. Similar to previous restoration projects on the lower American River (e.g., cbec 2015), the project could involve using large woody debris structures, side channel construction, and bar reshaping to improve rearing habitat and floodplain inundation.

Objectives

- Fundamental objective: Increase juveniles at Chipps Island per adult return
- Means objective: Abundance

Conceptual Model (Each Species and Life stage)

Increased rearing habitat would improve Fall-Run Chinook Salmon, Winter-Run Chinook Salmon, and CV Steelhead escapement from the lower American River by increasing the survival of juveniles through increased refuge during high flows, food availability, and cover from predators. This component addresses SAIL middle river juvenile hypothesis refuge habitat (H3) and the large woody debris structures and altered bar morphology might also affect food availability and quantity (H4) (Windell et al. 2017).

Current Condition

Reclamation has been building rearing habitat intermittently since 2007 in coordination with other restoration projects. Thus far, Reclamation has created roughly 5.5 acres of habitat in the lower American River. Constructing rearing habitat alongside spawning habitat has been a successful approach for Reclamation, but potential rearing habitat could be built downstream of River Bend where the river becomes sand bedded.

Background

Rearing habitat in the lower American River has been constrained by a legacy of land use in the watershed. Nineteenth century hydraulic mining caused widespread aggradation (James 1997) that was subsequently dredger mined, resulting in channel simplification and disturbed and disconnected floodplains (RCMP 2002). Levees and bank revetment confine the channel, particularly downstream of River Bend, further disconnecting the floodplain from the channel. The construction of Nimbus and Folsom dams decreases winter discharge and intercepted all large woody debris and coarse sediment supplied from upstream, leading to further habitat simplification. The dams also limited access to extensive spawning and rearing habitat upstream. Taken together, this land use history limits salmonid habitat in the lower American River and improving rearing habitat requires placing large woody debris structures and bar and floodplain regrading downstream of Lake Natoma.

Current Science

Restoration actions that increase floodplain inundation by bar reshaping during gravel augmentation and increased side channel habitat have increased rearing habitat in the lower American River. The CVPIA Science Integration Team assumes that two large Chinook emigrants will be produced per m2 (10.8 ft2) of rearing habitat (Reclamation and USFWS 2018). Existing gravel augmentation projects in the lower American River have improved connectivity and inundation of the floodplain, and juvenile abundance of fall Chinook Salmon and steelhead (Sellheim et al. 2016). Gravel projects have increased the density of fish in side channel habitat's from less than 3 juvenile salmon per 25 square meters to more than 82 juvenile salmon per 25 square meters. An experimental release of juvenile Chinook Salmon from the Sunrise boat launch suggested that juvenile survival was on average 94% through the lower American River but that survival decreased once the juveniles entered the Sacramento River and the Delta (Zeug 2016).

Justification

Increasing the extent of rearing habitat in the lower American River is explicitly called for in CVPIA Section 3406 (b)(13) to partially mitigate for CVP impacts through impaired habitat in the lower American River and lack of access to habitat upstream of Nimbus Dam. Channel simplification and trapping of large woody debris and gravel upstream of Nimbus and Folsom dams has decreased the quality and extent of juvenile rearing habitat in the lower American River. Increased rearing habitat availability should increase smolt survival (Windell et al. 2017).

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D1.3.4 Bay-Delta

D1.3.4.1 *Facility Improvements*

D1.3.4.1.1 <u>Delta Cross Channel Improvements</u>

Summary

Reclamation proposes to improve operations of the DCC by modernizing the gate materials/mechanics together with more comprehensive control systems to allow more frequent operation (e.g., tidally), in association with increased monitoring.

Description

The DCC is more than 65 years old and its gates rely on remote operators to travel to the facility to change their position. When the gates are open, they provide a critical diversion structure for freshwater reaching the CVP South Delta pumping station. The gates are closed to prevent scouring (during high flows), reduce salinity intrusion in the western Delta, and protect Sacramento River ESA-listed and non-listed salmonids. Frequent use of the DCC increases its risk of failure. Opening the DCC more frequently decreases salinity at Jones Pumping Plant and reduces the amount of outflow required to meet salinity requirements and therefore is desired. In particular, increasing the flexibility to operate the gates diurnally (closed in the evening and open during the day) could offer fish protection while also providing water quality and water supply benefits. Although this matter has been discussed by agencies and stakeholders it has not been attempted due to recent mechanical concerns and ongoing risks at the facility. Reclamation proposes to modernize DCC's gate materials and mechanics to include adding industrial control systems, increasing additional staff time, and improve physical and biological monitoring associated with the DCC daily and/or tidal operations as necessary to maximize water supply deliveries.

Objectives

- Fundamental objective: Increase juveniles at Chipps Island per adult return
- Means objective: Abundance

Conceptual Model (Each Species and Life stage)

The SAIL CM4 for Winter-Run Chinook Salmon (Windell et al. 2017) pertains to rearing to outmigrating juveniles in the Bay-Delta and is also pertinent to steelhead and Spring-Run Chinook Salmon from the Sacramento River basin. Per the SAIL model (Windell et al. 2017, p.23): "Human modification of the Delta has resulted in a channel network that no longer operates across predictable gradients for native fish and provides unnatural cues and routes for migration. In the interior Delta, longer travel times and lower survival have been documented." Closure of the DCC reduces juvenile salmonid entry into the interior Delta, thereby potentially reducing the risk of longer travel time and lower survival. In addition, the SAIL CM6 for Winter-Run Chinook Salmon describes potential effects on adult migration from the ocean to the upper Sacramento River, noting that "Natural and artificial barriers can delay the upstream passage and increase energetic costs to migration for salmon" and that "Water operations can influence the routing of Upper Sacramento River-origin water…and can create false attraction cues that cause salmon to deviate from the mainstem Sacramento River migration corridor" (Windell et al. 2017, p.30). Although these linkages are provided primarily in consideration of potential effects from stranding in the Yolo Bypass at Fremont Weir, they are relevant in consideration of the DCC and for fish returning to the Sacramento River, as well as to the San Joaquin River and Mokelumne River basins.

Current Conditions (RPA, WQCP, Facility)

DCC gate operations are primarily governed by NMFS RPA Action IV.1.2 and by the terms of the Bay-Delta Water Quality Control Plan (implementing D-1641). In summary, the DCC gates are closed between February 1 and May 15. From October 1 to November 30, the DCC gates may be closed based on exceedance of salmon monitoring density triggers and in consideration of meeting water quality criteria (Figure D1.3-1). From December 1 to December 14, the DCC gates are closed, except with approval from NMFS for salmon migration experiments, or to meet water quality criteria (in consideration of salmon monitoring density trigger values). From December 15 to January 31, the gates are also generally closed, with short-term exceptions for NMFS-approved experiments or to maintain Delta water quality in association with reduced south Delta exports. From May 16 to June 15, the DCC gates may be closed for up to 14 days (consistent with D-1641) if NMFS determines it is necessary. In addition to management as a result of the NMFS RPA and D-1641, whenever flows in the Sacramento River at Sacramento reach 20,000 to 25,000 cfs (on a sustained basis) the DCC gates are closed to reduce potential scouring and flooding that might occur in the channels on the downstream side of the gates (USFWS 2008). The WIIN Act requires the Interior and U.S. Department of Commerce (Department of Commerce) to "in close coordination with the DWR and the CDFW, implement a pilot project to test and evaluate the ability to operate the Delta cross-channel gates daily or as otherwise may be appropriate to keep them open to the greatest extent practicable to protect out-migrating salmonids, manage salinities in the interior Delta and any other water quality issues, and maximize CVP and SWP pumping, subject to the condition that the pilot project shall be designed and implemented consistent with operational criteria and monitoring criteria required by the California State Water Resources Control Board" (Public Law 114–322 130 stat. 1851).

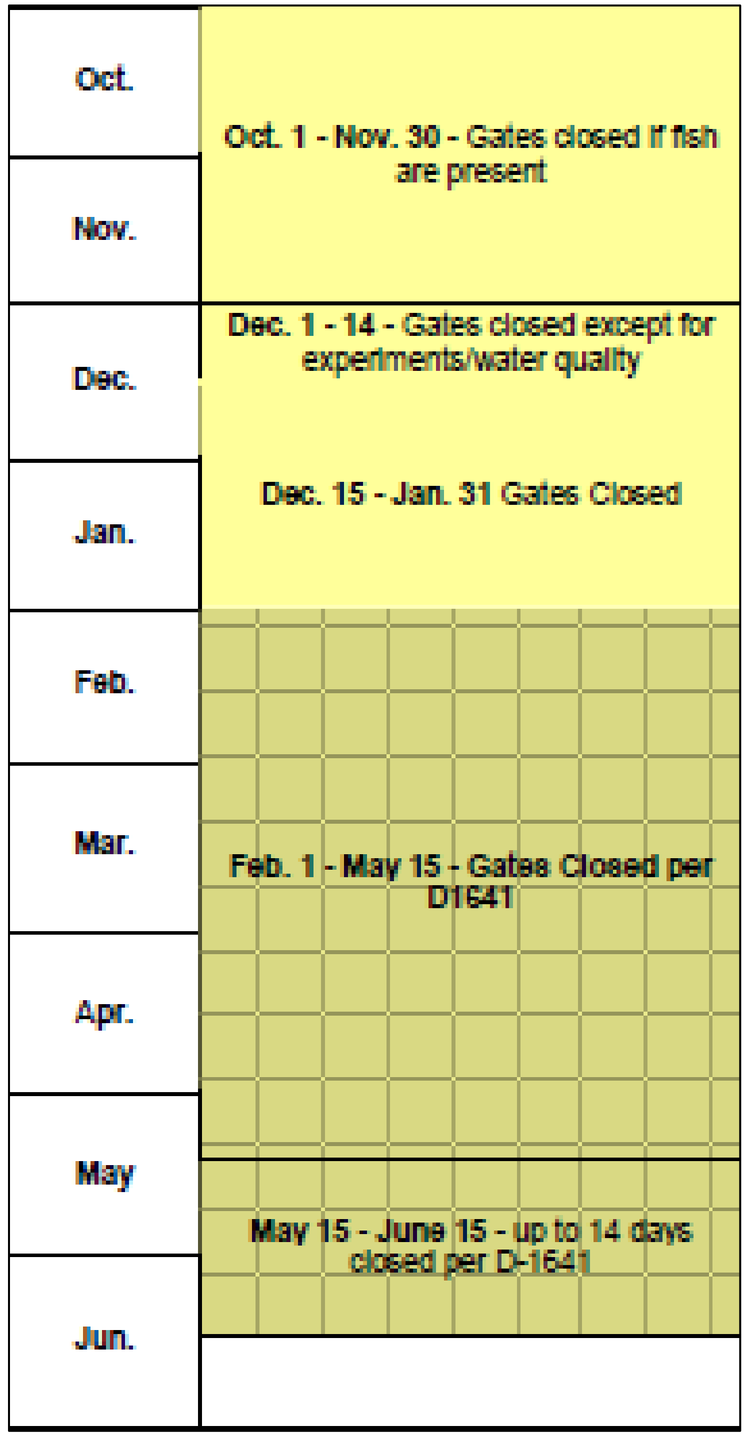

Figure D1.3-1. Summary of NMFS RPA Action IV.1 for Delta Cross Channel Operations (NMFS 2009).

Background (Old Science, Past Implementation, If Any)

The basis for DCC operations is largely from studies showing that survival of Sacramento River basin juvenile salmonids through the Delta generally is greater when the DCC is closed (e.g., Newman 2003). Survival through the interior Delta via the DCC generally has been shown to be lower than for fish migrating through north Delta channels (Sutter Slough, Steamboat Slough, and the Sacramento River) (e.g., Perry et al. 2010, Perry et al. 2012). Management since implementation of the 2009 NMFS RPA has resulted in DCC closures primarily in December-May, with closures in October through November, ranging from 0 to 18 days, and closures in June, ranging from 8 to 30 days (Table D1.3-1).

Table D1.3-1. Number of Days of Delta Cross Channel Gate Closure, October–June, Water Years 2010–2010.

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
2010	4	9	18	31	28	31	30	27	14
2011	2	3	31	31	28	31	30	31	30
2012	10	0	31	31	29	31	30	24	20
2013	0	4	31	31	28	31	30	27	8
2014	13	13	31	31	19	31	30	27	9
2015	2	5	31	31	28	31	30	20	13
2016	1	3	20	31	29	31	30	27	11
2017	0	10	31	31	28	31	30	31	22
2018	18	17	31	31	28	31	30	27	8

Source: http://www.usbr.gov/mp/cvo/vungvari/Ccgates.pdf

Current Science Related to Idea/Topic

Recent studies of acoustically tagged juvenile Chinook Salmon have shown that these fish tend to migrate at night and therefore tend to arrive at the DCC at night: although night made up 63% of the study period (11 November 2008 to 3 February 2009) and 61% of fish were released at night, 83% of fish arrived at the DCC at night (Plumb et al. 2016). These authors concluded that "Given that tidal effects and night-time fish arrival will be high when river flows are low, nighttime closure and daytime opening of the DCC during the winter months may represent one of the rare instances when operational changes may be used to minimize fish mortality and allow for water diversion."

Justification for Action

This action will increase flexibility in DCC operations, allowing greater opening frequency and therefore improving interior Delta water quality by reducing salinity. This will decrease salinity at Jones Pumping Plant and reduce the amount of Delta outflow necessary to meet D-1641 salinity requirements.

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D1.3.4.2 *Habitat*

D1.3.4.2.1 <u>Predator Hotspot Removal (including Old River Habitat Improvements)</u>

Summary

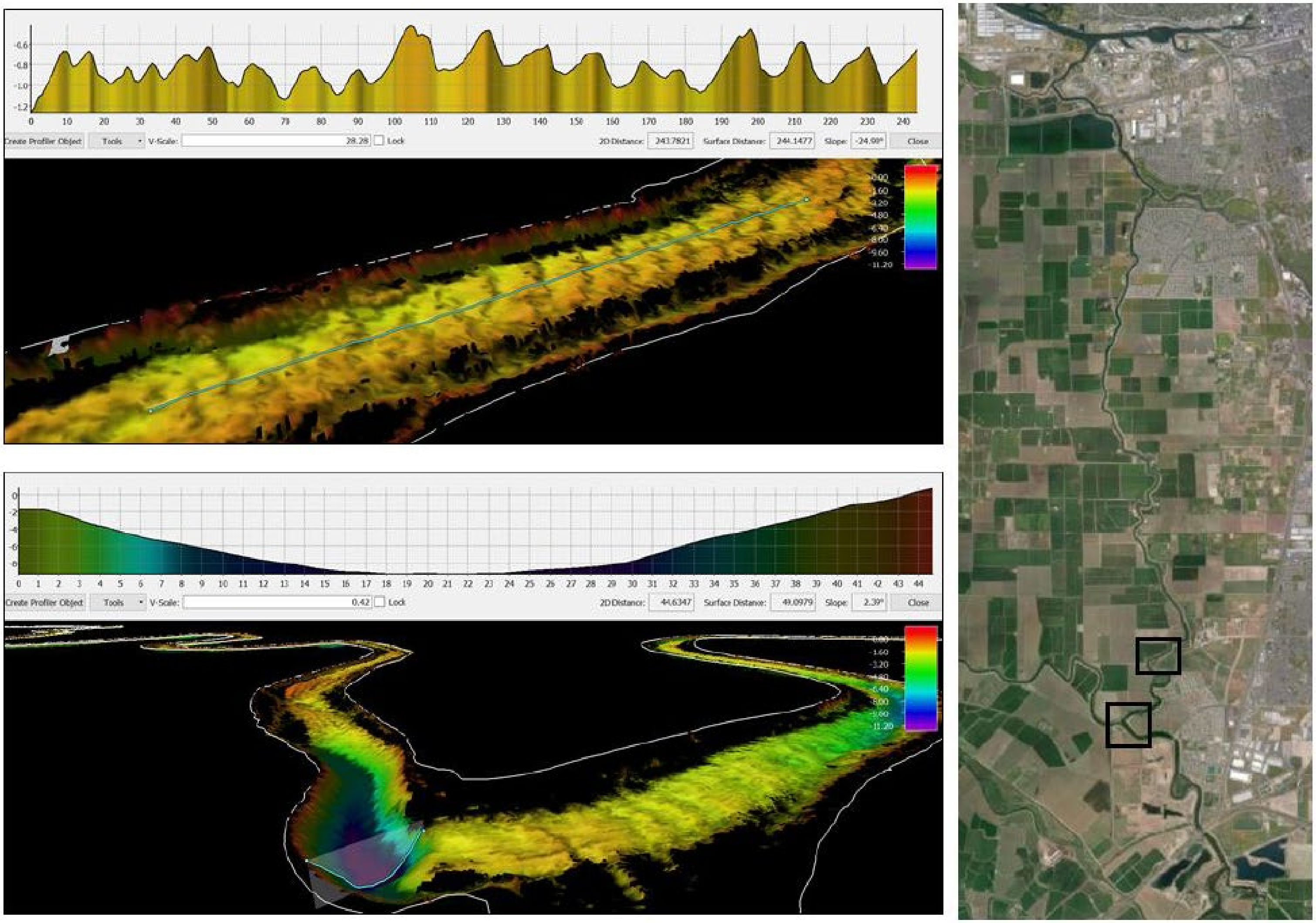
Reclamation and DWR propose to fill the scour hole near the Head of Old River in order to remove the predator hotspot. In addition, reconfiguration of the San Joaquin River–Old River junction area will be considered in order to increase passage down the San Joaquin River.

Description

Reclamation and DWR propose to fill the scour hole in the San Joaquin River just downstream of its junction with the Head of Old River. The scour hole is over 30 feet deep (Figure D1.3-2) and would be filled with sufficient materials such as rip rap in order to achieve a river bottom elevation similar to the remaining bathymetry of the junction. Substrate composition would be monitored to examine the extent to which spaces between the rip rap had been infilled with sediment from upstream to ensure that benthic predator ambush habitat was not created; surveys for predatory fish (e.g., with sonar imaging cameras) would also be undertaken to support this evaluation. To the extent necessary, interstitial spaces between the larger substrates (e.g., rip rap) used to fill the scour hole would be filled with additional small-diameter substrates if natural filling with sediment from upstream had not progressed to a satisfactory level. Detailed geotechnical investigations and modeling would be undertaken in order to ensure that filling the scour hole does not compromise flood protection. As such, based on the results of the modeling analysis, additional levee reinforcement would be undertaken as necessary in coordination with the appropriate authorities (e.g., Reclamation Districts 544, 2062, and 17, and others).

In conjunction with filling the scour hole, Reclamation and DWR propose to also investigate potential reconfiguration options for the entire junction area. One potential configuration that has been the subject of a pre-feasibility study is to modify the existing Y-shaped split between the San Joaquin River and Old

River to create a new channel intended to keep most juvenile salmonids in the San Joaquin River as opposed to entering Old River (Figure D1.3-3). In this concept, a new channel and 200-year flood levee would be constructed, and the new floodplain and upland habitat would be created by setting back the existing levee on the right bank of the San Joaquin River. A flood weir would be constructed in the San Joaquin River at the south end of the newly diverted channel in order to ensure that flows remained in the river under most flow conditions for which the existing Head of Old River Barrier (i.e., less than 10,000 cfs at Vernalis). A flood weir would be placed in the San Joaquin River at the northern end of the new channel to restrict flood flow and fish from entering the south Delta through Old River. The flood and training weirs would be overtopped during river flood flows. This reconfiguration represents one possibility for the junction that Reclamation and DWR may investigate further.



Source: Cutter et al. (2017). Notes: Elevations are in meters in relation to North American Vertical Datum of 1988 (NAVD 88). The Head of Old River bathymetry figure in the bottom left is oriented moving from upstream on the right to downstream on the left, with the Old River junction at the bottom of the figure.

Figure D1.3-2. Bathymetry of the Scour Hole at the Head of Old River (Lower Left Figures) and An Additional Location Further Downstream (Upper Left Figures).

Source: Stantec (2017).

Figure D1.3-3. Potential Reconfiguration at the Junction of the San Joaquin River and the Head of Old River.

Objectives

- Fundamental objective: Increase juveniles at Chipps Island per adult return
- Means objective: Abundance

Conceptual Model (Each Species and Life stage)

Although Winter-Run Chinook Salmon juveniles would not occur at the Head of Old River junction, the SAIL CM generally describes the issue of the "extremely poor survival rate in the South Delta, which is hypothesized to result from poor rearing conditions (such as low refuge habitat and food availability) and high predation risk" in affecting the transition from rearing to outmigrating juveniles (Windell et al. 2017, p.22). Features such as scour holes are bathymetric landscape attributes, which influence the amount of shallow water habitat as an environmental driver and therefore predation as a habitat attribute acting on survival of juvenile salmonids, per SAIL CM4 (Windell et al. 2017, p.24).

Current Conditions (RPA, WQCP, Facility)

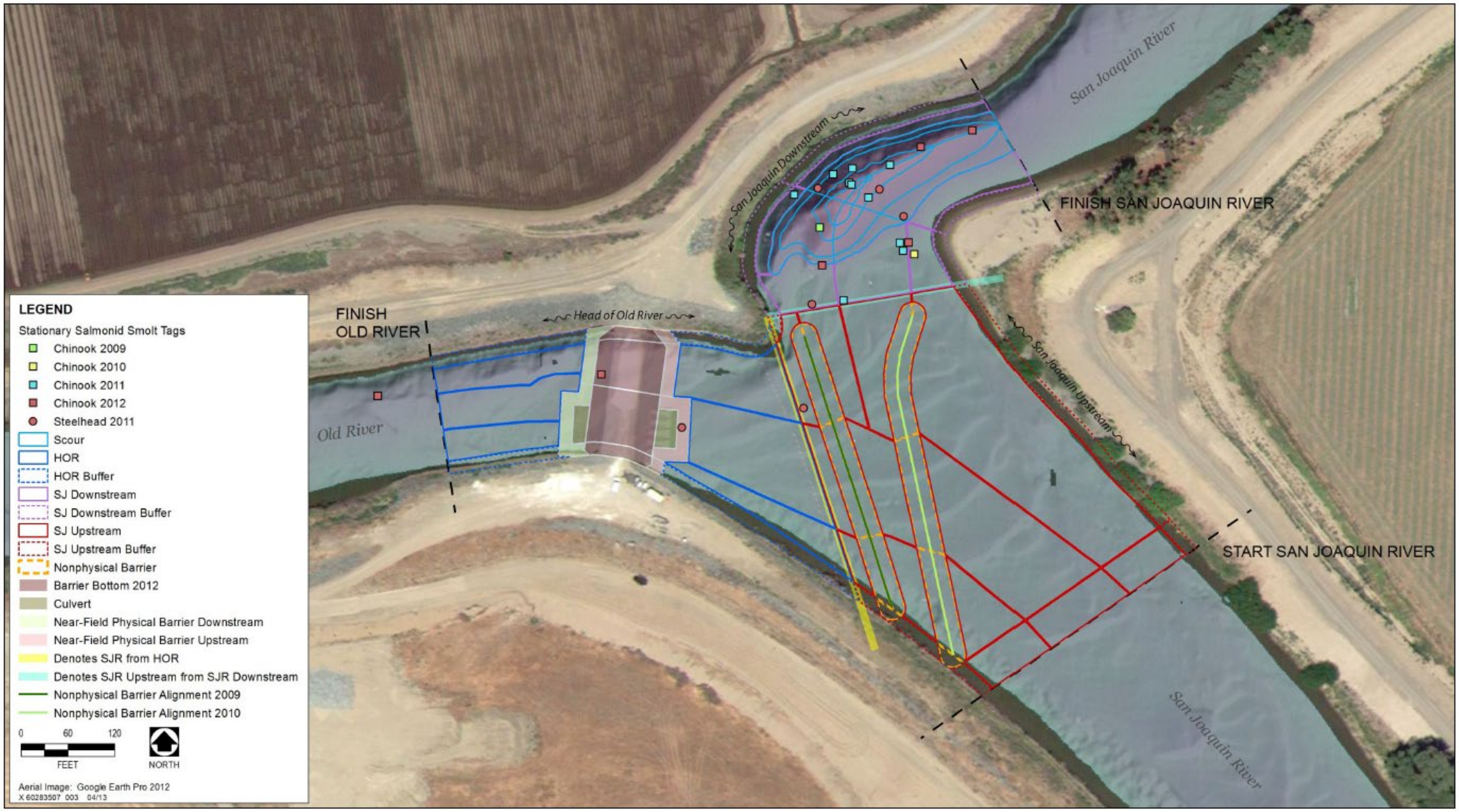
Action IV.1.3 of the NMFS RPA directs DWR and Reclamation to consider engineering solutions for further reducing diversion of emigrating juvenile salmonids to the interior and southern Delta. Action IV.1.3's objectives include preventing emigrating juvenile salmonids from entering channels in the south Delta, including Old River, that increase entrainment risk to steelhead migrating from the San Joaquin River through the Delta. Investigations in support of Action IV.1.3 have highlighted the importance of predation in the scour hole just downstream of the Head of Old River as an impediment to effective implementation of barriers installed at the Head of Old River to reduce entry into Old River (DWR 2015).

Background (Old Science, Past Implementation, If Any)

The importance of the scour hole and the Head of Old River as a predator and predation hotspot was originally suggested by Vogel (2007, 2010; as cited by SJRGA 2011). This inference was made by detection of many stationary acoustic tags originally implanted in juvenile Chinook Salmon, indicating that the tags had been consumed by predators and defecated in the scour hole. Large concentrations of fish in deep holes have been observed in other locations in the Delta, such as Horseshoe Bend in the Sacramento River (Miranda et al. 2010).

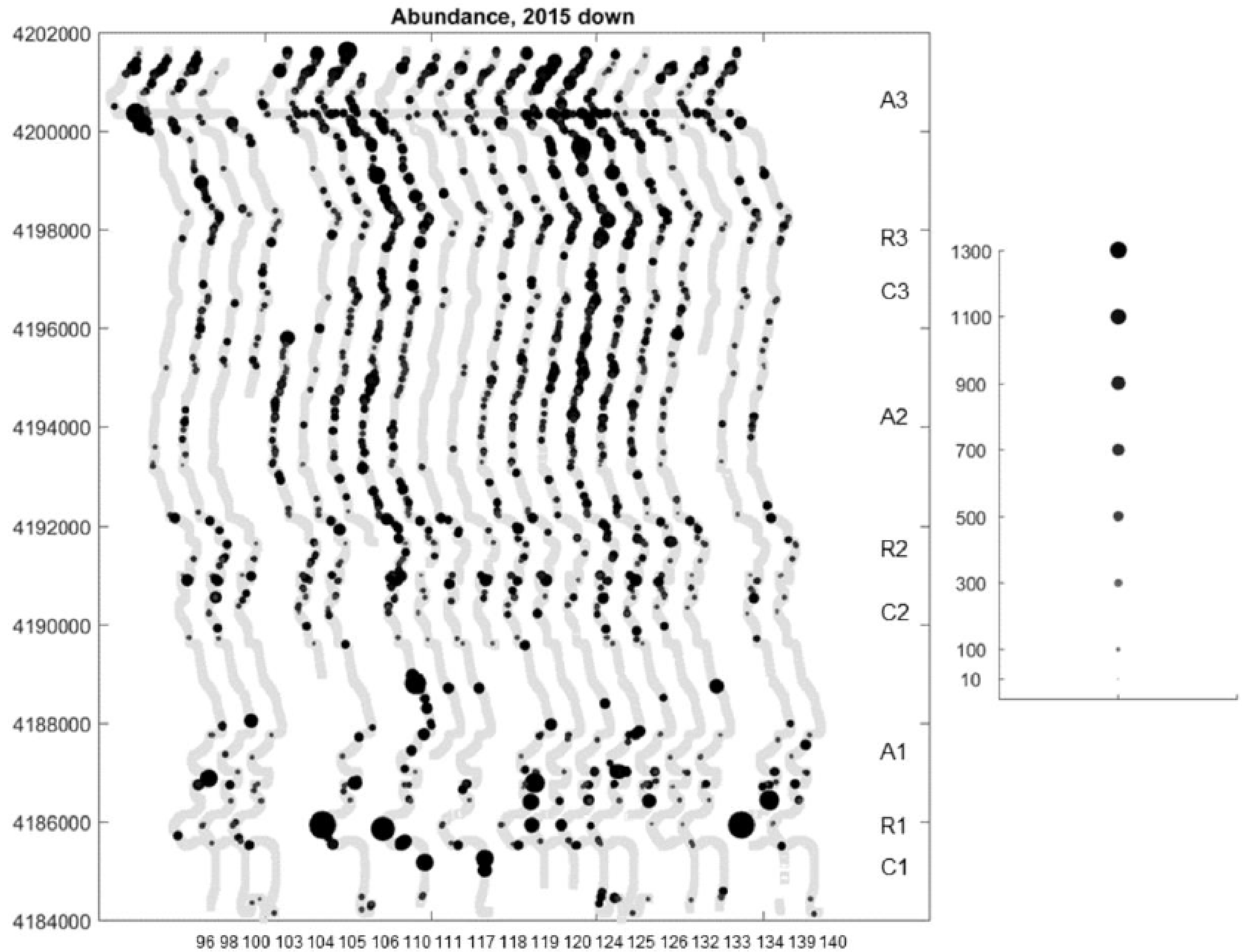
Current Science Related to Idea/Topic

Recent studies have confirmed that the scour hole at the Head of Old River is an area of high predation and high predator abundance. DWR (2015) found high predation (10–40%) of juvenile Chinook Salmon and steelhead entering the junction and hydroacoustic surveys showed that predator density was high in the scour hole. Consistent with Vogel (2007, 2010; as cited by SJRGA 2011), stationary acoustic tags that were originally implanted in juvenile salmonids were found to occur in high number in or near the scour hole, indicating consumption and defecation by predators (DWR 2015; Figure D1.3-4). Relative to other locations in the San Joaquin River between Lathrop and Stockton, the abundance of predators at the scour hole can be relatively high, although not always so (Cutter et al. 2017; Figure D1.3-5). Assessment of survival of juvenile Chinook Salmon tethered to predation event recorders (Demetras et al. 2016) in various study reaches in the San Joaquin River between Lathrop and Stockton found survival to be significantly negatively related to increasing depth, with the predicted proportion alive after around 1 hour being almost zero at 11 meters compared to around 50% at less than 1 meter depth (Smith et al. 2017; Figure D1.3-6).



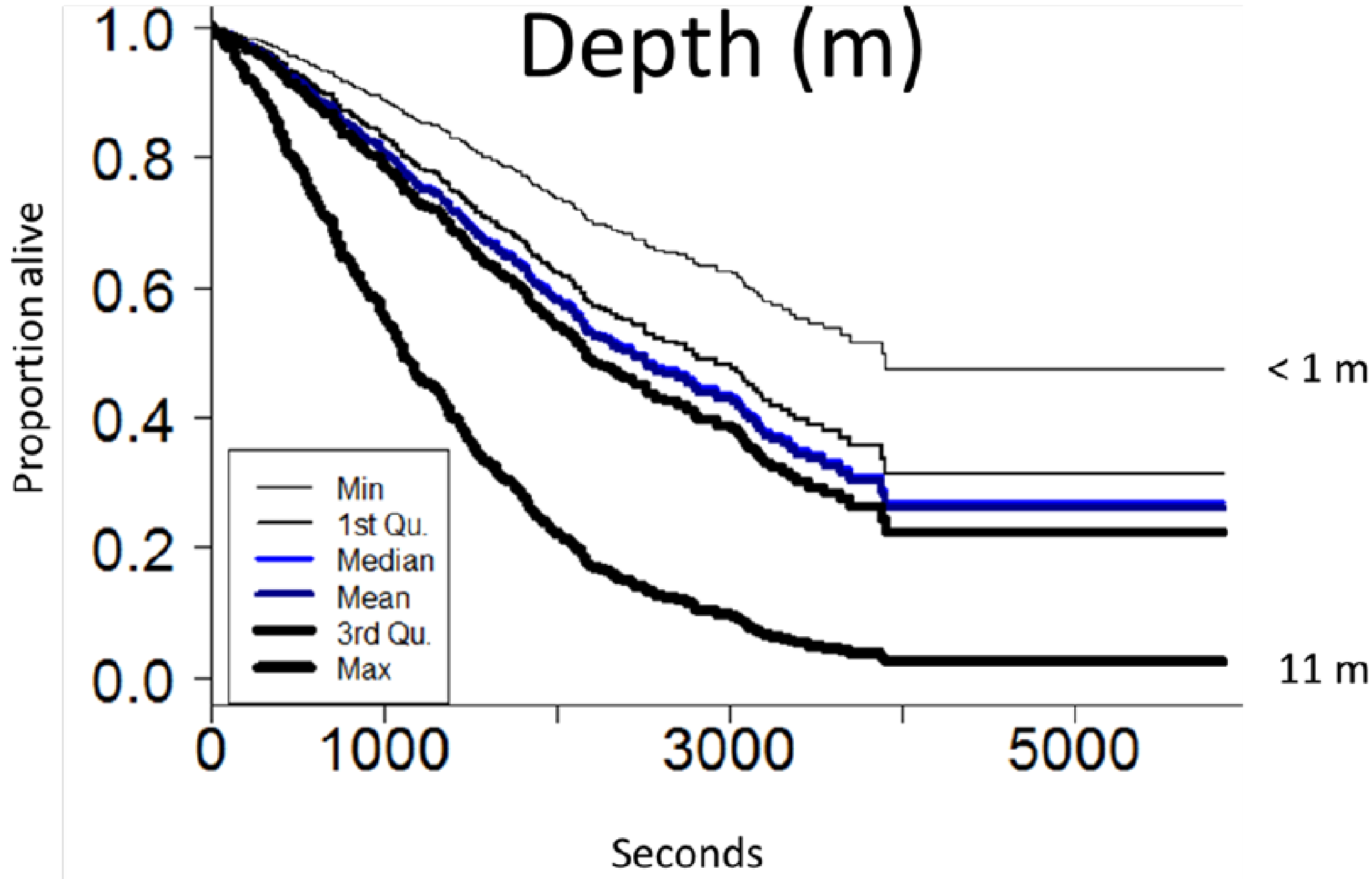
Source: DWR (2015).

Figure D1.3-4. Locations of Stationary Juvenile Salmonid Acoustic Tags at the Head of Old River, 2009–2012.



Source: Cutter et al. (2017). Notes: Head of Old River is indicated by R1 on the right-hand side of the figure. Size of filled dots indicate abundance estimates. Numbers on horizontal axis indicate Julian day of the year. Numbers on left vertical axis indicate northing (meters).

Figure D1.3-5. Abundance of Predatory Fish in the San Joaquin River between Lathrop (South End of Map) and Stockton (North End of Map), As Estimated by Downward Pointing Hydroacoustic Surveys.



Source: Smith et al. (2017).

Figure D1.3-6. Predicted Survival Plot for Juvenile Chinook Salmon Tethered to Predation Event Recorders As a Function of Water Depth in the San Joaquin River Between Lathrop and Stockton.

Justification for Action

Filling the scour hole at the Head of Old River as well as potential reconfiguration of the junction aims to increase juvenile salmonid survival through this area of the south Delta, which is considerably lower than survival in other parts of the Delta and elsewhere.

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D1.3.4.2.2 North Delta Food Subsidies

Summary

Reclamation would work with partners to flush agricultural drainage (i.e. nutrients) from the Colusa Basin Drain through Knight's Landing Ridge Cut and the Tule Canal to Cache Slough, improving the aquatic food web in the North Delta for fish species. Reclamation would work with DWR and partners to augment flow in the Yolo Bypass in July and/or September by closing Knights Landing Outfall Gates and routing water from Colusa Basin into Yolo Bypass to promote fish food production.

Description

Historically, the slow-moving wetlands and waterways of the Delta generated prodigious amounts of the microscopic plants and animals—phytoplankton and zooplankton—that support Delta Smelt. In the current Delta, Delta Smelt face a shortage of food, particularly during summer and fall. The project will augment flow in the Yolo Bypass by closing Knights Landing Outfall Gates and route water from Colusa Basin into Yolo Bypass in July and/or September to promote food production and export into areas where Delta Smelt are known to occur. Zooplankton produced on the Yolo Bypass would move downstream into an area where juvenile and adult Delta Smelt are known to occur at a time of year when food availability may be a limiting factor. Food web enhancement flows will also be considered for additional months in ways that will not conflict with agricultural and waterfowl management actions based on the availability of water to augment flows in the Yolo Bypass. The project could also increase outflow from the Yolo Bypass during the spring. The project is a collaboration between DWR, Reclamation, Glenn-Colusa Irrigation District, Reclamation District 108, USGS, Knaggs Ranch, and Conaway Preservation Group.

Objectives

- Fundamental objective: Maintain minimum population during drought
- Means objective: Abundance

Conceptual Model (Each Species and Life stage)

This measure would benefit Delta Smelt juvenile and sub-adult life stages and the Habitat Attributes that would be affected include Food Availability and Quality.

The IEP MAST CM specifically states that “Growth and survival are hypothesized to depend on food availability and food production and availability depends on interactions of a variety of landscape attributes and environmental drivers.”

> “Juvenile growth and survival is hypothesized to depend on availability and quantity of food. Food production during this summer period is hypothesized to involve complex interactions of clam grazing, nutrients, hydrology and harmful algal blooms. The probability of observing a harmful algal bloom is hypothesized to be a function of the same factors but with temperature playing an important role.”
>
> “Food availability and visibility are hypothesized to be important with respect to providing nutrition that allows Delta Smelt to grow into healthy, large adults that can produce a large numbers of high quality eggs as well as multiple clutches of eggs over the spawning season. The availability of food is considered dependent on both food production and the availability of such food to the fish.”

Current Condition

This project is being studied as part of the Delta Smelt Resiliency Strategy, which is being implemented by CDFW, DWR, Division of Boating and Waterways, USFWS, and Reclamation.

Background

In 2011 and 2012, following larger-than-normal agricultural return-flows from the Yolo Bypass, scientists observed an unusual phytoplankton bloom in the Rio Vista area of the lower Sacramento River. Scientists theorized that this production could benefit Delta Smelt if it could be replicated annually. In 2016 and 2018, state, federal and local water district officials partnered to send water through a wetland and tidal slough corridor of the Sacramento River system and into the Delta where it created a phytoplankton bloom, the foundation of the food web for smelt.

Current Science

Monitoring of the pilot studies shows that nutrient-rich “pulse flow” successfully generated a phytoplankton bloom and enhanced zooplankton growth and egg production. Data is still being analyzed on water quality, contaminants, and plankton that were collected before, during, and after the experimental flows.

Justification

Pilot studies for this project have shown promising results. In the summer of 2016, DWR and numerous partners piloted this action and monitoring indicated that the nutrient-rich “pulse flow” generated a phytoplankton bloom and led to enhanced zooplankton growth. Some of this water was donated, and the total water cost was $230,000 (200 to 500 cubic cfs for about 2½ weeks).

The project has is part of the Delta Smelt Resiliency Strategy, as well as ranking high on the Collaborative Adaptive Management Team (CAMT) structured decision-making process.

References

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D1.3.4.2.3 Sacramento Deepwater Ship Channel

Summary

Reclamation proposed to repair or replace the West Sacramento lock system to hydraulically reconnect the ship channel with the main stem of the Sacramento River. When combined with an ongoing food web study, the reconnected ship channel has the potential to flush food production into the north Delta. An increase in food supply is likely to benefit Delta Smelt and their habitat.

Description

Reclamation is currently conducting a food web related pilot study in the Sacramento Deep Water Ship Channel (SSC). The pilot study involves the addition of nitrogen into the SSC at levels that naturally occur in the summer season. When timed with the maximum solar radiation outputs, the nitrogen should enhance a phytoplankton and zooplankton bloom, which would promote food for listed species, such as Delta Smelt.

The SSC does not exchange water with the rest of the Delta. Water from the Sacramento River is impeded by the West Sacramento lock system and provides little to no flow into the SSC. Reclamation proposes to work with the Port of Sacramento to repair and operate the West Sacramento lock system. Through the operation of the locks, Reclamation could hydraulically reconnect the ship channel with the main stem of the Sacramento River. A functioning sector gate could be used to adaptively manage net flow of the Sacramento River down the ship channel as a way to export ship channel plankton to stimulate plankton production in the North Delta.

Objectives

- Fundamental objective: Increase abundance of Delta Smelt
- Means objective: Abundance

Conceptual Model (Each Species and Life stage)

Delta Smelt: Open waters of the Delta are considered food-limited (Kimmerer 2002). Increasing food resources (i.e., phytoplankton and zooplankton) would be expected to have a beneficial effect on the entire system, as well as for endangered native species such as Delta Smelt. Increasing nitrogen within an N-limited system should stimulate phytoplankton and zooplankton growth, which when combined with modifications to the West Sacramento lock system should make this additional food available to Delta Smelt.

Current Condition

Currently the West Sacramento lock system does not allow SSC to exchange water with the rest of the Delta or provide potential food for species such as Delta Smelt.

Background

Reclamation operates the CVP, a system of reservoirs, power plants, operable gates, pumping plants and canals that supply water for irrigation, municipal and industrial use and for wildlife refuges in the Central Valley. CVP operations are thought to contribute to the decline of Delta Smelt, an endemic fish listed as threatened under the ESA, by adversely affecting the extent and quality of its critical habitat. Under the CVPIA, Reclamation has the authority to fund activities that have the potential to reduce CVP impacts on smelt and their critical habitat and to undertake actions to improve Delta habitat conditions (Reclamation 2018).

Current Science

The CMs for the pelagic organism decline in the Sacramento-San Joaquin Delta suggest the potential for both “top-down” and “bottom-up” drivers of fish abundance. As in many estuaries, fish and other higher trophic level production in the open waters of the Delta region is fueled by phytoplankton production. However, the Delta has notably low phytoplankton production and biomass (Van Nieuwenhuyse 2007; Jassby 2008) resulting in low overall aquatic ecosystem productivity compared to other systems. Consequently, open waters of the Delta are considered food-limited (Kimmerer 2002). Increasing food resources (i.e., phytoplankton and zooplankton) would thus be expected to have a beneficial effect on the entire system, as well as for endangered native species such as Delta Smelt.

Previous research on the Toe Drain in the Yolo Bypass (Frantzich and Sommer 2015) demonstrated that pulses of algae-rich waters associated with enhanced net flows through the Toe Drain (as measured at the Lisbon Weir) can “seed” a significant algal bloom throughout the north Delta. A plausible mechanism for this phytoplankton bloom initiation is that the input of a large algal seed source from the Toe Drain into the relatively nutrient-rich waters from the lower Sacramento River (primary nutrient source is Sacramento Regional wastewater treatment facility) results in greatly enhanced phytoplankton production rates that exceed zooplankton and clam (*Corbicula*) grazing pressures. This allows the phytoplankton bloom to persist and propagate downstream until it is exported to the Bay.

A goal for food resource management in the north Delta would be to increase the standing stock of algal biomass (chlorophyll concentration) from the current range of 1 to 3 μg/L (microgram/Liter) to approx. 10 μg/L. A chlorophyll level of approximately 10 μg/L could support relatively high zooplankton production (Mueller-Solger et al. 2002) without adversely affecting water quality (e.g., dissolved oxygen concentration).

To optimize the export of food resources from the SSC, Reclamation’s multi-year (2012–present) dataset suggests that nitrogen additions should enhance both primary (phytoplankton) and secondary (zooplankton) production and standing crops. It is hypothesized that it should be possible to manipulate the SSC in a manner that would allow Reclamation to grow up standing stocks of phytoplankton and zooplankton and pulse these food resources into the north Delta where the phytoplankton/zooplankton bloom may be self-sustaining for a period of time (approximately 1 month but depending on river flows). In the SSC, there is the potential to control both water flow rates (diversions from Sacramento River) and nutrient concentrations (e.g., through nutrient additions) should preliminary studies support the efficacy of the system to enhance food resources in the north Delta (Reclamation 2018).

The SSC consists of three longitudinally distinct zones as illustrated by the specific conductance (electrical conductivity). These zones include an area of trapped water in the upper section (lentic conditions), a zone of mixing in the mid-reach, and the lower zone that experiences tidal exchange twice a day. Seasonally, small blooms of phytoplankton and zooplankton are observed in the “old water” zone; however, these food resources are trapped in this zone with minimal advection to the tidal mixing zone where it could enter into the north Delta. The more persistent blooms observed below the gates in the West Sacramento Port (WSP) are believed to be due to nutrient inputs from leakage through the gate (especially during high flow periods) and groundwater inputs from the Sacramento River. These observations suggest that nutrient enrichment has the potential to stimulate algal and zooplankton production in the SSC.

Given the consumption of nutrients by algal growth, dissolved inorganic nitrogen (DIN) (NH_4 + NO_3) is depleted to low levels (<0.1 mg N/L) in the upper SSC during the summer months. Thus, primary production is limited by the lack of bioavailable N for much of the spring-summer-fall period. Nitrogen is depleted faster than phosphorus (the other major potentially limiting nutrient) in part because denitrification (microbial conversion of nitrate to nitrogen gas) results in the permanent loss of nitrogen from the water column over time. By contrast, no such loss process exists for phosphorus. Thus, the DIN:PO_4-P molar ratio is generally less than 6 throughout the year compared to a Redfield N:P ratio of approximately 16 for algae. These conditions suggest that nitrogen enrichment, especially during the summer growing season, could stimulate primary production that in turn should theoretically lead to higher production of zooplankton.

Justification

Within the Delta, fish and other higher trophic level production in the open waters of the Delta region is fueled by phytoplankton production. However, the Delta has notably low phytoplankton production and biomass resulting in low overall aquatic ecosystem productivity compared to other systems. Consequently, open waters of the Delta are considered food-limited. Increasing food resources (i.e., phytoplankton and zooplankton) would thus be expected to have a beneficial effect on the entire system, as well as for endangered native species such as Delta Smelt.

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D1.3.4.2.4 Introduce Dredge Material for Turbidity

Summary

Reclamation and DWR propose to obtain sediment for introduction into the Bay-Delta in order to increase turbidity and thereby benefit Delta Smelt and juvenile salmonids, primarily through reduction in predation risk. Sediment for augmentation would be sourced from Bay-Delta watershed dredging projects and reservoirs.

Description

Reclamation and DWR will partner to augment sediment supply in the Bay-Delta by introducing sediment obtained from upstream reservoirs and Bay-Delta watershed dredging undertaken at locations such as marinas, ports, and shipping channels. Conceptually, this is similar to the California WaterFix proposed action to reintroduce sediment entrained at the proposed north Delta diversions (ICF International 2016, Chapter 3, p.3-88), from which the following description below has been partly adapted. In order to achieve the objective of sediment augmentation, Reclamation and DWR will collaborate with USFWS, NMFS, and CDFW to develop and implement a sediment augmentation program that provides the desired beneficial habitat effects of increased turbidity while addressing related permitting concerns (the proposed sediment augmentation is expected to require permits from the Central Valley Regional Water Quality Control Board and USACE). USFWS, NMFS, and CDFW will have approval authority for the sediment augmentation program and for monitoring measures, to be specified in the program, to assess its effectiveness. Modeling will be undertaken in order to assess potential sediment placement sites to maximize the habitat benefits (e.g., UnTRIM/SWAN/SediMorph: Bever and MacWilliams 2018, Bever et al. 2018; DSM2-STM: Hsu et al. 2018). In essence, the sediment augmentation program may consist of placement of sediment during low flow periods at seasonally inundated locations, such as channel margin benches constructed for the purpose along the mainstem Sacramento River. The sediment would then be mobilized and carried downstream following inundation during seasonal high flows (generally, the winter and spring months). Another option would be continuous introduction of batch sediment slurry that could be done during the low-flow months (Bever and MacWilliams 2018). The sediment augmentation program would be designed for consistency with Basin Plan objectives for turbidity, i.e., except for periods of storm runoff, turbidity of Delta waters not exceeding 50 NTU in the waters of the Central Delta and 150 NTU in other Delta waters. Exceptions to these Delta-specific objectives are considered when a dredging operation can cause an increase in turbidity, in which case, an allowable zone of dilution within which turbidity in excess of limits can be tolerated will be defined for the operation and prescribed in a discharge permit (Central Valley Water Board 1998, p. III-9.00).

Objectives

- Fundamental objective: Increase juveniles at Chipps Island per adult return
- Means objective: Abundance

Conceptual Model (Each Species and Life stage)

As described in the Delta Smelt Resiliency Strategy (CNRA 2016, p.8), per the IEP MAST Delta Smelt (2015) CM turbidity influences predation risk during the transitions between all life stages (adults to eggs/larvae in December-May; eggs/larvae to juveniles in March-June; juveniles to sub-adults in June-September; and sub-adults to adults in September-December) and is a function of the landscape attribute of erodible sediment supply. A similar mechanism is postulated for turbidity and predation risk affecting the transition from rearing to outmigrating juvenile in the Winter-Run Chinook Salmon SAIL CM (Windell et al. 2017, p.24) and for the transition from juvenile to sub-adult/adult in the SAIL green sturgeon CM (Heublein et al. 2017, p.21). Turbidity also is hypothesized to improve growth and survival in the transition between the Delta Smelt larval and juvenile life stages, presumably by providing a background of stationary particles that helps small larvae detect moving prey (IEP MAST 2015, p.53).

Current Conditions (RPA, WQCP, Facility)

As described in some detail in the IEP MAST CM for Delta Smelt (IEP MAST 2015: 49-55), turbidity in the Bay-Delta is spatially variable, tending to be highest in the Suisun and Cache Slough Complex regions. There has been a long-term decline in turbidity, e.g., total suspended sediment delivery from the Sacramento River watershed decreased ~50% from 1957 to 2001 (Wright and Schoellhamer 2004), and Delta-wide turbidity and associated suspended sediment decreased 40% (Cloern et al. 2011); these changes have resulted in a decline in abiotic habitat quality for Delta Smelt over time (Feyrer et al. 2011). RPA Action 4 of the USFWS (2008) SWP and CVP BO includes fall X2 criteria for wet and above normal years which position the low salinity zone over shallower areas that tend to have higher turbidity (Brown et al. 2014), and therefore greater habitat suitability for Delta Smelt (Feyrer et al. 2011).

Background (Old Science, Past Implementation, If Any)

Turbid conditions are associated with increased presence of Delta Smelt (Sommer and Mejia 2013). Survival of juvenile Chinook Salmon through the Delta was shown to be positively related to turbidity by Newman (2003). There has been no past implementation of a sediment augmentation program to increase turbidity in the Bay-Delta, although this is a proposed action for the Delta Smelt Resiliency Strategy (CNRA 2016) which is being investigated for its feasibility (Bever and MacWilliams 2018). Sediment reintroduction is also required to mitigate sediment entrainment by the California WaterFix project's proposed north Delta diversions on the Sacramento River in the north Delta (CDFW 2017, p.46-47 and p.162-163).

Current Science Related to Idea/Topic

Field studies have confirmed previous findings that the probability of predation on juvenile Chinook Salmon increases with decreasing turbidity (DWR 2015, 2016). Although there has been much focus on reduced sediment supply to the Bay-Delta resulting in decreases in suspended sediment concentration and turbidity (Schoellhamer et al. 2014), recent studies have shown that long-term reductions in wind speed have also been a major contributor to reductions in turbidity (Bever et al. 2018). In addition, approximately 21–70% of the declining trend in turbidity has been attributed to expansion of invasive submerged aquatic vegetation in the tidal freshwater Delta (Hestir et al. 2016). The Delta Smelt Resiliency Strategy proposes to increase the treatment of aquatic weeds through coordination with the Department of Boating and Waterways (CNRA 2016, p.7). An initial study informing the sediment augmentation proposed as part of the Delta Smelt Resiliency Strategy was recently completed by Bever and MacWilliams (2018). This study assumed that sediment was introduced to the Sacramento River at Decker Island as a continuous batch slurry with a flow rate of 5 m^3/s (~180 cfs) between May 1 and September 30, in order to achieve a 10-NTU turbidity increase between Emmaton and Mallard Island. The amount of sediment necessary to achieve this targeted increase was estimated at just over 3,500 cubic yards per day, and it was found that the effectiveness of the augmentation was increased during periods of lower Delta outflow.

Justification for Action

The decline in turbidity has resulted in decreases in abiotic habitat suitability for Delta Smelt (Feyrer et al. 2011). Augmenting sediment supply to the Bay-Delta has the potential to reverse the decline in turbidity and improve habitat suitability for Delta Smelt, juvenile salmonids, and Green Sturgeon, primarily by reducing predation risk (IEP MAST 2015; Windell et al. 2017; Heublein et al. 2017). Positioning the low salinity zone in areas of higher turbidity through increased Delta outflow as required by the USFWS RPA Action 4 affects water supply; sediment augmentation aims to increase turbidity in the Bay-Delta.

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D1.3.4.3 *Salvage Efficiency*

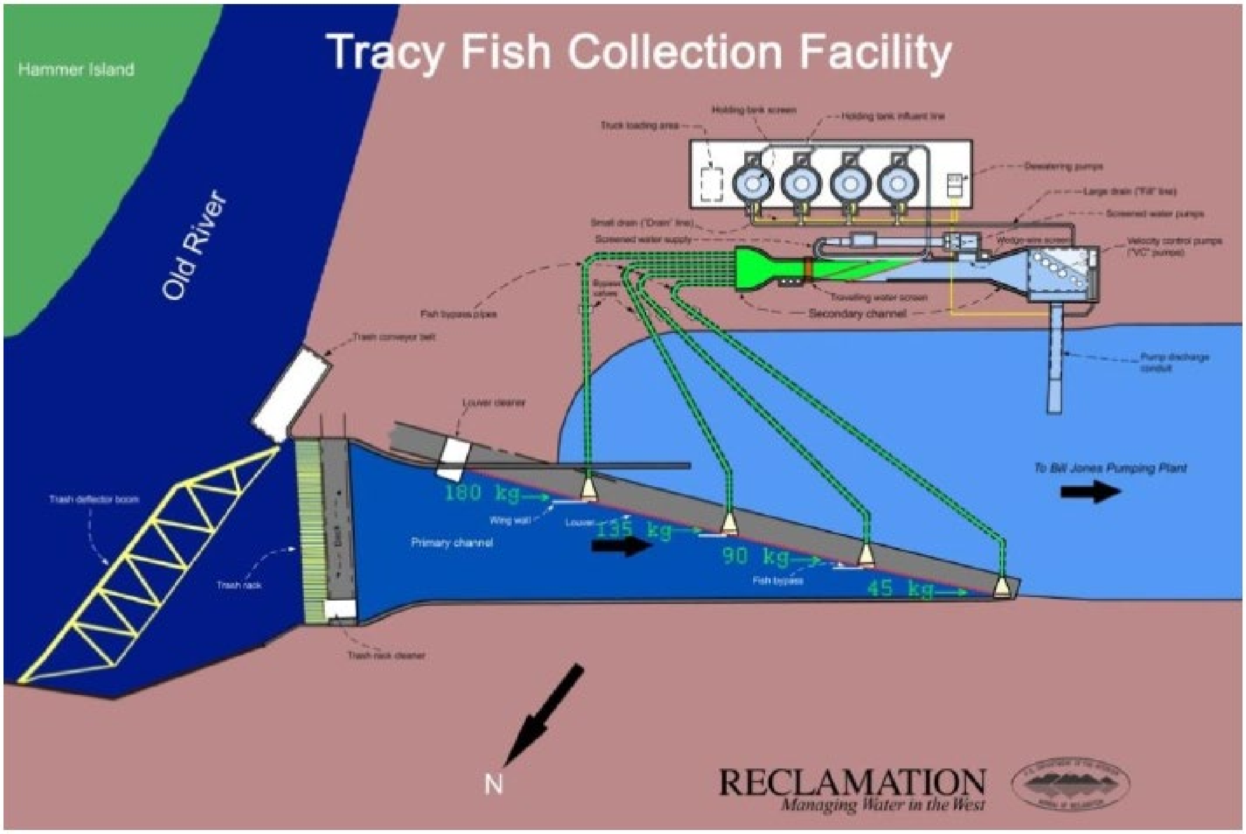
D1.3.4.3.1 Tracy Fish Facility Improvements

Summary

Reclamation proposes to improve salvage operations at the Tracy Fish Collection Facility (TFCF) by increasing predator removal activities, through (a) periodic large-scale application of carbon dioxide (CO2) for the primary channel, (b) authorizing angling in the primary channel by Reclamation workers, and (c) installing a CO2 injection device to allow remote anesthetization of predators within the salvage facility. Adaptive management actions are proposed for consideration in the form of (1) incorporating state of the art fish exclusion barrier technology into the primary fish removal barriers, (2) incorporating state of the art debris removal systems at each trash removal barrier, screen, and fish barrier, (3) constructing additional channels to distribute the fish collection and debris removal among redundant paths through the facility, (4) separating predators from other salvaged fish in the holding tanks, (5) installing smaller-mesh screens in the holding tank area to retain smaller fish, (6) constructing additional fish handling systems and holding tanks to improve system reliability, and (7) incorporating supervisory control and data acquisition (SCADA) into the design and construction of the facility.

Description

Reclamation proposes two main elements to improve salvage operations at the TFCF. The first element is increase of predator removal activities. This will be comprised of three activities. Large-scale application of solid CO2 (i.e., dry ice) to the primary channel will be done several times per year, with particular emphasis on the period before the late fall/winter period when salvage of listed species (smelts and salmonids) is most likely to begin. Application of CO2 results in anesthetization of the predatory fish and makes collection easier. The main focal area for CO2 application will be the upper primary channel, where predators occur most frequently (Wu et al. 2015). Angling in the primary channel for predatory fish by Reclamation workers will be authorized and will require that all applicable state regulations for size and daily catch limits are observed. Installation of a CO2 injection device will allow remote anesthetization of predators in the secondary channels of the TFCF. A pilot implementation of this process was tested by Wu and Bridges using blocks of dry ice placed into the primary fish bypass entrances (2014; Figure D1.3-7) and the procedure is currently done manually on a monthly basis. Injection of carbon dioxide would allow predatory fish to be collected from the TFCF bypass tubes and secondary channel, thereby reducing residence time and the risk of predation for prey fish. The injection device may use liquid CO2 or dry ice, with the specific locations of the injection to be determined by further study (e.g., directly into the secondary channel or at the front of the bypass tubes; Wu and Bridges 2014).



Source: Wu and Bridges (2014).

Figure D1.3-7. Schematic of the Tracy Fish Collection Facility Illustrating Dry Ice Injection Locations (Green Arrows), Mass of Dry Ice Injected (Green Text), and Treatment Area (Green Fill).

<u>Adaptive management of additional activities</u>

Several additional TFCF activities to improve salvage efficiency will be considered through adaptive management. First, a state of the art fish exclusion barrier technology will be considered for incorporation into the primary fish removal barriers. This technology could consist of large rotating fish screens replacing the primary louvers, thereby replacing a behavioral screening device with a physical barrier that would screen all but the smallest life stages, depending on the final mesh size. Although generally used for smaller intakes (i.e., less than 100 cfs), traveling screens have been implemented at larger intakes (e.g., 500 to 750 cfs) and are excellent for handling debris (Reclamation 2006).

Second, a state-of-the-art debris removal system will be considered for installation at each trash removal barrier and fish screening area. As noted above, traveling screens have excellent debris handling abilities and could be considered for the primary louvers. For the trash removal barrier in Old River, preliminary investigations have been undertaken to investigate the potential for modifying or replacing the existing conveyor system (Bhattacharya et al. 2016), which would allow more effective management of floating and submerged aquatic vegetation, including water hyacinth and *Egeria densa*. Traveling screens have also shown good potential for trash removal in the secondary channel at TFCF, while protecting fish (Vermeyen and Heiner 2015).

Third, additional channels will be considered for construction to distribute the fish collection and debris removal among redundant paths through the facility. This would allow cleaning and other maintenance to occur as necessary in some pathways while others remain open to facilitate continued effective salvage. Such modifications would require an overall enlarging of the TFCF, possibly doubling the size.

Separation of small predatory fish occurring in the holding tanks will be considered. This program would begin with manual separation of predatory fish during the regular fish counts, which sample 25% of salvaged fish. Based upon study of the effectiveness of this initial effort, additional efforts in the form of automatic fish separators could be considered.

Replacement of screens in the holding tank area will be considered. Currently, most of the screens in this area are 4-mm mesh, allowing retention of fish 30–35 mm in length. Replacement with screens of 2.1–2.3-mm mesh would allow retention of fish as small as 20 mm in length.

Additional fish handling systems and holding tanks will be considered for construction to improve system reliability, again to reduce risks associated with cleaning and maintenance. Concept-level designs for additional holding tanks have been completed, which aim to address the shortcomings of the existing holding tanks: these existing tanks are able to hold approximately 150,000 fish per tank, but the existing facility design only allows active fish collection from one tank at a time; when tanks are not actively collecting fish, but are used for short term storage of fish, water quality is diminished due to lack of fresh water (Heiner 2011).

Finally, in addition to these other potential activities, SCADA will be considered for incorporation into the design and construction of the TFCF, allowing local and remote automatic and manual control and monitoring of TFCF systems. SCADA systems have been used in water resources management in various locations worldwide (e.g., Gensler et al. 2009, Alghazali et al. 2013), and SCADA is proposed for inclusion in the California WaterFix project (California WaterFix 2018). Use of SCADA in the PA will improve the coordination between operations of the TFCF and the Jones Pumping Plant, e.g., by optimizing pump operations (number of pumps operating) given available diversion capacity, observed environmental and biological conditions, and factors such as louver efficiency and the need to shut down some systems for cleaning or other maintenance.

Objectives

- Fundamental objective: Increase juveniles at Chipps Island per adult return
- Means objective: Abundance

Conceptual Model (Each Species and Life stage)

As previously noted for other proposed actions, per the SAIL CM4 for Winter-Run Chinook Salmon rearing to outmigrating juveniles in the Bay-Delta (Windell et al. 2017, p.22), “Juvenile salmon arriving in the southern end of the Delta are at risk of entrainment in the Central Valley Project and State Water Project water intakes.” The green sturgeon SAIL CM for the transition from juvenile to adult/sub-adult notes “both juvenile green sturgeon distribution and behavior suggest that entrainment and impingement in diversions affect survival” (Heublein et al. 2017, p.22).

Current Conditions (RPA, WQCP, Facility)

The NMFS (2009) RPA Action IV.4.1 requires Reclamation to implement specific measures to reduce pre-screen loss and improve salvage efficiency at TFCF. Whole facility efficiency for salvage of Chinook Salmon, steelhead, and Green Sturgeon is required to be greater than 75% for each species. This is to be achieved through a number of actions including removal of predators in the primary channel so that prescreen loss is less than 10% of exposed salmonids; redesign of the secondary channel to enhance screening, fish survival, and predation reduction; reductions in Chinook Salmon and Green Sturgeon loss during louver cleaning operations; at least weekly removal of predators in the secondary channel; and various flow operational criteria to increase screening efficiency per design criteria.

Background (Old Science, Past Implementation, If Any)

Analysis in the NMFS (2009, p.352) BO identifies prescreen loss (15%), louver efficiency loss (53.2%), collection/handling/transport/release loss (2%), and post-release loss (10%) as the various elements contributing to approximately 35% survival of fish salvaged at the TFCF. Hydroacoustic studies have provided evidence that predators can be abundant at the release sites (Miranda et al. 2010).

Current Science Related to Idea/Topic

Recent tests with acoustically tagged juvenile Chinook Salmon suggest that the TFCF is likely not meeting the 75% whole facility efficiency required by NMFS RPA Action IV.4.1. Primary and secondary louver efficiency is high (75-100%) and it is predation loss that drives the whole facility efficiency estimates ranging from 0-40% with one Jones Pumping Plant pump operating to 45-75% with three to five pumps operating (Wu et al. 2018). Residence time of predatory fish in the TFCF can be very long, averaging ~75.4 days for Striped Bass (range = 0.01–290 days), which most frequently inhabited the upper primary channel and secondary channel (Wu et al. 2015). Removal of predatory fish from the primary channel has been shown to lead to significant reductions in prescreen loss of juvenile Chinook Salmon (Bridges et al., in draft, as cited by Sutphin 2014). Pilot testing of CO_2 injection into the primary bypass tubes (Figure D1.3-7) resulted in significantly greater numbers of predators (492 Striped Bass and 558 White Catfish) collected in the holding tanks than during a control period when no CO2 was injected (0 Striped Bass and 11 White Catfish) (Wu and Bridges 2014). Studies are underway to determine release site strategies in order to optimize release schedules at the multiple SWP/CVP release sites (Fullard et al. 2017, 2018). Consistent with the findings for Chinook Salmon (Wu et al. 2018), holding tank survival of Delta Smelt is high, indicating that holding tank conditions generally are relatively benign (Karp and Lyons 2015; although see Heiner 2011).

Justification for Action

Upgrades to the TFCF will aim to meet the requirements of the NMFS RPA by minimizing the effects of the salvage process on listed fishes, in particular juvenile salmonids and Green Sturgeon. Salvage improvements will improve survival of salvaged fish and potentially allow reduction of the expansion factors used to extrapolate take estimates from observed salvage. This may allow for additional certainty in OMR flow management by reducing pumping impacts to juvenile salmonids and Green Sturgeon.

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D1.3.4.4 *Routing*

D1.3.4.4.1 <u>North Delta Arc Routing into Sutter and Steamboat Sloughs</u>

Summary

The north Delta contains an “Arc” of suitable habitat for salmonid species in areas such as the Yolo Bypass, the Sacramento River, and Suisun Marsh. Reclamation proposes to manage and implement barriers throughout the “Arc” to maximize the benefits of these habitats and direct listed salmonids into these habitats.

Description

The University of California, Davis (UC Davis) Center for Watershed Sciences has identified Yolo Bypass as primary component of the North Delta Habitat Arc. It consists of a reconciled ecosystem strategy to create an arc of habitats connected by the flows of the Sacramento River. The Yolo Bypass is the upstream end of the arc, which continues through the Cache-Lindsey Slough-Liberty Island region, down the Sacramento River including Twitchell and Sherman Islands, and into Suisun.

Objectives

- Fundamental objective: Increase juveniles at Chipps Island per adult return
- Means objective: Abundance

Conceptual Model (Each Species and Life stage)

Focusing on habitat restoration and directed management actions in and adjacent to tidal marsh and other wetlands along the northern Delta arc of shoals, shallows, and open waters to improve habitat for native fish species.

Current Condition

Moyle et al. (2018) state that the North Delta Habitat Arc has a strong potential for habitat restoration. They note that the flows of the river are highly managed but provide basic connectivity needed—North Delta Arc needs to be recognized as an area in which natural and restoration sites are managed as an interconnected whole. EcoRestore projects have been ongoing and largely concentrated in the North Delta arc of habitat (Moyle et al. 2018) and additional projects should continue to be implemented.

Background

According to Durand (2012), the North Delta Arc refers to the suite of interconnected littoral and shallow water habitats along the northern rim of Suisun Bay and Delta which wrap the base of the Montezuma Hills. The Arc includes Suisun Marsh, Sherman Lake, the Cache-Lindsey Slough Complex, and Liberty Island. Durand (2012) describes these habitats as having more tendency to be more productive and biologically diverse than other regions in the Delta. Durand (2012) states that while multiple stressors have been implicated with fish declines throughout the Bay-Delta estuary, there are multiple physical and trophic drivers that support fishes in the Arc, providing a slower rate of declines for a number of native species. Conditions such as geomorphic structure, bathymetric gradient extending from above to below sea level, tidal exchange, freshwater flows promote the essential needs of local fishes by providing physical and hydrodynamic structure for habitat, trophic structure that supports foraging strategies, and corridors for transit or recruitment among habitats (Durand 2012). Comparisons with other regions of the Delta demonstrate that these conditions are not met throughout much of the ecosystem; the North Delta Arc is an exception (Durand 2012).

Current Science

Moyle et al. (2018) identified several initiatives to improve welfare of native fishes in the Delta and help to create a novel aquatic ecosystem with many desirable features. One of those initiatives was to expand restoration projects in the North Delta Habitat Arc. Moyle et al. (2008) states:

> Restoration projects in the North Delta Habitat Arc represent the best model for future projects because they consist of a portfolio of projects that are diverse in size, connectivity, and location;

all are linked to the Sacramento River and its riparian zone. The river provides a corridor that connects projects and habitats by water and land, providing opportunities for a dynamic biota to exist, and to expand as restoration projects are added to the portfolio.

Further restoration projects in the “Arc” are recommended that improve connectivity to other restoration sites and the Sacramento River (Moyle et al. 2008).

North Delta Arc areas with current restoration activities such as Yolo Bypass, North Delta (Lindsey-Cache Slough-Liberty Island), Sacramento River (Twitchell and Sherman Islands), and Suisun Marsh, each have their own distinctive characteristics and faunas (Moyle et al. 2016). Collectively, these projects should be regarded as a large-scale example of reconciliation ecology where new habitats are crated and closely managed to meet specific goals (Moyle et al. 2016). Moyle et al. (2016) recommends viewing the Arc as a large, interconnected and reconciled ecosystems to help with:

- Managing projects to benefit a full range of life history stages for key species
- Coordinating management of restoration projects with water project operations.
- Managing the system in a changing climate: longer droughts, bigger floods and warmer temperatures.
- Restoring tidal marshes as sources of food for pelagic fishes such as Delta Smelt.
- Comparing outcomes of different restoration strategies.
- Assessing how tidal marsh restoration projects affect tidal flow in projects, given that total tidal energy is more or less fixed.
- UC Davis Center for Watershed Sciences conducted preliminary research and identified several mechanisms critical to supporting the resiliency in the region’s [North Delta Arc] ecosystem, including habitat complexity, tidal interactions with the shore, water quality dynamics, and interconnected habitats (Schlesinger *date unknown*). Schlesinger (*date unknown*) states that the research indicates that tidal exchange of sediment and phytoplankton in the water help maintain a variety of habitats that may be beneficial to both native and desirable invasive species. UC Davis Center for Watershed Sciences researchers noted that phytoplankton growth appears to be most concentrated in the upper reaches of dead-end sloughs, possibly contributing to the local food web. Because these sloughs are well connected to the main channels of the estuary, aquatic life can readily move between them in search of food or refuge.

Justification

Moyle et al. (2016) states that native fishes in the Delta are in desperate conditions, with over 90% of fish sampled being non-native species. Native fish such as the Delta Smelt are nearing extinction (Moyle et al. 2016). Researchers, such as Moyle et al. (2016), state that if the trend toward extinction is to be reversed, there is a need to re-create a functioning estuary. An inter-connected series of habitats, mostly tidal, is needed with a unified conceptual, scientific, institutional and applied approach. The US Davis Center for Watershed Sciences conducted preliminary research and identified several mechanisms critical to supporting the resiliency in the region’s [North Delta Arc] ecosystem, including habitat complexity, tidal interactions with the shore, water quality dynamics, and interconnected habitats (Schlesinger *date unknown*). Schlesinger (*date unknown*) states that the research indicates that tidal exchange of sediment and phytoplankton in the water help maintain a variety of habitats that may be beneficial to both native and desirable invasive species. The UC Davis Center for Watershed Sciences researchers noted that phytoplankton growth appears to be most concentrated in the upper reaches of dead-end sloughs, possibly contributing to the local food web. Because these sloughs are well connected to the main channels of the estuary, aquatic life can readily move between them in search of food or refuge.

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D1.3.4.5 *Conservation Hatchery*

D1.3.4.5.1 Rio Vista Research Station

Summary

Reclamation would work with partner agencies to develop an Estuarine Research Station at the Rio Vista Army Reserve Center.

Description

The Rio Vista Research Station would:

- Establish a research station in a central location within the Bay-Delta to facilitate conducting monitoring and research;
- Co-locate the research station with a facility capable of studying fish in captivity (the Delta Smelt Conservation Hatchery); and
- Provide facilities to conduct monitoring and research on the Bay-Delta's aquatic resources. (USFWS 2017)

The Rio Vista Research Station will be located on the upper terrace of the center and will consist of a two-story office building, laboratory building, dry-dock boat storage building, open dry-dock boat storage area, shop building, storage area, restroom facility, and open field experimental yard. A marina, including a fixed pier, gangway, and boat launch, will be excavated on the shoreline of the Sacramento River.

Objectives

- Fundamental objective: Maintain minimum population during drought.
- Means objective: Productivity

Conceptual Model (Each Species and Life stage)

The Research Station would not specifically contribute to a portion of the conceptual model for Delta Smelt or salmon, but would enable monitoring and research to refine these models and increase understanding.

Current Condition

IEP research and monitoring activities are spread over a large geographical area, which limits interagency coordination and collaboration.

Background

This facility has been in discussion since 2015, and USFWS completed a BO in 2017 (USFWS 2017).

Current Science

A centralized location for scientific research and monitoring would improve the collaboration and scientific opportunities available.

Justification

This facility would help improve understanding of the various factors that affect listed species and ways to improve conditions.

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D1.3.5 Stanislaus River

D1.3.5.1 *Habitat*

D1.3.5.1.1 Spawning Habitat

Summary

Reclamation proposes to place 4,500 tons of gravel per year in the Stanislaus River to provide spawning habitat.

Description

Reclamation will primarily create spawning habitat via gravel augmentation. Key considerations involve substrate size and risk of sedimentation.

Objectives

- Fundamental objective: Increase juveniles at Chipps Island per adult return.
- Means objective: Productivity

Conceptual Model (Each Species and Life stage)

The overall SAIL CM (Windell et al. 2017) for Chinook Salmon comprises several separate CMs describing life stages, including "Egg to Fry Emergence." Each of the life stage-specific CMs includes numerous hypotheses about how habitat attributes affect that life stage.

The proposed spawning habitat improvements target the 'Egg to Fry Emergence' stage; SAIL includes nine hypotheses about how habitat attributes affect this life stage. Gravel augmentation is most likely to affect the hypotheses related to redd quality, stranding and dewatering, and sedimentation and gravel quantity.

Egg survival depends largely on redd quality and substrate size (Windell et al. 2017). Redd quality is affected by many habitat attributes including a couple affected by gravel augmentation, i.e., gravel size and composition, sedimentation. Gravel augmentation potentially reduces stranding and dewatering by changing water depth. Because sedimentation negatively affects egg survival, gravel should be cleaned before placement.

Current Condition

Stanislaus River riparian areas historically supported a diverse, dynamic ecosystem complex of seasonal wetlands, oxbow lakes and extensive forested floodplains, with meandering side channels (Elias 1924). However, historic gold and gravel mining have greatly altered geomorphic and hydraulic conditions under which Stanislaus River salmon populations evolved. Extensive alterations to Stanislaus River streambeds deeply incised the main channel, disconnected side channels and floodplains, and altered riparian vegetation. Regulated flows compounded incision, further eroded beds and banks, coarsened bed material, and inhibited the flushing of fine particles from the gravel (DWR 1994, Kondolf 1997). These impacts have reduced total salmonid spawning habitat extent and degraded remaining habitat.

Historically, both Spring- and Fall-Run Chinook Salmon were known to exist in the Stanislaus River, up to elevations of ~2,000 ft (Yoshiyama et al. 2001). By 1926, Goodwin Dam and Melones Dam had eliminated access to the upper Stanislaus River (Yoshiyama et al. 1996). Currently, spawning activity occurs primarily within the 12-mile reach between Goodwin Dam and Orange Blossom Bridge (Mesick 2001).

There is limited information on Chinook Salmon and steelhead populations in the Stanislaus River. Annual carcass surveys have been conducted by CDFW since 1975, and adult population estimates from these surveys range from 0-13,473 (average 3,370) returning spawners (CDFW 2018).

Background

Gravel augmentation is a widely accepted technique for rehabilitating anadromous salmonid spawning habitats within regulated streams of the California Central Valley (Wheaton et al. 2004a, 2004b). Several studies have demonstrated that gravel augmentation can increase Chinook Salmon spawning activity (Merz and Setka 2004, Zeug et al. 2013). Ideally placed gravels contain a range of substrate sizes appropriate for successful redd construction by all salmonids present at the site (Kondolf and Wolman 1993).

Physical and biological effects of gravel augmentation projects are influenced by a suite of intermediate mechanisms and external factors related to hydrodynamics, geomorphology, and ecology (Downs and Kondolf 2002). Therefore, the overall effects of restoration projects on river ecosystems and specified life stages of target species, and secondary influences on non-target organisms, are highly variable both within and among ecosystems. In addition, because even heavily regulated rivers are dynamic and both flow and physical engineering of spawning beds by salmon cause downstream sediment transport, a gravel augmentation project is not expected to function indefinitely and will be reduced as sediment is carried downstream (Merz et al. 2006, Humphries et al. 2012).

In the past two decades, several rehabilitation efforts have been undertaken on the Stanislaus River to improve the quality and quantity of salmonid spawning habitat. These are summarized in Table D1.3-2.

Table D1.3-2. CVPIA gravel augmentation on the Stanislaus River from 1997-2015 (Reclamation, unpublished data).

Year	Gravel augmentation (tons)
1997	2,000
1998	3,000
2000	1,300
2001	500
2002	4,000
2004	1,200
2005	2,500
2006	2,500
2007	4,100
2011	5,000
2012	3,000
2015	8,000
2017	4,000
TOTAL	29,100

Current Science

Few studies have been conducted on the Stanislaus River to assess gravel augmentation success. Mesick (2001) monitored spawning activity at augmented and unaugmented sites between Goodwin Dam and Riverbank from 1994 and 1997 and found variable habitat quality and spawning activity in augmented areas. Multiple effectiveness monitoring studies have been implemented on the nearby American River to test the effects of gravel augmentation on salmon adults, embryos, and juveniles; since the Stanislaus River has many of the same historical impacts and habitat limitations, this information is likely relevant to Stanislaus River gravel augmentation projects, so it is summarized below.

Zeug et al. (2013) found that gravel augmentation increased site utilization, but the degree to which a particular augmentation action was effective depended upon the species (Chinook salmon or steelhead) and substrate size. Cramer Fish Sciences (2017a) found that substrate size impacts benthic invertebrate prey production, with lower prey density in smaller gravels. Merz et al. (in press) also observed conflicting optimal gravel sizes between adult spawners and salmon embryos, with higher spawning activity in small gravel and higher embryo survival in large gravel. Cramer Fish Sciences (2017b) assessed gravel augmentation site longevity and that the positive effects of gravel augmentation (i.e., increased habitat utilization) declined to pre-project levels within 5-6 years after implementation.

Justification

In DWR's Comprehensive Salmonid Assessment (DWR 1994), Salmon habitat restoration sites were identified on the Stanislaus River from Knight's Ferry (RM 54.5) to Oakdale (RM 39.0). Recommendations included replacing gravel, cobble, and structure. The San Joaquin River Management Plan (1995) also suggests improving gravel quality to increase survival of salmonid eggs and enhance the channel and riparian corridor of the tributaries to the San Joaquin River, including the Stanislaus River. The USFWS (1995) Working Paper on salmonid restoration in the Central Valley identified the need to restore and protect instream and riparian habitat in the Stanislaus River to ensure the long-term sustainability of physical, chemical, and biological conditions needed to meet production goals for Chinook Salmon. The Stanislaus River is listed as high priority in the AFRP Final Restoration Plan (USFWS 2001), and collaboration among landowners, Stanislaus County, CDFW, USFWS, and Reclamation for projects that improve watershed management to restore and protect instream and riparian habitat, including restoring and replenishing spawning gravel, are also high priority. In the Central Valley Salmonid Recovery Plan, NMFS (2014) recommends as high priority recovery actions in the Stanislaus River: (1) continue to implement projects that increase the availability and quality of spawning and rearing habitat and (2) identify and implement floodplain and side channel projects to improve river function and increase habitat diversity.

Modeling Science

The proposed actions can be evaluated with a couple of different models. The Chinook Carrying Capacity Calculator (https://flowwest.shinyapps.io/carrying-capacity-app/) estimates spawning habitat need and availability for many rivers in the Central Valley, including the Stanislaus River.

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D1.3.5.1.2 Rearing Habitat

Summary

Reclamation proposes to create another 171 acres of side channel and floodplain rearing habitat in the Stanislaus River by 2030.

Description

Reclamation will primarily create rearing habitat via gravel augmentation, floodplain improvements, and side channel development. Key considerations involve the potential to inundate edge habitats and floodplains by increasing local water surface elevation. Side channel excavation, floodplain lowering, and woody debris placement will also be considered for the creation of juvenile rearing habitat.

Objectives

- Fundamental objective: Increase juveniles at Chipps Island per adult return
- Means objectives: Abundance

Conceptual Model (Each Species and Life stage)

The overall SAIL CM (Windell et al. 2017) for Chinook Salmon comprises several separate CMs describing life stages, including Rearing to Outmigrating Juveniles. Each of the life stage-specific CMs includes numerous hypotheses about how habitat attributes affect that life stage.

The proposed rearing habitat improvements target the Rearing to Outmigrating Juveniles stage; SAIL includes nine hypotheses about how habitat attributes affect this life stage. Gravel augmentation, side channel excavation, floodplain lowering, and woody debris placement are most likely to affect the hypotheses related to predation and competition, refuge habitat, and food availability and quality.

Fry survival depends largely on the quantity and quality of rearing habitat. Inundation of edge and floodplain habitats provides refuge from fast moving water, increased food availability, and reduced predation risk.

Current Condition

Stanislaus River riparian areas historically supported a diverse, dynamic ecosystem complex of seasonal wetlands, oxbow lakes and extensive forested floodplains, with meandering side channels (Elias 1924). However, historic gold and gravel mining have greatly altered geomorphic and hydraulic conditions under which Stanislaus River salmon populations evolved. Extensive alterations to Stanislaus River streambeds deeply incised the main channel, disconnected side channels and floodplains, and altered riparian vegetation. Regulated flows compounded incision, further eroded beds and banks, coarsened bed material, and inhibited the flushing of fine particles from the gravel (DWR 1994, Kondolf 1997). These impacts have reduced total salmonid rearing habitat extent and degraded remaining habitat.

Historically, both Spring- and Fall-Run Chinook Salmon were known to exist in the Stanislaus River, up to elevations of ~2,000 ft (Yoshiyama et al. 2001). By 1926, Goodwin Dam and Melones Dam had eliminated access to the upper Stanislaus River (Yoshiyama et al. 1996). Currently, spawning activity occurs primarily within the 12-mile reach between Goodwin Dam and Orange Blossom Bridge (Mesick 2001).

There is limited information on Chinook Salmon and steelhead populations in the Stanislaus River. Recent monitoring efforts by state and federal resource agencies have provided some information on juvenile salmon response to flow regimes (Zeug et al. 2014) and how juvenile outmigration strategies impact survival to adulthood (Sturrock et al. 2017).

Background

Physical and biological effects of gravel augmentation projects are influenced by a suite of intermediate mechanisms and external factors related to hydrodynamics, geomorphology, and ecology (Downs and Kondolf 2002). Therefore, the overall effects of restoration projects on river ecosystems and specified life stages of target species, and secondary influences on non-target organisms, are highly variable both within and among ecosystems. In addition, because even heavily regulated rivers are dynamic and both flow and physical engineering of spawning beds by salmon cause downstream sediment transport, a gravel augmentation project is not expected to function indefinitely and will be reduced as sediment is carried downstream (Merz et al. 2006, Humphries et al. 2012).

Current Science

Few studies have been conducted on the Stanislaus River to assess gravel augmentation success. Multiple effectiveness monitoring studies have been implemented on the nearby American River to test the effects of gravel augmentation on salmon adults, embryos, and juveniles; since the Stanislaus River has many of the same historical impacts and habitat limitations, this information is likely relevant to Stanislaus River gravel augmentation projects, so it is summarized below.

Cramer Fish Sciences (2017a) found that substrate size impacts benthic invertebrate prey production, with lower prey density in smaller gravels. Merz et al. (in press) also observed conflicting optimal gravel sizes between adult spawners and salmon embryos, with higher spawning activity in small gravel and higher embryo survival in large gravel. Sellheim et al. (2015) found that gravel augmentation improved juvenile rearing habitat by reconnecting remnant floodplains under lower streamflow conditions. Cramer Fish Sciences (2017b) assessed gravel augmentation site longevity and that the positive effects of gravel augmentation (i.e., increased habitat utilization) declined to pre-project levels within 5-6 years after implementation.

Justification

In DWR's Comprehensive Salmonid Assessment (DWR 1994), Salmon habitat restoration sites were identified on the Stanislaus River from Knight's Ferry (RM 54.5) to Oakdale (RM 39.0). Recommendations included replacing gravel, cobble and structure. The San Joaquin River Management Plan (1995) also suggests improving gravel quality to increase survival of salmonid eggs and enhance the channel and riparian corridor of the tributaries to the San Joaquin River, including the Stanislaus River. The USFWS (1995) working paper on salmonid restoration in the Central Valley identified the need to restore and protect instream and riparian habitat in the Stanislaus River to ensure the long-term sustainability of physical, chemical, and biological conditions needed to meet production goals for Chinook Salmon. The Stanislaus River is listed as high priority in the AFRP Final Restoration Plan (USFWS 2001), and collaboration among landowners, Stanislaus County, CDFW, USFWS, and Reclamation for projects that improve watershed management to restore and protect instream and riparian habitat are also high priority. In the Central Valley Salmonid Recovery Plan, NMFS (2014) recommends as high priority recovery actions in the Stanislaus River: (1) continue to implement projects that increase the availability and quality of rearing habitat and (2) identify and implement floodplain and side channel projects to improve river function and increase habitat diversity.

Modeling Science

The proposed actions can be evaluated with a couple of different models. The Chinook Carrying Capacity Calculator (https://flowwest.shinyapps.io/carrying-capacity-app/) estimates rearing habitat need and availability for many rivers in the Central Valley, including the Stanislaus River. The Emigrating Salmonid Habitat Estimation (ESHE) modeling framework estimates only juvenile rearing habitat need but provides more detailed estimates in time and space than the Chinook Carrying Capacity Calculator. Two separate ESHE modeling efforts, with different modeling assumptions, involved the Stanislaus River: San Joaquin River Basin ESHE (https://fishsciences.shinyapps.io/san-joaquin-eshe/) and Stanislaus ESHE (https://fishsciences.shinyapps.io/stanislaus-eshe/).

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D1.3.6 San Joaquin River Lower Basin

D1.3.6.1 *Habitat*

D1.3.6.1.1 <u>Lower San Joaquin River Rearing Habitat</u>

Summary

Reclamation will increase rearing habitat in the San Joaquin River by modifying channel topography to create seasonally-inundated floodplains. Key considerations involve the potential to inundate edge habitats and floodplains by increasing local water surface elevation. Side channel excavation, floodplain lowering, and woody debris placement will also be considered for the creation of juvenile rearing habitat.

Description

Reclamation proposes to create a regional partnership to define and implement a large-scale floodplain habitat restoration effort in the Lower San Joaquin River. This stretch of the San Joaquin River is cut-off from its floodplain due to an extensive levee system, with two notable exceptions at Dos Rios Ranch (1,600 acres) and the San Joaquin River National Wildlife Refuge (2,200 acres). In recent years, there has been growing interest in multi-benefit floodplain habitat restoration projects in the Central Valley that can provide increased flood protection for urban and agricultural lands, improved riparian corridors for terrestrial plants and wildlife, and enhanced floodplain habitat for fish. The resulting restoration could include thousands of acres of interconnected (or closely spaced) floodplain areas with coordinated and/or collaborative funding and management. Such a largescale effort along this corridor would require significant support from a variety of stakeholders, which could be facilitated through a regional partnership.

Objectives

- Fundamental objective: Increase juveniles at Chipps Island per adult
- Means objectives: Abundance, productivity, and spatial structure

Conceptual Model (Each Species and Life stage)

Restoration efforts target juvenile Chinook Salmon and steelhead during the in-river rearing phase of their life history, prior to outmigration. Restoration activities can reduce multiple stressors during this life stage including: reducing predation, providing refuge habitat, and increasing food availability (Windell et al. 2017).

Current Condition

The San Joaquin River is heavily impacted by water diversion, levees, flow regulation, and agricultural and urban runoff (SJRRP 2010). These factors have degraded salmon habitat quality throughout the San Joaquin River below Friant Dam. Physical barriers, reaches with poor water quality or no surface flow, and the presence of false migration pathways have reduced habitat connectivity for anadromous and resident fishes (SJRRP 2010, 2016, and references therein).

Background

Historically, several Chinook Salmon runs were present in the San Joaquin River, with population estimates in the hundreds of thousands (Yoshiyama et al. 1998). Following European expansion starting in the mid-1800's, the San Joaquin River Spring-Run Chinook Salmon population was extirpated. Fall-Run and Spring-Run Chinook Salmon were extirpated from the San Joaquin River following the completion of Friant Dam and resultant channel dewatering over 60 years ago. The last documented run of Spring-Run Chinook Salmon in the upper San Joaquin River Basin was observed in 1950 and consisted of only 36 individuals (Warner 1991). Since the 1950s, only Fall-Run Chinook Salmon remained in the San Joaquin River, found in its major tributaries (SJRRP 2010).

Current Science

Restoring side channel and floodplain connectivity in heavily impacted rivers can recover productive rearing habitat for juvenile salmonids (Richards et al. 1992; Heady and Merz 2007). Rearing habitat is described as the physical conditions, including water temperature, dissolved oxygen (DO), turbidity, substrate size and composition, water velocity and depth, and available cover (Bjornn and Reiser 1991; Healey 1991; Jackson 1992), which maintain the biological components (e.g., invertebrate prey resources) critical to habitat productivity for fish (Simenstad and Cordell 2000). The importance of floodplain habitats as productive foraging areas and predator refuge for rearing juvenile salmon, compared to main river channels, has been well documented (Grosholz and Gallo, 2006; Jeffres et al., 2008; Bellmore et al., 2013). Previous studies in the Central Valley and in other systems have demonstrated that creating or enhancing off-channel floodplain habitat can increase the quantity and quality of floodplain rearing habitat under a range of flow conditions, and that juvenile salmonids utilize these restored habitats

(Sellheim et al. 2015, CFS 2013, Ogston et al. 2014). Inundated floodplains can enhance juvenile salmonid growth and survival because water temperatures, prey biomass, and velocities are more favorable compared to main channel habitat (Kjelson et al., 1981; Ahearn et al., 2006). Juveniles that spend more time rearing in off-channel habitats and enter the ocean environment at a larger body size have increased survivorship (Sommer et al. 2001).

A recent study examined rearing habitat quality and juvenile Chinook Salmon growth within three distinct reaches of the San Joaquin River between Friant Dam and the SJNWR (Zeug et al., in revision). This study found that water quality, prey densities, and juvenile growth rates were highest in the site furthest downstream, which was within the Merced NWR. Rearing conditions were best early in the rearing period, before late spring when water temperatures became stressful.

Justification

Floodplain restoration areas could offer increased flood protection for urban (i.e., Stockton, Manteca, and Lathrop) and agricultural lands, especially in high runoff years like 2011 and 2017. Greater riparian habitat would support sensitive plant and wildlife species (e.g., riparian brush rabbit, Swainson's hawks, giant garter snakes). The Stanislaus, Tuolumne, Merced tributaries, and increasingly the San Joaquin River, all support populations of migratory salmonids that would benefit from floodplain access. Outmigrating juvenile salmonids utilizing floodplains grow faster, which may lead to increased survival through the South Delta, a region with unusually low survival.

Local agencies, NGOs, and private entities in the area would likely all be supportive of some form of multi-benefit restoration planning in the region, as long as they had opportunities for input in the process and had clear and direct benefits. The Bay-Delta Conservation Plan, The Delta Conservation Framework, and A Delta Renewed guide have identified the lower San Joaquin River and South Delta region as needing multi-benefit restoration projects to support the ecosystem and local landowners. Multi-benefit flood control projects are in keeping with the FloodSAFE California initiative and the Central Valley Flood Protection Plan. Several organizations and State and Federal agencies are involved in Central Delta Corridor Partnership (a similar partnership) and may be supportive of an effort in the lower San Joaquin River: TNC, Metropolitan Water District of Southern California, DWR, California Department of Parks and Recreation, California Waterfowl Association, Bureau of Land Management, USFWS, and CDFW.

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Appendix E Mitigation Measures

This appendix documents the mitigation measures outlined in the EIS. References for citations appearing in mitigation measure text can be found in the technical appendix for each resource.

E.1 Water Quality

Mitigation Measure WQ-1: Implement a Spill Prevention, Control, and Countermeasure Plan

Reclamation or their construction contractor will 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 will be completed before construction activities begin. Implementation of this measure will comply with State and Federal water quality regulations. The SPCCP will describe spill sources and spill pathways in addition to the actions that will be taken in the event of a spill (e.g., an oil spill from engine refueling will be cleaned up immediately with oil absorbents) or the exposure of an undocumented hazard. The SPCCP will 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 will also describe how and when employees are trained in proper handling procedures and spill prevention and response procedures.

Reclamation will review and approve the SPCCP before the onset of construction activities and will routinely inspect the construction area to verify that the measures specified in the SPCCP are properly implemented and maintained. Reclamation will notify its contractors immediately if there is a noncompliance issue and will require compliance.

If a spill is reportable, the construction contractor's superintendent will notify Reclamation, and Reclamation will take action to contact the appropriate safety and cleanup crews to ensure the SPCCP is followed. A written description of reportable releases will be submitted to the Regional Water Quality Control Board (RWQCB) and the California Department of Toxic Substances Control. This submittal will 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 will be documented on a spill report form.

Mitigation Measure WQ-2: Implement a Stormwater Pollution Prevention Plan

Prior to initiating construction and applicable maintenance activities that may result in ground disturbance or include ground disturbance activities, the construction contractor will prepare a stormwater pollution prevention plan (SWPPP) that describes best management practices (BMPs) that will be implemented to control accelerated erosion, sedimentation, and other pollutants during and after project construction. Specific BMPs that will be incorporated into the SWPPP will be site-specific and will be prepared in accordance with the regional water board field manual. The SWPPP will include, but not be limited to, the following standard erosion- and sediment-control BMPs:

- **Timing of construction**. All construction activites that include ground disturbance activities greater than 1 acre in size will 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. Such staging areas will not contain native or sensitive vegetation communities and will not support sensitive plant or animal species. Silt fences, non-monofilament fiber rolls, or similar devices will 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 will 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 will be staged in designated staging areas that meet the requirements identified above regarding stabilizing grading spoils.
- **Minimize soil and vegetation disturbance.** The construction contractor will minimize ground disturbance and the disturbance and/or destruction of existing vegetation. This will 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 will 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 WQ-3: Develop a Turbidity Monitoring Program

The Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River basins (Fifth Edition) (Central Valley RWQCB 2018) contains turbidity objectives. Specifically, the plan states that where natural turbidity is between 5 and 50 Nephelometric Turbidity Units (NTUs), turbidity levels may not be elevated by 20% 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 will not exceed 10%. A sampling plan will be developed and implemented based on specific site conditions and in consultation with the RWQCB. If turbidity limits exceed basin plan standards, construction-related earth-disturbing activities will slow to a point that would alleviate the problem.

Mitigation Measure WQ-4: Develop a Water Quality Mitigation and Monitoring Program

Reclamation will develop and implement a program to reduce, minimize, or eliminate increases in water quality constituents. The program will develop a monitoring plan, including frequent sampling and reporting, particularly for existing constituents of concern. Reclamation will coordinate with the implementation of the current Total Maximum Daily Loads to share monitoring information and contribute to the efforts to reduce constituents of concern. Monitoring efforts could include collection of water quality (through the water column), soil, and fish and invertebrate tissue monitoring.

E.2 Water Supply

None proposed.

E.3 Groundwater

None proposed.

E.4 Indian Trust Assets

Mitigation Measure ITA-1: Consult with Tribal Entities Consistent with Secretarial Order 3175

For programmatic actions, when footprints are determined, and as early as possible in the environmental compliance process, Reclamation will consult with nearby federally recognized Indian tribes in the study area to request their input regarding the identification of any properties to which they might attach religious and cultural significance to within the area of potential effect.

Once these areas are determined, Reclamation will make a good faith effort to avoid land or sites of religious importance and will enter into government-to-government consultations with potentially affected tribes to identify and address concerns for ITAs.

Mitigation Measure WQ-1: Implement a Spill Prevention, Control, and Countermeasure Plan

Described under Section E.1, Water Quality.

Mitigation Measure WQ-2: Implement a Stormwater Pollution Prevention Plan

Described under Section E.1, Water Quality.

Mitigation Measure WQ-3: Develop a Turbidity Monitoring Program

Described under Section E.1, Water Quality.

Mitigation Measure WQ-4: Develop a Water Quality Mitigation and Monitoring Program

E.5 Described under Section E.1, Water Quality.

E.5.1 Cultural Resources and Indian Sacred Sites

Mitigation Measure CUL-1: Conduct Archaeological Surveys before the Beginning of Any Project- or Program-Related Action and Implement Further Mitigation as Necessary

Before the beginning of any project- or program-related action that could affect cultural resources, qualified archaeologists will survey all portions of the site. The survey is conducted during a time when vegetation can be reduced or cleared from the affected area, so the natural ground surface can be examined for traces of prehistoric and/or historic-era cultural resources. Surveys of these areas would not be necessary if it is determined that they would not be affected by any project or program construction-related activity, including equipment staging or material stockpiling. If the survey reveals the presence of cultural resources on the project site, the procedures outlined in Mitigation Measure CUL-2 will be followed.

Mitigation Measure CUL-2: Restrict Ground Disturbance and Implement Measures to Protect Archaeological Resources if Discovered during Surveys or Ground-Disturbing Activities

If unrecorded cultural resources (e.g., unusual amounts of shell, animal bone, bottle glass, ceramics, structure/building remains, etc.) are encountered during surveys where ground disturbance is planned or during project-related ground-disturbing activities, all ground-disturbing activities will cease within a 100-foot radius of the find. A qualified archaeologist will identify the materials, determine their possible significance according to National Register of Historic Places (NRHP) criteria, and formulate appropriate measures for their treatment, which will be implemented by the lead agency and its contractors. Potential treatment methods for important and potentially important resources may include, but would not be limited to, no action (i.e., resources determined not to be important), avoidance of the resource through changes in construction methods or project design, and implementation of a program of testing and data recovery, in accordance with all applicable federal and state requirements.

Mitigation Measure CUL-3: Stop Potentially Damaging Work if Human Remains Are Uncovered during Construction, Assess the Significance of the Find, and Pursue Appropriate Management

If Native American human remains are discovered on federal lands, the Native American Graves Protection and Repatriation Act (NAGPRA) requires that the individual who makes the discovery notify the federal land manager of the discovery in writing. All ground-disturbing activities within 100 feet of the find will cease, and the materials are to be protected until the land manager can assess the find. Upon receipt of written confirmation of the discovery, the manager is required to: (1) certify receipt of the notification; (2) take immediate steps, if necessary, to further protect the materials; (3) notify by telephone, with written confirmation, the tribes likely to be culturally affiliated with the materials; and (4) initiate consultation with such tribes. If, after consultation with tribes, the manager determines that the material will be protected adequately in situ, without the need to excavate or remove the material from the area of discovery, then the requirements under NAGPRA will have been completed. If, after consultation with the tribes, the manager determines that the circumstances warrant intentional excavation or removal of the materials from the area of discovery, then 43 CFR Section 10.3 applies, and the manager must complete steps outlined therein for intentional excavations.

If Native American human remains are discovered outside of federal lands, California Health and Safety Code Sections 7050.5 and 7052 and California Public Resources Code (Public Res. Code) Section 5097 procedures are to be followed. In accordance with the California Health and Safety Code, if human remains are uncovered during ground-disturbing activities, all such activities within a 100-foot radius of the find will be halted immediately and a Reclamation cultural resources specialist (CRS) will be contacted. The Reclamation CRS will immediately notify the county coroner. The coroner is required to examine all discoveries of human remains within 48 hours of receiving notice of a discovery on nonfederal lands (Health and Safety Code §7050.5[b]). If the coroner determines that the remains are those of a Native American, he or she must contact the Native American Heritage Commission (NAHC) within 24 hours of making that determination (Health and Safety Code §7050[c]). The NAHC will immediately designate and contact the most likely descendent (MLD), who has 48 hours from completion of their examination of the find in which to make recommendations for treatment of the remains, as required by Public Res. Code 5097.98(a). Reclamation will then contact the landowner. Reclamation, the MLD, and the landowner will then devise a mitigation plan for treatment of the remains. Work in the area will continue only after the remains have been treated according to the above mitigation plan and Reclamation certifies that the mitigation plan was properly implemented.

If the remains are found not to be Native American in origin and do not appear to be in an archaeological context, construction will proceed at the direction of the coroner and Reclamation CRS. Once the remains have been appropriately and legally treated, construction may resume in the discovery area upon receipt of Reclamation's express authorization to proceed and under the direction of the CRS.

Mitigation Measure CUL-4: Complete Built-Environment Inventory and Evaluation prior to Construction and Implement Treatment Measures for Adverse Effects

Mitigation for program or project effects on historic built-environment resources consists of identification and evaluation of built-environment historic properties and assessing program or project effects. Reclamation will ensure that a qualified architectural historian meeting Secretary of Interior's Professional Qualifications Standards for work in history and/or architectural history per 36 CFR Part 61 conducts a historic built-environment inventory and evaluation of unsurveyed parcels that have potential to be affected by the proposed action. All historic built-environment resources located during the survey will be photographed, mapped, and recorded on applicable California Department of Parks and Recreation (DPR) 523 forms. For multifaceted resources such as cultural landscapes and historic districts, locational data will be collected with a global positioning system (GPS) receiver. The significance of any identified historic built-environment resource will be evaluated for NRHP eligibility. Reclamation will forward the resulting DPR 523 forms to the representative California Historical Resources Information System.

To mitigate for adverse effects on identified built-environment historic properties, a plan for detailed documentation of the historic property will be prepared prior to initiation of the project or program action; in cases when the action would prevent adequate completion of the documentation effort, documentation will be completed prior to initiating the program or project. This could include a range of specific mitigation measures to be determined in Section 106 consultation with the State Office of Historic Preservation. Documentation of identified built-environment historic properties could include a range of options, such as interpretive displays, online resources, archival quality photographic documentation, or historic contexts.

E.6 Air Quality

E.6.1 Measures to Minimize Generation of Fugitive Dust

Mitigation Measure AQ-1: Develop and Implement a Fugitive Dust Control Plan

Mitigation Measure AQ-2: Pave, Apply Gravel, or Otherwise Stabilize the Surfaces of Access Roads

Mitigation Measure AQ-3: Apply Water or Dust Palliatives to Access Roads as Necessary during High Wind Conditions.

Mitigation Measure AQ-4: Post and Enforce Speed Limits on Unpaved Access Roads

Mitigation Measure AQ-5: Stage Activities to Limit the Area of Disturbed Soils Exposed at Any One Time

Mitigation Measure AQ-6: Water, Stabilize, or Cover Disturbed or Exposed Earth Surfaces and Stockpiles of Dust-Producing Materials, as Necessary

Mitigation Measure AQ-7: Install Wind Fences around Disturbed Earth Areas if Windborne Dust Is Likely to Affect Sensitive Areas beyond the Site Boundaries (e.g., Nearby Residences)

Mitigation Measure AQ-8: Cover the Cargo Areas of Vehicles Transporting Loose Materials

Mitigation Measure AQ-9: Inspect and Clean Dirt from Vehicles, as Necessary, at Access Road Exits to Public Roadways

Mitigation Measure AQ-10: Remove from Public Roadways Visible Trackout or Runoff Dirt from the Activity Site (e.g., Using Street Vacuum Sweeping)

E.7 Greenhouse Gas Emissions

Mitigation Measure GHG-1: Minimize Potential Increases in GHG Emissions from Exhaust Associated with Construction Activities

BMPs are recommended to minimize potential increases in GHG emissions from exhaust associated with construction activities. The following are common BMPs that may be applicable depending on the activity and the equipment being used. These or similar practices are often required by air quality management districts and local jurisdictions to minimize construction impacts on GHG emissions:

- Ensure that all equipment and vehicles are maintained regularly to meet manufacturer specifications to achieve efficient combustion and minimum emissions.
- Ensure that all diesel engines are properly fueled (i.e., ultra-low sulfur diesel with a maximum 15 parts per million sulfur content).
- Limit idling of engines to no more than 5 minutes unless necessary for proper operation.
- Where feasible, use electric rather than engine-powered equipment. This may include using electric starting aids (such as block heaters) to warm engines.
- Develop and implement a traffic management plan.
- Where offsite traffic congestion is a concern, limit use of vehicles on public roads during peak traffic hours.
- Where offsite traffic congestion is a concern, or to limit vehicle volumes traveling to remote sites, require workers to park in designated areas and provide shuttle buses to work sites.

E.8 Visual Resources

None proposed.

E.9 Aquatic Resources

Mitigation Measure AQUA-1: Worker Awareness Training

Reclamation or its designees will provide training to field management and construction personnel on the importance of protecting sensitive natural resources (i.e., listed species and designated critical and/or suitable habitat for listed species). Training will be conducted during preconstruction meetings so that construction personnel are aware of their responsibilities and the importance of compliance. All trainees will be required to sign a sheet indicating their attendance and completion of environmental training. The training sheets will be provided to the fish and wildlife agencies if requested. These requirements also pertain to operations and maintenance personnel working in and adjacent to suitable habitat for listed species.

Construction personnel will be educated on the types of sensitive resources located in the project area and the measures required to avoid and minimize effects on these resources. Materials covered in the training program will include environmental rules and regulations for the specific project, requirements for limiting activities to approved work areas, timing restrictions, and avoidance of sensitive resource areas. In general, trainings will include the following components.

- Important timing windows for listed species (i.e., timing of fish migration, spawning, and rearing; and wildlife mating, nesting, and fledging).
- Specific training related to the relevant mitigation measures that will be implemented during construction for the protection of listed species and their habitat.
- The legal requirements for resource avoidance and protection.
- Identification of listed species potentially affected at the worksite, which will depend upon the work to be performed and the location of the work.
- Protocol for identifying the proper mitigation measures to implement for the protection of listed species based upon the nature, timing, and location of construction activities to be performed.
- Brief discussions of listed species of concern.
- Boundaries of the work area.
- Avoidance and minimization commitments.
- Exclusion and construction fencing methods.
- Roles and responsibilities.
- What to do when listed species are encountered (dead, injured, stressed, or entrapped) in work areas.
- Penalties for noncompliance.

A fact sheet or other supporting materials containing this information will be prepared and will be distributed along with a list of contacts (names, numbers, and affiliations) prior to initiating construction activities. A representative will be appointed by the project proponent to be the primary point of contact for any employee or contractor who might inadvertently take a listed species, or a representative will be identified during the employee education program and the representative's name and telephone number provided to the fish and wildlife agencies.

If new construction personnel are added to the project, the contractor will ensure that the personnel receive the mandatory training and sign a sheet indicating their attendance and completion of the environmental training before starting work. The training sheets for new construction personnel will be provided to the fish and wildlife agencies, if requested.

Mitigation Measure AQUA-2 Construction Best Management Practices and Monitoring

All construction and operation and maintenance activities in and adjacent to suitable habitat for listed species will implement BMPs and have construction monitored by a qualified technical specialist(s). Depending on the resource of concern and construction timing, construction activities and areas will be monitored for compliance with water quality regulations (SWPPP monitoring) and with Mitigation Measures developed for sensitive biological resources (biological monitoring).

Before initiating construction, Reclamation or its designee will prepare a construction monitoring plan for the protection of listed species. The plan will include, but not be limited to, the following elements.

- Reference to or inclusion of the SWPPP prepared under the Construction General Permit (CGP), where one is needed.
- Summaries or copies of planning and preconstruction surveys (if applicable) for listed species.
- Description of Mitigation Measures to be implemented.
- Descriptions of monitoring parameters (e.g., turbidity), including the specific activities to be monitored (e.g., dredging, grading activities) and monitoring frequency and duration (e.g., once per hour during all in-water construction activities), as well as parameters and reporting criteria.
- Description of the onsite authority of the monitors to modify construction activity and protocols for notifying CDFW, NMFS, and USFWS, if needed.
- A daily monitoring log prepared by the construction monitor, which documents the day's construction activities, notes any problems identified and solutions implemented to rectify those problems, and notifies the construction superintendent and/or the fish and wildlife agencies of any exceedances of specific parameters (e.g., turbidity) or observations of listed species. The monitoring log will also document construction start/end times, weather and general site conditions, and any other relevant information.

The following measures will be implemented prior to and during performance of the proposed action, for the protection of listed species and their habitat.

- All in-water construction activities within jurisdictional waters will be conducted during the following in-water work windows:
    - Within the legal Delta and Suisun Bay/Suisun Marsh: August 1 to October 31;
    - Sacramento River upstream of the Delta:
        - Keswick Dam (RM 302) to approximately 1.5 miles downstream (Zone 1): year-round (any time flows are less than 15,000 cfs);

        - Approximately 1.5 miles downstream of Keswick Dam (RM 300.5) to Cow Creek (RM 280) (Zone 2): October 1 to May 15 (any time flows are less than 10,000 cfs; pre-construction salmonid redd surveys conducted);
        - Cow Creek (RM 280) to Red Bluff Diversion Dam (RM 243): October 1 to March 1 (any time flows are less than 10,000 cfs; pre-construction salmonid redd surveys conducted);
        - Downstream of Red Bluff Diversion Dam (RM 243) to the boundary with the legal Delta: June 1 to October 1.
    - American River:
        - July 1 to September 30.
    - Feather River:
        - August 1 to October 31.
    - Stanislaus River:
        - July 15 to October 15.
    - Other locations proposed through programmatic actions (e.g., San Joaquin River, Battle Creek):
        - To be developed through coordination with NMFS, USFWS, and DFW.
    - Note: Work windows will be refined as necessary through coordination with NMFS, USFWS, and DFW. Work windows for some activities such as pile driving may be lengthened subject to agency approval based on demonstrated success of mitigation (e.g., bubble curtains) and real-time monitoring for fish presence. In-water activities associated with mobilization and demobilization are not subject to the work windows. Apart from impact pile driving, any other work may occur within a dewatered cofferdam regardless of the timing of in-water work windows. In-water impact pile installation may occur outside of the work windows if performed within a dewatered cofferdam and with in-channel acoustic monitoring to verify that generated sound thresholds do not exceed the 150-dB behavioral criterion. Any extension/reduction of work windows would focus on half-month increments.
- To the extent possible, in-water work will only occur for up to 12 hours per day, or from at least one hour after sunrise to at least one before sunset, in order to provide a crepuscular/nocturnal time window for fish migration without disturbance. Timing of this daily in-water work window will be refined as necessary through coordination with NMFS, USFWS, and DFW.
- Qualified biologists will monitor construction activities in areas identified as having listed species or their designated critical habitat. The intent of the biological monitoring is to ensure that specific Mitigation Measures that have been integrated into the project design and permit requirements are being implemented correctly during construction and are working appropriately and as intended for the protection of listed species.
- Biological monitors will be professional biologists selected for their knowledge of the listed species that may be affected by construction activities. The qualifications of the biologist(s) will be presented to the fish and wildlife agencies for review and written approval prior to initiating construction. The biological monitors will have the authority to temporarily stop work in any area where a listed species has been observed until that individual has passively or physically been moved outside of the work area, or when any Mitigation Measures are not functioning appropriately for the protection of listed species.

- Exclusionary fencing may be placed at the edge of active construction activities and staging areas (after having been cleared by biological surveys) to restrict wildlife access from the adjacent habitats. The need for exclusionary fencing will be determined during the preconstruction surveys and the construction planning phase and may vary depending on the species and habitats present. Exclusionary fencing will consist of taut silt fabric (non-monofilament), 24 inches high (36 inches high for California red-legged frog and giant garter snake), staked at 10-foot intervals, with the bottom buried 6 inches below grade. Fence stakes will face toward the work area (on the opposite side of adjacent habitat) to prevent wildlife from using stakes to climb over the exclusionary fencing. Exclusionary fencing will be maintained such that it is intact during rain events. Fencing will be checked by the biological monitor or construction foreman periodically throughout each work day. If fencing becomes damaged, it will be immediately repaired upon detection and the monitoring biologist will stop work in the vicinity of the fencing as needed to ensure that no sensitive wildlife species have entered. Active construction and staging areas will be delineated with high-visibility temporary fencing at least 4 feet in height, flagging, or other barrier to prevent encroachment of construction personnel and equipment outside the defined project footprint. Such fencing will be inspected and maintained daily by the construction foreman until completion of the project. Fencing will be removed from work areas only after all construction activities are completed and equipment is removed. No project-related construction activities will occur outside the delineated project construction areas.
- Project-related vehicles will observe a speed limit of 20 miles per hour in construction areas where it is safe and feasible to do so, except on county roads and state and federal highways. A vehicle speed limit of 20 miles per hour will be posted and enforced on all nonpublic access roads, particularly on rainy nights when California tiger salamanders and California red-legged frogs are most likely to be moving between breeding and upland habitats. Extra caution will be used on cool days when giant garter snakes may be basking on roads.
- All ingress/egress at the project site will be restricted to those routes identified in the project plans and description.
- All vehicle parking will be restricted to established areas, existing roads, or other suitable areas.
- To avoid attracting predators, all food-related trash items such as wrappers, cans, bottles, and food scraps will be disposed of in enclosed containers and trash will be removed and disposed of at an appropriate facility at least once a week from the construction or project site.
- To avoid injury or death to wildlife, no firearms will be allowed on the project site except for those carried by authorized security personnel or local, state, or federal law enforcement officials.
- To prevent harassment, injury, or mortality of sensitive wildlife by dogs or cats, no canine or feline pets will be permitted in the construction area.
- To prevent inadvertent entrapment of wildlife during construction, all excavated, steep-walled holes or trenches more than 1 foot deep will be covered at the close of each working day with plywood or similar material, and/or provided with one or more escape ramps constructed of earth fill or wooden planks. Before such holes or trenches are filled, they will be thoroughly inspected for trapped animals. If a listed species is encountered during construction work, to the extent feasible, construction activities should be diverted away from the animal until it can be moved by a USFWS- or CDFW-approved biologist.

- Capture and relocation of trapped or injured wildlife will only be performed by personnel with appropriate USFWS and CDFW handling permits. Any sightings and any incidental take will be reported to CDFW and USFWS via email within 1 working day of the discovery. A follow-up report will be sent to these agencies, including dates, locations, habitat description, and any corrective measures taken to protect listed species encountered. For each listed species encountered, the biologist will submit a completed CNDDB field survey form (or equivalent) to CDFW no more than 90 days after completing the last field visit to the project site.
- Plastic monofilament netting or similar material will not be used for erosion control, because smaller wildlife may become entangled or trapped in it. This includes products that use photodegradable or biodegradable synthetic netting, which can take several months to decompose. Acceptable materials include natural fibers such as jute, coconut, twine, or other similar fibers or tackified hydroseeding compounds. This limitation will be communicated to the contractor through specifications or special provisions included in the construction bid solicitation package.
- Listed species of wildlife can be attracted to den-like structures such as pipes and may enter stored pipes and become trapped or injured. All construction pipes, culverts, or similar structures, construction equipment, or construction debris left overnight in areas that may be occupied by wildlife will be inspected by the biological monitor or the contractor prior to being used for construction. Such inspections will occur at the beginning of each day's activities, for those materials to be used or moved that day. If necessary, and under the direct supervision of the biologist, the structure may be moved up to one time to isolate it from construction activities, until the listed species has moved from the structure of their own volition, been captured and relocated, or otherwise been removed from the structure.
- Rodenticides and herbicides will be used in accordance with the manufacturer-recommended uses and applications and in such a manner as to prevent primary or secondary poisoning of listed species and depletion of prey populations upon which they depend. All uses of such compounds will observe label and other restrictions mandated by the U.S. Environmental Protection Agency (EPA), the California Department of Pesticide Regulation, and other appropriate state and federal regulations, as well as additional project-related restrictions imposed by USFWS, NMFS and/or CDFW. If rodent control must be conducted in San Joaquin kit fox habitat, zinc phosphide should be used because of its proven lower risk to kit fox. In addition, the method of rodent control will comply with provisions of the 4(d) rule published in the final listing rule for California tiger salamander (69 *Federal Register* [FR] 47211–47248).
- Nets or bare hands may be used to capture and handle individuals of listed species. A professional biologist will be responsible for and direct any efforts to capture and handle listed species. Any person who captures and handles listed species will not use soaps, oils, creams, lotions, insect repellents, solvents, or other potentially harmful chemicals of any sort on their hands within 2 hours before handling listed species. Latex gloves will not be used either. To avoid transferring diseases or pathogens between aquatic habitats during the course of surveys or the capture and handling of listed species, all species captured and handled will be released in a safe, aquatic environment as close to the point of capture as possible, and not transported and released to a different water body. When capturing and handling listed species of amphibians, the biologists will follow the Declining Amphibian Task Force's *Code of Practice* (U.S. Fish and Wildlife Service no date). While in captivity, individual amphibians will be kept in a cool, moist, aerated

environment such as a dark (i.e., green or brown) bucket containing a damp sponge. Containers used for holding or transporting these species will be sanitized and will not contain any standing water.

- CDFW, NMFS and/or USFWS will be notified within 1 working day of the discovery of, injury to, or mortality of a listed species that results from project-related construction activities or is observed at the project site. Notification will include the date, time, and location of the incident or of the discovery of an individual listed species that is dead or injured. For a listed species that is injured, general information on the type or extent of injury will be included. The location of the incident will be clearly indicated on a U.S. Geological Survey 7.5-minute quadrangle and/or similar map at a scale that will allow others to find the location in the field, or as requested by CDFW, NMFS and/or USFWS. The biologist is encouraged to include any other pertinent information in the notification.
- Permanent and temporary construction disturbances and other types of ongoing project-related disturbance activities in suitable habitat for listed species will be minimized by adhering to the following activities.
  - Project designs will limit or cluster permanent project features to the smallest area possible while still permitting achievement of project goals.
  - To minimize temporary disturbances, all project-related vehicle traffic and material storage will be restricted to established and/or designated ingress/egress points, construction areas, and other designated staging/storage areas. These areas will be included in preconstruction surveys and, to the extent possible, will be established in locations disturbed by previous activities to prevent further effects.
  - To the extent possible, minimize effects to sensitive habitats outside of construction footprints. For example, in upstream areas, conduct aerial or boat pre-construction redd surveys downstream of construction areas and implement avoidance and minimization measures to limit potential effects, e.g., modification of work area, turbidity management (such as a sediment curtain), or placement of a gravel berm to redirect flow away from sensitive areas.
  - Upon completion of the project, all areas subject to temporary ground disturbance will be recontoured to preproject elevations, as appropriate and necessary, and revegetated with native vegetation to promote restoration of the area to preproject conditions. An area subject to “temporary” disturbance is any area that is disturbed to allow for construction of the project, but is not required for operation or maintenance of any project-related infrastructure, will not be subject to further disturbance after project completion, and has the potential to be revegetated. Appropriate methods and native plant species used to revegetate such areas will be determined on a site-specific basis in consultation with USFWS, NMFS, and/or CDFW, and biologists.
- Equipment will be inspected prior to arrival at the construction area, including the physical removal of plant seed and parts from equipment, and freezing equipment and saturation of equipment in chemical solution(s) to avoid the spread of invasive species such as zebra and quagga mussels, New Zealand mudsnails and Chytrid Fungus.

Mitigation Measure AQUA-3: Develop and Implement Program to Expand Adult Holding, Spawning, Egg Incubation, and Fry/Juvenile Rearing Habitat.

Reclamation will develop and implement a program to expand suitable adult holding, spawning, egg incubation, and fry/juvenile rearing habitat for Central Valley Spring-Run Chinook Salmon, Fall-/Late Fall-Run Chinook Salmon, and Central Valley Steelhead elsewhere in the Northwestern California Diversity Group. The program will be designed to prevent hybridization and improve genetic integrity of Spring-Run Chinook Salmon, and to improve spawning success, fry/juvenile survival, and production of all three species, thereby contributing to their recovery. Increases in Salmon and Steelhead production potential created by the program will equal or exceed the reduced production potential in Clear Creek that would result from cessation of the Clear Creek Restoration Program and reduced flows below Whiskeytown Dam. The program will be developed in coordination with and subject to approval by NMFS and CDFW.

Mitigation Measure AQUA-4: Erosion and Sediment Control Plan

An erosion and sediment control plan is typically required for ground-disturbing projects as part of the NPDES permitting process (U.S. Environmental Protection Agency 2007), depending on the size of the disturbed area. The proposed Phase II EPA rules would cover projects with greater than 1 acre of ground disturbance. Reclamation commits to implementing measures as described below as part of the construction activities and in advance of any necessary permit. In accordance with these environmental commitments, Reclamation will ensure the preparation and implementation of erosion and sediment control plans to control short-term and long-term erosion and sedimentation effects and to restore soils and vegetation in areas affected by construction activities. It is anticipated that multiple erosion and sediment control plans will be prepared for the construction activities included in the proposed action, each taking into account site-specific conditions such as proximity to surface water, erosion potential, drainage, etc. The plans will include all the necessary state requirements regarding erosion control and will implement BMPs for erosion and sediment control that will be in place for the duration of construction activities. These BMPs will be incorporated into the SWPPP (Section 3.F.1.1.1, *Conduct Planning-Level Surveys*).

The following erosion control measures will be included in the SWPPP.

- Install physical erosion control stabilization BMPs (hydroseeding with native seed mix, mulch, silt fencing, fiber rolls, sand bags, and erosion control blankets) to capture sediment and control both wind and water erosion. Erosion control may not utilize plastic monofilament netting or similar materials.
- Maintain emergency erosion control supplies onsite at all times during construction and direct contractor(s) to use these emergency stockpiles as needed. Ensure that supplies used from the emergency stockpiles are replaced within 48 hours. Remove materials used in construction of erosion control measures from the work site when no longer needed (property of the contractor).
- Design grading to be compatible with adjacent areas and result in minimal disturbance of the terrain and natural land features and minimize erosion in disturbed areas to the extent practicable.
- Divert runoff away from steep, denuded slopes, or other critical areas with barriers, berms, ditches, or other facilities.
- Retain native trees and vegetation to the extent feasible to stabilize hillsides, retain moisture, and reduce erosion.

- Limit construction, clearing of native vegetation, and disturbance of soils to areas of proven stability.
- Implement construction management and scheduling measures to avoid exposure to rainfall events, runoff, or flooding at construction sites to the extent feasible.
- Conduct frequent site inspections (before and after significant storm events) to ensure that control measures are intact and working properly and to correct problems as needed.
- Install drainage control features (e.g., berms and swales, slope drains) as necessary to avoid and minimize erosion.
- Install wind erosion control features (e.g., application of hydraulic mulch or bonded fiber matrix).

The following sediment control measures will be included in the SWPPP.

- Use sediment ponds, silt traps, wattles, straw bale barriers, or similar measures to retain sediment transported by onsite runoff.
- Collect and direct surface runoff at non-erosive velocities to the common drainage courses.
- When ground-disturbing activities are required adjacent to surface water, wetlands, or aquatic habitat, use of sediment and turbidity barriers, and implement measures for soil stabilization and revegetation of disturbed surfaces.
- Prevent mud from being tracked onto public roadways by installing gravel on primary construction ingress/egress points, and/or truck tire washing.
- Deposit or store excavated materials away from drainage courses and cover if left in place for more than 5 days or if storm events are forecast within 48 hours.

After construction is complete, site-specific restoration efforts will include grading, erosion control, and revegetation. Self-sustaining, local native plants that require little or no maintenance and do not create an extreme fire hazard will be used. All disturbed areas will be recontoured to preproject contours as feasible, and seeded with a native seed mix. Consideration will also be given to additional replacement of or upgrades to drainage facilities to avoid and minimize erosion. Paved areas damaged from use over and above ordinary wear-and-tear from lawful use by construction activities will be repaved to avoid erosion due to pavement damage.

Mitigation Measure AQUA-5: Spill Prevention, Containment, and Countermeasure Plan

As required by local, state, or federal regulations, Reclamation will require that construction contractors develop an SPCC plan for implementation at each site where ground-disturbing activities occur. Each SPCC plan will comply with the regulatory requirements of the Spill Prevention, Control, and Countermeasure Rule (40 Code of Federal Regulations [CFR] 112) under the Oil Pollution Act of 1990. This rule regulates non-transportation-related onshore and offshore facilities that could reasonably be expected to discharge oil into navigable waters of the United States or adjoining shorelines. The rule requires the preparation and implementation of site-specific SPCC plans to prevent and respond to oil discharges that could affect navigable waters. Each SPCC plan will address actions used to prevent spills in addition to specifying actions that will be taken should any spills occur, including emergency notification procedures. The SPCC plans will include the following measures and practices.

- Discharge prevention measures will include procedures for routine handling of products (e.g., loading, unloading, and facility transfers) (*40 CFR 112.7(a)(3)(i)*).
- Discharge or drainage controls will be implemented such as secondary containment around containers and other structures and equipment, and procedures for the control of a discharge (*40 CFR 112.7(a)(3)(ii)*).
- Countermeasures will be implemented for discharge discovery, response, and cleanup (both the facility's capability and those that might be required of a contractor) (*40 CFR 112.7(a)(3)(iii)*).
- Methods of disposal of recovered materials will comply with applicable legal requirements (*40 CFR 112.7(a)(3)(iv)*).
- Personnel will be trained in emergency response and spill containment techniques, and will also be made aware of the pollution control laws, rules, and regulations applicable to their work.
- Petroleum products will be stored in nonleaking containers at impervious storage sites from which an accidental spill cannot escape.
- Absorbent pads, pillows, socks, booms, and other spill containment materials will be stored and maintained at the hazardous materials storage sites for use in the event of an accidental spill.
- Watertight forms and other containment structures will be used to prevent spills or discharge of raw concrete, wash water, and other contaminants from entering surface waters and other sensitive habitats during overwater activities (e.g., casting of barge decks).
- Contaminated absorbent pads, pillows, socks, booms, and other spill containment materials will be placed in nonleaking sealed containers until transported to an appropriate disposal facility.
- When transferring oil or other hazardous materials from trucks to storage containers, absorbent pads, pillows, socks, booms, or other spill containment material will be placed under the transfer area.
- Refueling of construction equipment will occur only in designated areas that will be a minimum of 150 feet from surface waters and other sensitive habitats, such as wetlands.
- Equipment used in direct contact with water will be inspected daily for oil, grease, and other petroleum products. All equipment will be cleaned of external petroleum products prior to beginning work where contact with water may occur in order to prevent the release of such products to surface waters.
- Oil-absorbent booms will be used when equipment is used in or immediately adjacent to waters.
- All reserve fuel supplies will be stored only within the confines of a designated staging area, to be located a minimum of 150 feet from surface waters and other sensitive habitats, such as wetlands.
- Fuel transfers will take place a minimum of 150 feet from surface waters and other sensitive habitats, such as wetlands, and absorbent pads will be placed under the fuel transfer operation.
- Staging areas will be designed to contain contaminants such as oil, grease, fuel, and other petroleum products so that should an accidental spill occur they do not drain toward receiving waters or storm drain inlets.

- All stationary equipment will be staged in appropriate staging areas and positioned over drip pans.
- In the event of an accidental spill, personnel will identify and secure the source of the discharge and contain the discharge with sorbents, sandbags, or other material from spill kits and will contact appropriate regulatory authorities (e.g., National Response Center will be contacted if the spill threatens navigable waters of the United States or adjoining shorelines, as well as other appropriate response personnel).

Methods of cleanup may include the following.

- Physical methods for the cleanup of dry chemicals include the use of brooms, shovels, sweepers, or plows.
- Mechanical methods could include the use of vacuum cleaning systems and pumps.
- Chemical methods include the use of appropriate chemical agents such as sorbents, gels, and foams.

Mitigation Measure AQUA-6: Disposal of Spoils and Dredged Material

In the course of constructing or operating project facilities, substantial quantities of material are likely to be removed from their existing locations based upon their properties or the need for excavation of particular features. Spoils refer to excavated native soils and are associated with construction of proposed new facilities. Dredged material refers to sediment removed from the bottom of a body of water for the purposes of in-water construction. The quantities of these materials generated by construction or operation of proposed facilities will vary based on various factors, such as location, topography, and structure being constructed. These materials will require handling, storage, and disposal, as well as chemical characterization. Storage areas are designated for these materials. Many of these materials will be suitable for reuse (e.g., as engineered fill or for purposes of habitat restoration), but such use is not part of the PA and projects using this material have not been identified.

Storage Area Determination

Spoils and dredged material will be stored in designated storage areas, with these locations to be provided by Reclamation during consultation with NMFS and USFWS.

The designated storage areas are sized to accommodate all material expected to be generated by the proposed action, i.e., it is assumed that none of that material will be reused, sold, or otherwise relocated under the proposed action. In practice, the area that will be needed for material storage will depend on several factors.

- The speed with which material is brought to the surface, stored, dried, tested, and moved to storage locations will be important in determining the final size of storage areas. If alternative end uses for the material can be identified and if those uses can be permitted within the timeframe of the proposed action (such permitting is not included in the proposed action, so separate authorizations would have to be obtained), then a smaller area may be needed for material storage.
- The depth to which the material is stacked. Material that is stored in deeper piles will require less area but may dry more slowly. Calculation of needed materials storage areas has assumed that materials would be placed in piles with a depth of six feet.

Storage Site Preparation

A portion of the storage sites selected for storage of spoils and dredged material will be set aside for topsoil storage. The topsoil will be saved for reapplication to disturbed areas postconstruction. Vegetative material from work site clearing will be chipped, stockpiled, and spread over the topsoil after earthwork is completed, when practicable and appropriate to do so and where such material does not contain seeds of undesirable nonnative species (i.e., nonnative species that are highly invasive and threaten the ecological function of the vegetation community to be restored in that location). Cleared areas will be grubbed as necessary to prepare them for grading or other construction activities. Rocks and other inorganic grubbed materials will be used to backfill borrow areas. The contractor will remove from the work site all debris, rubbish, and other materials not directed to be salvaged, and will dispose of them in an approved disposal site after obtaining all permits required.

Draining, Chemical Characterization, and Treatment

In instances of spoils and dredged material being deemed unsuitable for reuse, the material will be disposed of at a site for which disposal of such material is approved.

Hazardous materials excavated during construction will be segregated from other construction spoils and properly handled in accordance with applicable federal, state, and local regulations. Riverine or in-Delta sediment dredging and dredged material disposal activities may involve potential contaminant discharges not addressed through typical NPDES or SWRCB CGP processes. Construction of dredge material disposal sites will likely be subject to the SWRCB General Permit (Order No. 2009-0009-DWQ).

To better define potential effects to listed species or aquatic habitat, and to streamline the collection and incorporation of newer information (i.e., monitoring data or site-specific baseline information), the following protocol will be followed. Reclamation will work with State and Federal resource agencies with authorization and jurisdiction to identify the timeline for information gathering in relation to initiation of the specific action, but it is anticipated to be at least several months prior to the initiation of the action. At that time, Reclamation will follow the protocol below.

- Reclamation will ensure the preparation and implementation of a pre-dredge sampling and analysis plan (SAP). The SAP will be developed and submitted by the contractor(s) as part of the water plan required per standard DWR contract specifications (Section 01570). Prior to initiating any dredging activity, the SAP will evaluate the presence of contaminants that may affect water quality from the following discharge routes.
    - Instream discharges during dredging.
    - Direct exposure to contaminants in the material through ingestion, inhalation, or dermal exposure.
    - Effluent (return flow) discharge from an upland disposal site.
    - Leachate from upland dredge material disposal that may affect groundwater or surface water.
- Concentrations of the identified chemical constituents in the core samples will be screened through appropriate contaminant screening tables to ensure compliance with applicable agency guidelines.
- Results of the sediment analyses and the quality guidelines screening will determine the risk associated with the disturbance of the sediment horizons by identifying specific pathways of exposure to adverse effects.

- Results of the testing will be provided to all relevant State and Federal agencies for their use in monitoring or regulating the activities under consideration.
- If the results of the chemical analyses of the sediment samples indicate that one or more chemical constituents are present at concentrations exceeding screening criteria, then additional alternative protocols to further minimize or eliminate the release of sediments into the surrounding water column must be implemented.
- The applicant must provide to CDFW, NMFS and USFWS a plan to reduce or eliminate the release of contaminated sediment prior to the start of any actions that will disturb the sediments in the proposed construction area. Plans using a shrouded hydraulic cutterhead, or an environmentally sealed clamshell bucket may be acceptable provided that adequate supporting information is provided with the proposed plan. Plans should also include descriptions of the methods employed to treat, transport, and dispose of the contaminated sediment, as well as any resulting decant waters.

The following list of BMPs will be implemented during handling and disposal of any potentially hazardous dredged material.

- Conduct dredging within the allowable in-water work windows specified in Mitigation Measure AQUA-2 *Construction Best Management Practices*.
- Conduct dredging activities in a manner that will not cause turbidity in the receiving water, as measured in surface waters 300 feet down-current from the construction site, to exceed the Basin Plan objectives beyond an approved averaging period by the Central Valley Regional Water Quality Control Board and CDFW. Existing threshold limits in the Basin Plan for turbidity generation are as follows.
    - Where natural turbidity is between 0 and 5 NTUs, increases will not exceed 1 NTU.
    - Where natural turbidity is between 5 and 50 NTUs, increases will not exceed 20%.
    - Where natural turbidity is between 50 and 100 NTUs, increases will not exceed 10 NTUs.
    - Where natural turbidity is greater than 100 NTUs, increases will not exceed 10%.
- If turbidity generated during dredging exceeds implementation requirements for compliance with the Basin Plan objectives, silt curtains will be used to control turbidity. Exceptions to turbidity limits set forth in the Basin Plan may be allowed for dredging operations; in this case, an allowable zone of dilution within which turbidity exceeds the limits will be defined and prescribed in a discharge permit.
- The dredged material disposal sites will be designed to contain all of the dredged material. All systems and equipment associated with necessary return flows from the dredged material disposal site to the receiving water will be operated to maximize treatment of return water and optimize the quality of the discharge.
- The dredged material disposal sites will be designed by a registered professional engineer.
- The dredged material disposal sites will be designed, constructed, operated, and maintained to prevent inundation or washout due to floods with a 100-year return frequency.

- Two feet of freeboard above the 100-year flood event elevation will be maintained in all dredged material disposal site settling ponds at all times when they may be subject to washout from a 100-year flood event.
- Dredging equipment will be kept out of riparian areas and dredged material will be disposed of outside of riparian corridors.

Temporary storage sites will be constructed using appropriate BMPs such as erosion and sediment control measures (Mitigation Measure AQUA-*4 Erosion and Sediment Control Plan*) to prevent discharges of contaminated stormwater to surface waters or groundwater.

Once the excavated spoils or dredged material have been suitably dewatered, and as the constituents of the material will allow, it will be placed in either a lined or unlined storage area suitable for long-term storage. These long-term storage areas may be the same areas in which the material was previously dewatered or it may be a new area adjacent to the dewatering site. The storage areas will be created by excavating and stockpiling the native topsoil for future reuse. Once the area has been suitably excavated, and if a lined storage area is required, an impervious liner will be placed on the invert of the material storage area and along the interior slopes of the berms surrounding the pond. Due to the expected high groundwater tables at some storage areas, it is anticipated that there will be minimal excavation for construction of the long-term material storage areas. Additional features of the long-term material storage areas will include berms and erosion protection measures to contain storm runoff as necessary and provisions to allow for truck traffic during construction.

Mitigation Measure AQUA-7: Fish Rescue and Salvage Plan

Fish rescue operations will occur at any in-water construction site where dewatering and resulting isolation of fish may occur, or where fish exclusion netting is placed to exclude fish. Fish rescue and salvage plans will be developed by Reclamation or its contractors and will include detailed procedures for fish rescue and salvage to minimize the number of individuals of listed fish species subject to stranding during placement and removal of cofferdams or enclosure by exclusion netting. The plans will identify the appropriate procedures for removing fish from construction zones and preventing fish from reentering construction zones prior to dewatering and other construction activities. A draft plan will be submitted to the fish and wildlife agencies for review and approval. An authorization letter from NMFS, USFWS, and CDFW will be required before in-water construction activities with the potential for stranding fish can proceed.

Some construction activities may involve placement of cofferdams to isolate construction areas and minimize adverse effects to aquatic species and habitat during construction activities. However, these species can become trapped within the cofferdam and will need to be rescued or salvaged prior to dewatering. Although the following discussion focuses primarily on the application of this plan to cofferdam construction, the plan will also need to describe potential fish protection methods that may be implemented during other in-water activities with the potential to trap fish. For example, potential measures to exclude fish from active dredging areas may include deployment of silt curtains in a manner that directs fish away from the silt curtains and prevents fish from re-entering these areas during dredging operations. To the extent possible, fish will be gently encouraged (e.g., swept with seine nets; see below) to leave any areas that are scheduled to be dewatered or otherwise disturbed.

All fish rescue and salvage operations will be conducted under the guidance of a qualified fish biologist and in accordance with required permits. Each fish rescue plan will identify the appropriate procedures for excluding fish from the construction zones, and procedures for removing fish, should they become trapped. The primary procedure will be to block off the construction area and use seines (nets) and/or dip nets to collect and remove fish, although electrofishing techniques may also be authorized under certain conditions. It is critical that fish rescue and salvage operations begin as soon as possible and be completed within 48 hours after isolation of a construction area to minimize potential predation and adverse water quality impacts (high water temperature, low dissolved oxygen) associated with confinement. In the case of cofferdam construction, the cofferdam will be installed to block off the construction area before fish removal activities occur. For other in-water construction activities, block nets or other temporary exclusion methods (e.g., silt curtains) could be used to exclude fish or isolate the construction area prior to the fish removal process. The appropriate fish exclusion or collection method will be determined by a qualified fish biologist, in consultation with a designated fish and wildlife agency biologist, based on site-specific conditions and construction methods. Capture, release, and relocation measures will be consistent with the general guidelines and procedures set forth in Part IX of the most recent edition of the California Salmonid Stream Habitat Restoration Manual (currently, California Department of Fish and Game 2010) to minimize impacts on listed species of fish and their habitat.

All fish rescue and salvage operations will be conducted under the guidance of a fish biologist meeting the qualification requirements of Section 3.F.2.8.1 Qualifications of Fish Rescue Personnel. The following description includes detailed fish collection, holding, handling, and release procedures of the plan. Unless otherwise required by project permits, the construction contractor will provide the following:

- A minimum 7-day notice to the appropriate fish and wildlife agencies, prior to an anticipated activity that could result in isolating fish, such as installation of a cofferdam.
- A minimum 48-hour notice to the appropriate fish and wildlife agencies of dewatering activities that are expected to require fish rescue.
- Unrestricted access for the appropriate fish and wildlife agency personnel to the construction site for the duration of implementation of the fish rescue plan.
- Temporary cessation of dewatering if fish rescue workers determine that water levels may drop too quickly to allow successful rescue of fish.
- A work site that is accessible and safe for fish rescue workers.

Qualifications of Fish Rescue Personnel

Personnel active in fish rescue efforts will include at least one person with a 4-year college degree in fisheries or biology, or a related degree. This person also must have at least 2 years of professional experience in fisheries field surveys and fish capture and handling procedures. The person will have completed an electrofishing training course such as Principles and Techniques of Electrofishing (USFWS, National Conservation Training Center), or similar course, if electrofishing is used. In order to avoid and minimize the risk of injury to fish, attempts to seine and/or net fish will always precede the use of electrofishing equipment.

Seining and Dipnetting

Fish rescue and salvage operations will begin prior to or immediately after completing the cofferdam. For example, it may be necessary to herd fish from the construction area before installing the last sections of the cofferdam. Where larger areas are being enclosed by cofferdams, fish exclusion and/or rescue activities may need to be conducted incrementally in coordination with cofferdam placement to minimize the number of fish subjected to prolonged confinement and stressful conditions associated with crowding, capture, and handling. If the enclosed area is wadable (less than 3 feet deep), fish can be herded out of the cofferdam enclosure by dragging a seine (net) through the enclosure, starting from the enclosed end and continuing to the cofferdam opening. Depending on conditions, this process may need to be conducted several times. After completing this fish herding process, the net or an exclusion screen will be positioned at the cofferdam opening to prevent fish from reentering the enclosure while the final section of the cofferdam is installed. The net or screen mesh will be no greater than 0.125 inch, with the bottom edge of the net (lead line) securely weighted down to prevent fish from entering the area by moving under the net. Screens will be checked periodically and cleaned of debris to permit free flow of water.

After installing the last sections of the cofferdam, remaining fish in the enclosed area will be removed using seines, dip nets, electrofishing techniques, or a combination of these depending on site conditions. If the water depth within the cofferdam is too deep to effectively remove fish using these methods, dewatering activities may be used to reduce the water level to an appropriate and safe depth (Section 3.F.2.8.5, *Contingency Plans*). Dewatering activities will also conform to the guidelines specified below (Section 3.F.2.8.4, *Dewatering*).

Following each sweep of a seine through the enclosure, the fish rescue team will do the following.

- Carefully bring the ends of the net together and pull in the wings, ensuring the lead line is kept as close to the substrate as possible.
- Slowly turn the seine bag inside out to reveal captured fish, ensuring fish remain in the water as long as possible before transfer to an aerated container.
- Follow the procedures outlined in Section 3.F.2.8.3, *Electrofishing*, and relocate fish to a predetermined release site.

Dipnetting is best suited for very small, shallow pools in which fish are concentrated and easily collected. Dip nets will be made of soft (nonabrasive) nylon material and small mesh size (0.125 inch) to collect small fish.

Electrofishing

After conducting the herding and netting operations described above, electrofishing may be necessary to remove as many fish as possible from the enclosure. Electrofishing will be conducted in accordance with NMFS electrofishing guidelines (National Marine Fisheries Service 2000) and other appropriate fish and wildlife agency guidelines. Electrofishing will be conducted by one or two 3- to 4-person teams, with each team having an electrofishing unit operator and two or three netters. At least three passes will be made through the enclosed cofferdam areas to remove as many fish as possible. Fish initially will be placed in 5-gallon buckets filled with river water. Following completion of each pass, the electrofishing team will do the following.

- Transfer fish into 5-gallon buckets filled with clean river water at ambient temperature.
- Hold fish in 5-gallon buckets equipped with a lid and an aerator, and add fresh river water or small amounts of ice to the fish buckets if the water temperature in the buckets becomes more than 2°F warmer than ambient river waters.
- Maintain a healthy environment for captured fish, including low densities in holding containers to avoid effects of overcrowding.
- Use water-to-water transfers whenever possible.
- Release fish at predetermined locations.
- Segregate larger fish from smaller fish to minimize the risk of predation and physical damage to smaller fish from larger fish.

- Limit holding time to about 10 minutes, if possible.
- Avoid handling fish during processing unless absolutely necessary. Use wet hands or dip nets if handling is needed.
- Handle fish with hands that are free of potentially harmful products, including but not limited to sunscreen, lotion, and insect repellent.
- Avoid anesthetizing or measuring fish.
- Note the date, time, and location of collection; species; number of fish; approximate age (e.g., young-of-the-year, yearling, adult); fish condition (dead, visibly injured, healthy); and water temperature.
- If positive identification of fish cannot be made without handling the fish, note this and release fish without handling.
- In notes, indicate the level of accuracy of visual estimates to allow appropriate reporting to the appropriate fish and wildlife agencies (e.g., “Approx. 10–20 young-of-the-year steelhead”).
- Release fish in appropriate habitat either upstream or downstream of the enclosure, noting release date, time, and location.
- Stop efforts and immediately contact the appropriate fish and wildlife agencies if mortality during relocation or the limits on take (harm or harassment) of federally listed species exceeds 5%.
- Place dead fish of listed species in sealed plastic bags with labels indicating species, location, date, and time of collection, and store them on ice.
- Freeze collected dead fish of listed species as soon as possible and provide the frozen specimens to the appropriate fish and wildlife agencies, as specified in the permits.
- Sites selected for release of rescued fish either upstream or downstream of the construction area will be similar in temperature to the area from which fish were rescued, contain ample habitat, and have a low likelihood of fish reentering the construction area or being impinged on exclusion nets/screens.

Dewatering

Dewatering will be performed in coordination with fish rescue operations as described above. A dewatering plan will be submitted as part of the SWPPP/Water Pollution Control Program detailing the location of dewatering activities, equipment, and discharge point. Dewatering pump intakes will be screened to prevent entrainment of fish in accordance with NMFS screening criteria for salmonid fry (National Marine Fisheries Service 1997), including the following.

- Perforated plate: screen openings shall not exceed 3/32 inch (2.38 mm), measured in diameter.
- Profile bar: screen openings shall not exceed 0.0689 inch (1.75 mm) in width.
- Woven wire: screen openings shall not exceed 3/32 inch (2.38 mm), measured diagonally (e.g., 6–14 mesh).
- Screen material shall provide a minimum of 27% open area.

During the dewatering process, a qualified biologist or fish rescue team will remain onsite to observe the process and remove additional fish using the rescue procedures described above.

Contingency Plans

Where fish rescue and salvage operations cannot be conducted effectively or safely by fish rescue workers, it may be necessary to begin the dewatering process prior to fish rescue. During the dewatering process, a qualified biologist or fish rescue team will be onsite with the aim of minimizing the number of fish that become trapped in isolated areas or impinged on pump screen(s) or isolation nets, based on the professional judgment of the onsite fish biologist and the terms and conditions of the incidental take permit. In the event that the proposed methods are found to be insufficient to avoid undue losses of fish, the qualified biologist will modify these methods or implement alternative methods to minimize subsequent losses.

Final Inspections and Reporting

Upon dewatering to water depths at which neither electrofishing nor seining can effectively occur (e.g., less than 3 inches [0.1 meter]), the fish rescue team will inspect the dewatered areas to locate any remaining fish. Collection by dip net, data recording, and relocation will be performed as necessary according to the procedures outlined in Section 3.F.2.8.3, *Electrofishing*. The fish rescue team will notify the contractor when the fish rescue has been completed and construction can recommence. The results of the fish rescue and salvage operations (including date, time, location, comments, method of capture, fish species, number of fish, approximate age, condition, release location, and release time) will be reported to the appropriate fish and wildlife agencies, as specified in the pertinent permits**.**

Mitigation Measure AQUA-8: Underwater Sound Control and Abatement Plan

Reclamation will develop and implement an underwater sound control and abatement plan outlining specific measures that will be implemented to avoid and minimize the effects of underwater construction noise on listed species of fish, particularly the underwater noise effects associated with impact pile driving activities. Potential underwater noise effects on listed species from impact pile driving will be avoided and minimized by regulating the period during which impact pile driving is permitted and by controlling and/or abating underwater noise generated during impact pile driving.

The underwater sound control and abatement plan will be provided to the appropriate fish and wildlife agencies for their review and approval prior to implementation of any in-water impact pile driving activities. The plan will evaluate the potential effects of underwater noise on listed species of fish in the context of applicable and interim underwater noise thresholds established for disturbance and injury of fish (California Department of Transportation 2009). The thresholds include the following.

- Injury threshold for fish of all sizes includes a peak sound pressure level of 206 decibels (dB) relative to 1 micropascal.
- Injury threshold for fish less than 2 grams is 183 dB relative to 1 micropascal cumulative sound exposure level, and 187 dB relative to 1 micropascal cumulative sound exposure level for fish greater than or equal to 2 grams.
- Disturbance threshold for fish of all sizes is 150 dB root mean square relative to 1 micropascal.

The specific number of pilings that will be driven per day with an impact pile driver, and thus the number of pile strikes per day, will be defined as part of the design of project elements that require pilings.

The sound control and abatement plan will restrict in-water work to the in-water work windows specified in specified in Mitigation Measure AQUA-2 *Construction Best Management Practices*.

The underwater noise generated by impact pile driving will be abated using the best available and practicable technologies. Examples of such technologies include, but are not limited to, the use of cast-in-drilled-hole rather than driven piles; use of vibratory rather than impact pile driving equipment; using an impact pile driver to proof piles initially placed with a vibratory pile driver; noise attenuation using pile caps (e.g., wood or micarta), bubble curtains, air-filled fabric barriers, or isolation piles; or installation of piling-specific cofferdams. Specific techniques to be used will be selected based on site-specific conditions.

In addition to primarily using vibratory pile driving methods and establishing protocols for attenuating underwater noise levels produced during in-water construction activities, Reclamation will develop and implement operational protocols for when impact pile driving is necessary. These operational protocols will be used to minimize the effects of impact pile driving on listed species of fish. These protocols may include, but not be limited to, the following: monitoring the in-water work area for fish that may be showing signs of distress or injury as a result of pile driving activities and stopping work when distressed or injured fish are observed; initiating impact pile driving with a "soft-start," such that pile strikes are initiated at reduced impact and increase to full impact over several strikes to provide fish an opportunity to move out of the area; restricting impact pile driving activities to specific times of the day and for a specific duration to be determined through coordination with the fish and wildlife agencies; and, when more than one pile driving rig is employed, ensure pile driving activities are initiated in a way that provides an escape route and avoids "trapping" fish between pile drivers in waters exposed to underwater noise levels that could potentially cause injury. These protocols are expected to avoid and minimize the overall extent, intensity, and duration of potential underwater noise effects associated with impact pile driving activities.

Mitigation Measure AQUA-9: Methylmercury Management

Tidal and other habitat restoration under the proposed action has the potential to result in increased availability of mercury, and specifically the bioavailable form methylmercury, to the foodweb in the Delta and river systems where restoration would occur. Due to the complex and very site-specific factors that will determine if mercury becomes mobilized into the foodweb, Mitigation Measure AQUA-9 *Methylmercury Management* is included to provide for site-specific evaluation for each restoration project. Mitigation Measure AQUA-9 will be implemented in coordination with other similar efforts to address mercury in the Delta and other waterways, and specifically with the DWR Mercury Monitoring and Analysis Section, as further described below.

This Mitigation Measure will promote the following actions.

- Assessment of pre-restoration conditions to determine the risk that the project could result in increased mercury methylation and bioavailability
- Definition of design elements that minimize conditions conducive to generation of methylmercury in restored areas
- Definition of strategies that can be implemented to monitor and minimize actual postrestoration creation and mobilization of methylmercury into environmental media and biota

The restoration design will always focus on the ecosystem restoration objectives and design elements to mitigate mercury methylation that will not interfere with restoration objectives. Design elements that help to mitigate mercury methylation will be integrated into site-specific restoration designs based on site conditions, community type (tidal marsh, nontidal marsh, floodplain, riverine habitats), and potential concentrations of mercury in pre-restoration sediments. Strategies to minimize postrestoration creation and mobilization of methylmercury can be applied where site conditions indicate a high probability of methylmercury generation and effects on listed species.

Implementation

Mitigation Measure AQUA-9 will be developed and implemented in coordination with the Sacramento-San Joaquin Delta Methylmercury Total Maximum Daily Load (Methylmercury TMDL) (Central Valley Regional Water Quality Control Board 2011a) and Amendments to 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 Delta Estuary (Mercury Basin Plan Amendments)(Central Valley Regional Water Quality Control Board 2010 and 2011). Mitigation Measure AQUA-9 will also be implemented to meet requirements of the U.S. Environmental Protection Agency (EPA) or the California Department of Toxic Substances Control actions.

The DWR Mercury Monitoring and Evaluation Section is currently working on DWR's compliance with the Methylmercury TMDL and Mercury Basin Plan Amendments. The Methylmercury TMDL programs are responsible for developing measures to control methylmercury generation and loading into the Delta in accordance with Methylmercury TMDL goals. Phase I emphasizes studies and pilot projects to develop and evaluate management practices to control methylmercury. Phase I (effective October 2011) will be underway for the next 7 years, with an additional 2 years to evaluate Phase I results and plan for Phase II. Phase II involves implementation of mercury control measures.

The DWR Mercury Monitoring and Evaluation Section is required as part of Phase I to submit final reports that present the results and descriptions of methylmercury control options, their preferred methylmercury controls, and proposed methylmercury management plan(s) (including implementation schedules) for achieving methylmercury allocations. Results will be integrated into Project-Specific Mercury Management Plans, which will be developed for each tidal wetland restoration project. The Plans will include the components listed below.

- A brief review of available information on levels of mercury expected in site sediments/soils based on proximity to sources and existing analytical data.
- A determination if sampling for characterization of mercury concentrations
- A plan for conducting the sampling, if characterization sampling is recommended.
- A determination of the potential for the restoration action to result in increased mercury methylation
- If a potential for increased mercury methylation under the restoration action is identified, the following will also be included:
    - Identification of any restoration design elements, mitigation measures, adaptive management measures that could be used to mitigate mercury methylation, and the probability of success of those measures, including uncertainties
    - Conclusion on the resultant risk of increased mercury methylation, and if appropriate, consideration of alternative restoration areas

Because methylmercury is an area of active research in the Delta and elsewhere in the Central Valley, each new project-specific methylmercury management plan will be updated based on the latest information about the role of mercury in Delta and other ecosystems or methods for its characterization or management. Results from monitoring of methylmercury in previous restoration projects will also be incorporated into subsequent project-specific methylmercury management plans.

In each of the project-specific methylmercury management plans developed under Mitigation Measure AQUA-9, relevant findings and mercury control measures identified as part of TMDL Phase I control studies will be considered and integrated into restoration design and management plans.

Mitigation Measure AQUA-10: Noise Abatement

In addition to the underwater sound control and abatement plan (Mitigation Measure AQUA-8), Reclamation and contractors hired to construct any components of proposed facilities will implement a noise abatement plan to avoid or reduce potential in-air noise impacts related to construction, maintenance, and operations. As applicable, the following components will be included in the plan.

Construction and Maintenance Noise

- To the extent feasible, the contractor will employ best practices to reduce construction noise during daytime and evening hours (7:00 a.m. to 10:00 p.m.) such that construction noise levels do not exceed 60 dBA (A-weighted decibel) L_{eq} (1 hour) at the nearest residential land uses.
- Limit construction during nighttime hours (10:00 p.m. to 7:00 a.m.) such that construction noise levels do not exceed 50 dBA L_{max}[1] at the nearest residential land uses. Limit pile driving to daytime hours (7 a.m. to 7 p.m.).
- In the event of complaints by nearby residents due to construction noise generated during nighttime hours, the contractor will monitor noise levels intermittently between 10:00 p.m. to 7:00 a.m. at the property line of the nearest residential use. In the event that construction noise during nighttime hours exceeds 50 dBA L_{max}, the construction contractor will cease nighttime construction activity in the area until sound-attenuating mitigation measures, such as temporary sound walls, are implemented, and nighttime construction noise at the nearest residential use is reduced to a level of 50 dBA L_{max}or lower.
- Locate, store, and maintain portable and stationary equipment as far as possible from nearby residents.
- Employ preventive maintenance including practicable methods and devices to control, prevent, and minimize noise.
- Route truck traffic in order to reduce construction noise impacts and traffic noise levels at noise-sensitive land uses (i.e., places where people reside, schools, libraries, and places of worship).
- To the extent feasible, schedule construction activities so that the loudest noise events, such as blasting, occur during peak traffic commute hours.
- Limit offsite trucking activities (e.g., deliveries, export of materials) to the hours of 7:00 a.m. to 10:00 p.m. to minimize impacts on nearby residences.

Operation Noise

Facilities will be designed and constructed such that facility operation noise levels at nearby residential land uses do not exceed 50 dBA L_{eq} during daytime hours (7:00 a.m. to 10:00 p.m.) and 45 dBA L_{eq} during nighttime hours (10 p.m. to 7 a.m.). Acoustical measures such as terrain shielding,

[1] L_{max} is the maximum sound level measured for a given interval of time.

enclosures, and acoustical building treatments will be incorporated into the facility design to meet this performance standard.

Mitigation Measure AQUA-11: Hazardous Materials Management

Reclamation will ensure that each contractor responsible for site work under the proposed action will develop and implement a hazardous materials management plan (HMMP) before beginning construction. It is anticipated that multiple HMMPs will be prepared for the various construction sites, each taking into account site-specific conditions such as hazardous materials present onsite and known historical site contamination. A database on historical instances of contamination and results of any field inspections regarding the presence of hazardous chemicals will be maintained. The HMMPs will provide detailed information on the types of hazardous materials used or stored at all sites associated with the water conveyance facilities (e.g., intake pumping plants, maintenance facilities); phone numbers of applicable city, county, state, and federal emergency response agencies; primary, secondary, and final cleanup procedures; emergency-response procedures in case of a spill; and other applicable information. The HMMPs will include appropriate practices to reduce the likelihood of a spill of toxic chemicals and other hazardous materials during construction and facilities operation and maintenance. A specific protocol for the proper handling and disposal of hazardous materials will be established before construction activities begin and will be enforced by Reclamation.

The HMMPs will include, but not be limited to, the following measures or practices.

- Fuel, oil, and other petroleum products will be stored only at designated sites.
- Hazardous materials containment containers will be clearly labeled with the identity of the hazardous materials contained therein, handling and safety instructions, and emergency contact.
- Storage, use, or transfer of hazardous materials in or near wet or dry streams will be consistent with California Fish and Game Code (Section 5650) and/or with the permission of CDFW.
- Material Safety Data Sheets will be made readily available to the contractor’s employees and other personnel at the work site.
- The accumulation and temporary storage of hazardous wastes will not exceed 90 days.
- Soils contaminated by spills or cleaning wastes will be contained and removed to an approved disposal site.
- Hazardous waste generated at work sites, such as contaminated soil, will be segregated from other construction spoils and properly handled, hauled, and disposed of at an approved disposal facility by a licensed hazardous waste hauler in accordance with state and local regulations. The contractor will obtain permits required for such disposal.
- Emergency spill containment and cleanup kits will be located at the facility site. The contents of the kits will be appropriate to the type and quantities of chemical or goods stored at the facility.

Mitigation Measure AQUA-12: Construction Site Security

To ensure adequate construction site security, Reclamation or their contractors will arrange to provide for 24-hour onsite security personnel. Security personnel will monitor and patrol construction sites, including staging and equipment storage areas. Security personnel will serve as the first line of defense against criminal activities and nuisances at construction sites. Private patrol security operators hired to provide site security will have the appropriate licenses from the California Bureau of Security and Investigative Services. Individual security personnel will have a minimum security guard registration license that meets the California Bureau of Security and Investigative Services requirements for training and continuation training as required for that license. All security personnel will also receive environmental training similar to that of onsite construction workers so that they understand the environmental conditions and issues associated with the various areas for which they are responsible at a given time.

Security operations and field personnel will be given the emergency contact phone numbers of environmental response personnel for rapid response to environmental issues resulting from vandalism or incidents that occur when construction personnel are not onsite. Security operations will also maintain a contact list of backup support from city police, county sheriffs, California Highway Patrol, water patrols (such as the Contra Costa County Marine Patrol), helicopter response, and emergency response (including fire departments, ambulances/emergency medical technicians). The appropriate local and regional contact list will be made available to security personnel by Reclamation or their contractors, as will the means to make that contact via landline phones, mobile phones, or radios. When on patrol, security personnel will always have the ability to contact backup using mobile phones or two way radios. Security personnel who are on patrol will have the appropriate geographic contact list for their location and the ability to summon appropriate backup or response via the security patrol local dispatch site or outside authorities.

Mitigation Measure AQUA-13: Notification of Activities in Waterways

Similar to the requirements specified in the fish rescue and salvage plan (Mitigation Measure AQUA-7), and underwater sound control and abatement plan (Mitigation Measure AQUA-8), before in-water construction or maintenance activities begin, Reclamation will ensure notification of appropriate fish and wildlife agency representatives when these activities could affect water quality or aquatic species. The notification procedures will follow stipulations included in applicable permit documents for the construction operations. However, in general, the notification information will include site location(s), schedules, and work activities. Information on detours will include site-specific details regarding any temporary partial channel closures, including contacting the U.S. Coast Guard, boating organizations, marina operators, city or county parks departments, and the California Department of Pesticide Regulation, where applicable.

Mitigation Measure AQUA-14: Fugitive Dust Control

Reclamation or their contractors will implement basic and enhanced control measures at all construction and staging areas to reduce construction-related fugitive dust. Although the following measures are outlined in the Sacramento Metropolitan Air Quality Management District’s (SMAQMD) CEQA guidelines, they are required for the entirety of the construction area, including areas within the Bay Area Air Quality Management District (BAAQMD), San Joaquin Valley Air Pollution Control District (SJVAPCD), and Yolo-Solano Air Quality Management District (YSAQMD), and are sufficient to address BAAQMD, SJVAPCD, and YSAQMD fugitive dust control requirements. Reclamation or their contractors will ensure the project commitments are appropriately implemented before and during construction, and that proper documentation procedure is followed.

Basic Fugitive Dust Control Measures

Reclamation or their contractors will take steps to ensure that the following measures will be implemented to the extent feasible to control dust during general construction activities.

- Water will be applied to all exposed surfaces as reasonably necessary to prevent visible dust from leaving work areas. Frequency will be increased during especially dry or windy periods or in areas with a lot of construction activity. Exposed surfaces include (but are not limited to) soil piles, graded areas, unpaved parking areas, staging areas, and access roads.

- Cover or maintain at least 2 feet of freeboard space on haul trucks transporting soil, sand, or other loose material on the site. Any haul trucks that will be traveling along freeways or major roadways should be covered.
- Use wet power vacuum street sweepers to remove any visible trackout mud or dirt onto adjacent public roads at least once a day. Use of dry power sweeping is prohibited.
- Limit vehicle speeds on unpaved roads to 15 miles per hour.
- All roadway, driveway, sidewalk, and parking lot paving 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, or other reasonable mitigation measures are used.

Enhanced Fugitive Dust Control Measures for Land Disturbance

Reclamation or their contractors will take steps to ensure that the following measures will be implemented to the extent feasible to control dust during soil disturbance activities.

- Water exposed soil with adequate frequency for continued moist soil. However, do not overwater to the extent that sediment flows off the site.
- Suspend excavation, grading, and/or demolition activity when wind speeds exceed 20 miles per hour.
- Install wind breaks (e.g., plant trees, solid fencing) on windward side(s) of construction areas.
- Plant vegetative ground cover (fast-germinating native grass seed) in disturbed areas as soon as possible after construction is completed. Water appropriately until vegetation is established.

Measures for Entrained Road Dust

Reclamation or their contractors will take steps to ensure that the following measures will be implemented to the extent feasible to control entrained road dust from unpaved roads.

- Install wheel washers for all exiting trucks, or wash off all trucks and equipment leaving the site.
- Treat site accesses to a distance of 100 feet from the paved road with a 6- to 12-inch layer of wood chips, mulch, or gravel to reduce generation of road dust and road dust carryout onto public roads.
- Post a publicly visible sign with the telephone number and person to contact at the lead agency regarding dust complaints. This person will respond and take corrective action within 48 hours. The phone number of the air quality management district will also be visible to ensure compliance.

Measures for Concrete Batching

Reclamation or their contractors will take steps to ensure that the following measures will be implemented to the extent feasible to control dust during concrete batching activities.

- Implementation of fugitive dust control measures to achieve a 70% reduction in dust from concrete batching.

- Implementation of fugitive dust control measures to achieve an 80% reduction in dust from aggregate and sand pile erosion at the concrete batch plants.
- Use of a hood system vented to a fabric filter/baghouse during cement delivery and hopper and central mix loading.

E.10 Terrestrial Resources

Mitigation Measure BIO-1: Vernal Pool Fairy Shrimp, Vernal Pool Tadpole Shrimp, Conservancy Fairy Shrimp, Longhorn Fairy Shrimp

Reclamation will avoid vernal pool crustacean habitat, including habitat for vernal pool fairy shrimp, vernal pool tadpole shrimp, conservancy fairy shrimp, and longhorn fairy shrimp with a minimum 250-foot nondisturbance buffer. Reclamation will either conduct protocol-level surveys to assess whether habitat is occupied or will assume presence of the species.

Reclamation will avoid affecting any of the primary constituent elements of critical habitat for vernal pool fairy shrimp or vernal pool tadpole shrimp within designated critical habitat units.

Mitigation Measure BIO-2: Valley Elderberry Longhorn Beetle

Suitable Habitat

Valley elderberry longhorn beetle habitat is defined as elderberry shrubs within the study area. Elderberry shrubs in the study area could be found in riparian areas, along levee banks, grasslands, and in agricultural settings where vegetation is not being maintained (e.g., fence rows, fallow fields).

Avoidance and Minimization

Activities will be located to avoid or minimize disturbance of valley elderberry longhorn beetle suitable habitat within the species' range to the greatest extent practicable.

Reclamation will avoid valley elderberry longhorn beetle critical habitat during implementation of the project components.

Complete avoidance (i.e., no adverse effects) may be assumed when elderberry shrubs are not present or within a 165-foot buffer of the activity. USFWS will be consulted before any disturbances, including construction, within the 165-foot buffer area if it contains elderberry shrubs and/or riparian habitat.

Preconstruction surveys for elderberry shrubs will be conducted within all project construction footprints and areas within 165 feet by a biologist familiar with the appearance of valley elderberry longhorn beetle exit holes in elderberry shrubs. When possible, preconstruction surveys will be conducted in the calendar year prior to disturbance and will follow the guidance of USFWS's Framework for Assessing Impacts to the Valley Elderberry Longhorn Beetle (USFWS 2017), herein referred to as the 2017 VELB Framework.

For elderberry shrubs not directly affected by construction but that occur between 20 feet and 165 feet from ground-disturbing activities, the following measures will be implemented.

- All areas to be avoided during construction activities will be fenced and/or flagged as close to construction limits as feasible.

- Activities that may damage or kill an elderberry shrub (e.g., trenching, paving, etc.) may need an avoidance area of at least 20 feet (6 meters) from the drip-line, depending on the type of activity.
- A qualified biologist will provide training for all contractors, work crews, and any onsite personnel on the status of the valley elderberry longhorn beetle, its host plant and habitat, the need to avoid damaging the elderberry shrubs, and the possible penalties for noncompliance.
- A qualified biologist will monitor the work area at project-appropriate intervals to assure that all avoidance and minimization measures are implemented. The amount and duration of monitoring will depend on the project specifics and should be discussed with the USFWS biologist.
- As much as feasible, all activities that could occur within 165 feet (50 meters) of an elderberry shrub will be conducted outside of the flight season of the valley elderberry longhorn beetle (March to July).
- Trimming may remove or destroy valley elderberry longhorn beetle eggs and/or larvae and may reduce the health and vigor of the elderberry shrub. To avoid and minimize adverse effects to valley elderberry longhorn beetle, trimming will occur between November and February and will avoid the removal of any branches or stems that are greater than or equal to 1 inch in diameter. Measures to address regular and/or large-scale maintenance (trimming) should be established in consultation with the USFWS.
- Herbicides will not be used within the drip-line of the shrub. Insecticides will not be used within 98 feet (30 meters) of an elderberry shrub. All chemicals will be applied using a backpack sprayer or similar direct application method.
- Mechanical weed removal within the drip-line of the shrub will be limited to the season when adults are not active (August to February) and will avoid damaging the elderberry.
- Erosion control will be implemented, and the affected area will be revegetated with appropriate native plants.
- The potential effects of dust on valley elderberry longhorn beetle will be minimized by applying water during construction activities or by presoaking work areas that will occur within 100 feet of any potential elderberry shrub habitat. Elderberry shrubs with stems greater than 1 inch that are directly affected by construction should be transplanted under the following conditions:
  - If the elderberry shrub cannot be avoided.
  - If indirect effects will result in the death of stems or the entire shrub.

The removal of the elderberry shrub may either include the roots or just the removal of the aboveground portion of the plant. When possible, the entire root ball will be retained and the elderberry shrub will be transplanted as close as possible to its original location. Elderberry shrubs will be relocated adjacent to the project footprint if (1) the planting location is suitable for elderberry growth and reproduction; and (2) the project proponent is able to protect the shrub and ensure that the shrub becomes reestablished. If these criteria cannot be met, the shrub may be transplanted to an appropriate USFWS-approved mitigation site. Any elderberry shrub that is unlikely to survive transplanting because of poor condition or location, or a shrub that would be extremely difficult to move because of access problems, may not be appropriate for transplanting. The following transplanting guidelines may be used by agencies/applicants in developing their valley elderberry longhorn beetle conservation measures:

- A qualified biologist will be onsite for the duration of transplanting activities to ensure compliance with avoidance and minimization measures and other conservation measures.
- Exit-hole surveys will be completed immediately before transplanting. The number of exit holes found, GPS location of the plant to be relocated, and the GPS location of where the plant is transplanted will be reported to the USFWS and to the CNDDB.
- Elderberry shrubs will be transplanted when the shrubs are dormant (November through the first 2 weeks in February) and after they have lost their leaves. Transplanting during the nongrowing season will reduce shock to the shrub and increase transplantation success.
- Transplanting will follow the most current version of the ANSI A300 (Part 6) guidelines for transplanting (http://www.tcia.org/).
- Trimming will occur between November and February and should minimize the removal of branches or stems that exceed 1 inch in diameter.

Compensation for Unavoidable Effects

Reclamation will coordinate with the USFWS to offset unavoidable impacts on elderberry shrubs by either creating valley elderberry longhorn beetle habitat or by purchasing the equivalent credits at a USFWS-approved conservation bank with a service area that overlaps with the study area. Compensatory mitigation will be coordinated with the USFWS to determine the appropriate type and amount of compensatory mitigation and follow criteria in the 2017 VELB Framework. These guidelines recommend that the permanent loss of valley elderberry longhorn beetle habitat be replaced with habitat that is commensurate with the type (riparian or nonriparian) and amount of habitat lost. For plants in riparian areas, compensation may be appropriate for any impacts to valley elderberry longhorn beetle habitat. In nonriparian areas, compensation may be appropriate for occupied shrubs. Suitable riparian habitat may be replaced at a minimum ratio of 3:1 for all acres that will be permanently affected by the project. Suitable nonriparian habitat may be replaced at a minimum ratio of 1:1 for all acres that will be permanently affected by the project. Impacts on individual shrubs in riparian areas may be replaced by the purchase of two credits (one credit = 1,800 square feet) at a USFWS-approved bank for each shrub that will be trimmed regardless of the presence of exit holes. If the shrub will be completely removed by the activity, the entire shrub may be transplanted to a USFWS-approved location in addition to the credit purchase. Impacts on individual shrubs in nonriparian areas be replaced through a purchase of 1 credit at a USFWS-approved bank for each shrub that will be trimmed if exit holes have been found in any shrub on or within 165 feet of the project. If the shrub will be completely removed by the activity, the entire shrub will be transplanted to a USFWS-approved location in addition to a credit purchase. These ratios may apply if compensation occurs prior to or concurrent with the impacts. If compensation occurs after the impacts, a higher ratio may be required by USFWS. Appropriate compensatory mitigation may include purchasing credits at a USFWS-approved conservation bank, providing onsite mitigation, or establishing and/or protecting habitat for valley elderberry longhorn beetle.

Mitigation Measure BIO-3: California Tiger Salamander and Western Spadefoot Toad

For restoration projects and construction of the Conservation Hatchery, Reclamation will avoid California tiger salamander and western spadefoot toad upland and aquatic habitat. Reclamation will avoid affecting any of the primary constituent elements of critical habitat for California tiger salamander within designated critical habitat units.

Mitigation Measure BIO-4: Foothill Yellow-Legged Frog

Species-specific mitigation for foothill yellow-legged frog will only be required for projects occurring within or adjacent to suitable habitat as identified by assessments conducted during the project component planning phase. A qualified biologist will conduct a field evaluation for foothill yellow-legged frog for all project activities that occur within suitable habitat.

Prior to any ground-disturbing activity scheduled to occur during the dry season (June 1–October 15), a qualified biologist will survey potential breeding habitat for the presence of foothill yellow-legged frogs using methods from the *Draft Visual Encounter Survey Protocol for* Rana boylii *in Lotic Environments* (Peek et al. 2017) or other more recent guidelines, if available. Surveys will be conducted no more than 30 days before the start of ground-disturbing activities and will be spatially phased to precede construction activities. Avoidance and minimization measures, including moving individuals to nearby ponds or other appropriate measures, will be implemented with authorizations issued under the California Endangered Species Act (CESA).

Compensation for Unavoidable Effects

Reclamation will provide compensatory mitigation for unavoidable permanent impacts on habitat for foothill yellow-legged frog. Impacts on occupied or presumed occupied aquatic habitat will be compensated for at a ratio of 3:1 for breeding and foraging habitat.

Mitigation Measure BIO-5: Giant Garter Snake

Avoidance and Minimization Measures

Species-specific mitigation for giant garter snake will be required only for projects occurring within or adjacent to suitable habitat, as identified by assessments conducted during the project component planning phase. A qualified biologist will conduct a field evaluation of suitable upland or aquatic habitat for giant garter snake for all covered activities that occur within suitable giant garter snake habitat.

If the project does not fully avoid effects on suitable habitat, the following measures will be required:

- Initiate construction between May 1 and October 1 within suitable giant garter snake upland habitat, which corresponds with the snake’s active period. Work in giant garter snake upland habitat may also occur between October 2 and November 1 or between April 1 and May 1 if ambient temperatures exceed 75 degrees Fahrenheit (°F) during construction activities and maximum daily temperatures have exceeded 75°F for a least 3 consecutive days immediately preceding work. During these periods, giant garter snakes are more likely to be active in aquatic habitats and less likely to be found in upland habitats. To the extent practicable, conduct all activities within paved roads, farm roads, road shoulders, and similarly disturbed and compacted areas; confine ground disturbance and habitat removal to the minimum area necessary to facilitate construction activities. For construction activities and any conveyance facility maintenance involving heavy equipment, giant garter snake aquatic and upland habitat that can be avoided will be clearly delineated on the work site, with high-visibility fencing and signage identifying these areas as sensitive. The fencing will be installed before equipment is moved onsite and before any ground-disturbing activities begin. The purpose of the fencing is to prevent construction activities from encroaching into sensitive habitat areas and not intended to exclude animals. To minimize the potential for snakes and other ground-dwelling animals to be caught in the construction fencing, the fencing will be placed with at least a 6-inch gap between the ground and the bottom of the fencing to allow animals to pass under.

- All construction personnel and personnel involved in operations and maintenance in or near giant garter snake habitat will attend worker environmental awareness training (as described in Appendix O, Aquatic Resources Technical Appendix). This training will include instructions to workers on how to recognize giant garter snakes, their habitat(s), and the nature and purpose of protection measures.
- Within 24 hours prior to construction activities or maintenance activities requiring heavy equipment within giant garter snake habitat, a USFWS-approved biologist will survey all areas planned for disturbance and at least 50 feet outside the disturbance area where giant garter snake could be present. The surveyor will inspect all burrows, soil cracks, and crevices that could be used by giant garter snake. To the extent that these habitat features can be avoided within the work area, they will be flagged, and the locations will be provided to the biological monitor. This survey of the work area will be repeated if a lapse in construction activity of 2 weeks or greater occurs during the giant garter snake inactive period (October 1 to May 1) or if the lapse in construction activity is more than 12 hours during the active period (May 1 to October 1). If a giant garter snake is encountered during surveys or construction, activities will cease until appropriate corrective measures have been completed, it has been determined that the giant garter snake will not be harmed, or the giant garter snake has left the work area.
- For all construction activities that occur in giant garter snake habitat that could result in injury or mortality of snakes (e.g., movement of heavy equipment; excavation of soil, rock, or existing structures; grading; vegetation removal), a USFWS-approved biologist will be present to monitor these activities. As work is performed, the biologist will visually scan work areas, under equipment, and excavated materials for giant garter snakes. The biologist will also help guide access and construction work around wetlands, active rice fields, and other sensitive habitats capable of supporting giant garter snake to minimize habitat disturbance and risk of injuring or killing giant garter snakes.
- Report all observations of giant garter snakes to the USFWS-approved biological monitor. If a giant garter snake is observed in the work area, the monitor will have the authority to stop work in the immediate vicinity of the snake. If possible, the snake will be allowed to leave the work area on its own volition and the monitor will remain in the area until the snake is safely out of harm’s way. A giant garter snake may be captured and relocated out of the work area with prior authorization from USFWS and by an individual with the appropriate handling permit. The snake will be relocated to suitable habitat at least 200 feet from the work area.
- Maintain all construction and operations and maintenance equipment to prevent leaks of fuel, lubricants, and other fluids and use extreme caution when handling and or storing chemicals (such as fuel and hydraulic fluid) near waterways, and abide by all applicable laws and regulations. Follow all applicable hazardous waste BMPs and keep appropriate materials onsite to contain, manage, and clean up any spills.
    - Conduct service and refueling procedures in uplands in staging areas and at least 200 feet away from waterways when practicable.

- During construction and operation and maintenance activities in and near giant garter snake habitat, employ erosion (non-monofilament silt fence), sediment, material stockpile, and dust control BMPs. Avoid using fill or allowing runoff into wetland areas or waterways to the extent practicable.
- Return temporary work areas to pre-existing contours and conditions upon completion of work. Where revegetation and soil stabilization are necessary in nonagricultural habitats, revegetate with appropriate noninvasive native plants at a density and structure similar to that of preconstruction conditions. Restoration of aquatic vegetation in giant garter snake aquatic habitat and annual grassland within giant garter snake upland habitat will be detailed in a mitigation and monitoring plan that will be reviewed and approved by USFWS prior to the start of construction. Habitat will be restored within one season (defined as May 1 to October 1).
- Properly contain and remove from the worksite all trash and waste items generated by construction and crew activities to prevent the encouragement of predators such as raccoons and coyotes from occupying the site.
- Permit no pets, campfires, or firearms at the worksite.
- Store equipment in designated staging area areas at least 200 feet away from giant garter snake aquatic habitat to the extent practicable.
- Confine any vegetation clearing to the minimum area necessary to facilitate construction activities.
- Limit vehicle speed to 10 miles per hour (mph) on access routes (except for public roads and highways) and within work areas that are within 200 feet of giant garter snake aquatic habitat but not protected by exclusion fencing to avoid running over giant garter snakes.
- Visually check for giant garter snake under vehicles and equipment prior to moving them. Cap all onsite materials (conduits, pipe, etc.), precluding wildlife from becoming entrapped. Check any crevices or cavities in the work area where individuals may be present including stockpiles that have been left for more than 24 hours where cracks or crevices may have formed.
- For proposed activities that will occur within suitable aquatic giant garter snake habitat during the active giant garter snake season (May 1 through October 1), prior to proposed construction activities that will commence during the inactive period, and when unavoidable, all aquatic giant garter snake habitat will be dewatered for at least 14 days prior to excavating or filling the dewatered habitat. Dewatering is necessary because aquatic habitat provides prey and cover for giant garter snake; dewatering serves to remove the attractant and increase the likelihood that giant garter snake will move to other available habitat. Any deviation from this measure will be done in coordination with, and with approval of, the USFWS.
- Following dewatering of aquatic habitat, all potential affected areas that provide suitable aquatic or upland giant garter snake habitat will be surveyed for giant garter snake by the USFWS-approved biologist. If giant garter snakes are observed, they will be passively allowed to leave the area, or the USFWS will be consulted to determine the appropriate course of action for removing giant garter snake from the area.

Maintenance activities such as vegetation and rodent control, embankment repair, and channel maintenance will occur at conveyance facilities with permanent structures and at conveyance facility and restoration sites with flexible locations (e.g., transmission line right of ways, restoration locations, etc.). The following avoidance and minimization measures will be applied to maintenance activities in suitable aquatic habitat and uplands within 200 feet of suitable aquatic habitat, to minimize effects on the giant garter snake:

- Vegetation control will take place during the active period (May 1 through October 1) when snakes are able to move out of areas of activity.
- Trapping or hunting methods will be used for rodent control rather than poison bait. All rodent control methods will be approved by USFWS. If trapping or other nonpoison methods are ineffective, the USFWS will be consulted to determine the best course of action.
- Movement of heavy equipment will be confined to outside 200 feet of the banks of giant garter snake aquatic habitat to minimize habitat disturbance.
- All construction personnel and personnel involved in operations and maintenance in or near giant garter snake habitat will attend worker awareness training (as described in Appendix O, Aquatic Resourc*es Technical Appendix*). This training will include instructions to workers on how to recognize giant garter snakes, their habitat, and the nature and purpose of protection measures.

Compensation for Unavoidable Effects

Where giant garter snake habitat cannot be avoided, compensation for the permanent loss of the habitat will occur at a rate of 3:1 for aquatic and upland habitat.

Mitigation Measure BIO-6: Western Pond Turtle

Species-specific mitigation for western pond turtle will only be required for projects occurring within or adjacent to suitable habitat as identified by assessments conducted during the project component planning phase. A qualified biologist will conduct a field evaluation of suitable upland or aquatic habitat for western pond turtles for all covered activities that occur within suitable pond turtle habitat.

If the project does not fully avoid effects on suitable habitat, the following measures will be required.

- The project proponent will retain a qualified wildlife biologist to conduct a preconstruction survey within 48 hours of disturbance in aquatic and riparian habitats to determine presence or absence of pond turtles in the construction work area.
- If possible, the surveys will be timed to coincide with the time of day and year when turtles are most likely to be basking and visible (during the cooler part of the day, 8:00 a.m. to 12:00 p.m., during spring, summer, and late summer). Prior to conducting presence/absence surveys the biologist will locate the microhabitats for turtle basking (logs, rocks, brush thickets) and determine a location to quietly observe turtles.
- Each survey will include a 30-minute wait time after arriving at the site to allow startled turtles to return to open basking areas. The survey will consist of a minimum 15-minute observation time per area where turtles could be observed.
- If turtles are observed during a survey, they will be relocated outside of the construction area to appropriate aquatic habitat by a biologist.

Mitigation Measure BIO-7: California Black Rail

Preconstruction surveys for California black rail will be conducted where potentially suitable habitat for this species occurs within 500 feet of work areas where access is available. Potentially suitable habitat includes tidal and nontidal seasonal or perennial wetlands at least 2 acres in size with any kind of vegetation types consistent with black rail use in the Delta, as determined by field evaluations conducted by a qualified biologist with experience surveying for black rail, over 10 inches high, whether or not the patch in question was mapped as modeled habitat. Surveys will be initiated sometime between January 15 and February 1. A minimum of four surveys will be conducted. The survey dates will be spaced at least 2 to 3 weeks apart and will be scheduled so that the last survey is conducted no more than 2 weeks before April 15. This will allow the surveys to encompass the time period when the highest frequency of calls is likely to occur. These surveys will involve the following protocols (based on Evens et al. 1991), or other approved survey methodologies that may be developed using new information and best-available science, and will be conducted by biologists with the qualifications stipulated in the approved methodologies.

- Listening stations will be established at 300-foot intervals throughout potential black rail habitat that will be affected by covered activities. Listening stations will be placed along roads, trails, and levees to avoid trampling.
- California black rail vocalization recordings will be played at each station, and playing will cease immediately once a response is detected.
- Each listening station will be occupied for 6 minutes, including 1 minute of passive listening, 1 minute of "grr" calls followed by 30 seconds of "ki-ki-krrr" calls, then followed by another 3.5 minutes of passive listening.
- Each survey will include a survey at sunrise and a survey at sunset.
- Sunrise surveys will begin 60 minutes before sunrise and conclude 75 minutes after sunrise (or until presence is detected).
- Sunset surveys will begin 75 minutes before sunset and conclude 60 minutes after sunset (or until presence is detected).
- Surveys will not be conducted when tides are greater than National Geodetic Vertical Datum or when sloughs and marshes are more than bank-full.
- California black rail vocalizations will be recorded on a data sheet. A GPS receiver and compass will be used to identify surveys stations, angles to call locations, and call locations and distances. The call type, location, distance from listening station, and time will be recorded on a data sheet.

The project will be implemented in a manner that will not result in take of California black rail, as defined by Section 86 of the California Fish and Game Code. If California black rail is present in the immediate construction area, the following measures will apply during construction activities:

- To avoid the loss of individual California black rails, activities within 500 feet of potential habitat will not occur within 2 hours before or after extreme high tides (6.5 feet or above, as measured at the Golden Gate Bridge). During high tide, protective cover for California black rail is sometimes limited, and activities could prevent them from reaching available cover.
- To avoid the loss of individual California black rails, activities within 500 feet of tidal marsh areas and managed wetlands will be avoided during the rail breeding season (February 1 to

August 31), unless surveys are conducted to determine that no rails are present within the 500-foot buffer.

- If breeding California black rail is determined to be present, activities will not occur within 500 feet of an identified calling center (unless a qualified biologist determines that a smaller distance will not result in the take of the state-listed species). If the intervening distance between the rail calling center and any activity area is greater than 200 feet and across a major slough channel or substantial barrier (e.g., constructed noise barrier) it may proceed at that location within the breeding season.
- If California black rail are determined to be present in habitat that must be disturbed, vegetation will be removed during the nonbreeding season (September 1 to January 31) to encourage them to leave the area. Vegetation removal will be completed carefully using hand tools or vegetation removal equipment that is approved by a biologist. The biologist will search vegetation immediately in front of the removal equipment, and will stop removal if rails are detected. Vegetation removal will resume when the black rail leaves the area.
- If construction activities require removal of potential California black rail habitat, whether or not black rails have been detected there, vegetation will be removed during the nonbreeding season (September 1 to January 31). Vegetation removal will be completed carefully using hand tools or vegetation removal equipment that is approved by an biologist. The biologist will search vegetation immediately in front of the removal equipment, and will stop removal if rails are detected. Vegetation removal will resume when the rail leaves the area.
- Exception: Inspection, maintenance, or nonconstruction monitoring activities may be performed during the California black rail breeding season (February 1 to August 31) in areas within or adjacent to breeding habitat (within 500 feet) with CDFW approval and under the supervision of a permitted, approved biologist.
- If the construction footprint is within 500 feet of a known calling center, noise reduction structures such as temporary noise reducing walls, will be installed at the edge of construction footprint, as determined by an onsite biologist. Noise-causing construction will begin during the nonbreeding season (September 1 to January 31) so that rails can acclimate to noise and activity prior to initiating nests.

Mitigation Measure BIO-8: California Ridgway’s Rail

If construction or restoration activities are necessary during the breeding season, preconstruction surveys for California Ridgway’s rail will be conducted where suitable habitat for these species occurs within or adjacent to work areas. Surveys will be initiated sometime between January 15 and February 1. A minimum of four surveys will be conducted. The survey dates will be spaced at least 2 to 3 weeks apart and will cover the time period from the date of the first survey through the end of March and mid-April. This will allow the surveys to encompass the time period when the highest frequency of calls is likely to occur. These surveys will involve the following protocols (based on USFWS 2015 and Evens et al. 1991), or other approved survey methodologies that may be developed based on new information and evolving science, and will be conducted by biologists with the qualifications stipulated in the approved methodologies.

- Listening stations will be established at 200-meter intervals along roads, trails, and levees that will be affected by covered activities.

- California Ridgway's rail vocalization recordings will be played at each station, and playing will cease immediately once a response is detected.
- For California Ridgway's rail, each listening station will be occupied for a period of 10 minutes, followed by 1 minute of playing California Ridgway's rail vocalization recordings, then followed by an additional minute of listening.
- Sunrise surveys will begin 60 minutes before sunrise and conclude 75 minutes after sunrise (or until presence is detected).
- Sunset surveys will begin 75 minutes before sunset and conclude 60 minutes after sunset (or until presence is detected).
- Surveys will not be conducted when tides are greater than 4.5 National Geodetic Vertical Datum or when sloughs and marshes are more than bank-full.
- California Ridgway's rail vocalizations will be recorded on a data sheet. A GPS receiver and compass will be used to identify surveys stations, angles to call locations, and call locations and distances. The call type, location, distance, and time will be recorded on a data sheet.

If California Ridgway's rail is present in the immediate construction area, the following measures will apply during construction activities.

- To avoid the loss of individual California Ridgway's rails, activities within or adjacent to the species' habitat will not occur within 2 hours before or after extreme high tides (6.5 feet or above, as measured at the Golden Gate Bridge), when the marsh plain is inundated. During high tide, protective cover for California Ridgway's rail is sometimes limited, and activities could prevent them from reaching available cover.
- To avoid the loss of individual California Ridgway's rails, activities within or adjacent to tidal marsh areas will be avoided during the rail breeding season (February 1 through August 31), unless surveys are conducted to determine rail locations and territories can be avoided.
- If breeding California Ridgway's rail are determined to be present, activities will not occur within 500 feet of an identified calling center (unless a qualified biologist determines that a smaller distance will not result in the take of the state-listed species). If the intervening distance is across a major slough channel or across a substantial barrier between the rail calling center and any activity area is greater than 200 feet, it may proceed at that location within the breeding season.
- Exception: Inspection, maintenance, or nonconstruction monitoring activities may be performed during the California Ridgway's breeding season in areas within or adjacent to breeding habitat (within 500 or 200 feet, as specified above) as long as a qualified biologist determines the action will not result in take. These activities will be conducted under the supervision of a qualified, permitted biologist.

Mitigation Measure BIO-9: Greater and Lesser Sandhill Crane

If construction and restoration activities are to occur during sandhill crane wintering season (September 15 through March 15) in a greater sandhill crane winter use area or within suitable lesser sandhill crane wintering habitat, the following avoidance and minimization measures will be implemented.

- Construction will be minimized during the sandhill crane wintering season to the extent practicable in light of project schedule and cost and logistical considerations.
- To the extent feasible, construction that cannot be completed prior to commencement of the wintering season will be started before September 15 or after March 15, such that no new sources of noise or other major disturbance that could affect cranes will be introduced after the cranes arrive at their wintering grounds.
- Preconstruction surveys will be conducted for sandhill crane temporary and permanent roost sites within 0.75 mile of the construction area boundary where access is available. Surveys will be conducted during the winter prior to project implementation, over multiple days within the survey area by a qualified biologist with experience observing the species. Alternatively, roost sites within 0.75 mile of the construction area boundary can be identified by a qualified sandhill crane biologist familiar with roost sites. If a sandhill crane roost site is located within 0.75 mile of the construction area boundary, then to the extent practicable, nighttime (1 hour before sunset to 1 hour after sunrise) project activities will be relocated to maintain a 0.75-mile nondisturbance buffer.
- Route truck traffic to reduce headlight impacts in roosting habitat.
- Install light barriers to block the line-of-sight between the nearest roosting areas and the primary nighttime construction light source areas.
- Operate portable lights near roosting habitat at the lowest allowable wattage and height, while in accordance with the National Cooperative Highway Research Program's (NCHRP's) *Report 498: Illumination Guidelines for Nighttime Highway Work*.
- Screen all lights and direct them down toward work activities and away from the night sky and nearby roost sites. A biological construction monitor will ensure that lights are properly directed at all times.
- Limit the number of nighttime lights used to the greatest extent practicable in light of worker safety requirements.
- If restoration takes place near Stone Lake NWR, install a vegetation screen or other noise and visual barrier along the south side of Hood Franklin Road along the length of Stone Lake NWR's property to reduce disturbance to sandhill cranes. The noise and visual barrier will be a minimum of 5 feet high (above the adjacent elevated road, if applicable) and will provide a continuous surface impenetrable by light. This height may be obtained by installing a temporary structure, such as fencing (e.g., chain link with privacy slats) or a semipermanent structure, such as a concrete barrier (e.g., a roadway median barrier or architectural concrete wall system) retrofitted with an approved visual screen, if necessary, to meet the required height. This barrier will not be installed immediately adjacent to crane foraging habitat, and placement will be coordinated with a qualified crane biologist.

Mitigation Measure BIO-10: Least Bell's Vireo

Species-specific mitigation measures for least Bell's vireo will be required for activities occurring within suitable habitat within the species' range. Prior to disturbing an area potentially supporting habitat for the species, a USFWS approved biologist will evaluate the area to identify suitable habitat.

Activities will be located to avoid or minimize disturbance of least Bell's vireo suitable habitat within the species' range. The following measures will be required for project components unable to avoid least Bell's vireo habitat:

- Prior to construction, all suitable least Bell's vireo habitat within the species' range in the construction area will be surveyed.
- At least five surveys will be conducted in suitable habitats within 30 days of the onset of construction, with the last survey conducted within 3 days of the onset of construction, by a qualified biologist with experience surveying and observing these species and familiar with their vocalizations.
- If an active nest site is present, a 500-foot nondisturbance buffer will be established around nest sites during the breeding season (generally, late February through late August).
- Disturbance to previous least Bell's vireo nesting sites (for up to 3 years since known nest activity) will also be avoided during the breeding season unless the disturbance is to maintain public safety. Least Bell's vireo uses previous nesting sites, and disturbance during the breeding season may preclude birds from using existing unoccupied nest sites.
- The required buffer may be reduced in areas where barriers or topographic relief are sufficient to protect the nest from excessive noise or other disturbance, as determined by a the qualified biologist on a case-by-case basis.
- If occupied nests are identified, a qualified biologist will monitor construction activities in the vicinity of all active least Bell's vireo nests to ensure that covered activities do not affect nest success.
- If surveys find least Bell's vireos in the area where vegetation will be removed, vegetation removal will be done when the birds are not present.
- If an activity is to occur within 1,200 feet of least Bell's vireo habitat (or within 2,000 feet if pile driving will occur) during the breeding period for least Bell's vireos, the following measures will be implemented to avoid noise effects on least Bell's vireo.
  - Prior to the construction, a noise expert will create a noise contour map showing the 60 A-weighted decibel noise contour specific to the type and location of construction to occur in the area.
  - During the breeding period for least Bell's vireo, a USFWS-approved biologist will survey any suitable habitat for least Bell's vireo within the 60 dBA noise contour daily during a 2-week period prior to construction. While construction is occurring within this work window, the USFWS-approved biologist will conduct daily surveys in any suitable habitat where construction related noise levels could exceed 60 dBA L_{eq} (1 hour). If a least Bell's vireo is found, sound will be limited to 60 dBA in the habitat being used until the USFWS-approved biologist has confirmed that the bird has left the area.
  - Limit pile driving to daytime hours (7:00 a.m. to 7:00 p.m.).

- Locate, store, and maintain portable and stationary equipment as far as possible from suitable least Bell's vireo habitat.
- Employ preventive maintenance including practicable methods and devices to control, prevent, and minimize noise.
- Route truck traffic to reduce construction noise impacts and traffic noise levels within 1,200 feet of suitable least Bell's vireo habitat during migration periods.
- Limit trucking activities (e.g., deliveries, export of materials) to the hours of 7:00 a.m. to 10:00 p.m.
- Screen all lights and direct them down toward work activities away from migratory habitat. A biological construction monitor will ensure that lights are properly directed at all times.
- Operate portable lights at the lowest allowable wattage and height, while in accordance with NCHRP's *Report 498: Illumination Guidelines for Nighttime Highway Work* (Transportation Research Board 2003).

Compensation to Offset Effects

Reclamation will offset the loss of least Bell's vireo habitat through habitat creation or restoration at a 2:1 ratio. Reclamation will develop a riparian restoration plan that will identify the location and methods for riparian creation or restoration, and this plan will be subject to USFWS approval.

Mitigation Measure BIO-11: Suisun Song Sparrow, Saltmarsh Common Yellowthroat, Yellow-Breasted Chat, Yellow Warbler

Preconstruction surveys of potential breeding habitat for the Suisun song sparrow, saltmarsh common yellowthroat, yellow-breasted chat, and yellow warbler will be conducted within 500 feet project activities where access is available. At least five surveys will be conducted in suitable habitats within 30 days of the onset of construction, with the last survey conducted within 3 days of the onset of construction, by a qualified biologist with experience surveying and observing these species and familiar with their vocalizations.

If an active nest site is present, a 250-foot nondisturbance buffer will be established around nest sites during the breeding season (generally, late February through late August for yellow-breasted chat, early April through mid-July for saltmarsh common yellowthroat and yellow warbler, and early April through late August for Suisun song sparrow).

The required buffer may be reduced in areas where barriers or topographic relief are sufficient to protect the nest from excessive noise or other disturbance, as determined by a qualified biologist on a case-by-case basis.

If occupied nests are identified, a qualified biologist will monitor construction activities in the vicinity of all active nests to ensure that covered activities do not affect nest success.

To the extent feasible, the contractor will employ the following best practices to reduce construction noise during daytime and evening hours (7:00 a.m. to 10:00 p.m.) such that construction noise levels do not exceed 60 dBA Leq (1 hour) during migration periods:

- Limit construction during nighttime hours (10:00 p.m. to 7:00 a.m.) such that construction noise levels do not exceed 50 dBA Lmax (1 hour) at the nearest residential land uses.
- Limit construction activities to daytime hours (7:00 a.m. to 7:00 p.m.), where feasible.

- Locate, store, and maintain portable and stationary equipment 300 feet away from suitable nesting habitat during migration periods, and 300 feet from active breeding sites.
- Employ preventive maintenance including practicable methods and devices to control, prevent, and minimize noise.
- Except where equipment must cross through riparian zones, route truck traffic to at least 300 feet from suitable avian migratory habitat during migration periods.
- Limit trucking activities (e.g., deliveries, export of materials) to the hours of 7:00 a.m. to 10:00 p.m. within 300 feet of migration habitat during migration periods.
- Screen all lights and direct them down toward work activities away from migratory habitat. A biological construction monitor will ensure that lights are properly directed at all times.
- Operate portable lights at the lowest allowable wattage and height, while in accordance with the NCHRP *Report 498: Illumination Guidelines for Nighttime Highway Work* (Transportation Research Board 2003).

Mitigation Measure BIO-12: Swainson's Hawk

Preconstruction surveys will be conducted to identify the presence of active nest sites of tree-nesting raptors within 0.25 mile of project sites, staging and storage areas, construction access roads, work areas, and soil stockpile areas where accessible by a qualified biologist with experience identifying Swainson's hawk. Transportation routes along public roads (roads leading to and from work areas) are considered disturbed, and no surveys or monitoring are required for nests along those roadways unless they are within 0.25 mile of work areas. Surveys for nesting Swainson's hawks will be conducted to ensure nesting activity is documented prior to the onset of construction activity. Swainson's hawks nest in the study area between approximately March 15 and September 15. While many nest sites are traditionally used for multiple years, new nest sites can be established in any year. Therefore, construction activity that is planned after March 15 of any year will require surveys during the year of the construction. If construction is planned before March 15 of any year, surveys will be conducted the year immediately prior to the year of construction. If construction is planned before March 15 of any year and subject to prior-year surveys, but is later postponed to after March 15, surveys will also be conducted during the year of construction.

The survey protocol shown in Table P.2-2 is modified from the recommended timing and methodology for Swainson's hawk nesting surveys in the Central Valley (Swainson's Hawk Technical Advisory Committee 2000). This protocol will be used to detect active nests for Swainson's hawk. If active nests are found, appropriate avoidance and minimization measures will be implemented as described. If no activity is found, then construction can proceed with no restrictions until the following breeding season. Survey results will be documented in a memo no less than 5 days prior to commencement of construction activities, and provided to the Program Environmental Manager and Construction Supervisor. The designated biologist will include the location of any known nest trees (occupied within 1 or more of the last 5 years) present within 0.25 mile of the construction footprint.

Removal of known nest trees (defined as a tree that has been used for nesting at least once in the last 3 years) will be avoided to the maximum extent feasible. No trees with occupied nests will be removed until the nest is vacated.

The designated biologist will survey potential Swainson's hawk nest trees and monitor occupied Swainson's hawk nests as described below. When proposed construction will occur within 0.25 mile of known nest trees, construction activities will be limited to outside the breeding season if feasible, or until the tree site is determined to be inactive.

Where construction activities cannot be restricted to more than 0.25 mile of an occupied nest site, activities will be restricted during the period of egg-laying to post-hatching to the extent feasible. If construction activities must occur in that time frame, construction will be initiated prior to egg-laying to the extent feasible. This will allow time for Swainson's hawks to acclimate to disturbance before eggs are laid, reducing the potential for abandonment. If construction activities must begin after egg-laying is initiated, a 650-foot-radius nondisturbance buffer will be established at least until eggs have hatched.

When construction activities will occur within 0.25 mile of an occupied Swainson's hawk nest, a 650-foot-radius nondisturbance buffer will be established around each occupied hawk nest tree. To the greatest extent feasible, no construction activity will be allowed to occur within the buffer while a Swainson's hawk nest is occupied. A nest is considered occupied from the time the nest is being constructed until the young leave the nest, or until the nesting attempt fails and the nest is abandoned. Occupied nests will be monitored to track progress of nesting activities. The buffer will be clearly delineated with fencing or other conspicuous marking.

Where construction will occur within 0.25 mile of an occupied Swainson's hawk nest tree, the following monitoring plan will be implemented. If a project nesting bird monitoring and management plan is prepared by a designated biologist, it will prevail where it differs from the measures below.

- A designated biologist will observe any nest site that is within 0.25 mile of construction activities for at least 1 hour and until normal nesting behavior can be determined 5 days and 3 days prior to the initiation of construction. The biologist will determine nest status and document normal nesting behaviors, which may be used to compare to the hawks' activities once construction begins. The results of preconstruction monitoring will be reported in a memo and provided to the Program Environmental Manager and Construction Supervisor.
- Where a Swainson's hawk occupied nest occurs less than 325 feet from construction activities, the designated biologist will observe the nest periodically throughout the day where covered activities occur to ensure the hawks are engaged in normal nesting behavior.
- Where a Swainson's hawk occupied nest occurs between 325 and 650 feet from construction, the designated biologist will observe the nest for at least 2 hours per construction day where covered activities occur to ensure the hawks are engaged in normal nesting behavior.
- Where a Swainson's hawk occupied nest occurs between 650 and 1,300 feet from construction, the designated biologist will observe the nest for at least 3 days per construction week to ensure the hawks are engaged in normal nesting behavior and to check the status of the nest.

Physical contact with an active nest tree will be prohibited from the time of egg laying to fledging. Construction personnel outside of vehicles must remain at least 650 feet, unless the biologist determines that a smaller buffer will not result in take of this state-listed species, from the nest tree unless construction activities require them to be closer.

All personnel will be out of the line of sight of an occupied nest during breaks if within 650 feet of the nest (as stated above, activities will only occur within 650 feet of a nest with approval by the designated biologist).

If during construction the designated biologist determines that a nesting Swainson's hawk within 0.25 mile of the project is disturbed by project activities, to the point where their reproductive failure could occur, the designated biologist will immediately notify the Construction Supervisor and Program

Environmental Manager. The Program Environmental Manager will contact CDFW, and it will be determined by the parties whether additional protection measures can be implemented.

Potential nest abandonment and failure may be indicated if Swainson's hawk exhibits distress and/or abnormal nesting behavior such as swooping/stooping at construction equipment or personnel, excessive vocalization (distress calls) or agitation directed at construction equipment or personnel, failure to remain on nest, or failure to deliver prey items for an extended time period. Additional protection measures will remain in place until the Swainson's hawk behavior has normalized. The designated biologist will notify CDFW if nests or nestlings are abandoned and if the nestlings are still alive to determine appropriate actions for salvaging the eggs or returning nestlings to the wild.

In addition to the measures described above, the following measures will also be implemented for activities for which the extent and location of the activity have not yet been fully planned.

- Restoration exploration activities will fully avoid Swainson's hawk nesting habitat.
- Restoration exploration will not be conducted within 0.25 mile of an occupied Swainson's hawk nest.

Table P.2-2. Timing and Methodology for Swainson's Hawk Nesting Surveys

Survey Dates	Survey Time	Number of Surveys	Methodology
First week of April	Sunrise to 12:00 p.m.; 4:00 p.m. to sunset	1	Position the surveyor at 50 to 200 feet from suitable nesting habitat with a clear view of trees and surrounding area. Scan all trees for a minimum of 2 hours within 0.25 mile of the project boundary. Observe perching, nest building, mating, courtship, and other prenesting behaviors to identify a nest or nesting activity area.
Second week of April	Sunrise to 12:00 p.m.; 4:00 p.m. to sunset	1	Repeat the above survey in areas not determined to be occupied during the first survey. Attempt to confirm nest locations within nesting activity areas.
Third week of April	Sunrise to 12:00 p.m.; 4:00 p.m. to sunset	1	Repeat the above survey in areas not determined to be occupied during the first and second survey. In cases where a nest site was not identified within a nesting activity area during the first two surveys, approach the nesting activity area carefully to locate nests. If a nest is not found where there is reasonable certainty of nesting activity, rely on observations of courtship, mating, nest building, and other behaviors to define a nesting area and establish a buffer.
June 10 through July 15	Sunrise to 12:00 p.m.; 4:00 p.m. to sunset	3 surveys spaced at least 3 days apart	Inspect all previously identified nests for activity status. Walk and scan all other suitable nest trees within 0.25 mile of the project boundary for nests not found during the initial survey.

Mitigation Measure BIO-13: Tricolored Blackbird

Prior to implementation of project activities, a qualified biologist with experience surveying for and observing tricolored blackbird will conduct a preconstruction survey to establish use of suitable habitat by tricolored blackbird colonies. Surveys will be conducted in suitable habitat within 1,300 feet of proposed construction areas, where access allows, during the nesting season (generally March 15 to July 31) 1 year prior to, and then again the year of, construction. During each year, surveys will be conducted monthly in March, April, May, June, and July. If construction is initiated at a site during the nesting season, three surveys will be conducted within 15 days of construction with one of the surveys within 5 days of the start of construction. The CDFW Suisun Marsh Unit tracks tricolored blackbird colonies yearly in Suisun Marsh as part of the University of California, Davis/USFWS tricolored blackbird portal project; these records will also be searched and staff at the portal project consulted for recent colony information. If active tricolored blackbird nesting colonies are identified, minimization requirements and construction monitoring will be required.

- Project activities will avoid active tricolored blackbird nesting colonies and associated habitat during the breeding season (generally March 15 to July 31). Avoidance measures will include relocating covered activities away from the nesting colonies and associated habitat to the maximum extent practicable.
- Projects (construction and restoration) will be designed to avoid construction activity to the maximum extent practicable up to 1,300 feet, but not less than a minimum of 300 feet, from an active tricolored blackbird nesting colony. This minimum buffer may be reduced in areas with dense forest, buildings, or other habitat features between the construction activities and the active nest colony, or where there is sufficient topographic relief to protect the colony from excessive noise or visual disturbance as determined by a biologist experienced with tricolored blackbird.
- Project activities potentially affecting a nesting colony will be monitored by a qualified biologist to verify that the activity is not disrupting the colony. If it is, the activity will be modified, as practicable, by either delaying construction until the colony abandons the site or until the end of the breeding season, whichever occurs first; temporarily relocating staging areas; or temporarily rerouting access to the construction site. Reclamation technical staff will consult with the fish and wildlife agencies and evaluate exceptions to the minimum nondisturbance buffer distance on a case-by-case basis.
- Prior to initiation of construction within 300 feet of suitable roosting habitat, a biologist with experience surveying for and observing tricolored blackbirds will conduct preconstruction surveys to establish use of roosting habitat by tricolored blackbird colonies. Surveys will be conducted in suitable habitat where access is available within 300 feet of proposed construction areas during the nonbreeding season (generally August 1 to March 14) 1 year prior to, and then again the year of, construction. If construction is initiated at a site during the nonbreeding season, three surveys will be conducted within 15 days prior to construction with one of the surveys within 5 days prior to the start of construction.
- Construction and restoration projects will also be designed to avoid construction activity within at least 300 feet from occupied active tricolored blackbird roosting habitat. This minimum buffer may be reduced in areas with dense forest, buildings, or other habitat features between the construction activities and the active roosting site, or where there is sufficient topographic relief to protect the roosting site from excessive noise or visual disturbance, or where sound curtains are used, as determined by a biologist experienced with tricolored blackbird.
- Construction activities that are within 300 feet of occupied roosting habitat will be monitored by a biologist familiar with tricolored blackbird behavior patterns to verify that the activity is not disrupting the roosting birds. If it is, the activity will be modified, as practicable, by delaying construction until the blackbirds are no longer using the roosting site, temporarily relocating

staging areas, temporarily rerouting access to the construction site, or use of sound curtains. The biologist will evaluate the nondisturbance buffer distance on a case-by-case basis.

Unavoidable loss of foraging habitat will be mitigated through foraging habitat protection at a 1:1 ratio, and unavoidable loss of nesting habitat through riparian restoration at a 2:1 ratio.

Mitigation Measure BIO-14: Western Burrowing Owl

Species-specific measures for western burrowing owl will only be required for water conveyance construction, restoration, and operations and maintenance activities occurring within suitable habitat as identified from habitat assessments conducted in advance of initiating ground-disturbing and staging activities. This measure incorporates survey, avoidance, and minimization guidelines taken primarily from the *Staff Report on Burrowing Owl Mitigation* (CDFG 2012).

Preconstruction Surveys

Western burrowing owl surveys will be required within and adjacent to (within 500 feet) water conveyance work areas and restoration sites where suitable habitat has been identified during habitat assessment surveys where access is available. Surveys will be conducted during the breeding season that precedes construction.

Four survey visits will be conducted with at least one site visit between February 15 and April 15 and a minimum of three survey visits, at least 3 weeks apart, between April 15 and July 15, with at least one visit after June 15. Surveys will be conducted between 10:00 a.m. and 2 hours before sunset. A qualified biologist will survey the study area and record and map all burrowing owl observations and burrows that may be occupied (as indicated by tracks, feathers, egg shell fragments, pellets, prey remains, cast pellets, whitewash, or decoration) on the project site. The surveys will be conducted while walking transects throughout the entire project footprint, plus all accessible areas within a 500-foot radius of the project footprint. The centerlines of these transects will be spaced 15 to 60 feet apart and will vary in width to account for changes in terrain and vegetation that can preclude complete visual coverage of the area. For example, in hilly terrain with patches of tall grass, transects will be closer together, while in open areas with little vegetation they can be 60 feet apart. Surveyors will stop at least every 300 feet along each transect to scan the entire visible area for presence of burrowing owls. Adjacent parcels under different land ownership will be surveyed only if access is granted or if the parcels are visible from authorized areas.

In addition, preconstruction surveys will be conducted with one occurring 14 days prior to ground breaking and/or staging activities and another within 24 hours of these activities. These surveys will confirm whether owls identified during the breeding season surveys are still present or whether the site has since become occupied by burrowing owls.

Avoidance and Minimization

To the extent feasible, burrowing owls will be avoided by relocating work areas with flexible locations, such as geotechnical exploration sites and restoration sites. Within the construction footprint where ground disturbance cannot avoid burrowing owls, owls will be relocated during the nonbreeding season and burrows will be excavated.

If an active burrow is identified near a work area and work cannot be conducted outside of the nesting season (February 1 to August 31), a qualified biologist will establish a nondisturbance buffer that extends a minimum of 250 feet around the burrow. If burrowing owls are present at the site during the nonbreeding season (September 1 through January 31), a qualified biologist will establish a nondisturbance buffer that extends a minimum of 150 feet around the burrow.

If the appropriate nondisturbance buffer for breeding or nonbreeding burrowing owls cannot be established, a wildlife biologist experienced in burrowing owl behavior will evaluate site-specific conditions and recommend a smaller buffer that still minimizes the potential to disturb the owls (and still allows reproductive success during the breeding season), if possible. The site-specific buffer will be established by taking into consideration the type and extent of the proposed activity occurring near the occupied burrow, the duration and timing of the activity, the sensitivity and habituation of the owls to existing conditions, and the dissimilarity of the proposed activity to background activities. If an appropriate buffer cannot be established around the active owl burrows, actions will be taken to exclude the owls from the site per the requirements below.

A biological monitor will be present during all construction activities occurring within any reduced buffers. If during the breeding season there is any change in owl nesting and foraging behavior as a result of construction activities, the biological monitor will work with construction personnel and the Environmental Manager to provide additional protections to reduce disturbance, such as adding visual and sound curtains; any modifications to the standard protections will be approved by a qualified biologist.

If monitoring indicates that the nest is abandoned prior to the end of nesting season and the burrow is no longer in use by owls, the nondisturbance buffer may be removed. If necessary because the burrow cannot be avoided by construction activity, the biologist will excavate and collapse the burrow to prevent reoccupation.

Relocation

No exclusion of burrowing owls will occur during the breeding season. If burrowing owls are present within the construction footprint and cannot be avoided during the nonbreeding season (generally September 1 through January 31), they will be relocated through passive relocation, with or without burrow exclusion. Passive relocation will be used when (1) there is a sufficient amount of suitable habitat adjacent to the work area to support nesting and foraging, (2) there are compatible land use practices in the area and 3) the area is preferably currently under or proposed for conservation.

Passive relocation will be conducted during the nonbreeding season; however passive relocation techniques may be used during the breeding season (February 1 through August 30) if a qualified biologist determines through site surveillance that the burrow is not occupied by a breeding pair, young, or eggs. To the extent feasible, passive relocation will first be considered without the use of exclusion devices to avoid and minimize harassment of owls.

<u>Passive Relocation without Exclusion</u>

Prior to relocating owls, all potential burrowing owl burrows in suitable nesting habitat and within the project footprint and 75 feet around the footprint, will be surveyed for owl use, and excavated if no owls are found. If occupied burrows are found, two natural or artificial burrows will be provided for each occupied burrow in the above defined survey area, at least 250 feet from the construction footprint. Artificial burrows will be installed following the methods in Barclay (2008) and Johnson et al. (2010). Sites used for artificial burrows will either be properties currently used for or proposed for conservation. After constructing the artificial burrows, the owls will be given 60 days to relocate on their own. The study area will be monitored weekly for up to 60 days to determine whether the owls have left the burrow and to attempting to confirm occupancy at the artificial or other nearby burrows. The formerly occupied burrows will then be excavated. Whenever possible, burrows will be excavated using hand tools and refilled to prevent reoccupation. Sections of flexible plastic pipe (at least 3 inches in diameter) will be inserted into burrows during excavation to maintain an escape route for any animals inside the burrow.

<u>Passive Relocation with Exclusion</u>

If the burrowing owls found in the above survey area do not relocate on their own through the above methodology, passive relocation will be accomplished by installing one-way doors (e.g., modified dryer vents). The one-way doors will be left in place for a minimum of 48 hours and be monitored twice daily to ensure that the owls have left the burrow. The burrow will be excavated using hand tools, and a section of flexible plastic pipe (at least 3 inches in diameter) will be inserted into the burrow tunnel during excavation to maintain an escape route for any animals that may be inside the burrow.

Compensation for Unavoidable Effects

Mitigate unavoidable loss of nesting, wintering, and satellite burrows, and burrowing owl habitat in comparable habitat at an approved mitigation ratio in consultation with CDFW. The mitigation strategy will be consistent with the mitigation guidance in the *Staff Report on Burrowing Owl Mitigation* (CDFG 2012).

Mitigation Measure BIO-15: Western Yellow-Billed Cuckoo

This measure for western yellow-billed cuckoo will be required for activities occurring within suitable habitat, or in the vicinity of suitable habitat. Prior to disturbing an area potentially supporting habitat for the species, a USFWS-approved biologist will evaluate the area to identify suitable habitat.

Project activities will be located to avoid or minimize disturbance of western yellow-billed cuckoo suitable habitat within the species' range. The following measures will be required for project components unable to avoid western yellow-billed cuckoo habitat.

- Permanent or temporary loss of all suitable migratory habitat will be minimized by all activities associated with the proposed action through project design.
- Prior to construction, all suitable western yellow-billed cuckoo habitat in the construction area will be surveyed.
- At least five surveys will be conducted in suitable habitats within 30 days of the onset of construction, with the last within 3 days of the onset of construction, by a qualified biologist with experience surveying and observing this species and familiar with its vocalizations.
- If an active nest site is present, a 500-foot nondisturbance buffer will be established around nest sites during the breeding season (generally, late February through late August).
- The required buffer may be reduced in areas where barriers or topographic relief are sufficient protect the nest from excessive noise or other disturbance, as determined by a qualified biologist on a case-by-case basis.
- If occupied nests are identified, a qualified biologist will monitor construction activities in the vicinity of all active western yellow-billed cuckoo nests to ensure that covered activities do not affect nest success.
- If surveys find western yellow-billed cuckoos in the area where vegetation will be removed, vegetation removal will be done when cuckoos are not present.
- If an activity is to occur within 1,200 feet of western yellow-billed cuckoo habitat (or within 2,000 feet if pile driving will occur) during the period of from June 15 through September 1 (the period in which yellow-billed cuckoos have been observed in the legal Delta) the following

measures will be implemented to avoid noise effects on migrating western yellow- billed cuckoos.

- Prior to the construction, a noise expert will create a noise contour map showing the 60 dBA noise contour specific to the type and location of construction to occur in the area.
- During the period between June 15 and September 1, a qualified biologist will survey any suitable migratory habitat for yellow-billed cuckoos within the 60 dBA noise contour on a daily basis during a two-week period prior to construction. While construction is occurring within this work window, the USFWS-approved biologist will conduct daily surveys in any suitable habitat where construction related noise levels could exceed 60 dBA L_{eq} (1 hour). If a yellow-billed cuckoo is found, sound will be limited to 60 dBA in the habitat being used until the USFWS-approved biologist has confirmed that the bird has left the area.
- Locate, store, and maintain portable and stationary equipment as far as possible from suitable western yellow-billed cuckoo habitat.
- Employ preventive maintenance including practicable methods and devices to control, prevent, and minimize noise.
- Route truck traffic to reduce construction noise impacts and traffic noise levels within 1,200 feet of suitable western yellow-billed cuckoo migratory habitat during migration periods.
- Limit trucking activities (e.g., deliveries, export of materials) to the hours of 7:00 a.m. to 10:00 p.m.
- Screen all lights and direct them down toward work activities away from migratory habitat. A biological construction monitor will ensure that lights are properly directed at all times.
- Operate portable lights at the lowest allowable wattage and height, while in accordance with the NCHRP *Report 498: Illumination Guidelines for Nighttime Highway Work* (Transportation Research Board 2003).

Compensation to Offset Effects

Reclamation will offset the loss of western yellow-billed cuckoo migratory habitat through the creation or restoration at a 3:1 ratio, for a total of [to be determined] acres of migratory riparian habitat creation or restoration in USFWS-approved location. For restoration, Reclamation will develop a riparian restoration plan that will identify the location and methods for riparian creation or restoration, and this plan will be subject to USFWS approval.

Mitigation Measure BIO-16: White-Tailed Kite

Preconstruction surveys will be conducted to identify the presence of active nest sites of tree nesting raptors within 0.25 mile of project sites, staging and storage areas, construction access roads, work areas, and soil stockpile areas where accessible, by a qualified biologist with experience identifying white-tailed kite nests. Transportation routes along public roads (roads leading to and from work areas) are considered disturbed, and no surveys or monitoring are required for nests along those roadways unless they are within ¼ mile of work areas. Surveys for nesting white-tailed kites will be conducted within 30 days prior to construction to ensure nesting activity is documented prior to the onset of construction activity during the nesting season. White-tailed kites nest in the study area between approximately March 15 and September 15. While many nest sites are traditionally used for multiple years, new nest sites can be established in any year. Therefore, construction activity that is planned after March 15 of any year will require surveys during the year of the construction. If construction is planned before March 15 of any year, surveys will be conducted the year immediately prior to the year of construction. If construction is planned before March 15 of any year and subject to prior-year surveys, but is later postposed to after March 15, surveys will also be conducted during the year of construction.

Construction will be restricted to the greatest extent possible during the nesting season where nest sites occur within 0.25 mile of construction activities, unless an already existing suitable buffer between the construction activity and the nest site is identified by a biologist. Surveys for white-tailed kite nests and nesting activity will occur in conjunction with the surveys for bald eagles under MM BIO-17 and follow the same protocol. If active nests are found or nesting activity is identified within 0.25 mile of construction activities appropriate avoidance and minimization measures will be implemented as described. Results of the surveys will be summarized in a memo(s) and provided to the Program Environmental Manager and Construction Supervisor prior to the commencement of construction.

Removal of known nest trees will be avoided to the maximum extent feasible. No trees with occupied nests will be removed until the nest is vacated.

The biologist will conduct a second survey of potential nesting trees and active nests, and monitor white-tailed kite nests no more than 72 hours prior to construction. If no nesting activity is found, then construction can proceed with no restrictions.

Where construction activities within 0.25 mile of an active nest cannot feasibly be avoided, construction will be initiated prior to egg-laying to the extent possible. If eggs and or young are present in the nest, work will be restricted until a biologist determines that white-tailed kites have acclimated to disturbance and exhibit normal nesting behavior.

A 650-foot-radius nondisturbance buffer will be established around each active white-tailed kite nest site. No construction activity will be allowed to occur in the buffer while a nest site is occupied by white-tailed kite during the breeding season. The buffer size may be modified based on the field examination and determination by the biologist of conditions that may minimize disturbance effects, including line-of-sight, topography, land use, type of disturbance, existing ambient noise and disturbance levels, and other relevant factors. The buffer will be clearly delineated with fencing or other conspicuous marking. Active nests will be monitored to track progress of nesting activities. Entry into the buffer will be granted when the biologist determines that the young have fledged and are capable of independent survival or the nest has failed and the nest site is no longer active.

Where it is infeasible to avoid construction within 0.25 mile of an active white-tailed kite nest identified in preconstruction surveys, at a minimum the following measures will be implemented as part of a nesting bird monitoring and management plan. The final plan may include additional measures that are specific to site conditions.

- A designated biologist will observe any nest site that is within 0.25 mile of construction activities for at least 1 hour and until normal nesting behavior can be determined 5 days and 3 days prior to the initiation of construction. The biologist will determine nest status and observe normal nesting behaviors, which may be used to compare to the nesting activities once construction begins. The results of preconstruction monitoring will be reported in a memo and provided to the Program Environmental Manager and Construction Supervisor.
- Where pre-project surveys have identified an occupied white-tailed kite nest less than 325 feet from construction, the designated biologist will observe the nest periodically throughout the day where covered activities occur to ensure the white-tailed kites demonstrate normal nesting behavior.

- Where pre-project surveys have identified an occupied white-tailed kite nest between 325 to 650 feet from construction, the designated biologist will observe the nest for at least 2 hours per construction day where covered activities occur to ensure the white-tailed kites are engaged in normal nesting behavior.
- Where pre-project surveys have identified an occupied white-tailed kite nest between 650 to 1,300 feet from construction, the Biological Monitor will observe the nest for at least 3 days per construction week to ensure the white-tailed kites are engaged in normal nesting behavior and to check the status of the nest.

During construction or ongoing operation and maintenance activities, physical contact with an active nest tree is prohibited from the time of egg laying to fledging, unless approved by CDFW. Construction personnel outside of vehicles must remain at least 650 feet, or the length of a buffer approved by a qualified biologist which will not result in take, from the nest tree unless construction activities require them to be closer.

All personnel will remain out of the line of sight of an occupied white-tailed kite nest during breaks if within 650 feet of the nest (as stated above, activities will only occur within 650 feet of a nest with approval by the designated biologist).

The project will be implemented in a manner that will not result in take of white-tailed kite as defined by Section 86 of the California Fish and Game Code. If during construction monitoring, the designated biologist determines that a nesting white-tailed kite within 650 feet of construction is disturbed by construction activities, to the point where reproductive failure could occur, the designated biologist will immediately notify the Construction Supervisor and Program Environmental Manager. The Program Environmental Manager will contact CDFW, and it will be determined by the parties whether additional protection measures can be implemented.

Potential nest abandonment and failure may be indicated if white-tailed kite exhibits distress and/or abnormal nesting behavior such as swooping/stooping at construction equipment or personnel, excessive vocalization (distress calls) or agitation directed at construction equipment or personnel, failure to remain on nest or failure to deliver prey items for an extended time period. Additional protection measures will remain in place until the white-tailed kite behavior has normalized.

Mitigate unavoidable loss of foraging habitat through foraging habitat protection at a 1:1 ratio, and unavoidable loss of nesting habitat through riparian restoration at a 2:1 ratio.

Mitigation Measure BIO-17: Bald Eagle

The following measures will be implemented to avoid and minimize impacts on bald eagle during Reclamation project activities.

- If restoration activities, including helicopter flights, need to take place during the nesting season and within 0.5 mile of potential bald eagle nesting habitat, qualified agency-approved biologists will conduct a preconstruction survey for occupied bald eagle nest in and within 0.5 mile of the work areas. An occupied nest is a “nest used for breeding in the current year by a [bald or golden eagle] pair” (Pagel et al. 2010). Survey procedures, including required surveyor qualifications, will follow the USFWS’ Interim Golden Eagle Inventory and Monitoring Protocols; and Other Recommendations (Pagel et al. 2010) or other more recent guidelines, if available.
- Reclamation will implement, at a minimum, the following measures to avoid disturbance of active eagle nests (i.e., “a golden eagle [or bald eagle] nest characterized by the presence of any

adult, egg, or dependent young at the nest in the past 10 consecutive days immediately prior to, and including, at present" [Pagel et al. 2010]):

- No activities involving loud noise (>90 decibels) or helicopter flight paths will be permitted within 0.5 mile of any active eagle nest found during preconstruction surveys. This restriction will be in effect from January to August 31 unless nest monitoring by a qualified agency-approved biologist reveals that the nest is no longer active (e.g., adults did not nest that year, nest failure from natural causes, young fledged).
- Activities that do not involve loud noise will maintain an exclusion zone of 0.25 mile around all active eagle nests found during preconstruction surveys. This restriction will be in effect from January to August 31 unless nest monitoring by a qualified agency-approved biologist reveals that the nest is no longer active.

- Eagle nest exclusion zones may be removed if monitoring reveals the nest to be inactive, and considered to be an "alternate nest" under current regulations under the Bald and Golden Eagle Protection Act. An alternate nest is "one of potentially several nests within a nesting territory that is not an in-use nest at the current time" (USFWS 2016). Monitoring to demonstrate that nests are not in-use will follow observational procedures described by Pagel et al. (2010).

Mitigation Measure BIO-18: Bank Swallow

The following measures will be implemented to avoid and minimize impacts on bank swallow individuals, colonies, current and potential habitat (i.e., natural banks), and, if feasible, to river processes. This applies to activities year-round, whether bank swallows are present or not.

Preconstruction Surveys

Prior to beginning project activities within 500 feet of the Sacramento River, Feather River, and lower American River during the bank swallow nesting season (April 1 through August 31), a preconstruction survey for bank swallow colonies will be conducted where bank swallow habitat is present within 500 feet of work areas. If no active nesting colonies are present, no further measures are required.

If an active colony is found and work must occur during the nesting season (April 1 through August 31), Reclamation will establish a nondisturbance buffer (in consultation with a biologist) around the colony during the breeding season. In addition, the biologist will monitor any active colony within 500 feet of work areas to ensure that activities do not affect nest success. No project activities will take place within the disturbance buffer.

Avoidance and Minimization

Prevent Impacts on Individuals, Colonies, and Habitat

To the extent feasible, where proposed water management or land-use projects (i.e., restoration activities) projects would impact bank swallows or river processes, alternatives such as setback levees can be used to avoid those impacts.

Consult with a biologist when planning projects within the floodplain of the Sacramento River and its tributaries to ensure projects do not affect colonies or current or potential habitat.

Develop flow criteria that avoid impacts of high water flows by limiting frequency and duration of peak flows over 14,000 cfs (Sacramento River) or rapid draw-downs to nesting bank swallow habitat during the breeding season (April 1 through August 31); this includes downstream tributary flows when timing water releases (Bank Swallow Technical Advisory Committee 2013).

Prevent Impacts on River Processes

To the extent feasible, where restoration activities would impact river processes, alternatives to bank stabilization, such as setback and adjacent levees, should be used to preserve dynamic river processes.

Maintain flow regimes during the nonbreeding season (September 1 through March 31) that promote natural river processes and create bank swallow habitat by providing annual flows that cause local bank erosion and a minimum of one bankfull flood event every 3 years to promote bank erosion, meander migration, and channel cutoff. (Bank Swallow Technical Advisory Committee 2013).

Mitigation Measure BIO-19: California Least Tern

For restoration projects, Reclamation will avoid California least tern nesting colony sites.

Mitigation Measure BIO-20: Migratory Birds (Osprey, Short-Eared Owl, Tule Greater White-fronted Goose, Black Tern, Least Bittern, White-Faced Ibis)

The following measures will be implemented to avoid and minimize impacts on nesting migratory birds, including special-status birds, during Reclamation restoration activities.

- A qualified wildlife biologist with experience with nesting birds will conduct nesting surveys before the start of restoration activities. A minimum of three separate surveys will be conducted within 30 days prior to the initiation of work, with the last survey within 3 days prior to work beginning in a given work area. Surveys will include a search of all suitable nesting habitat in the work area. In addition, a 500-foot radius around the work area, where accessible, will be surveyed for nesting raptors, and an area within 50 feet of the work area will be surveyed for other nesting birds protected by the MBTA. If no active nests are detected during these surveys, no additional measures are required.

If active nests are found in the survey area, nondisturbance buffers will be established around the nest sites to avoid disturbance or destruction of the nest site until the end of the breeding season (approximately September 1) or until a qualified wildlife biologist determines that the young have fledged and moved out of the study area. The end of the breeding season varies by species and the stage of the nesting effort (i.e., nest building, egg laying, incubation, feeding nestling, feathered young, fledged young, etc.) as determined by the qualified wildlife biologist. A qualified wildlife biologist will monitor activities in the vicinity of the nests to ensure that activities do not affect nest success. The extent of the buffers will be determined by the biologist and will depend on the level of noise or disturbance, line-of-sight between the nest and the disturbance, ambient levels of noise and other disturbances, and other topographical or artificial barriers. Suitable buffer distances may vary between species.

Mitigation Measure BIO-21: Riparian Woodrat and Riparian Brush Rabbit

The measures for riparian woodrat and riparian brush rabbit will be implemented for projects occurring within suitable habitat. Within the study area, based on the known distribution of the species, suitable habitat is defined to include the areas within the legal Delta along San Joaquin and Stanislaus Rivers south of State Route 4 and Old River Pipeline. Within this area, suitable riparian habitat includes the vegetation types that make up a dense, brushy understory shrub layer with a minimum patch size of 0.05 acres. Riparian brush rabbit grassland habitat includes grasslands with a minimum patch size of 0.05 acres that are adjacent to riparian brush rabbit riparian habitat.

A qualified biologist will conduct a field evaluation of suitable habitat for both species for all covered activities that occur within the defined area for these species' habitat as described above. If the project cannot fully avoid effects on suitable habitat, the following measures will be required.

- A qualified biologist will assess habitat suitability for both species. If the qualified biologist determines the habitat to be suitable for the species, then Reclamation will avoid disturbing suitable habitat while accessing restoration sites (i.e., access to enhancement sites for in-stream activities such as gravel placement).
- If a habitat or floodplain restoration component would disturb suitable habitat, Reclamation will assume presence or conduct protocol-level surveys according to the USFWS Draft Habitat Assessment Guidelines and Survey Protocol for the Riparian Brush Rabbit and the Riparian Woodrat (USFWS n.d.).
- If occupied riparian woodrat or riparian brush rabbit habitat is present, or the habitat is assumed to be occupied, Reclamation will redesign the project to avoid occupied habitat. Avoidance requires the following buffers and avoidance measures:
    - Establish minimum 250-foot nondisturbance buffers between project activities and suitable riparian habitat that is occupied or assumed to be occupied. The nondisturbance buffer is not necessary for access to restoration sites provided existing access roads are used.
    - Establish a 1,400-foot buffer between any lighting and suitable riparian habitat that is occupied or assumed to be occupied.
    - Screen all lights and direct them down toward work activities away from riparian habitat that is occupied or assumed to be occupied. A biological construction monitor will ensure that lights are properly directed at all times.
    - Operate portable lights at the lowest allowable wattage and height, while in accordance with the NCHRP *Report 498: Illumination Guidelines for Nighttime Highway Work* (Transportation Research Board 2003).
- If the suitable habitat is determined through surveys to be unoccupied, Reclamation will implement the following measures to minimize long-term effects on the habitat so that it may provide for the recovery of the species. No more than 45 acres of suitable, unoccupied riparian habitat and 30 acres of adjacent grasslands may be permanently removed by levee construction in the San Joaquin River watershed. No more than 35 acres of suitable riparian habitat and 20 acres of adjacent grassland habitat may be temporarily removed for levee construction in the San Joaquin watershed. No more than 10 acres of suitable, unoccupied riparian habitat may be affected in the Stanislaus River watershed.
    - Floodplain restoration projects will be designed to minimize the removal of mature oaks in areas providing suitable habitat for the riparian woodrat.
    - Include refugia within the restored floodplains to provide shelter from flood events for any individuals of these species that may come to occupy the area.
- Reclamation will additionally implement the following measures to avoid and minimize noise and lighting-related effects on riparian brush rabbit:
    - Establish a 1,200-foot nondisturbance buffer between any project activities and suitable riparian habitat.

- Offset any unavoidable loss of suitable riparian habitat through restoration at a 3:1 ratio, using the following restoration design measures:
- Restoration must meet specific ecological requirements for the species.
- Restoration is adjacent to, or facilitates connectivity with, existing occupied or potentially occupied habitat.

Mitigation Measure BIO-22: Salt Marsh Harvest Mouse and Suisun Shrew

Where suitable salt marsh harvest mouse and Suisun shrew habitat has been identified within a tidal restoration work area or within 100 feet of a tidal restoration work area where ground-disturbing activities will occur (e.g., at a levee breach or grading location) a biologist will conduct preconstruction surveys for the mouse or shrew prior to ground disturbance. If a mouse or shrew is discovered, tidal restoration activities near the mouse or shrew will cease until wildlife staff can be contacted and a relocation plan can be developed. Prior to tidal restoration ground-disturbing activities, vegetation will first be removed with nonmechanized hand tools (e.g., goat or sheep grazing, or, in limited cases where the biological monitor can confirm that there is no risk of harming salt marsh harvest mouse or Suisun shrew, hoes, rakes, and shovels may be used) to allow salt marsh harvest mouse and Suisun shrew to passively move out of the location. Vegetation must be cleared to bare ground and removed from the work area, including roads. The upper 6 inches of soil excavated within salt marsh harvest mouse and Suisun shrew habitat will be stockpiled and replaced on top of backfilled material. Vegetation will be removed under supervision of a biological monitor familiar with salt marsh harvest mouse and Suisun shrew. Vegetation removal will start at the edge farthest from the salt marsh and work its way toward the salt marsh. This method of removal provides cover for salt marsh harvest mouse and Suisun shrew and allows them to move toward the salt marsh as vegetation is being removed.

Temporary exclusion fencing will be placed around a defined tidal restoration work area before construction activities start and immediately after vegetation removal. The fence should be made of material that does not allow a salt marsh harvest mouse or Suisun shrew to pass through and should be buried to a depth of 2 inches so that mice cannot crawl under the fence. Supports for the fence must be placed on the inside of the exclusion area. Prior to the start of daily activities during initial ground disturbance, the biologist will inspect the salt marsh harvest mouse-proof boundary for holes or rips. The work area will also be inspected to ensure no mice are trapped inside. Any mice or shrews found along or outside the fence will be closely monitored until they move away from the construction site. Tidal restoration work will be scheduled to avoid extreme high tides (6.5 feet or above, as measured at the Golden Gate Bridge) to allow for salt marsh harvest mouse to more easily move to higher grounds.

The biologist with previous salt marsh harvest mouse and Suisun shrew experience will be onsite during construction activities related to tidal restoration in suitable habitat. The biologist will document compliance with the project permit conditions and avoidance and conservation measures. The approved biologist will have the authority to stop tidal restoration activities if any of the requirements associated with these measures are not being fulfilled. If the biologist requests work stoppage because of take of any listed species, CDFW and USFWS staff will be notified within 1 day by email or telephone.

Mitigation Measure BIO-23: Ring-Tailed Cat

Because ring-tailed cats maintain multiple dens, the loss of one den would be a negligible impact. However, the loss of a natal or maternity den would be significant. Reclamation will implement the following measure for ring-tailed cat:

- A qualified biologist familiar with ring-tailed cat biology will conduct a habitat assessment of the proposed construction area. If highly suitable denning habitat is present, the area will be designated as an Environmental Sensitive Area and marked on project maps.
- When possible, the removal of vegetation and construction activities will be conducted outside of the breeding season for ring-tailed cat (February 1 through May 1).
- If the denning season cannot be completely avoided, a qualified biologist will conduct a preconstruction survey within 2 weeks prior to commencement of construction for potential natal or maternity den trees. If an active den is found, a qualified biologist, will determine a construction-free buffer zone to be establish around the den until the young have left the den.
- A biological monitor will be present when construction activities take place when active ring-tailed cat dens are identified within the construction work area and work takes place within 150 feet of the den.

Mitigation Measure BIO-24: Special-Status Bats

The following measure was designed to avoid and minimize adverse direct and indirect effects on special-status bats. Baseline data are not available or are limited on how bats use the study area and on individual numbers of bats and how they vary seasonally. Accordingly, it is difficult to determine if there would be a substantial reduction in species numbers. Bat species with potential to occur in the study area employ varied roost strategies, from solitary roosting in foliage of trees to colonial roosting in trees and artificial structures, such as buildings and bridges. Daily and seasonal variations in habitat use are common. To obtain the highest likelihood of detection, preconstruction bat surveys will be conducted by Reclamation and will include these components:

- Identification of potential roosting habitat within project footprint.
- Daytime search for bats and bat sign in and around identified habitat.
- Evening emergence surveys at potential day-roost sites, using night-vision goggles and/or active full-spectrum acoustic monitoring where species identification is sought.
- Passive full-spectrum acoustic monitoring and analysis to detect bat use of the area from dusk to dawn over multiple nights.
- Additional onsite night surveys as needed following passive acoustic detection of special-status bats to determine nature of bat use of the structure in question (e.g., use of structure as night roost between foraging bouts).
- Qualified biologists will have knowledge of the natural history of the species that could occur in the study area and experience using full-spectrum acoustic equipment. During surveys, biologists will avoid unnecessary disturbance of occupied roosts.

Preconstruction Bridge and Other Structure Surveys

Before work begins on the bridge/structure, qualified biologists will conduct a daytime search for bat sign and evening emergence surveys to determine if the bridge/structure is being used as a roost. Biologists conducting daytime surveys would listen for audible bat calls and would use naked eye, binoculars, and a high-powered spotlight to inspect expansion joints, weep holes, and other bridge features that could house bats. Bridge surfaces and the ground around the bridge/structure would be surveyed for bat sign, such as guano, staining, and prey remains.

Evening emergence surveys will consist of at least one biologist stationed on each side of the bridge/structure watching for emerging bats from a half hour before sunset to 1–2 hours after sunset for a minimum of 2 nights within the season that construction would be taking place. Night-vision goggles and/or full-spectrum acoustic detectors shall be used during emergence surveys to assist in species identification. All emergence surveys would be conducted during favorable weather conditions (calm nights with temperatures conducive to bat activity and no precipitation predicted).

Additionally, passive monitoring with full-spectrum bat detectors will be used to assist in determining species present. A minimum of 4 nights of acoustic monitoring surveys will be conducted within the season that the construction would be taking place. If site security allows, detectors should be set to record bat calls for the duration of each night. To the extent possible, all monitoring will be conducted during favorable weather conditions (calm nights with temperatures conducive to bat activity and no precipitation predicted). The biologists will analyze the bat call data using appropriate software and prepare a report with the results of the surveys. If acoustic data suggest that bats may be using the bridge/structure as a night roost, biologists will conduct a night survey from 1 to 2 hours past sunset up to 6 hours past sunset to determine if the bridge is serving as a colonial night roost.

If suitable roost structures will be removed, additional surveys may be required to determine how the structure is used by bats, whether it is as a night roost, maternity roosts, migration stopover, or for hibernation.

Preconstruction Tree Surveys

If tree removal or trimming is necessary, qualified biologists will examine trees to be removed or trimmed for suitable bat roosting habitat. High-value habitat features (large tree cavities, basal hollows, loose or peeling bark, larger snags, palm trees with intact thatch, etc.) will be identified and the area around these features searched for bats and bat sign (guano, culled insect parts, staining, etc.). Riparian woodland, orchards, and stands of mature broadleaf trees should be considered potential habitat for solitary foliage roosting bat species.

If bat sign is detected, biologists will conduct evening visual emergence surveys of the source habitat feature from a half hour before sunset to 1–2 hours after sunset for a minimum of 2 nights within the season that construction would be taking place. Methodology should follow that described above for the bridge emergence survey.

Additionally, if suitable tree roosting habitat is present, acoustic monitoring with a bat detector will be used to assist in determining species present. These surveys would be conducted in coordination with the acoustic monitoring conducted for the bridge structure.

Protective Measures for Bats using Bridges/Structures and Trees

Avoidance and minimization measures shall be necessary if it is determined that bats are using the bridge/structure or trees as roost sites and/or sensitive bats species are detected during acoustic monitoring. Appropriate measures shall include, as applicable, the measures listed below.

- Ensure that bats are protected from noise, vibrations, and light that result from construction activities associated with water conveyance facilities, conservation components, and ongoing habitat enhancement, as well as operations and maintenance of above-ground water conveyance facilities, including the transmission facilities. This would be accomplished by either directing noise barriers and lights inward from the disturbance or ensuring that the disturbances do not extend more than 300 feet from the point source.

- Disturbance of the bridge will be avoided between March 1 and October 31 (the maternity period) to avoid impacts on reproductively active females and dependent young.
- Installation of exclusion devices from March 1 through October 31 to preclude bats from occupying the bridge during construction. Exclusionary devices will only be installed by or under the supervision of an experienced bat biologist.
- Tree removal will be avoided between April 15 and September 15 (the maternity period for bat species that use trees) to avoid impacts on pregnant females and active maternity roosts (whether colonial or solitary).
- Tree removal will be conducted between September 15 and October 31 to the maximum extent feasible, which corresponds to a time period when bats would not likely have entered winter hibernation and would not be caring for flightless young.
- Trees will be removed in pieces, rather than felling the entire tree.
- If a maternity roost is located, whether solitary or colonial, that roost will remain undisturbed with a buffer as determined in by a qualified biologist until September 15 or until the qualified biologist has determined the roost is no longer active.
- If a non-maternity roost is found, that roost will be avoided to the maximum extent feasible and an appropriate buffer established in consultation with a qualified biologist. Every effort would be made to avoid the roost to the maximum extent feasible, as methods to evict bats from trees are largely untested. However, if the roost cannot be avoided, eviction will be attempted and procedures designed in consultation with the qualified biologist will be employed to reduce the likelihood of mortality of evicted bats. In all cases:
    - Eviction would not occur before September 15.
    - Qualified biologists would carry out or oversee the eviction tasks and would monitor the tree trimming/removal.
    - Eviction would take place late in the day or in the evening to reduce the likelihood of evicted bats falling prey to diurnal predators.
    - Eviction would take place during weather and temperature conditions conducive to bat activity.
    - Special-status bat roosts would not be disturbed.
- Eviction procedures shall include but are not limited to the following:
    - Pre-eviction surveys to obtain data to inform the eviction approach and subsequent mitigation requirements. Relevant data may include the species, sex, reproductive status and/or number of bats using the roost, and roost conditions themselves such as temperature and dimensions. Surveys may include visual emergence, night vision, acoustic, and/or capture.
    - If needed, structural changes to the roost, performed without harming bats, such that the conditions in the roost are undesirable to roosting bats and the bats leave on their own (e.g., open additional portals so that temperature, wind, light and precipitation regime in the roost change).
    - Non-injurious harassment at the roost site to encourage bats to leave on their own, such as ultrasound deterrents or other sensory irritants.

- Prior to removal/trimming, after other eviction efforts have been attempted, any confirmed roost tree would be shaken, repeatedly struck with a heavy implement such as an axe and several minutes should pass before felling trees or trimming limbs to allow bats time to arouse and leave the tree. The biologists should search downed vegetation for dead and injured bats. The presence of dead or injured bats would be reported to CDFW.

Compensatory mitigation for the loss of roosting habitat will include the construction and installation of suitable replacement habitat onsite. Depending on the species and type of roost lost, various roost replacement habitats have met with some success (e.g., bat houses, “bat bark,” planting cottonwood trees, leaving palm thatch in place rather than trimming). Creating natural habitat onsite is generally preferable to artificial habitat.

Artificial roosts are often unsuccessful, and care must be taken to determine as closely as possible the conditions in the natural roost to be replaced. Even with such care, artificial habitat may fail. Several artificial roosts have been highly successful in replacing bridge roost habitat when incorporated into new bridge designs. “Bat bark” has been successfully used by the Arizona Department of Game and Fish to create artificial crevice-roosting bat habitat mounted on pine trees (Mering and Chambers 2012:765). Bat houses have at best an inconsistent track record but information is mounting on how to create successful houses. There is no single protocol or recipe for bat-house success. Careful study of the roost requirements of the species in question; the particular conditions at the lost roost site including temperature, orientation of the openings, airflow, internal dimensions and structures (cavity vs. crevice, etc.) should increase the chances of designing a successful replacement.

Restoring riparian woodland with plantings shows signs of success in Colorado. Western red bat activity has been positively correlated with increased vegetation and tree growth, canopy complexity and restoration acreage at cottonwood-willow restoration sites along the Lower Colorado River (Broderick 2010). These complex woodland areas would ultimately provide a wider range of bat species with preferred roost types, including both foliage-roosting and crevice-/cavity-roosting bats.

Mitigation Measure BIO-25: Suisun Thistle and Soft Bird’s-Beak

A complete botanical survey of project sites will be completed using *Guidelines for Conducting and Reporting Botanical Inventories for Federally Listed, Proposed and Candidate Plants* (USFWS 1996) and *Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Sensitive Natural Communities* (CDFW 2018). The surveys will be floristic in nature and conducted in a manner that maximizes the likelihood of locating Suisun thistle and soft bird’s-beak (i.e., during the appropriate season and at an appropriate level of ground coverage).

Special-status plant surveys required for project-specific permit compliance will be conducted early in the planning process to allow design of the individual restoration projects to avoid adverse modification of habitat for specified covered plants. The purpose of these surveys will be to verify that the locations of Suisun thistle and soft bird’s-beak identified in previous record searches or surveys are extant, identify any new occurrences, and cover any portions of the study area not previously identified. The extent of compensation for direct loss of or indirect effects on Suisun thistle and soft bird’s-beak will be based on these survey results. Locations of the plants in proposed construction areas will be recorded using a GPS unit and flagged.

The following measures will be implemented:

- Design restoration projects to avoid the direct, temporary loss of occupied habitat from construction activities for Suisun thistle. In tidal restoration areas, Suisun thistle occurrences may experience the indirect effect of tidal damping. This effect will be monitored and adaptively managed to ensure the occurrence is protected from loss.

- If a soft bird's-beak occurrence has more than 10 individuals, no more than 5% of the total number of individuals in the occurrence will be removed. If an occurrence has 10 or fewer individuals, all individuals may be removed. Loss of individuals for all occurrences will be offset through replacement of occupied habitat at a ratio of at least 1:1, to achieve no net loss of occupied habitat.
- To minimize the spread of nonnative, invasive plant species from restoration sites, Reclamation will retain a qualified botanist or weed scientist prior to clearing operations to determine if affected areas contain invasive plants. If areas to be cleared contain invasive plants, then chipped vegetation material from those areas will not be used for erosion control; in these cases, the material will be disposed of to minimize the spread of invasive plant propagules (e.g., by burning, composting). All revegetation materials (such as mulches and seed mixtures used during restoration) shall be certified weed-free and come from locally adapted native plant materials.
- To minimize the introduction of invasive plant species, construction vehicles and construction machinery will be cleaned prior to entering construction sites that are in or adjacent to natural communities other than cultivated lands and prior to entering any restoration sites or conservation lands other than cultivated lands. Vehicles travelling off paved roads in areas with infestations of invasive plant species will be cleaned before travelling to other parts of the study area. Cleaning stations will be established at the perimeter of covered activities along construction routes as well as at the entrance to reserve system lands. Biological monitoring will include locating and mapping locations of invasive plant species within the construction areas during the construction phase and the restoration phase. Infestations of invasive plant species will be targeted for control or eradication as part of the restoration and revegetation of temporarily disturbed construction areas.
- Reclamation will ensure that covered activities in designated critical habitat areas for Suisun thistle or soft bird's-beak, if any, will not result in the adverse modification of any of the primary constituent elements for Suisun thistle or soft bird's-beak critical habitat. The CDFW Suisun Marsh Unit tracks both of these species (GIS-mapped) in Suisun Marsh. No covered activities will take place within designated Suisun thistle or soft bird's-beak critical habitat areas without prior written concurrence from USFWS that such activities will not adversely modify any primary constituent elements of Suisun thistle or soft bird's-beak critical habitat. Primary constituent elements for Suisun thistle are defined as follows.
    - Persistent emergent, intertidal, estuarine wetland at or above the mean high water mark as extended directly across any intersecting channels).
    - Open channels that periodically contain moving water with ocean-derived salts in excess of 0.5%.
    - Gaps in surrounding vegetation to allow for seed germination and growth.
- Primary constituent elements for soft bird's-beak are defined as follows.
    - Persistent emergent, intertidal, estuarine wetland at or above the mean high water mark (as extended directly across any intersecting channels).
    - Rarity or absence of plants that naturally die in late spring (winter annuals).
    - Partially open spring canopy cover at ground level, with many small openings to facilitate seedling germination.

Mitigation Measure BIO-26: Other Special-Status Plant Species (Contra Costa Goldfields, Delta Button-Celery, Delta Tule Pea, Mason's Lilaeopsis, Suisun Marsh Aster, Bolander's Water Hemlock, Sanford's Arrowhead)

A complete botanical survey of project sites in areas of suitable habitat for special-status plants will be completed using *Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Sensitive Natural Communities* (CDFW 2018). The surveys will be floristic in nature and conducted in a manner that maximizes the likelihood of locating special-status plant species or special-status natural communities that may be present (i.e., during the appropriate season and at an appropriate level of ground coverage).

Special-status plant surveys required for project-specific permit compliance will be conducted during the planning phase to allow design of the individual project activities to avoid or minimize adverse impacts to habitat for specified covered plants. The purpose of these surveys will be to verify that the locations of special-status plants identified in previous record searches or surveys are extant, identify any new special-status plant occurrences, and cover any portions of the study area not previously identified. The extent of mitigation of direct loss of or indirect effects on special-status plants will be based on these survey results. Locations of special-status plants in proposed construction areas will be recorded using a GPS unit and flagged.

The following measures will be implemented.

- Design restoration projects to avoid the direct, temporary loss of occupied habitat from construction activities for other special-status plant species. If other special-status plant species occur in a floodplain restoration area, restoration projects may be designed to include occupied habitat in the restored floodplain provided ground disturbance is avoided in the occupied habitat and the restoration is designed such that the anticipated level of flooding and scouring is compatible with the life-history needs of the covered plant species. In tidal restoration areas, occurrences may experience the indirect effect of tidal damping. This effect will be monitored and adaptively managed to ensure the occurrence is protected from loss.
- Avoid modeled habitat for vernal pool plants to the maximum extent practicable. Where practicable, no ground-disturbing activities or alterations to hydrology will occur within 250 feet of vernal pools. Reclamation will ensure that there will be no adverse modification of critical habitat for vernal pool plants.
- Avoid the loss of extant occurrences of all other special-status plant species.
- If an occurrence has more than 10 individuals, no more than 5% of the total number of individuals in the occurrence will be removed. If an occurrence has 10 or fewer individuals, all individuals may be removed. Loss of individuals for all occurrences will be offset through replacement of occupied habitat at a ratio of at least 1:1, to achieve no net loss of occupied habitat.
- To minimize the spread of nonnative, invasive plant species from restoration sites, Reclamation will retain a qualified botanist or weed scientist prior to clearing operations to determine if affected areas contain invasive plants. If areas to be cleared contain invasive plants, then chipped vegetation material from those areas will not be used for erosion control; in these cases, the material will be disposed of to minimize the spread of invasive plant propagules (e.g., by burning, composting). All revegetation materials (such as mulches and seed mixtures used during restoration) shall be certified weed-free and come from locally adapted native plant materials.

- To minimize the introduction of invasive plant species, construction vehicles and construction machinery will be cleaned prior to entering construction sites that are in or adjacent to natural communities other than cultivated lands, and prior to entering any project restoration sites or conservation lands other than cultivated lands. Vehicles travelling off paved roads in areas with infestations of invasive plant species will be cleaned before travelling to other parts of the project. Cleaning stations will be established at the perimeter of covered activities along construction routes as well as at the entrance to conservation lands. Biological monitoring will include locating and mapping locations of invasive plant species within the construction areas during the construction phase and the restoration phase. Infestations of invasive plant species will be targeted for control or eradication as part of the restoration and revegetation of temporarily disturbed construction areas.
- This mitigation measure does not apply to the routine management and maintenance activities of Reclamation. Reclamation will determine during implementation the most effective and cost-efficient means to minimize the unintentional spread of invasive plants through vehicle travel.

E.10.1.1 *Mitigation Measures for Wetlands and Waters of the United States*

Mitigation Measure BIO-27: Wetlands and Waters of the United States

Reclamation will avoid fill of wetlands and waters of the United States to the extent feasible, and will offset unavoidable effects through wetland creation, restoration, or enhancement with the goal of achieving no net loss of wetland acres and functions.

E.11 Regional Economics

None proposed.

E.12 Land Use and Agricultural Resources

Mitigation Measure AG-1: Diversify Water Portfolios

Water users should diversify their water portfolios. Diversification could include the sustainable conjunctive use of groundwater and surface water, water transfers, water conservation and efficiency upgrades, and increased use of recycled water where available.

Mitigation Measure AG-2: Impose Conditions on Discretionary Land Use Approvals

Agencies that approve changes in land use that involve conversion of agricultural land to nonagricultural use should impose conditions on such approvals. Conditions should provide for the protection of an equal area of agricultural land to the agricultural land that would be converted and could include the following methods:

- Provide for a new conservation easement through grant or purchase to protect agricultural land that is not protected at the time of approval.
- Pay in-lieu fees sufficient to purchase easement or land into a fund specified for such purposes.

E.13 Recreation

None proposed.

E.14 Environmental Justice

None proposed.

E.15 Power

None proposed.

E.16 Noise

Mitigation Measure NOI-1. Employ Standard Measures to Reduce Noise Levels from Heavy Equipment

Where applicable, Reclamation and DWR will implement best practices to reduce construction noise levels at noise-sensitive land uses to reduce the potential for negative community reaction. These methods would be implemented to limit construction noise levels to 70 dBA L_{eq} (1 hour) during daytime hours (7:00 a.m. to 7:00 p.m.) and 60 dBA Leq (1 hour) during evening/nighttime hours (7:00 p.m. to 7:00 a.m.) wherever possible.

Potential measures identified to limit construction noise include the following:

- Limiting noise-generating construction operations to daytime hours.
- Locating stationary equipment (e.g., generators, compressors, rock crushers, cement mixers, idling trucks) as far as possible from noise-sensitive land uses.
- Prohibiting gasoline or diesel engines from having unmuffled exhaust.
- Requiring that all construction equipment powered by gasoline or diesel engines have sound-control devices that are at least as effective as those originally provided by the manufacturer and that all equipment be operated and maintained to minimize noise generation.
- Preventing excessive noise by shutting down idle vehicles or equipment.
- Using noise-reducing enclosures around noise-generating equipment.
- Selecting haul routes that affect the fewest number of people.
- Constructing barriers between noise sources and noise-sensitive land uses, or taking advantage of existing barrier features (e.g., terrain, structures) to block sound transmission to noise-sensitive land uses. Barriers would be designed to obstruct the line of sight between the noise-sensitive land use and on-site construction equipment.
- Notifying adjacent residents in advance of construction work.

E.17 Hazards and Hazardous Materials

Mitigation Measure HAZ-1: Prepare and Implement Site-Specific Mosquito Management Plans

Reclamation will consult/coordinate with appropriate Mosquito and Vector Control Districts (MVCDs) in the study area prior to implementing tidal and floodplain habitat restoration to develop and implement site-specific mosquito management plans to aid in mosquito management. The mosquito management plans, which will include applicable BMPs from *Best Management Practices for Mosquito Control in California* (CDPH and MVCAC 2012), will address habitat design considerations, water management practices, vegetation management, biological controls, and restored habitat maintenance.

Mitigation Measure HAZ-2: Comply with FAA Safety Guidelines on Wetlands and Wildlife Attractants as Identified in the FAA Draft Advisory Circular 150/5200-33C

For habitat restoration in the study area that is within 5 miles of a public use airport and has the potential to attract waterfowl and other birds, Reclamation will comply with FAA safety guidelines on wetlands and wildlife attractants, as identified in the FAA Draft Advisory Circular 150/5200-33C Sections 1 and 2.4 (FAA 2019), to avoid or minimize the potential for bird-aircraft strikes resulting from habitat restoration.

Mitigation Measure HAZ-3: Prepare and Implement a Hazardous Materials Management Plan for Actions That Will Require Handling Hazardous Materials in Reportable Quantities (CCR, Title 19, Division 2)

For actions that will require handling hazardous materials in quantities equal to or greater than 55 gallons of a liquid, 500 pounds of a solid, or 200 cubic feet of compressed gas, or extremely hazardous substances above the threshold planning quantity (40 CFR, Part 355, Appendix A), Reclamation will prepare and implement a hazardous materials management plan (HMMP). The HMMP will contain, at minimum, the following elements:

- A site plan
- An emergency plan
- An inventory of hazardous materials
- A description of preventative measures to be implemented to avoid accidental spills, hazardous materials management, and storage
- A description of the actions that will be taken in the event of a hazardous material spill
- A training program for employees on the safe on-site use and storage of hazardous materials.

E.18 Geology and Soils

None proposed.