HATCHERY AND STOCKING PRACTICES REVIEW
STUDY REPORT

LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

Prepared for:
Turlock Irrigation District – Turlock, California
Modesto Irrigation District – Modesto, California

Prepared by:
HDR, Inc.

February 2017

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Acronyms and Abbreviations

ac-ft ....acre-foot
BLM............................Bureau of Land Management
BOR ....Bureau of Reclamation
CCSF..........................City and County of San Francisco
CDFG.........................California Department of Fish and Game, now CDFW
CDFW........................California Department of Fish and Wildlife
cfs...............................cubic feet per second
CG ....Conservation Groups
Districts......................Turlock Irrigation District and Modesto Irrigation District
FERC..........................Federal Energy Regulatory Commission
FLA ....Final License Application
FPA ....Federal Power Act
GIS ....geographic information system
ILP..............................Integrated Licensing Process
ISR ....Initial Study Report
LGDD ....La Grange Diversion Dam
LPs ....licensing participants
M&I............................municipal and industrial
MID............................Modesto Irrigation District
NMFS.........................National Marine Fisheries Service
NPS ....National Park Service
O&M..........................operation and maintenance
PAD............................Pre-Application Document
PSP.............................Proposed Study Plan
QA/QC.......................quality assurance/quality control
RM ....river mile
RSP ....Revised Study Plan
SD2 ....Scoping Document 2
SPD ....Study Plan Determination
TAF ....thousand acre-feet
TID.............................Turlock Irrigation District
TM..............................technical memorandum
USFWS ....United States Fish and Wildlife Service
USGS ....United States Geological Survey
USR............................Updated Study Report

1.0 INTRODUCTION

1.1 Background

The Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) own the La Grange Diversion Dam (LGDD) located on the Tuolumne River in Stanislaus County, California (Figures 1.1-1 and 1.1-2). LGDD is 131 feet high and is located at river mile (RM) 52.2 at the exit of a narrow canyon, the walls of which contain the pool formed by the diversion dam. Under normal river flows, the pool formed by the diversion dam extends for approximately one mile upstream. When not in spill mode, the water level upstream of the diversion dam is between elevation 294 feet and 296 feet approximately 90 percent of the time. Within this 2-foot range, the pool storage is estimated to be less than 100 acre-feet of water.

The drainage area of the Tuolumne River upstream of LGDD is approximately 1,550 square miles. Tuolumne River flows upstream of LGDD are regulated by four reservoirs: Hetch Hetchy, Lake Eleanor, Lake Lloyd (known as Cherry Lake), and Don Pedro. The Don Pedro Hydroelectric Project (Federal Energy Regulatory Commission [the Commission or FERC] No. 2299) is owned jointly by the Districts, and the other three dams are owned by the City and County of San Francisco (CCSF). Inflow to the La Grange pool is the sum of releases from the Don Pedro Project, located 2.3 miles upstream, and very minor contributions from two small intermittent streams downstream of Don Pedro Dam.

LGDD was constructed from 1891 to 1893 displacing Wheaton Dam, which was built by other parties in the early 1870s. LGDD raised the level of the Tuolumne River to permit the diversion and delivery of water by gravity to irrigation systems owned by TID and MID. The Districts' irrigation systems currently provide water to over 200,000 acres of prime Central Valley farmland and drinking water to the City of Modesto. Built in 1924, the La Grange hydroelectric plant is located approximately 0.2 miles downstream of LGDD on the east (left) bank of the Tuolumne River and is owned and operated by TID. The powerhouse has a capacity of slightly less than five megawatts. The La Grange Hydroelectric Project (La Grange Project or Project; FERC No. 14581) operates in a run-of-river mode. The LGDD provides no flood control benefits, and there are no recreation facilities associated with the Project or the La Grange pool.

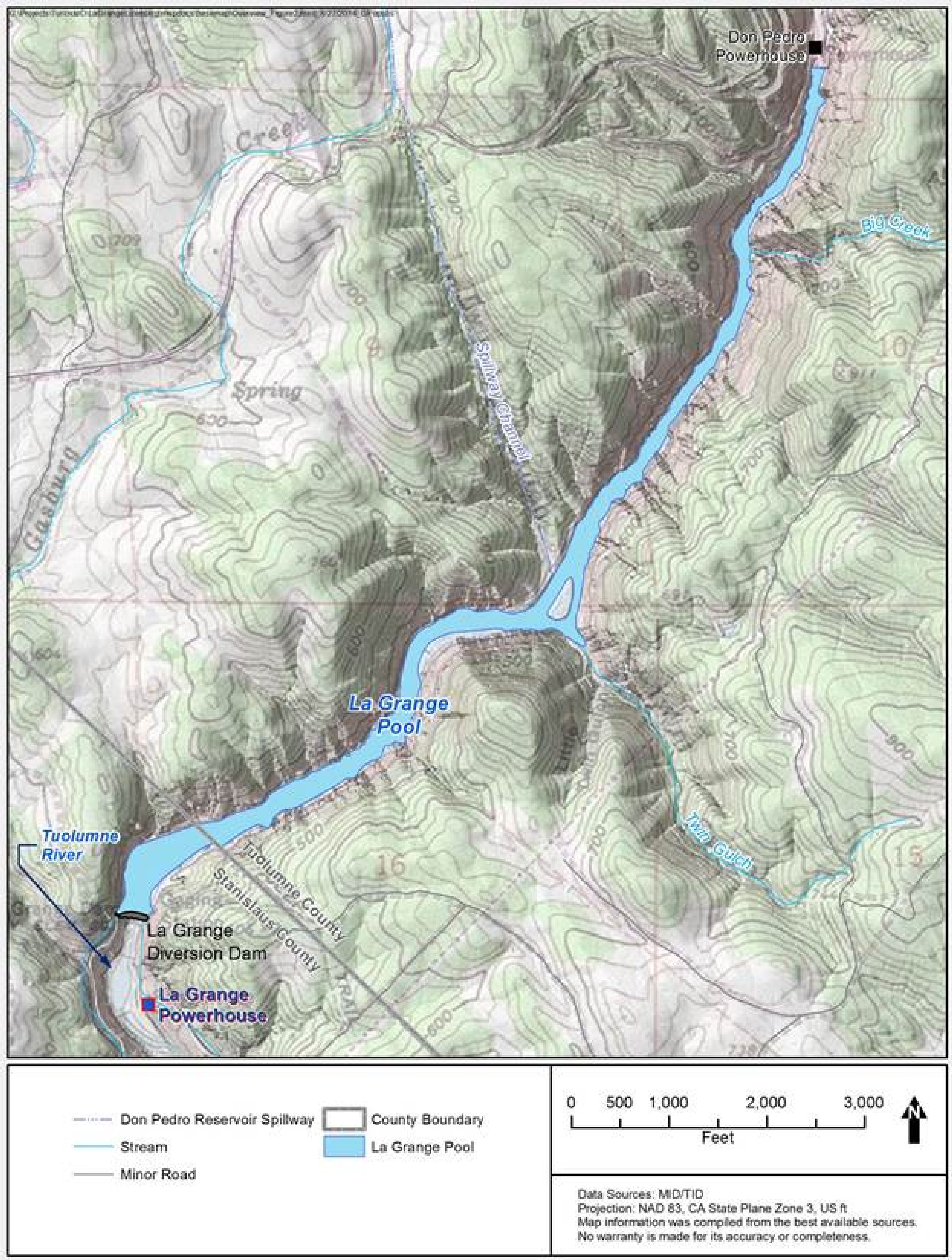

Figure 1.1-1. La Grange Hydroelectric Project location map.

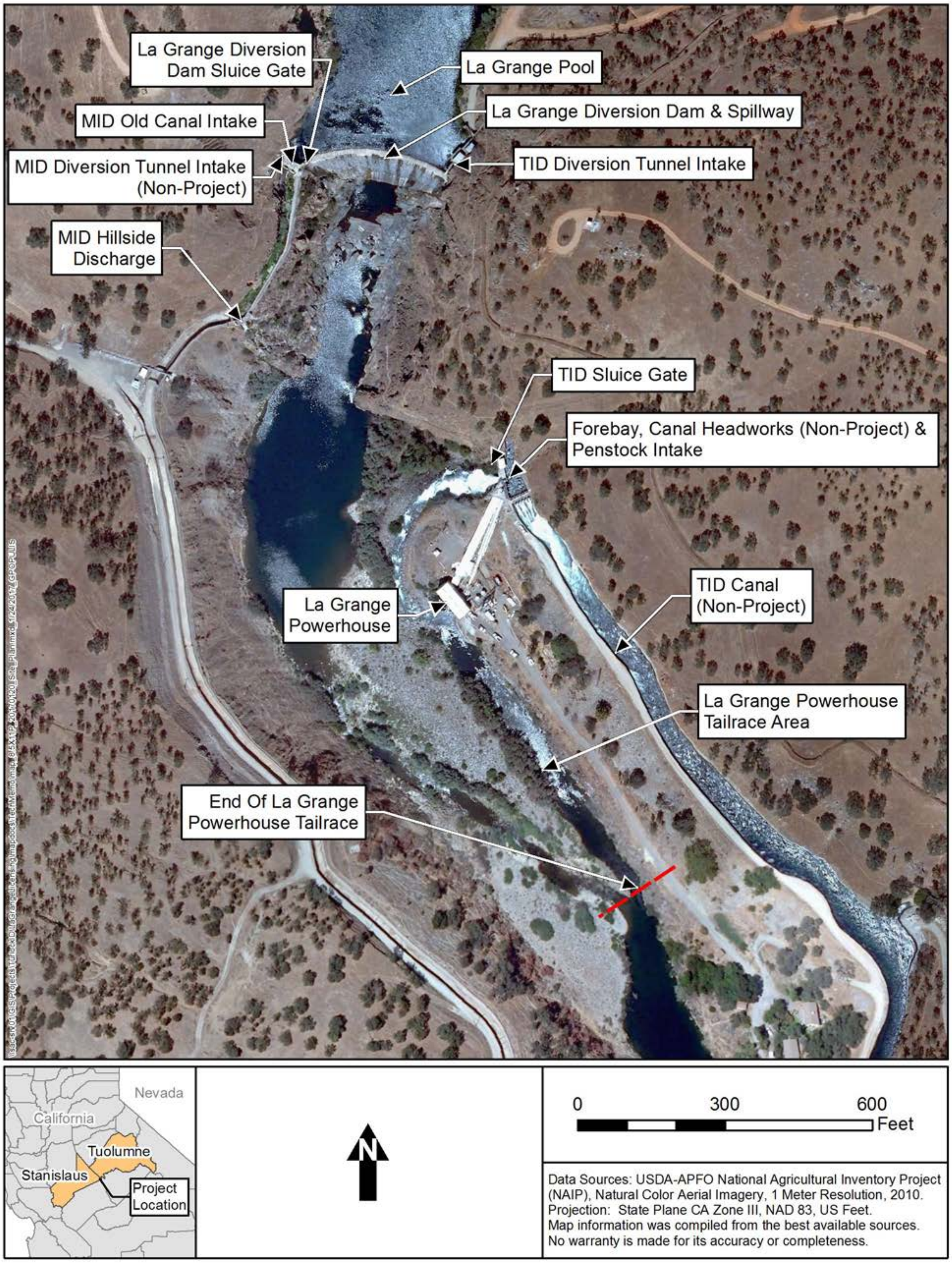

Figure 1.1-2. La Grange Hydroelectric Project site plan.

1.2 Licensing Process

In 2014, the Districts commenced the pre-filing process for the licensing of the La Grange Project by filing a Pre-Application Document with FERC[1]. On September 5, 2014, the Districts filed their Proposed Study Plan to assess Project effects on fish and aquatic resources, recreation, and cultural resources in support of their intent to license the Project. On January 5, 2015, in response to comments from licensing participants, the Districts filed their Revised Study Plan (RSP) containing three study plans: (1) Cultural Resources Study Plan; (2) Recreation Access and Safety Assessment Study Plan; and (3) Fish Passage Assessment Study Plan[2].

On February 2, 2015, FERC issued the Study Plan Determination (SPD), approving or approving with modifications six studies (Table 1.2-1). Of those six studies, five had been proposed by the Districts in the RSP. The Districts note that although FERC's SPD identified the Fish Passage Barrier Assessment, Fish Passage Facilities Alternatives Assessment, and Fish Habitat and Stranding Assessment below La Grange Diversion Dam as three separate studies, all three assessments are elements of the larger Fish Passage Assessment as described in the RSP. The sixth study approved by FERC, Effects of the Project and Related Activities on the Losses of Marine-Derived Nutrients in the Tuolumne River, was requested by the National Marine Fisheries Service (NMFS) in its July 22, 2014 comment letter.

Table 1.2-1. Studies approved or approved with modifications in FERC's Study Plan Determination.

No.	Study	Approved by FERC in SPD without Modifications	Approved by FERC in SPD with Modifications
1	Recreation Access and Safety Assessment		X
2	Cultural Resources Study		X
3	Fish Passage Barrier Assessment		X[1]
4	Fish Passage Facilities Alternatives Assessment		X
5	Fish Habitat and Stranding Assessment below La Grange Dam		X
6	Effects of the Project and Related Activities on the Losses of Marine-Derived Nutrients in the Tuolumne River	X[2]	

[1] Page A-1 of Appendix A of FERC's SPD states that FERC approved with modifications the Fish Passage Barrier Assessment. However, the Districts found no modifications to this study plan in the SPD and page B-7 of the SPD states that "no modifications to the study plan are recommended."
[2] FERC directed the Districts to conduct the study plan as proposed by NMFS.

In the SPD, FERC recommended that, as part of the Fish Passage Facilities Alternatives Assessment, the Districts evaluate the technical and biological feasibility of the movement of anadromous salmonids through La Grange and Don Pedro project reservoirs if the results from

1 On December 19, 2012, Commission staff issued an order finding that the La Grange Hydroelectric Project is required to be licensed under Section 23(b)(1) of the Federal Power Act. Turlock Irrigation District and Modesto Irrigation District, 141 FERC ¶ 62,211 (2012), aff'd Turlock Irrigation District and Modesto Irrigation District, 144 FERC ¶ 61,051 (2013). On May 15, 2015, the U.S. Court of Appeals for the District of Columbia Circuit denied the Districts' appeal and affirmed the Commission's finding that the La Grange Hydroelectric Project requires licensing. Turlock Irrigation District, et al., v. FERC, et al., No. 13-1250 (D.C. Cir. May 15, 2015).
2 The Fish Passage Assessment Study Plan contained a number of individual, but related, study elements.

Phase 1 of that study indicate that the most feasible concept for fish passage would involve fish passage through Don Pedro Reservoir or La Grange pool. On September 16, 2016, the Districts filed the final study plan with FERC. On November 17, 2016, the Districts filed a letter with FERC after consulting with fish management agencies (i.e., NMFS and the California Department of Fish and Wildlife [CDFW]) regarding the availability of test fish and a determination that no fish would be available to support conducting this study in 2017. On January 12, 2017, the Districts filed a letter with FERC stating that with FERC's approval, they intend to conduct the study in 2018 if the results from the Fish Passage Facilities Alternatives Assessment indicate that upstream or downstream fish passage at La Grange and Don Pedro projects would require anadromous fish transit through one or both reservoirs.

In addition to the six studies noted in Table 1.2-1, the SPD required the Districts to develop a plan to monitor anadromous fish movement in the vicinity of the Project's powerhouse draft tubes to determine the potential for injury or mortality from contact with the turbine runners. The Districts filed the Investigation of Fish Attraction to La Grange Powerhouse Draft Tubes study plan with FERC on June 11, 2015, and on August 12, 2015, FERC approved the study plan as filed.

On February 2, 2016, the Districts filed the Initial Study Report (ISR) for the La Grange Project. The Districts held an ISR meeting on February 25, 2016, and on March 3, 2016, filed a meeting summary. Comments on the meeting summary and requests for new studies and study modifications were to be submitted to FERC by Monday, April 4. One new study request was submitted; NMFS requested a new study entitled Effects of La Grange Hydroelectric Project Under Changing Climate (Climate Change Study). On May 2, 2016, the Districts filed with FERC a response to comments received from licensing participants and proposed modifications to the Fish Passage Facilities Alternatives Assessment and the La Grange Project Fish Barrier Assessment. On May 27, 2016, FERC filed a determination on requests for study modifications and new study. The May 27, 2016 determination approved the Districts' proposed modifications and did not approve the NMFS Climate Change Study.

This study report describes the objectives, methods, and results of the Hatchery Stocking Practices and Review, which is one of eight studies being implemented voluntarily by the Districts (see Section 1.3 for more information). Documents relating to the Project licensing are publicly available on the Districts' licensing website at www.lagrange-licensing.com/.

1.3 Voluntary Studies

As part of the Fish Passage Facilities Alternatives Assessment, in September 2015, the Districts provided to licensing participants Technical Memorandum No. 1, which identified a number of information gaps critical to informing the biological and associated engineering basis of conceptual design. To address these critical information gaps, in November 2015 licensing participants formed a Plenary Group and adopted a plan to implement the Upper Tuolumne River Fish Reintroduction Assessment Framework (Framework) intended to develop the information needed to undertake and complete the Fish Passage Facilities Alternatives Assessment and to assess the overall feasibility of reintroducing anadromous salmonids into the upper Tuolumne River (TID/MID 2016a). In support of the Framework, licensing participants agreed on the need for site-specific studies to inform decisions regarding fish reintroduction and fish passage and, in January 2016, formed a Technical Committee to take the lead on assessing site-specific information needs and study plan development.

The Districts are implementing a number of voluntary studies in support of the licensing proceeding and in support of the Fish Passage Facilities Alternatives Assessment (Table 1.3-1). Although FERC's SPD did not require the Districts to undertake the Upper Tuolumne River Basin Habitat Assessment studies proposed in the RSP, in 2015 the Districts voluntarily began implementing both the Upper Tuolumne River Basin Fish Migration Barriers Study and the Upper Tuolumne River Basin Water Temperature Monitoring and Modeling Study.

Table 1.3-1. Studies being conducted voluntarily by the Districts.

No.	Study
1	Upper Tuolumne River Basin Fish Migration Barriers Study
2	Upper Tuolumne River Basin Water Temperature Monitoring and Modeling Study
3	Upper Tuolumne River Chinook Salmon and Steelhead Spawning Gravel Mapping Study
4	Upper Tuolumne River Habitat Mapping Assessment
5	Upper Tuolumne River Macroinvertebrate Assessment
6	Upper Tuolumne River Instream Flow Study
7	Hatchery and Stocking Practices Review
8	Socioeconomic Scoping Study
9	Regulatory Context for Potential Anadromous Salmonid Reintroduction into the Upper Tuolumne River Basin

Based on Technical Committee feedback provided on a preliminary list of studies, the Districts drafted study plans for seven additional voluntary studies: (1) Upper Tuolumne River Chinook Salmon and Steelhead Spawning Gravel Mapping Study; (2) Upper Tuolumne River Habitat Mapping Assessment; (3) Upper Tuolumne River Macroinvertebrate Assessment; (4) Upper Tuolumne River Instream Flow Study; (5) Hatchery and Stocking Practices Review; (6) Socioeconomic Scoping Study; and (7) Regulatory Context for Potential Anadromous Salmonid Reintroduction into the Upper Tuolumne River Basin. The study plans were refined through a collaborative process with the Technical Committee and final study plans were posted to the La Grange Project licensing website in July 2016. In the summer of 2016, the Districts began implementing these seven additional studies and continued the second year of implementation on the two voluntary studies that began in 2015 (i.e., Upper Tuolumne River Basin Fish Migration Barriers Study and Upper Tuolumne River Basin Water Temperature Monitoring and Modeling Study).

On May 2, 2016, the Districts filed a proposal with FERC to revise the remaining portion of the pre-filing licensing schedule to allow more time for both the Districts to complete ongoing FERC-approved studies and voluntary studies and for NMFS to complete its Upper Tuolumne River Habitat and Carrying Capacity Study and its study of Tuolumne River *O. mykiss* genetics. On May 27, 2016, FERC filed a determination on requests for study modifications and new study, approving the revised schedule as proposed.

1.4 Description of Upper Tuolumne River Basin

The upper Tuolumne River originates from tributary streams located on Mount Lyell and Mount Dana in the Sierra Nevada. These tributaries join at Tuolumne Meadows (elevation 8,600 feet), and from this point the upper Tuolumne River descends rapidly through a deep canyon in wilderness areas of Yosemite National Park to Hetch Hetchy Reservoir (at an elevation of about 3,500 feet). Six miles below O'Shaughnessy Dam, which impounds Hetch Hetchy Reservoir, the Tuolumne River leaves Yosemite National Park and enters the Stanislaus National Forest. Except for a short reach at Early Intake Reservoir, the river flows unimpeded through a deep canyon for approximately 40 miles, from O'Shaughnessy Dam to the upstream end of Don Pedro Reservoir (Figure 1.4-1).

The mainstem Tuolumne River is joined by several tributaries–including (from upstream to downstream) Cherry Creek, the South Fork/Middle Fork Tuolumne River, the Clavey River, and the North Fork of the Tuolumne River–before entering the Don Pedro Project Boundary at approximately RM 80.8[3]. There are two dams in the Cherry Creek basin: Cherry Dam, which impounds Cherry Lake, located on Cherry Creek about 12 miles above its confluence with the Tuolumne River and Eleanor Dam, which impounds Lake Eleanor, located about 3.5 miles upstream of its confluence with Cherry Creek (SFPUC 2008).

1.4.1 Geomorphology of the Upper Tuolumne River Basin

The upper Tuolumne River and its tributaries flow through steep, narrow valleys that confine the river channel. In most areas the channels have high gradients, and habitat consists mostly of bedrock chutes, boulder cascades, and pools (SFPUC 2008). From the Poopenaut Valley to Early Intake, channel morphology is diverse, ranging from low-gradient, sand-bedded areas and wetland meadows to steep, bedrock-confined reaches. Although hydraulic conditions in the upper Tuolumne River are controlled primarily by channel width constrictions or expansions and resistant bedrock outcrops, there are smaller geomorphic controls that give rise to a complex morphology, which provide a variety of aquatic and riparian habitats (McBain and Trush 2004).

From Early Intake to the confluence with the South Fork of the Tuolumne River, the channel is deeply incised with steep side slopes. Channel gradient in this reach is as high as four percent, and habitat consists mostly of pools separated by steep cascades, although alluvial bars and side-channels occur in places where the valley widens or bedrock controls reduce channel gradient. From the South Fork to the Clavey River, the channel consists of boulder cascades separated by pools. Downstream of the Clavey River, gradient decreases, and the channel becomes semi-alluvial. There are three major waterfalls on the upper mainstem Tuolumne River: Clavey Falls (RM 91), Lumsden Falls (RM 98.25), and Preston Falls (RM 110).

[3] At its normal maximum water surface elevation of 830 feet, Don Pedro Reservoir extends upstream to about RM 79.5.

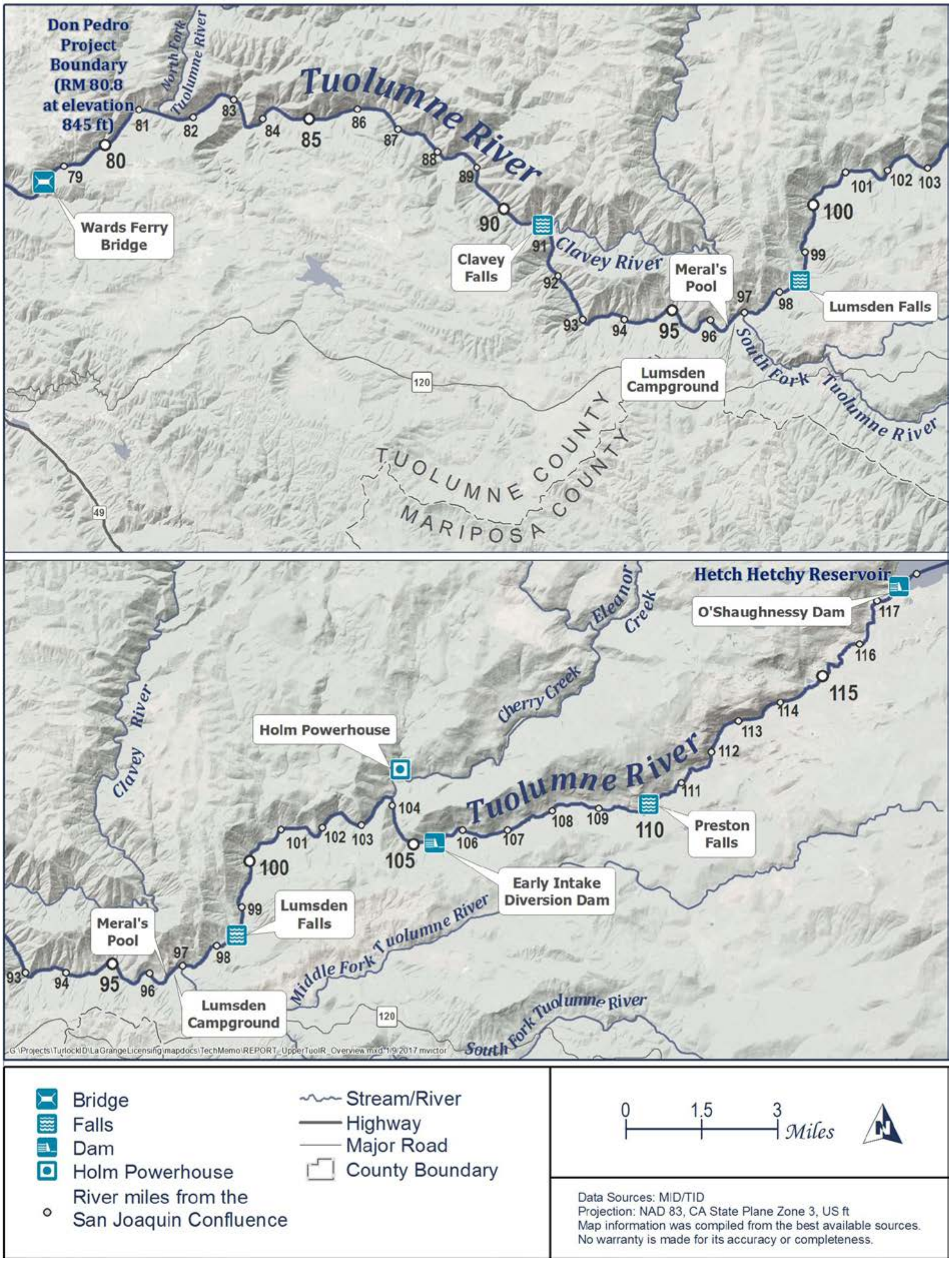

Figure 1.4-1. **The Tuolumne River basin upstream of Don Pedro Project. The top map depicts the river from Wards Ferry Bridge to RM 101, and the bottom map depicts the river from RM 94 to RM 118.**

Cherry Creek is a steep stream (≈ five percent gradient) confined within a narrow bedrock canyon (SFPUC 2008). Its bed consists mainly of boulders and bedrock, although much sand is stored in pools. Immediately downstream of Cherry Dam there are low gradient gravel-bedded sections interspersed with steep, bedrock chutes. In the upper reaches of Cherry Creek, riparian and upland vegetation have encroached onto formerly active alluvial bars due to flow regulation. For most of its length, Eleanor Creek, a tributary to Cherry Creek, flows through a bedrock canyon, with a steep channel (≈ six percent gradient) made up of a series of pools and waterfalls (SFPUC 2008).

The Clavey River is the longest unregulated river in the Sierra Nevada (McBain & Trush 2004). Research suggests that in the Clavey River (1) frequent small floods scour and deposit sand at pools and bars, (2) moderate-sized floods (every 12 to 17 years) move gravel and cobbles, reshape side channels, and may move large woody debris, and (3) large floods (every 70 to 100 years) erode large bars, remove and create side channels, and move large boulders over short distances (SFPUC 2008). Based on existing information, it is unclear to what extent channel-forming events in the other tributaries mirror those in the Clavey River.

1.4.2 Hydrology of the Upper Tuolumne River Basin

The Tuolumne River upstream of Don Pedro Dam has a watershed area of about 1,533 square miles. Above 5,000 feet, the flow regimes of the Tuolumne River and its tributaries are snowmelt-dominated. Smaller streams in this elevation range may have extremely low summer flows, although groundwater and interflow may provide small amounts of water in late summer. About 75 percent of the natural runoff above 5,000 feet occurs between April and July, with 20 percent or less occurring from December through March, and as little as 5 percent occurring from August through November (ACOE 1972). In the middle elevations, from 3,000 to 5,000 feet, more precipitation occurs as rainfall, and there can be multiple rain-on-snow events each year. Much of the runoff in these elevations occurs from December through March during winter rains, with most of the remaining runoff occurring from April through July (ACOE 1972).

In 1918, CCSF completed Lake Eleanor, a reservoir on Eleanor Creek, a tributary to Cherry Creek, which is in turn a tributary to the Tuolumne River (SFPUC 2008). Hetch Hetchy Reservoir was built on the mainstem Tuolumne River in 1923 and expanded in 1938. CCSF completed Cherry Lake (also known as Lake Lloyd) on Cherry Creek in 1955 (SFPUC 2008).

The San Francisco Public Utilities Commission (SFPUC) diverts water from Hetch Hetchy Reservoir and conveys it to the San Francisco Bay Area via the Hetch Hetchy water conveyance system, which consists of a series of facilities that extend to Crystal Springs Reservoir in San Mateo County (SFPUC 2008). Water from Hetch Hetchy Reservoir is delivered through the Canyon Power Tunnel to Kirkwood Powerhouse above Early Intake. Water exiting the powerhouse is returned either to the Tuolumne River or discharged into the Mountain Tunnel, which conveys water to Priest Reservoir and Moccasin Powerhouse. Water released from Moccasin Powerhouse is returned to the Tuolumne River via Moccasin Reservoir and Moccasin Creek or routed to the Foothill Tunnel for delivery to the Bay Area. Priest and Moccasin reservoirs are small waterbodies used to control flow into Moccasin Powerhouse and regulate discharge to Moccasin Creek, respectively (SFPUC 2008).

The SFPUC uses most of the water in Cherry Lake to generate hydroelectric power at Holm Powerhouse (SFPUC 2008). Water released from Holm Powerhouse returns to Cherry Creek and is used to satisfy the Districts' water rights (SFPUC 2008). Water impounded in Lake Eleanor is conveyed to Cherry Lake and subsequently to Holm Powerhouse. The SFPUC diverts an average of 244,000 acre-feet per year (218 million gallons per day) from the Tuolumne River at Hetch Hetchy Reservoir to supply water to about 2.4 million people in Tuolumne, Alameda, Santa Clara, San Mateo, and San Francisco counties (SFPUC 2008). Water diverted by the SFPUC for water supply represents about 32.6 percent of the average annual unimpaired runoff at Hetch Hetchy Reservoir, which is estimated to be 749,607 acre-feet (SFPUC 2008).

There are four locations of streamflow measurement (i.e., U.S. Geological Survey [USGS] stream gages) in the Tuolumne River basin upstream of Don Pedro Reservoir: (1) Tuolumne River below Early Intake near Mather; (2) Cherry Creek below Holm Powerhouse; (3) South Fork Tuolumne River near Oakland Recreation Camp; and (4) Middle Tuolumne River at Oakland Recreation Camp. The sum of flow measurements from these four gages accounts for the majority of flow in the Tuolumne River watershed. Based on USGS gage measurements, the annual unimpaired flow of the Tuolumne River just upstream of Don Pedro Reservoir has averaged about 1.97 million acre-feet since 1975. The maximum annual unimpaired runoff since 1975 was 4.6 million acre-feet (Water Year [WY] 1983), and the minimum was 0.38 million acre-feet (WY 1977). A substantial portion of the difference between historical and current unimpaired flows to Don Pedro Reservoir is accounted for by out-of-basin diversions by the SFPUC to provide water to residential, commercial, and industrial users in the Bay Area.

The hydrogeologic units underlying the Tuolumne River from Hetch Hetchy Reservoir to Don Pedro Reservoir exhibit low permeability (SFPUC 2008), and as a result there are no large groundwater bodies along this reach of the river. Significant groundwater storage in the basin occurs in the permeable terrain downstream of Don Pedro Reservoir, i.e., the San Joaquin Valley Groundwater Basin, which underlies the foothills and valley floor.

1.4.2.1 Within-day Flow Variability in the Upper Tuolumne River

Daily flows in the Tuolumne River upstream of Don Pedro Reservoir can vary greatly, as illustrated by data summarized in Tables 1.4-1, 1.4-2, and 1.4-3, which characterize how flows may vary within a single day in the Tuolumne River downstream of the Clavey River confluence during Critical, Below Normal, and Above Normal water years[4].

Table 1.4-1. Within-day flow fluctuation (cfs) in Critical water years, by month, in the Tuolumne River below Clavey River confluence.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	0	0	7	19	9	6	2	2	1	0	0	0
Percentile (5^{th})	1	1	39	55	28	38	397	286	49	3	1	4
Median	135	218	223	517	620	794	798	688	377	184	134	157

[4] California Department of Water Resources CDEC Historical Water Year Hydrologic Classification Indices.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Percentile (95th)	721	736	783	1,033	1,021	1,209	1,142	1,071	805	478	582	746
Maximum	5,142	1,549	1,110	2,122	1,058	1,285	1,209	1,366	1,109	1,074	1,211	3,822

Table 1.4-2. Within-day flow fluctuation (cfs) in Below Normal water years, by month, in the Tuolumne River below Clavey River confluence.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	0	3	8	8	7	2	5	3	1	0	1	0
Percentile (5th)	4	110	34	55	23	18	48	10	2	3	14	11
Median	337	451	545	513	354	651	984	818	269	223	260	283
Percentile (95th)	1,245	756	964	950	1,163	1,293	1,021	1,016	619	638	826	796
Maximum	6,105	906	2,064	2,410	6,101	2,576	1,249	1,066	1,032	1,207	2,009	1,998

Table 1.4-3. Within-day flow fluctuation (cfs) in Above Normal water years, by month, in the Tuolumne River below Clavey River confluence.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	0	14	9	14	8	35	7	2	1	0	0	0
Percentile (5th)	35	36	36	45	74	129	63	50	6	2	1	2
Median	319	331	196	218	420	684	816	923	411	180	136	231
Percentile (95th)	1,162	1,243	1,364	1,002	2,562	2,341	1,599	1,152	977	688	828	1,320
Maximum	14,307	5,571	12,910	5,774	20,390	5,789	6,934	1,365	1,160	4,095	1,975	23,764

1.4.2.2 Flow Releases to Support Fisheries and Whitewater Boating

Minimum flow releases from Hetch Hetchy Reservoir, which were developed to support rainbow (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) throughout their life histories, vary according to water-year type. Releases in normal, dry, and critically dry years total at least 59,235; 50,019; and 35,215 acre-feet, respectively (SFPUC 2008). SFPUC must release an additional 64 cfs into the river below Hetch Hetchy Reservoir when the diversion through Canyon Tunnel (which flows from Hetch Hetchy Reservoir to Kirkwood Powerhouse) exceeds 920 cfs. Once minimum flow releases are made at O'Shaughnessy Dam, they cannot be diverted at Early Intake, but instead must remain in the Tuolumne River where they are supplemented by tributary flows and occasional releases at Kirkwood Powerhouse to the Tuolumne River.

The minimum required stream flow below Cherry Lake is 5 cfs from October through June and 15.5 cfs from July through September (RMC and McBain & Trush 2007, Revised 2016). In years when no pumping takes place between Lake Eleanor and Cherry Lake, the required minimum flow downstream of Lake Eleanor is 5 cfs from October through June and 15.5 cfs from July through September (RMC and McBain & Trush 2007, Revised 2016). In years when pumping does occur the minimum required stream flow is 5 cfs from November through February, 10 cfs from March 1 through April 14, 20 cfs from April 15 through September 15, and 10 cfs from September 16 through September 30 (RMC and McBain & Trush 2007, Revised 2016). There are no specific minimum flow releases required for October in years when pumping occurs, but the SFPUC operational practice in pumping years has been to continue the September 16-30 release of 10 cfs through October 31 (RMC and McBain & Trush 2007, Revised 2016). These minimum flows were established based on the life-history requirements of trout, and take into consideration the effects of seasonal water temperatures on habitat suitability.

Flows in the Tuolumne River downstream of its confluence with Cherry Creek are also regulated during summer to provide flows for whitewater rafting (SFPUC 2008). SFPUC releases pulses of water from Cherry Lake via Holm Powerhouse to support whitewater recreation on most summer days (SFPUC 2008).

1.4.3 Water Quality in the Upper Tuolumne River Basin

The Tuolumne River watershed upstream of Hetch Hetchy Reservoir lies entirely within the less developed parts of Yosemite National Park, and as a result water quality in Hetch Hetchy Reservoir is excellent. Nitrogen and phosphorus concentrations are typically near or below detection limits, and dissolved oxygen concentrations are usually at or near saturation (SFPUC 2008).

Water quality in the Tuolumne River between O'Shaughnessy Dam and Don Pedro Reservoir is very good, but nutrient concentrations increase slightly with distance downstream. The Districts conducted a study during the summer of 2012 to characterize water quality in the Tuolumne River just upstream of Don Pedro Reservoir (TID/MID 2013a). This sampling confirmed that water in the river just upstream of Don Pedro Reservoir was clear, DO was near saturation, alkalinity was low (<16 mg/L), pH was near neutral, fecal coliform bacteria were below detection limits, nitrogen and phosphorous occurred at concentrations generally less than 1 mg/L, and algae blooms were absent.

Maximum summer (June through July) water temperatures in the Tuolumne River between Hetch Hetchy and Don Pedro reservoirs at times can exceed 23°C (TID/MID 2016b). The Districts developed a Tuolumne River Flow and Water Temperature Model, Without Dams Assessment (Jayasundara et al. 2014) to simulate water temperatures in the Tuolumne River without the effects of the Hetch Hetchy (including Cherry Lake and Eleanor Lake), Don Pedro, and La Grange projects. Comparison of the seven-day average of daily maximum (7DADM) temperatures under with- and without-dams conditions indicates that summer/fall maximum water temperatures in the upper Tuolumne River would be substantially higher, up to 7°C, in the absence of the Hetch Hetchy impoundments than they are under existing conditions, particularly at RM 98 (Figures 1.4-1 and 1.4-2). During of the remainder of the year, 7DADM temperatures are similar to or slightly higher, up to 2°C, with the dams in place (Figures 1.4-1 and 1.4-2). As noted in the figure captions, plots for RM 98 and RM 88 compare simulated without-dams temperatures to empirically derived with-dams temperatures. The without-dams simulation also reveals that 7DADM water temperatures in the Tuolumne River mainstem, in the absence of impoundments, would approach thermal equilibrium well upstream of the current location of the Don Pedro Project.

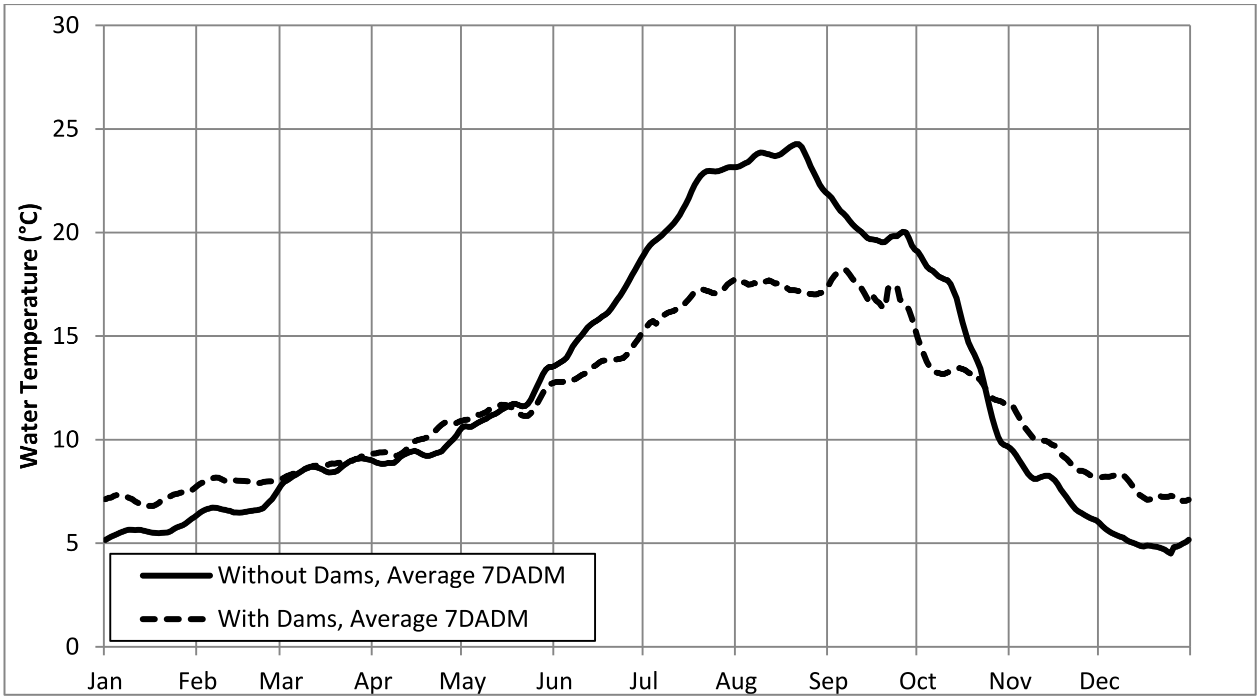

Figure 1.4-2. **Comparison of 7DADM water temperatures under with- and without-dams conditions in the Tuolumne River below the South Fork Tuolumne River (≈RM 98). Without-dams temperatures are simulated based on the period 1970 - 2012 (Jayasundara et al. 2014), and with-dams temperatures are based on data collected by temperature loggers from 2005 - 2012.**

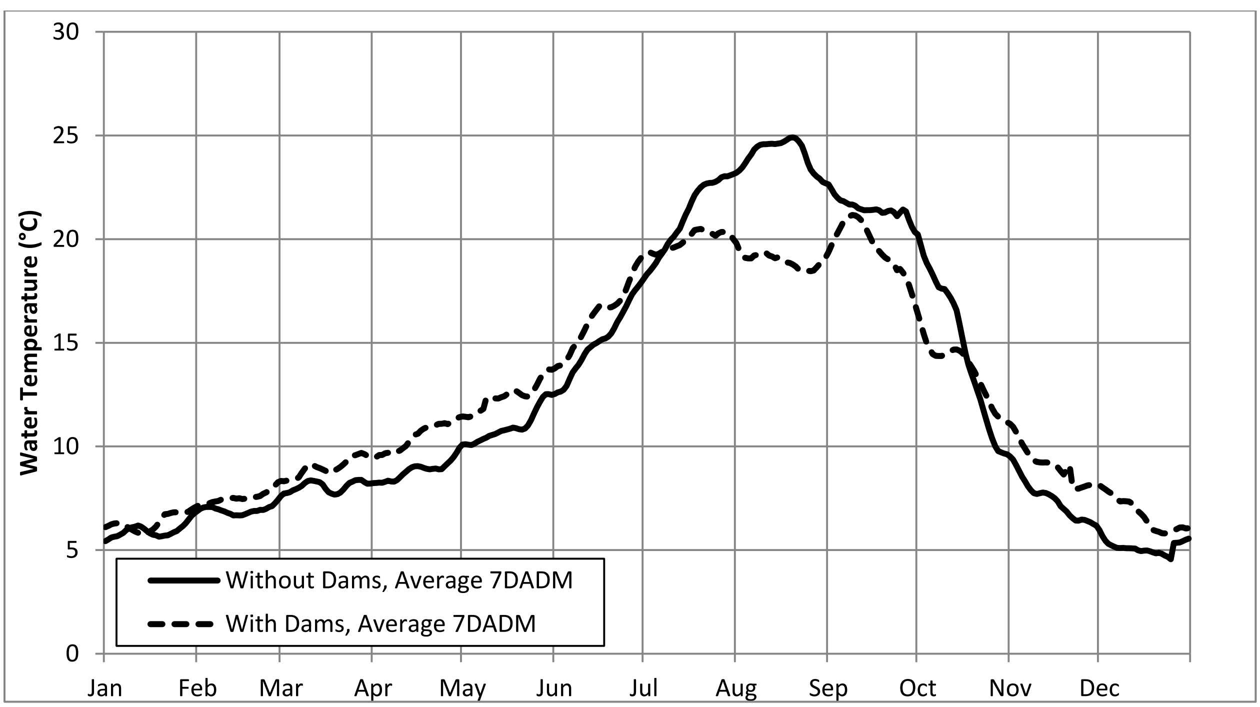

Figure 1.4-3. **Comparison of 7DADM water temperatures under with- and without-dams conditions in the Tuolumne River below Indian Creek (≈RM 88). Without-dams temperatures are simulated based on the period 1970 - 2012 (Jayasundara et al. 2014), and with-dams temperatures are based on data collected by temperature loggers from 2009 – 2012.**

1.4.4 Existing Fish Species in the Upper Tuolumne River Basin

The fish assemblage in the upper Tuolumne River and its tributaries consists mainly of rainbow trout, brown trout, Sacramento sucker (*Catostomus occidentalis*), Sacramento pikeminnow (*Ptychocheilus grandis*), California roach (*Hesperoleucus symmetricus*), and hardhead (*Mylopharodon conocephalus*) (SFPUC 2008).

During 2009, CDFW conducted a Heritage and Wild Trout Program Phase 1 assessment of the upper Tuolumne River near the USFS Lumsden Campground. During the survey, the following salmonid species were identified in an approximately 1,500-foot survey reach: coastal rainbow trout (*O. mykiss irideus*), Chinook salmon (*O. tshawytscha*), kokanee (*O. nerka*), and brown trout (Weaver and Mehalick 2009). Some of the coastal rainbow and brown trout exceeded 18 inches (457 mm) in length, and estimated average rainbow trout and brown trout densities were 1,122 and 128 fish per mile, respectively (Weaver and Mehalick 2009). Farther upstream, fish species observed during a 2014 survey in the Tuolumne River between Early Intake and Hetch Hetchy Dam included rainbow trout, brown trout, riffle sculpin (*Cottus gulosus*), California roach, and Sacramento sucker (Stillwater Sciences 2016). According to Weaver and Mehalick (2009), however, no trout species are native to the Tuolumne River upstream of Preston Falls, so "the NPS [National Park Service] does not support Wild Trout designation in this portion of the river [i.e., above the falls]."

Although some brook trout (*Salvelinus fontinalis*) reportedly still occur in headwater areas, they are not considered self-sustaining in the mainstem Tuolumne River (De Carion et al. 2010). Because of its relatively low spring flows and high spring and summer temperatures, the North Fork Tuolumne River supports smallmouth bass (*Micropterus dolomieu*) (De Carion et al. 2010). Brook trout, kokanee, brown trout, and smallmouth bass are nonnative to the basin, and brown trout and smallmouth bass can be highly piscivorous. Other non-native fish species that have been documented in the upper Tuolumne River basin include golden shiner (*Notemigonus crysoleucas*) and green sunfish (*Lepomis cyanellus*) in Cherry Lake (SFPUC 2008).

Field observations made from October 20, 1987 to June 14, 1990 confirmed that self-sustaining rainbow and brown trout populations exist in the upper Tuolumne River basin (SFPUC 2008). There is also anecdotal evidence that kokanee and adfluvial Chinook salmon from the Don Pedro Reservoir spawn in the upper basin (SFPUC 2008, Bacher 2013, Perales et al. 2015). Juvenile Chinook were observed in the upper Tuolumne River in May 2012 moving downstream to Don Pedro Reservoir (Perales et al. 2015).

CDFW stocks rainbow trout throughout the upper Tuolumne River watershed (CDFW 2016a). CDFW has released, or continues to release, kokanee, brook trout, rainbow trout, coho salmon, Chinook salmon, brown trout, Eagle Lake trout, and largemouth bass (*Micropterus salmoides*) in Don Pedro Reservoir. Largemouth bass are also stocked in Don Pedro Reservoir by the Don Pedro Recreation Agency. Kokanee and adfluvial Chinook reproducing in the upper Tuolumne River (see preceding paragraph) are the product of CDFW stocking programs conducted in Don Pedro Reservoir (Perales et al. 2015). The planted Chinook are "surplus" juveniles from Iron Gate Hatchery, located on the Klamath River, outside the Central Valley (Perales et al. 2015).

1.4.5 Fish Habitat in the Upper Tuolumne River Basin

Twelve habitat types have been identified in the Tuolumne River reach between O'Shaughnessy Dam and Early Intake: deep pools, shallow pools, pocket waters, cascades, cascades/deep pools, cascades/pocket waters, chutes, riffles, runs, glides, side channels, and backwaters (SFPUC 2008).

Water temperatures may at times affect trout in the upper basin. Maximum summer (June–July) water temperatures in the Tuolumne River between Hetch Hetchy and Don Pedro reservoirs can exceed 23°C, which could adversely affect rainbow and brown trout (SFPUC 2008). Winter water temperatures are typically low and might limit the successful egg incubation and emergence of brown trout (SFPUC 2008).

SFPUC makes minimum releases from Hetch Hetchy Reservoir, Cherry Lake, and Lake Eleanor to support resident fisheries (see Section 1.4.2). However, flows in the Tuolumne River downstream of its confluence with Cherry Creek are also regulated during summer to provide flows for whitewater rafting (SFPUC 2008). SFPUC releases pulses of water from Cherry Lake via Holm Powerhouse to support rafting for several hours on most summer days (SFPUC 2008). The resulting flow fluctuations in the upper Tuolumne River (see Section 1.4.2) influence resident trout habitat and may result in the stranding of trout, other fish species, and macroinvertebrates.

1.4.6 Species of Interest for Upper Tuolumne River Studies

There are three anadromous salmonid species/runs of interest that pertain to upper Tuolumne River Basin studies, i.e., those that can be considered potential candidates for reintroduction into the upper Tuolumne River Basin: Central Valley (CV) Spring-Run and Fall-Run Chinook Salmon (*O. tshawytscha*) and California Central Valley (CCV) Steelhead (anadromous *O. mykiss*). The federal Endangered Species Act (ESA) listing status is described below for each species/run.

1.4.6.1 Central Valley Spring-Run Chinook Salmon

The Central Valley spring-run Chinook salmon ESU was originally listed as a threatened species in 1999 (64 FR 50394). After the development of the NMFS hatchery listing policy, the status of the ESU was re-evaluated, and a final determination was made that reaffirmed the threatened species status for the ESU (70 FR 37204) (NMFS 2016a). NMFS proposed critical habitat for Central Valley spring-run Chinook salmon on December 10, 2004 (69 FR 71880) and published a final rule designating critical habitat for the ESU on September 2, 2005 (70 FR 52488) (NMFS 2016a). There is no CV spring-run Chinook salmon critical habitat in the Tuolumne River watershed.

1.4.6.2 California Central Valley Steelhead

NMFS listed the CCV steelhead as a threatened species on March 19, 1998 (63 FR 13347), and on September 8, 2000, pursuant to a July 10, 2000 rule issued by NMFS under Section 4(d) of the ESA (16 USC § 1533(d)), statutory take restrictions that apply to listed species began to apply, with certain limitations, to CCV steelhead (65 FR 42422) (NMFS 2016b). On January 5, 2006, NMFS reaffirmed the threatened status of CCV steelhead and decided to apply the joint U.S. Fish and Wildlife Service-National Marine Fisheries Service DPS policy (61 FR 4722). NMFS proposed critical habitat for CCV steelhead on February 5, 1999 (64 FR 5740) in compliance with Section 4(a)(3)(A) of the ESA. In the Tuolumne River, critical habitat for CCV steelhead extends from the confluence with the San Joaquin River upstream to La Grange Diversion Dam.

1.4.6.3 Central Valley Fall-Run Chinook Salmon

Because of concerns over population size and hatchery influence, the Central Valley fall/late fall-run Chinook salmon ESU is considered a Species of Concern under the ESA.

2.0 STUDY GOALS AND OBJECTIVES

The overall goal of this study was to assess historical and current hatchery stocking practices in the Tuolumne River Basin (and adjacent watersheds) and identify potential interactions between stocking activities and the reintroduction of anadromous salmonids to the reach of the Tuolumne River between the upstream end of the Don Pedro Project and the City and County of San Francisco's (CCSF) Early Intake. Specific objectives of this study are listed below:

- identify species, source hatcheries and their stocking practices in the area, and time periods of fish that were historically stocked in the Tuolumne River, tributaries to the Tuolumne River, and in Don Pedro Reservoir;
- identify stocking location and seasonal timing of stocking for species currently stocked (and that may be stocked in the future) in the Tuolumne River, tributaries to the Tuolumne River, and in Don Pedro Reservoir;
- identify stocking activities in the San Joaquin River and its other tributaries
- identify and describe self-sustaining potamodromous populations (species of fish that migrate [upstream or downstream] exclusively in freshwater) originating from previously stocked species, their life history characteristics, and population characteristics, as available;
- identify available information on documented incidents of disease in hatchery stocks and in the Tuolumne River basin;
- describe life histories of stocked species, as well as their spatial and temporal migrations and distributions to identify the potential to interact with reintroduced anadromous salmonids;
- describe potential spatial and temporal overlap of stocked species and lifestages with potentially-reintroduced species and lifestages (i.e., steelhead and spring-run Chinook salmon) in the Tuolumne River; and
- identify potential effects of historical and existing/future hatchery and stocking practices on efforts to reintroduce anadromous salmonids to the Tuolumne River.

3.0 STUDY AREA

The study area for this desktop literature review encompasses' the Tuolumne River Basin, including Don Pedro Reservoir and the mainstem Tuolumne River, and associated tributaries (e.g., North Fork Tuolumne River, Clavey River, Cherry Creek, etc.), to the extent that information is available regarding historical or current hatchery and stocking practices. In addition, because of the connectivity between the lower Tuolumne River and the San Joaquin River, the study area for this review also includes hatchery practices in the San Joaquin River and its other tributaries.

4.0 METHODOLOGY

A desktop literature review was conducted and includes a review of agency technical memoranda, fish stocking data, fish health information, journal articles, and websites used to identify and describe historical, current, and future hatchery and stocking practices in the Tuolumne River watershed and greater San Joaquin River Basin. Agencies and organizations involved with hatchery and stocking activities have been contacted to gather additional information on historical and existing fish stocking activities in the study area, including the Don Pedro Recreation Agency (DPRA) and California Department of Fish and Wildlife (CDFW).

Based on the information collected regarding historical and current/future stocking practices, existing hatchery operations, life histories of stocked fish species, and literature on interactions between stocked fish species and anadromous salmonids, potential effects of hatchery and stocking practices to an anadromous salmonid reintroduction effort are described and evaluated. Potential risks associated with hatchery and stocking practices to an anadromous salmonid reintroduction program are also identified and described.

5.0 RESULTS

5.1 Background

California has an almost 150-year history of artificially stocking waterways with non-native fish. Out of the approximately 111 species of freshwater and euryhaline fishes that occur in California (excluding the Salton Sea), 53 have been introduced from outside the state and have been successfully established (Dill and Cordone 1997).

The American shad (*Alosa sapidissima*) was the first non-native fish species that was formally introduced to the state, and was first planted within the Sacramento River in 1871. Over the subsequent 145 years, various native and introduced fish species have been planted in waterways throughout the state, from coastal rivers and bays, to high mountain lakes and streams (Dill and Cordone 1997). The state's first fish hatchery was the Baird Hatchery on the McCloud River in Shasta County, which was owned and operated by the U.S. Fish Commission from 1872-1883 and 1888-1935 (Leitritz 1970). Many of the earliest hatcheries in California were operated to supply inexpensive fish to anglers living within the state. During the twentieth century, hatcheries were constructed throughout the state to supplement native anadromous fish populations to mitigate for dam construction. There are currently 11 fish hatcheries in the state that produce Chinook salmon, coho salmon and/or steelhead, nine of which were constructed for mitigation purposes (California HSRG 2012). Annual production from salmon and steelhead hatcheries in California approaches 50 million juveniles, with fall-run Chinook salmon the predominant stock in terms of overall production. During most years, over 32 million fall-run Chinook salmon are produced at five hatcheries in California's Central Valley and nearly 9 million are produced at two hatcheries in the Klamath-Trinity Basin. Hatchery production, particularly of Sacramento River fall-run Chinook salmon, contributes to major recreational and commercial fisheries in ocean and inland areas (California HSRG 2012). The CDFW currently operates a total of 21 hatcheries throughout the state that raise a variety of trout and salmon species for recreational stocking. The CDFW currently stocks those fish in over 500 locations, across 25 counties throughout California (CDFW 2016a).

5.2 San Joaquin River Watershed Hatcheries

Because the Tuolumne River is a tributary to the San Joaquin River, individual and population movement and gene flow can occur between Tuolumne River fishes and fish populations in adjacent San Joaquin River tributaries (i.e., Merced River, Stanislaus River, and Mokelumne River). Therefore, a reintroduction program that transports anadromous salmonids returning to the lower Tuolumne River to the upper Tuolumne River should also consider the potential effects of hatchery activities in the lower San Joaquin River and its other tributaries, given their proximity and connectivity to the Tuolumne River.

Formal stocking of fish within the San Joaquin River watershed began in the 1930s by the CDFW. However, the exact planting locations were not always recorded (SCEC 2004). Nonetheless, CDFW records indicate that 82 percent of the fish stocked within the South Fork of the San Joaquin River (above Friant Dam) were rainbow trout, and after 1941 almost all fish stocked within this reach were rainbow trout (SCEC 2004).

CDFW operates four hatcheries within the San Joaquin River watershed, including: (1) the San Joaquin Hatchery along the San Joaquin River in the town of Friant; (2) the Merced River Hatchery along the Merced River in the town of Snelling; (3) the Mokelumne River Hatchery along the Mokelumne River in the town of Clements; and (4) the Moccasin Creek Hatchery along Moccasin Creek (a tributary to the upper Tuolumne River) in the town of Moccasin.

Fish species raised at these hatcheries include brook trout (*Salvelinus fontinalis*), Eagle Lake trout (*Oncorhynchus mykiss aquilarum*), golden trout (*Oncorhynchus aguabonita*), kokanee (*Oncorhynchus nerka*), rainbow trout/steelhead (*Oncorhynchus mykiss*), Chinook salmon (*Oncorhynchus tshawytscha*), brown trout (*Salmo trutta*), and Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*). However, only steelhead and Chinook salmon are released by these hatcheries into the lower San Joaquin, Merced, Mokelumne and Tuolumne rivers, as described further below.

In addition to the CDFW hatcheries, the San Joaquin River Restoration Program (SJRRP) operates the Interim Salmon Conservation and Research Facility (Interim Facility), located immediately west of the existing San Joaquin Hatchery below Friant Dam on the San Joaquin River. The SJRRP has released juvenile Central Valley spring-run Chinook salmon into the San Joaquin River annually since 2014.

A brief discussion of the San Joaquin, Merced River, Mokelumne River, Interim Facility, and Moccasin Creek hatcheries is provided below.

5.2.1 San Joaquin Hatchery

The current San Joaquin Hatchery began operating in 1954. Prior to the construction of the San Joaquin Hatchery, the Friant Bass Hatchery operated from 1932 until 1937 at the same site as the existing San Joaquin Hatchery. The Friant Bass Hatchery allowed for California fish culturists to learn how to raise smallmouth bass for recreational fish stocking (Leitritz 1970). The current San Joaquin Hatchery was constructed to rear catchable-sized trout, replacing the production of less efficient hatcheries that were abandoned (Leitritz 1970), and is currently one of the largest hatcheries in the state (CDFW 2016b).

Historically, the hatchery annually produced 3,000,000 fingerlings, 20,000 subcatchables, and 800,000 catchables, comprising a total weight of 165,000 pounds (Leitritz 1970). Currently, the San Joaquin Hatchery raises brook trout, cutthroat trout, Eagle Lake trout, golden trout, kokanee salmon, and rainbow trout (CDFW 2016c). Annual average production during 2004-2008 included approximately 6,000 brook trout (mostly fingerlings), 1,700 cutthroat throat (subcatchables), 171,000 Eagle Lake trout (fingerlings, subcatchables and yearlings), 26,000 golden trout (fingerlings), 314,000 kokanee (fingerlings), and 1.2 million rainbow trout (primarily fingerlings and yearlings) (CDFG and USFWS 2010).

Kokanee salmon eggs incubated at the San Joaquin Hatchery are transported annually to the hatchery after being taken from spawning kokanee in the Little Truckee River near Stampede Reservoir, and in Taylor Creek near Lake Tahoe. CDFW is a partner with Kokanee Power (a non-profit organization that promotes recreational fisheries enhancement) to annually collect the eggs and care for them until they are released into local reservoirs the following spring (USFS 2015).

Over much of the last century the upper reach of the lower San Joaquin River below Friant Dam has been dry and has disconnected the upper reach of the river below the dam from the downstream reaches of the river from Sack Dam to the confluence of the Merced River. Subsequently, the San Joaquin Hatchery, immediately downstream of Friant Dam, has not been hydrologically connected to areas where Tuolumne River salmonids would occur. However, restoration flows from the SJRRP are and will continue to provide hydrologic connectivity between the upper and lower reaches of the San Joaquin River (SJRRP 2016).

5.2.2 Merced River Hatchery

The original Merced River Hatchery was constructed in 1970 by the Merced Irrigation District (MID) and initially was a Chinook salmon spawning channel designed to enhance spawning habitat availability. During the 1980s and 1990s, the facility was converted into a spawning and rearing hatchery. The original purpose of the facility was to mitigate for lost habitat resulting from construction of the Crocker-Huffman, Merced Falls, and Exchequer dams. This mitigation was to be achieved by producing approximately 960,000 fall-run Chinook salmon smolts and 330,000 yearlings per year. However the yearling program was discontinued due to high fish losses from proliferative kidney disease (PKD), caused by *Tetracapsuloides bryosalmonae*, an endemic myxozoan parasite in the Merced River.

Fall-run Chinook salmon is the only species/run raised at this hatchery (California HSRG 2012). The goal of the program is to take two million fall-run Chinook salmon eggs and release one million smolts at 60 fish-per-pound (fpp) (80 mm fork length) between late April and mid-May. Based on reported hatchery release data (PSMFC 2016), Merced River Hatchery releases have fluctuated since 1978, but have averaged about 500,000 juveniles between 1978 and 2015 (Figure 5.2-1). Releases ranged from about 300,000 to about 1 million fish between 1994 and 2007, and ranged from near 0 to about 200,000 fish between 2008 and 2012. During 2013 through 2015, releases ranged from about 1 million to 1.5 million fish (Figure 5.2-1).

Juvenile Chinook salmon raised at CDFW's Merced River Hatchery have been released at multiple locations, including: (1) at the hatchery; (2) at other lower Merced River locations; (3) at various locations in the lower San Joaquin River, and (4) in the Stanislaus and Tuolumne rivers (Figure 5.2-1). During the mid-1990s to the mid-2000s, Merced River Hatchery juveniles were released in similar annual abundances in the San Joaquin and Merced rivers, with lesser numbers released into the Stanislaus and Tuolumne rivers for fisheries studies. Although releases were relatively low during 2008 through 2012, most releases occurred in the Merced River or in the San Joaquin River. During recent years (i.e., 2013 through 2015), almost all Merced River Hatchery fall-run Chinook salmon juveniles have been released in the San Joaquin River at Jersey Point or at Mossdale. Between 1986 and 2015, 1,662,023 Merced River Hatchery fall-run Chinook salmon juveniles have been released in the lower Tuolumne River (PSMFC 2016; Figure 5.2-1).

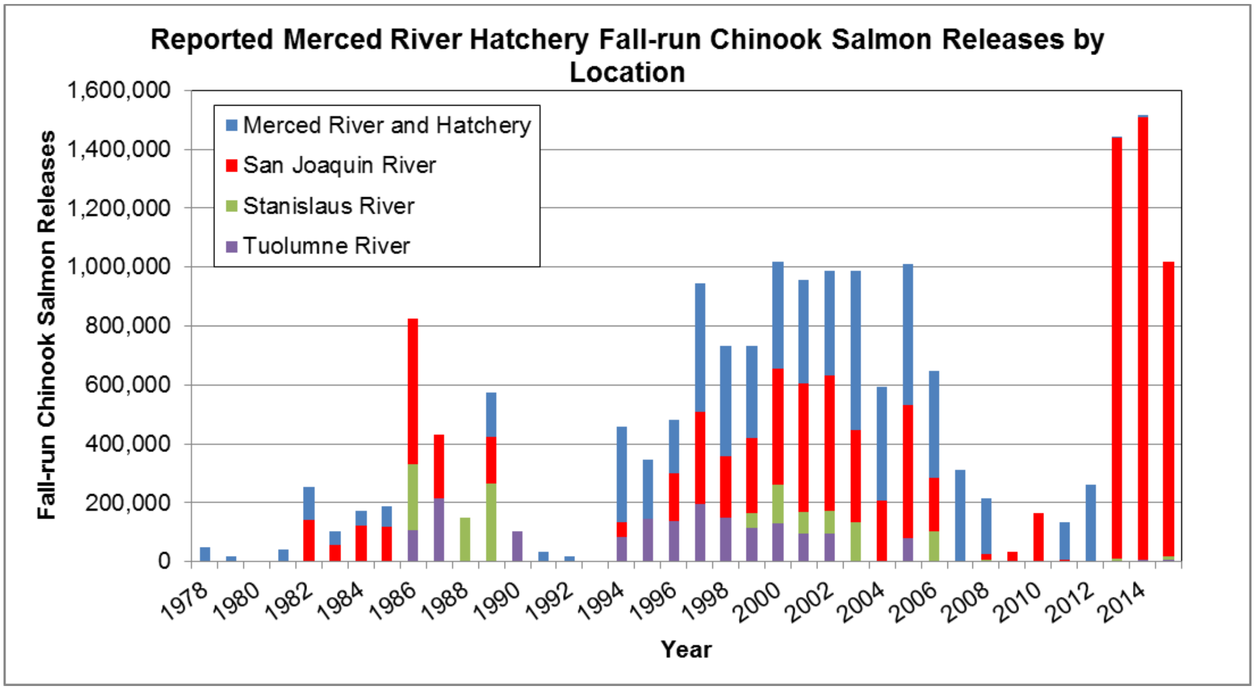

Figure 5.2-1 **Reported releases of juvenile fall-run Chinook salmon from the Merced River Hatchery by release location.**

5.2.3 Mokelumne River Hatchery

The Mokelumne River Hatchery was constructed in 1963 as mitigation to offset the loss of spawning habitat resulting from the construction of Camanche Dam by East Bay Municipal Utility District (EBMUD; CDFW 2016d).

Chinook salmon and steelhead are the only two species that are raised at the Mokelumne River Hatchery (CDFW 2016e). The hatchery has an annual goal to release up to five million fall-run Chinook salmon smolts that average 60 fpp or larger for harvest purposes. Approximately two million additional Chinook salmon are raised to post-smolt size (45 fpp) each year for an ocean enhancement program. The hatchery also has an annual goal of releasing 250,000 yearling steelhead at 4 fpp into the Mokelumne River. The program has experimented with small releases (less than 2,000 fish) of two-year-old steelhead juveniles (California HSRG 2012).

Based on reported hatchery release data (PSMFC 2016), Mokelumne River Hatchery fall-run Chinook salmon releases have fluctuated since 1974, but have averaged about 1.8 million juveniles during 1974-2015 (Figure 5.2-2). Reported annual releases of fall-run Chinook salmon were relatively low (i.e., about 50,000 or less) from 1974 through 1989. Releases increased to 2 million or more fish during 1995 through 2000, decreased to less than 1 million during 2001 and 2002, and further decreased to about 200,000 during 2003 through 2006. With the exception of 2009 and 2010, annual releases increased to about 4.5 to 6.5 million from 2007 through 2015 (Figure 5.2-2).

Juvenile Chinook salmon raised at Mokelumne River Hatchery have been released at multiple locations, including: (1) at the hatchery; (2) at other lower Mokelumne River locations; (3) at various locations in the lower San Joaquin River, (4) in the San Francisco estuary; (5) in the Sacramento River within the Delta; and (6) in the ocean. During the 1990s to the mid-2000s, Mokelumne River Hatchery Chinook salmon juveniles were released primarily in the Mokelumne River, with fewer numbers released in the estuary. During 2007, approximately half of the releases occurred in the Mokelumne River and half occurred in the estuary. During 2008, most of the releases occurred in the estuary. From 2009 through 2015, nearly all releases occurred in the San Joaquin River (PSMFC 2016; Figure 5.2-2).

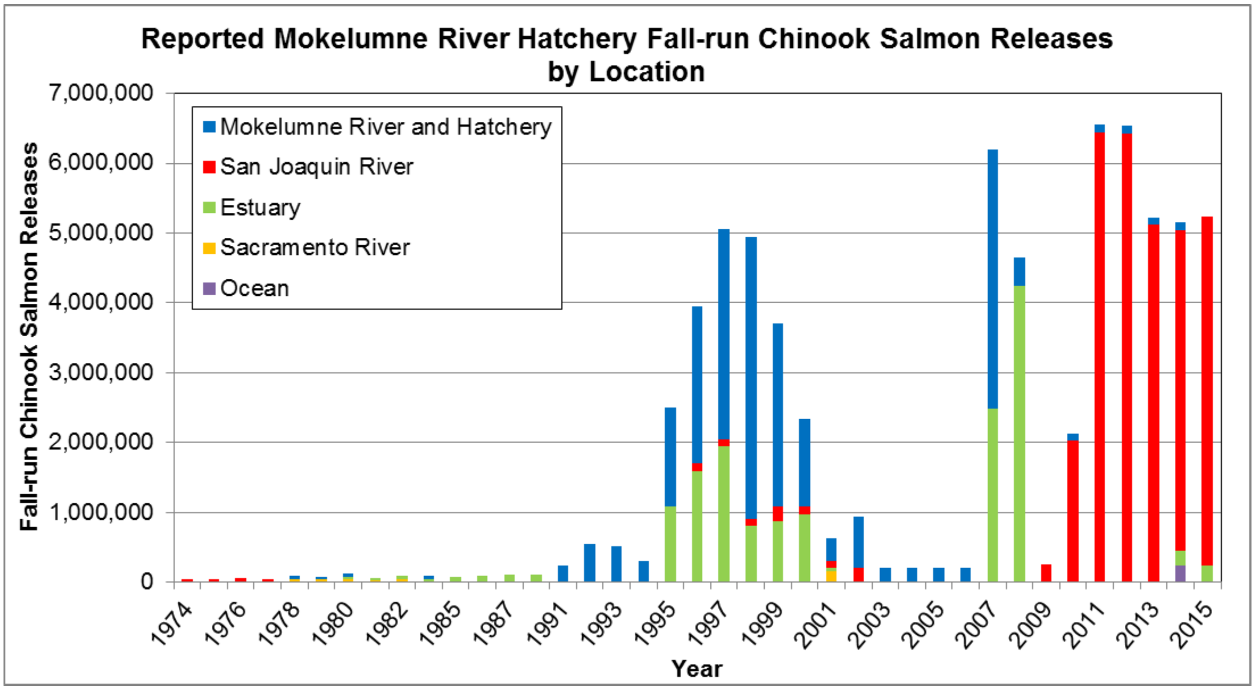

Figure 5.2-2. Reported releases of juvenile fall-run Chinook salmon from the Mokelumne River Hatchery by release location.

Mokelumne River Hatchery steelhead releases since 1996 have all been yearlings after approximately one year of growth (California HSRG 2012). Although all Mokelumne River Hatchery steelhead have been adipose fin-clipped since brood year 1998, coded wire-tagging was not implemented until 2004. Reported hatchery release data from 2003 through 2011 (PSMFC 2016) indicate an average of about 244,000 steelhead juveniles have been released annually (Figure 5.2-3). Reported annual releases of steelhead have occurred primarily in the Mokelumne River, with the exception of 2008 when most of the juveniles were released into the estuary, and some were released in the San Joaquin River (PSMFC 2016; Figure 5.2-3).

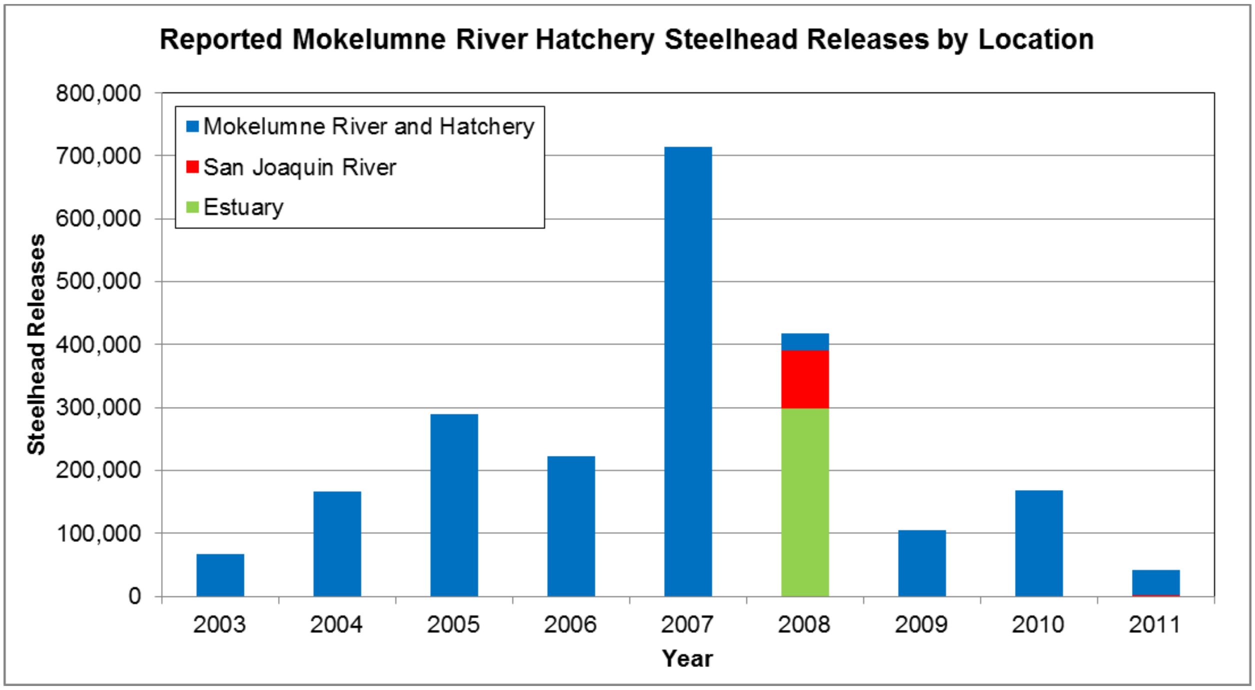

Figure 5.2-3. Reported releases of juvenile steelhead from the Mokelumne River Hatchery by release location.

5.2.4 Interim Facility (Interim Salmon Conservation and Research Facility)

As part of the SJRRP, the Interim Facility was constructed and operated to support research activities on Central Valley spring-run Chinook salmon and to facilitate the establishment of a self-sustaining population of spring-run Chinook salmon in the San Joaquin River (SJRRP 2016). The Interim Facility started a broodstock program in 2012 using phenotypic spring-run Chinook salmon from the Feather River Fish Hatchery. Although relatively small numbers of spring-run Chinook salmon are currently produced at the Interim Facility, the Interim Facility is intended to be replaced by a permanent facility at the same location that will be capable of greater production.

Juvenile spring-run Chinook salmon were released by the SJRRP during 2014, 2015, and 2016 downstream of the lower-most fish passage barrier (downstream of State Route 165). During 2014 and 2015, 54,000 juvenile spring-run Chinook salmon were released, all of which were raised at the Feather River Fish Hatchery (Reclamation 2014; 2015). During 2016, 105,000 juvenile spring-run Chinook salmon were released, 45,000 of which were produced at the Interim Facility and the remaining 60,000 were produced at the Feather River Fish Hatchery (Reclamation 2016). During 2016, spring-run Chinook salmon adult broodstock also were released from the Interim Facility for a proposed study (Reclamation 2016). Juvenile spring-run Chinook salmon may be released upstream of the confluence with the Merced River in the future if hydrologic connectivity is re-established through future SJRRP actions (SJRRP 2016).

5.2.5 Moccasin Creek Hatchery

The Moccasin Creek Hatchery is located on Don Pedro Reservoir in the Tuolumne River watershed. The initial construction of Moccasin Creek Hatchery was completed in 1954. Water supply for the hatchery is sourced from the afterbay of the Moccasin Creek Powerhouse, which is a part of the Hetch Hetchy water supply system (CDFW 2016f). Total annual fish production has averaged around 1 million fish, dominated by rainbow trout. In addition to rainbow trout, the hatchery also raises brown trout, Lahontan cutthroat trout, Eagle Lake rainbow trout, and golden trout, and has historically raised brook trout. These fishes are planted in lakes and rivers throughout the local region and across Northern California, including in the upper Tuolumne River watershed (described below in Section 5.3.1.1). Specifically, rainbow trout and Eagle Lake rainbow trout are released within Alpine, Calaveras, Alameda, Madera, Mariposa, Merced, Stanislaus, and Tuolumne counties. Golden trout are released within Alpine, Sierra, Fresno, Inyo, and Mono counties, while brown trout are released in Tuolumne County, and Lahontan cutthroat trout are released in El Dorado County (B. Sears, personal communication 2015).

Annual average production of Moccasin Creek Hatchery during 2004-2008 included approximately 41,000 brook trout (mostly fingerlings), about 88,000 brown trout (fingerlings and subcatchables), 21,000 Lahontan cutthroat throat (mostly fingerlings), 124,000 Eagle Lake trout (mostly yearlings), and 807,000 rainbow trout (primarily yearlings and fingerlings) (CDFG and USFWS 2010).

Due to drought conditions and a lack of coldwater supply from Millerton Reservoir to the San Joaquin Hatchery in 2014, kokanee eggs from the Little Truckee River (eggs were unable to be taken from Taylor Creek) were transported to Moccasin Creek Hatchery for incubation and rearing.

5.3 Tuolumne River Fisheries and Fish Stocking

5.3.1 Fish Communities and Stocking

The native fish assemblage in the Tuolumne River watershed historically consisted of all four of the assemblages historically found in tributaries to the Central Valley, namely the rainbow trout assemblage, California roach assemblage, pikeminnow-hardhead-sucker assemblage, and in the lowlands, the deep-bodied fish assemblage (Moyle 2002).

Fish communities are fairly distinct among the following areas: (1) the upper Tuolumne River (downstream of Early Intake) and its tributaries upstream of Don Pedro Reservoir; (2) within Don Pedro Reservoir; (3) within the La Grange Pool (i.e., from New Don Pedro Dam downstream to La Grange Diversion Dam); and (4) in the lower Tuolumne River (i.e., below La Grange Diversion Dam). Fish species stocking in the watershed also has varied both historically and in recent years among these areas. Resulting fish species that are known to occur in the watershed, either due to natural reproduction and/or due to ongoing stocking practices, are described below for each of the four areas.

5.3.1.1 Upper Tuolumne River and Tributaries between Early Intake and upstream extent of Don Pedro Reservoir

In the upper Tuolumne River and its tributaries, the fish assemblage is reported to generally be dominated by rainbow and brown trout, Sacramento sucker, Sacramento pikeminnow and California roach. Although some brook trout may be present in the mainstem, they reportedly were forced downstream from upper areas of tributaries and apparently are not self-sustaining in the mainstem (De Carion et al. 2010).

Early explorations of the upper Tuolumne River watershed by Col. Harry C. Benson indicate that rainbow trout or steelhead and Chinook salmon were not present upstream of the falls at the head of Hetch Hetchy Valley, presumably Wapama Falls (J. Snyder, personal communication January 19, 1999). However, as early as 1877 and 1880, homesteader Horace J. Kibbe planted rainbow trout, presumably of local Tuolumne River origin, into Eleanor, Vernon, Laurel, and Kibbe lakes. These plantings are the earliest available written record of trout stocking in the upper Tuolumne River watershed. In 1883, Mariposa County sheriff, Bob Proudy, and pioneer sheep rancher, Jim Shaw, also planted local rainbow trout into Lake Benson. By 1893, rainbow trout had been extensively stocked throughout Yosemite National Park. Many of the plants originated from trout within Lake Eleanor, but other strains such as Shasta trout, steelhead, and McCloud River trout are listed in early stocking records (Wallis 1952). Today, the reaches of the mainstem Tuolumne River below Yosemite National Park are stocked by CDFW with rainbow trout, which are raised at the Moccasin Creek Hatchery (J. Kroeze, personal communication April 9, 2015).

CDFW stocks trout in a variety of areas throughout the upper watershed, including rainbow trout and Eagle Lake trout in the North, Middle, and South Forks of the Tuolumne River (CDFW 2016a). Specifically, rainbow trout and Eagle Lake trout are stocked at: (1) Hulls Crossing, Jenness Park, and Camp High Sierra in the North Fork; (2) San Jose Camp within Lee's Resort, a bridge upstream from Lee's Resort, the Spinning Wheel USFS facility at Sawmill Mt. Road, Diamond O Campground, and a bridge on Evergreen Road in the Middle Fork; and (3) the Highway 120 bridge and the Carlon Day Use area in the South Fork (J. Kroeze, personal communication April 9, 2015).

In response to legislation codified in the Fish and Game Code in 2012, CDFW now raises and stocks sterile (triploid) trout in most areas where native trout occur, including the upper Tuolumne River watershed. Therefore, Moccasin Creek Hatchery currently stocks triploid rainbow trout and triploid brown trout in the upper Tuolumne River watershed.

As reviewed by CCSF (2008), fish species in Cherry Creek are dominated by rainbow trout. Sacramento sucker, riffle sculpin, and California roach have been observed during stream surveys in Cherry Creek, particularly near the confluence with the mainstem Tuolumne River where water temperatures are generally warmer (CCSF 2008).

Eleanor Creek, a tributary to Cherry Creek, reportedly supports fishes mostly comprised of brown trout and rainbow trout (CCSF 2008). Eleanor Creek is not currently stocked, but a hatchery was reportedly historically operated on one of its tributaries (Frog Creek) until the

1950s, and raised rainbow trout sourced from Lake Eleanor. Sacramento sucker, sculpin and roach may be present in Eleanor Creek, and would be expected to occur in greater abundance towards the confluence with Cherry Creek, where water temperatures are generally slightly warmer (CCSF 2008).

The Clavey River is designated by the California Fish and Game Commission as Wild Trout Waters and Heritage Trout Waters, and supports mostly native fish species including rainbow trout, Sacramento sucker, California roach, hardhead and Sacramento pikeminnow. However, non-native brook trout reportedly occur in the headwaters of Clavey Creek due to historical fish stocking in the upper meadows (De Carion et al. 2010). In addition, during 1975 and 1976, more than 100,000 brown trout fingerlings were stocked by CDFG into the Clavey River. Although they reportedly grew faster than the rainbow trout, the brown trout did not establish a self-sustaining population (De Carion et al. 2010).

The North Fork Tuolumne River exhibits different hydrologic and water temperature conditions than the mainstem Tuolumne River and Clavey River due to lower spring flows and higher water temperatures during the spring and summer (De Carion et al. 2010). Smallmouth bass is reportedly the primary biological driver of the fish assemblage of the North Fork Tuolumne River, which preys upon other fishes, invertebrates, amphibians and small mammals. Preliminary snorkel surveys at the confluence of the North Fork and mainstem Tuolumne rivers suggested that smallmouth bass and invasive crayfish, and rainbow trout were the dominant species, while juvenile Sacramento pikeminnow, Sacramento sucker and California roach were present in limited numbers (De Carion et al. 2010).

It has previously been reported that both Chinook salmon and kokanee salmon (presumably originating from Don Pedro Reservoir stocking) may naturally reproduce in the upper Tuolumne River above the reservoir - natural reproduction of kokanee salmon was reportedly documented in 1992, and Chinook salmon were believed to have spawned in the upper Tuolumne River during the mid-1990s, when Chinook salmon was not being stocked in the reservoir (CCSF 2008; Bacher 2013). Recent anecdotal observations indicate that both species likely do spawn in the upper Tuolumne River.

During the Fall of 2016 (October 13-17) approximately 20 spawning kokanee were reportedly observed to be spawning at RM 87, and a single, unidentified salmon (potentially a Chinook salmon) was observed digging a red in the tailout of Merals Pool (J. Guignard, personal communication, November 2, 2016).

During 2012, eight Chinook salmon juveniles (65-100 mm; ~2.5-4 in FL) were collected in the Tuolumne River above Don Pedro Reservoir, six of which were collected during May about 14 km (8.7 miles) above the reservoir and the other two during June above the confluence with the Clavey River (Perales et al. 2015). All of the juveniles were reported to be in "good condition" and were silvery bright, suggesting that they were smolts moving downstream to the reservoir. During a separate survey during October of 2009, three adult Chinook salmon (250-450 mm; ~10-18 in FL) were reportedly observed near Lumsden Campground about 8 km (5 miles) upstream of where the smolts were collected (Weaver and Mehalick 2009).

Due to annual stocking of Chinook salmon in Don Pedro Reservoir, Perales et al. (2015) could not conclude whether the spawning of Chinook salmon in the upper Tuolumne River is self-sustaining. However, the authors suggest that a self-sustaining population is likely present above Folsom Reservoir because stocking of Chinook salmon had not occurred in the reservoir for 4 years prior to observing evidence of spawning above Folsom Reservoir. In 2014, a program of planting triploid (sterile) juvenile Chinook Salmon was initiated for New Don Pedro and Folsom reservoirs, which may eventually allow for assessing whether the existing potamodromous Chinook salmon populations are self-sustaining (Perales et al. 2015).

5.3.1.2 Don Pedro Reservoir

Don Pedro Reservoir supports a diverse assemblage of native and introduced fishes, primarily centrarchid, catfish, trout and salmon species, which support several popular fisheries. The principal fish species in the reservoir include black bass (i.e., largemouth bass, spotted bass, and smallmouth bass), rainbow trout, brown trout, brook trout, Chinook salmon, kokanee salmon, black crappie (*Pomoxis nigromaculatus*), white crappie (*Pomoxis annularis*), channel catfish (*Ictalurus punctatus*), white catfish (*Ameiurus catus*), green sunfish (*Lepomis cyanellus*), bluegill (*Lepomis macrochirus*), and threadfin shad (*Dorosoma petenese)* (DPRA 2016; TID/MID 2013b; CCSF 2008). Although relatively few were caught during Don Pedro Reservoir fish population surveys in 2012, kokanee was the most abundant coldwater fish species captured, all of which were collected during gillnetting surveys (TID/MID 2013b). Largemouth bass comprised the greatest amount of fish biomass caught during the reservoir fish population surveys (TID/MID 2013b).

The CDFW and DPRA have been releasing hatchery-raised fish into Don Pedro Reservoir since 1953, when more than 10,000 kokanee salmon were planted (CDFW, unpublished data; TID and MID 2011; Table 5.3-1). During the following three years (1954-1956), approximately 49,000 to 57,000 kokanee were planted annually. In 1959, about 222,000 brook trout were planted, and in 1964, about 389,000 rainbow trout were planted in the reservoir. From 1972 onward, stocking of various fish species in Don Pedro Reservoir became more frequent and consistent. Coho salmon were stocked through the 1970’s, until 1980. Kokanee, Chinook salmon, brown trout, rainbow trout, Eagle Lake trout and largemouth bass have been regularly stocked in the reservoir in recent years (CDFW, unpublished data ; D. Jigour, personal communication, September 22, 2016; TID/MID 2011). Brook trout have been sporadically stocked in the reservoir since the late 1970s (CDFW, unpublished data).

Table 5.3-1. Fish Stocked (in number of fish of all sizes) within Don Pedro Reservoir 1953-2016.

Year	Kokanee Salmon	Chinook Salmon	Brook Trout	Brown Trout	Rainbow Trout	Eagle Lake Trout	Largemouth Bass	Coho Salmon
1953	10,440	0	0	0	0	0	0	0
1954	48,825	0	0	0	0	0	0	0
1955	57,240	0	0	0	0	0	0	0
1956	57,020	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	0
1959	0	0	222,200	0	0	0	0	0
1960	0	0	0	0	0	0	0	0

Year	Kokanee Salmon	Chinook Salmon	Brook Trout	Brown Trout	Rainbow Trout	Eagle Lake Trout	Largemouth Bass	Coho Salmon
1961	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0
1964	0	0	0	0	388,800	0	0	0
1965	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0
1972	0	0	0	0	813,012	0	0	27,584
1973	0	0	0	0	0	0	0	72,800
1974	0	0	0	0	52,500	0	0	111,241
1975	0	0	0	0	40,150	0	0	36,480
1976	0	0	0	0	660,810	10,320	0	102,295
1977	17,184	0	0	0	16,036	15,660	0	111,600
1978	0	0	135,500	0	18,080	0	0	100,208
1979	0	0	228	200	64,800	22,000	0	0
1980	0	0	0	0	25,530	18,150	0	100,000
1981	6,000	0	0	600	36,160	31,260	0	0
1982	25,155	131,510	0	0	1,200	3,600	7,500	0
1983	0	66,920	7,600	0	1,900	20,010	0	0
1984	0	0	0	0	50,500	10,000	0	0
1985	0	61,130	0	0	5,780	10,075	0	0
1986	0	0	0	0	5,029	10,105	0	0
1987	0	0	0	0	62,485	0	0	0
1988	0	54,800	0	0	70,150	0	0	0
1989	0	0	0	0	77,705	0	0	0
1990	0	0	0	0	164,635	0	0	0
1991	0	30,600	0	0	228,905	0	0	0
1992	0	25,500	0	0	112,760	0	0	0
1993	0	0	0	0	170,340	0	15,000	0
1994	0	0	0	0	77,920	0	2,222	0
1995	0	0	190,405	20,124	0	0	2,711	0
1996	0	0	22,450	40,912	0	0	2,222	0
1997	0	0	0	20,400	36,980	0	2,222	0
1998	0	0	0	20,000	101,736	0	2,222	0
1999	0	40,000	35,341	22,925	13,055	0	1,682	0
2000	45,982	0	2,000	20,070	59,100	0	1,980	0
2001	50,103	0	3,520	19,800	65,600	0	2,758	0
2002	10,080	0	0	14,600	52,450	0	1,719	0
2003	10,043	0	0	0	71,675	0	1,825	0
2004	9,984	0	0	26,400	179,263	0	3,621	0
2005	10,143	100,440	118,400	73,687	262,585	3,600	2,000	0
2006	4,061	70,015	0	22,100	388,720	405	1,062	0
2007	6,517	91,000	0	15,860	41,720	72,680	1,667	0
2008	10,080	93,885	18,222	10,050	37,617	31,600	1,680	0
2009	10,050	100,006	5,610	31,320	329,495	93,790	1,367	0
2010	10,032	100,000	0	0	4,800	52,300	1,755	0
2011	10,260	129,980	0	16,000	44,300	55,300	0	0

Year	Kokanee Salmon	Chinook Salmon	Brook Trout	Brown Trout	Rainbow Trout	Eagle Lake Trout	Largemouth Bass	Coho Salmon
2012	10,000	99,997	0	15,400	52,300	37,900	2,000	0
2013	12,012	0	0	0	88,800	18,350	1,300	0
2014	9,991	90,035	0	0	64,770	59,800	0	0
2015	0	50,000	0	14,950	18,750	0	0	0
2016	19,980	0	0	0	7,650	0	1,423	0

The DPRA has been stocking Florida-strain largemouth bass, from Willow Creek Fisheries in O'Neals, CA, in the lake on an annual basis since the early 1980s (D. Jigour, personal communication, September 22, 2016; TID and MID 2011). Stocked kokanee salmon originate from the San Joaquin Hatchery. Chinook salmon planted in the 1980s and 90s originated from the Feather River Hatchery, while Chinook salmon stocked in 2001 were sourced from the Nimbus Fish Hatchery, and plantings since 2002 have originated from the Iron Gate Hatchery on the Klamath River (which were subsequently quarantined at the Silverado Fisheries Base near Napa, CA) (Perales et al. 2015). Because Iron Gate Hatchery raises Klamath River fall-run Chinook salmon, it is presumed that Chinook salmon in Don Pedro Reservoir are of Klamath River fall-run origin. Starting in 2014, sterile (triploid) Chinook salmon from the Iron Gate Hatchery/Silverado Fisheries Base have been stocked in Don Pedro Reservoir (Perales et al. 2015). All other trout plantings have originated from Moccasin Creek Hatchery (CDFW, unpublished data).

The Don Pedro Reservoir largemouth bass fishery is one of the most successful warmwater fisheries in California, and supports approximately 45-80 official black bass contests annually based on CDFW black bass fishing contest reports (Murphy 2009; 2010; 2011; Krogman 2012; 2013; Fish 2014; 2015; 2016). Based on data compiled by CDFW on black bass fishing contests from 1985-2016, the reported mean weight per fish caught during fishing tournaments in Don Pedro Reservoir generally gradually increased from 1985 to about 2007 (Figure 5.3-1). Between 2007 and 2016, the average weight per fish caught has fluctuated between about 1.9 and 2.3 pounds.

Don Pedro Reservoir fish population surveys conducted by TID and MID (2013b) during 2012 indicate that largemouth bass represented the largest proportion (~32 percent) of the total biomass of fish collected in the reservoir, and included a broad representation of age classes (ages 0-3+). Although fewer were collected, smallmouth bass and spotted bass collected also represented age-0 through age-3 fish. Consistent with the abundances and associated age classes of black bass found in the reservoir, and consistent with bass nesting habitat analyses conducted by TID and MID (2013b), Don Pedro Reservoir provides suitable conditions for successful black bass nesting and growth.

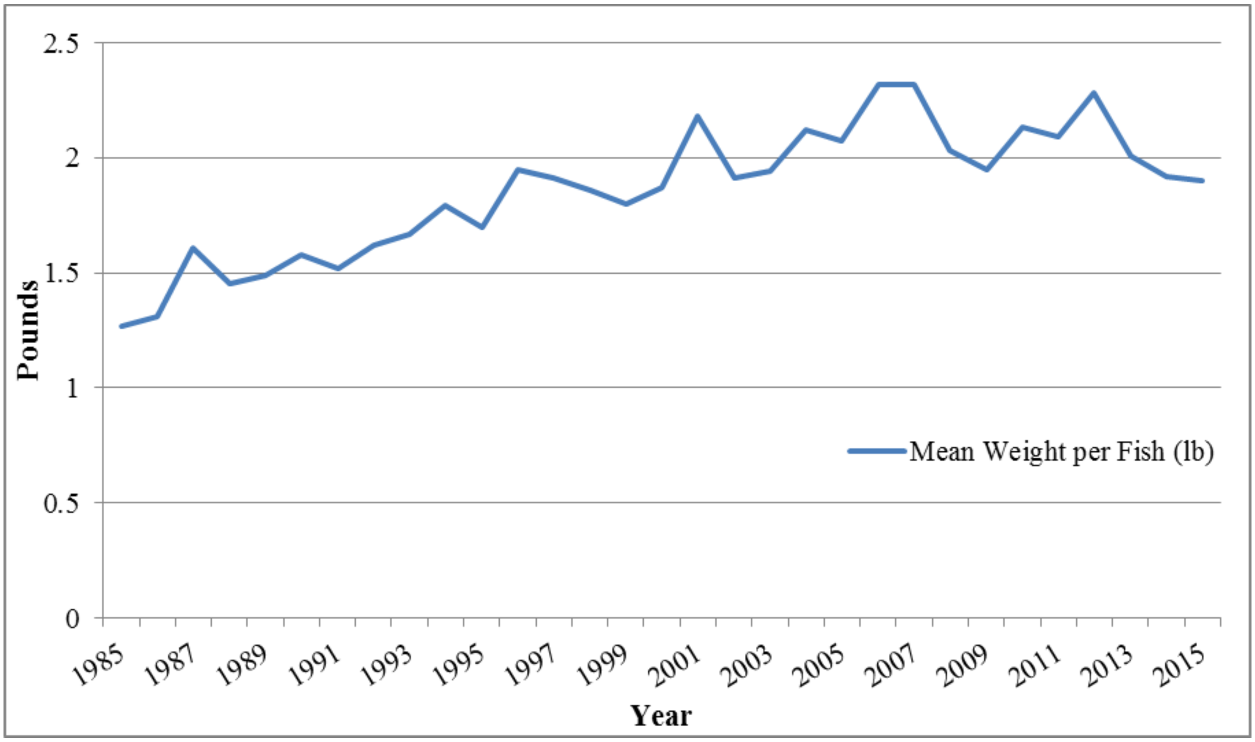

Figure 5.3-1. Mean weight per largemouth bass caught during black bass fishing contests in Don Pedro Reservoir (1985-2016).

TID and MID (2013b) identified 20 tributaries to Don Pedro Reservoir with the potential to be accessed by salmonids in Don Pedro Reservoir. Although there is little information on fish species occurring in most of the reservoir's tributaries, Moccasin Creek supports a fish community consisting of California roach, Sacramento sucker (*Catostomus occidentalis*), sculpin, and rainbow trout (CCSF 2008). Moccasin Creek is stocked with rainbow trout to support a local recreational fishery, and is considered a popular angling location (CDFG 2006a).

5.3.1.3 La Grange Pool

The 2013 study by TID and MID (2013b) indicates that the reach of the Tuolumne River between Don Pedro Dam and La Grange Diversion Dam is limited to two fish species - rainbow trout and prickly sculpin, both of which are distributed throughout the reach. No known stocking has occurred in this reach, indicating that successful natural reproduction of rainbow trout and prickly sculpin may occur in this reach (TID/MID 2013b).

5.3.1.4 Downstream of La Grange Diversion Dam

The historical resident fish populations downstream of La Grange Diversion Dam were part of the deep-bodied fish assemblage (Moyle 2002), likely including tule perch, Sacramento splittail, Sacramento blackfish, hitch, Sacramento sucker, Sacramento pikeminnow, and the extirpated Sacramento perch and extinct thicktail chub (TID/MID 2011).

TID and MID (2011) conducted a review to identify fish species currently utilizing the lower Tuolumne River, which included 14 native anadromous and resident fish species and 22 introduced species.

Native fish species included Pacific lamprey, river lamprey, Chinook salmon, steelhead/rainbow trout, white sturgeon, Sacramento blackfish, hitch, hardhead, Sacramento pikeminnow, Sacramento splittail, Sacramento sucker, tule perch, prickly sculpin and riffle sculpin. Introduced fish species included threadfin shad, common carp, goldfish, golden shiner, red shiner, fathead minnow, channel catfish, white catfish, brown bullhead, wagasaki, western mosquitofish, inland silverside, striped bass, white crappie, black crappie, warmouth, green sunfish, bluegill, redear sunfish, largemouth bass, smallmouth bass, and bigscale logperch.

The earliest recorded fish plantings in the lower Tuolumne River occurred in the 1930s. In 1936, some spotted bass held at the Central Valleys Hatchery at Elk Grove escaped into the San Joaquin River. The following year the fish were intentionally planted in the San Joaquin, Tuolumne, and Cosumnes rivers, with 4,314 fish being planted in the Tuolumne River. Northern spotted bass were also planted in the Tuolumne River from 1938 through 1941 (Dill and Cordone 1997). While spotted bass became established in the Cosumnes River, they reportedly never established a self-sustaining population within the Tuolumne River (Leitritz 1970).

During recent years, the only release of hatchery-raised fish in the Tuolumne River are fall-run Chinook salmon from the Merced River Hatchery, which have been periodically released to conduct fisheries studies.

5.3.2 Life Histories of Stocked Species

Historical and current stocking practices in the Tuolumne River watershed have the potential to affect an anadromous salmonid reintroduction program through the spread of diseases, as well as through interspecific competition and predation interactions between the stocked species and the introduced anadromous salmonids. In order to evaluate potential interactions among stocked species and re-introduced anadromous salmonids in the upper Tuolumne River watershed, life histories and habitat preferences of the species planted (historically and/or currently) within the upper watershed that are still present are briefly discussed below.

5.3.2.1 Brown Trout

Brown trout is a salmonid that is native to Eurasia and northern Africa, but has been introduced and established throughout most of the United States and Canada. Brown trout tend to occupy low reaches of low to moderate gradient reaches (<1 percent) in high gradient river systems (Raleigh et al. 1986b). In addition to stable flow and water temperature regimes, optimal brown trout habitat is characterized by: (1) relatively silt-free rocky substrate in riffle-run areas; (2) a 50-70 percent pool to 30-50 percent riffle-run habitat combination with areas of slow, deep water; (3) well-vegetated and stable banks; and (4) abundant instream cover (Raleigh et al. 1986b).

When multiple trout species inhabit the same river system, brook trout or cutthroat trout tend to occupy the colder, swifter headwater region, while rainbow trout often inhabit the mid-region, and brown trout tend to inhabit the deeper, lower velocity and warmer downstream region (Raleigh et al. 1986b).

Brown trout spawning generally occurs during the fall and winter (primarily November and December), with juvenile emergence occurring between April and September (CCSF 2008). Brown trout prefer spawning gravel with a diameter of about 1-7 cm (0.4-2.8 in), but will utilize gravel ranging from 0.3-10 cm (0.1-3.9 in) (Raleigh et al. 1986a). Fry prefer relatively flow water velocities and are often found in shallower areas such as riffles, near instream cover (Raleigh et al. 1986a). Juvenile brown trout in streams feed mainly on aquatic and terrestrial drift invertebrates, whereas in lakes they feed on zooplankton and benthic invertebrates (Sublette et al. 1990). As brown trout exceed 25 cm (10 in) in length, fish and crustaceans become more important in their diet (reviewed by Raleigh et al. 1986b). Larger brown trout (i.e., over 15 in) reportedly feed almost exclusively on other fish (UCD 2016a). Adult brown trout reportedly seek cover more than any other trout species (Raleigh et al. 1986b). Brown trout can have a life span in the wild of about 10-12 years (CCSF 2008).

As previously mentioned, current stocking of brown trout in the upper watershed is limited to triploid (sterile) brown trout. Studies have reportedly shown that after 3 years of age, triploid trout tend to grow larger than a non-sterile trout due to relatively less energy being expended for reproductive purposes (CDFG 2006b).

5.3.2.2 Rainbow Trout

Optimal rainbow trout habitat is characterized by conditions similar to those described for brown trout, including: (1) silt-free rocky substrate in riffle-run areas; (2) an approximately 1:1 pool-to-riffle ratio, with areas of slow, deep water; (3) well-vegetated and stable stream banks; and (4) abundant instream cover (Raleigh et al. 1984).

Rainbow trout spawn almost exclusively in streams, although some hybrid species have reproduced in lakes without tributary streams (Raleigh et al. 1984). Rainbow trout residing in lakes will spawn in an inlet or outlet stream if available (Raleigh et al. 1984). Rainbow trout spawning within the upper Tuolumne River reportedly occurs primarily between mid-February and mid-June, with juvenile emergence occurring from about mid-March to early July (CCSF 2008). Similar to brown trout, rainbow trout prefer spawning gravel with a diameter of about 1.5-6 cm (0.6-2.4 in), but will utilize gravel ranging from 0.3-10 cm (0.1-3.9 in) (Raleigh et al. 1984). Rainbow trout fry prefer relatively shallow water and slow water velocities, particularly in pool habitats within 1 meter of cover (Raleigh et al. 1984). Both juvenile and adult rainbow trout are opportunistic feeders and consume a wide variety of foods, particularly aquatic insects (Raleigh et al. 1984).

5.3.2.3 Eagle Lake Trout

Eagle Lake trout is a subspecies of rainbow trout that is endemic to California. The historic range for the species was Eagle Lake within Lassen County, and its main tributaries, Pine Creek and Papoose Creek (Moyle 2002). Introduced Eagle Lake trout in other watersheds are maintained from hatchery stock, and even the population in Eagle Lake is not a self-sustaining population (CDFW 2013). The requirements of spawners and juveniles in streams have not been well-studied, but are presumably similar to those of other rainbow trout (Moyle 2002).

For the purposes of evaluating potential interactions between reintroduced salmonids and stocked fish species (i.e. hybridization and disease), potential interactions involving resident rainbow trout are assumed to encompass potential interactions with Eagle Lake trout as well.

5.3.2.4 Brook Trout

Brook trout are native to most of eastern Canada and the northeastern US, but have been established throughout much of the U.S. The species prefers cold, clear lakes and steams, and have become established in small, spring fed, headwater streams and isolated mountain lakes (UCD 2016b). Brook trout apparently are typically displaced by both brown and rainbow trout in the absence of very cold water temperatures (De Carion et al. 2010). They can acclimate to water temperatures up to 26°C (~79°F), although temperatures over 19°C (~66°F) reportedly results in a reduction of growth (UCD 2016b). The brook trout spawning season in California is typically between mid-September and early January (UCD 2016b). Spawning areas typically are characterized by water deeper than 15 inches with water upwelling through the substrate, pea-to-walnut-sized gravel, and nearby cover (UCD 2016b). Embryo incubation requires about 100-144 days at 2-5°C (36-41°F), and the alevins will remain in the gravel for another 3-4 weeks (UCD 2016b), suggesting fry emergence may occur during approximately February through June. They feed on a wide variety of organisms, including worms, leeches, crustaceans, insects, mollusks, fishes, amphibians, and even small mammals (Scott and Crossman 1973). Individuals can live for 4-5 years and reach almost 2 feet in length (UCD 2016b).

5.3.2.5 Kokanee Salmon

Kokanee salmon prefer well-oxygenated, open waters with temperatures in the range of 10–15°C (50-59°F), normally in large lakes and reservoirs (UCD 2016c). Kokanee life cycles can range from 2 to 7 years, with the majority reaching a mature stage within 4 years (UCD 2016c). Spawning reportedly occurs in August into early February, but can occur later, depending on environmental factors and water temperatures. For example, in California, kokanee have been found spawning as late as April (UCD 2016c). Females build redds in gravel substrate near the mouths of streams or near lake spawning sites where they were spawned or planted, and adults die soon after spawning (UCD 2016c). Depending on when the spawning occurred, fry emerge during April through June and subsequently move downstream to mature in lakes (UCD 2016c). The kokanee diet changes little as the fish grow larger but is highly dependent on zooplankton availability, which may change throughout the seasons (Moyle 2002). Kokanee salmon feed primarily on zooplankton, with a preference for water fleas, but small fish and insects are occasionally taken as well (UCD 2016c).

5.3.2.6 Chinook Salmon

Suitable Chinook salmon habitat is characterized by conditions similar to those described for brown trout and rainbow trout, including: (1) silt-free rocky substrate in riffle-run areas; (2) an approximately 1:1 pool-to-riffle ratio; (3) well-vegetated and stable stream banks; and (4) abundant instream cover (Raleigh et al. 1986a).

Because Chinook salmon in Don Pedro Reservoir are likely of Klamath River fall-run Chinook salmon origin, it may be expected they would migrate upstream from the reservoir during the late summer or fall if they were to attempt to spawn, and spawn during October through December. Because Chinook salmon are the largest species of Pacific salmon, Chinook salmon tend to use slightly higher water velocities and larger gravel for spawning than other salmonids (Raleigh et al. 1986a). Chinook salmon prefer spawning gravel with a diameter of about 2-10.6 cm (0.8-4.2 in), but will utilize gravel ranging from 0.3-15 cm (0.1-5.9 in) (Raleigh et al. 1986a). Chinook salmon fry rearing may occur during primarily January through April. Young-of-year Chinook salmon prefer relatively shallow water and slow water velocities near cover (Raleigh et al. 1986a). Juvenile Chinook salmon use water depth, surface turbulence, instream structures and substrate as cover (Raleigh et al. 1986a). Juvenile Chinook salmon are typically considered to be opportunistic foragers, with diets closely resembling the composition of benthic and/or drift samples, such as caddis and mayfly larvae (Utz et al. 2012). Land-locked adults may be relatively selective foragers. For example, in the Great Lakes, Chinook salmon have been found to prey primarily on alewife (*Alosa pseduoharengus*), despite the availability of other prey species and an overall reduction in alewife prey abundance over time (Jacobs et al. 2012).

5.3.2.7 Largemouth Bass

Largemouth bass are most common in warm, shallow waters with moderate clarity and beds of aquatic plants (Moyle 2002). Lake populations stay close to the shore in water that is about 3-9 feet deep. They can survive very warm water temperatures, but 27°C (~81°F) is generally preferred (UCD 2016d). Largemouth bass reach maturity during their second or third spring once they have grown to 7-8 inches for males and 8-10 inches for females (UCD 2016d). Spawning takes place from April through June, up to temperatures of 24°C (75ºF) (Moyle 2002). During spawning, males will build nests in sand, gravel, or debris-littered substrates. The offspring stay in the nest for 5-8 days after hatching, but will remain guarded by the male for another 2-4 weeks. Emergent fry feed on crustaceans and rotifers, before starting to become piscivorous when they reach about 50-60 mm (~2-2.4 in), and commonly feed on fish about half of its size (McGinnis 2006). Largemouth bass become primarily piscivorous at 4-5 inches in length, feeding on crayfish, tadpoles, frogs, and fishes (UCD 2016d). Growth is highly variable, but can range from 2-8 inches in the first year (UCD 2016d). Adults become solitary hunters and hide among plants, roots, or limbs to stalk or ambush their prey. Individuals may live for up to 16 years (Moyle 1976).

5.3.2.8 Smallmouth Bass

Smallmouth bass were originally distributed throughout the upper Mississippi River drainage, south roughly through Arkansas, as well as the Great Lakes watershed (Moyle 2002). Dill and

Cordone (1997) indicated that smallmouth bass were potentially the first bass species introduced into California around 1874 but were then reported only as "black bass." Optimum riverine habitat for smallmouth bass is composed of complex habitat with deep pools, riffles, rocky bottoms, overhanging vegetation and a moderate gradient. Lake populations tend to prefer narrow bays along shorelines, where rocky shelves project under water (Moyle 2002). In California, smallmouth bass spawn from May to June, when water temperatures range from 13-16°C (~55-61°F) (Moyle 2002). Male smallmouth bass construct nests at about 1 m in depth near the shore in lakes and downstream from boulders or some other obstruction in streams. After spawning has concluded, the male protects the nest and aerates the embryos for one to two weeks, and then guards the fry for another one to four weeks. Fry begin to disperse into shallow water when they are 2-3 cm (~1 in) in length (UCD 2016e). As with other black bass, fry begin to feed on zooplankton, switching to insect larvae and finally fish and crayfish as they grow. Adult smallmouth bass are opportunistic feeders, preying on insects, fish, amphibians, and small mammals (UCD 2016e).

5.3.3 Temporal Distributions of Reintroduced Anadromous Salmonids

In order to evaluate potential interactions among stocked species and reintroduced anadromous salmonids in the upper Tuolumne River watershed, potential temporal distributions of Central Valley fall-run Chinook salmon, spring-run Chinook salmon and steelhead are summarized below. Because it is unknown which specific species/runs may be considered for reintroduction, Central Valley fall-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead are all addressed in this report.[5] Assumed species and lifestage-specific temporal distributions in the upper Tuolumne River watershed were developed for the reintroduction feasibility assessment (Table 5.3-2).

Table 5.3-2. Assumed lifestage-specific temporal distributions for fall-run Chinook salmon, spring-run Chinook salmon, and steelhead in the upper Tuolumne River watershed.

Lifestage	Fall-Run Chinook Salmon	Spring-Run Chinook Salmon	Steelhead
Adult upstream migration	Mid-September through December	March through May	October through March
Adult holding	NA	April through mid-August	NA
Spawning	October through mid-January	Mid-August through October	Mid-December through April
Egg incubation and fry emergence	October through February	Mid-August through December	Mid-December through mid-May
Fry rearing	January through May	November through March	February through mid-July
Juvenile rearing	NA	Year-round	Year-round
Juvenile/smolt outmigration	February through May	October through May	January through May

NA means not applicable.

[5] Based on its elevation, Don Pedro Reservoir is likely to be near the area that represented the historical upstream extent of fall-run Chinook salmon (Yoshiyama et al. 2001).

5.3.4 Potential Interactions between Stocked Fish Species and Anadromous Salmonids

The potential for hybridization (and associated genetic effects), competition, or predation between stocked fish species and introduced anadromous salmonids would depend on the spatial and temporal overlap in distributions of particular lifestages. Potential overlap in spatial and temporal distributions were identified to address potential interactions associated with: (1) competition during the spawning and juvenile rearing lifestages of reintroduced salmonids; (2) hybridization during the spawning lifestages of reintroduced salmonids; and (3) predation (i.e., predation of reintroduced salmonids) during the juvenile rearing and emigration lifestages of reintroduced salmonids. Although not specific to one geographic area, a reintroduction effort may also increase the potential for incidence of disease transmission between resident, stocked and reintroduced anadromous salmonids.

Relevant species and lifestage-specific temporal distributions are indicated separately for: (1) the upper Tuolumne River and its tributaries upstream of Don Pedro Reservoir to Early Intake; (2) tributaries to Don Pedro Reservoir (besides the upper Tuolumne River); and (3) Don Pedro Reservoir.

The extent and intensity of potential population-related impacts on reintroduced anadromous salmonids associated with currently or formerly stocked fish species would depend on a multitude of factors and their interactions. Therefore, examples of potential interactions associated with coincident lifestage periodicities, and effects of interactions that have been observed among anadromous salmonids and stocked fish species in other regions, are reviewed in the following Sections.

5.3.4.1 Upper Tuolumne River and Tributaries

Spawning Habitat Competition

Table 5.3-3 displays the expected potential temporal distributions of spawning reintroduced salmonids (shown in blue) and stocked fish species (shown in red) that may occur in the upper Tuolumne River and/or its tributaries. The distributions indicate various extents of overlap in spawning timing among reintroduced salmonids and stocked fish species. Most notably, reintroduced fall-run and spring-run Chinook salmon spawning may coincide with the timings of spawning of brown trout, brook trout, and potamodromous kokanee and Chinook salmon. In addition, reintroduced steelhead spawning may coincide with the spawning of resident rainbow trout, and to a lesser extent, the spawning of brown trout, brook trout, kokanee, and smallmouth bass.

Table 5.3-3 Spawning temporal distributions in the upper Tuolumne River and its tributaries.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fall-run Chinook Salmon												
Spring-run Chinook Salmon												
Steelhead												
Brown Trout												
Rainbow Trout												
Brook Trout												
Kokanee												
Chinook Salmon												
Smallmouth Bass												

Due to similar spawning habitat preferences and overlapping temporal distributions, reintroduced fall-run and spring-run Chinook salmon may need to compete for spawning habitat with brown trout, brook trout, and potamodromous kokanee and Chinook salmon. In addition, reintroduced steelhead may need to compete for spawning habitat with resident rainbow trout, and to a lesser extent, brown trout, brook trout, kokanee and smallmouth bass. Competition for spawning habitat may result in reintroduced Chinook salmon and steelhead utilizing less suitable spawning areas and/or may result in increased potential for redd superimposition among individuals, potentially resulting in relatively lower survival of embryos and subsequent year-class abundance.

In addition to the potential for redd superimposition among the fall-spawning reintroduced salmonids and the fall-spawning stocked salmonids, resident rainbow trout spawning during the winter and spring also may result in damage to embryos of reintroduced Chinook salmon that spawned during the fall.

Hybridization and Genetic Effects

In addition to the potential for competition for spawning habitat, intraspecific hybridization may occur between reintroduced and potamodromous Chinook salmon, and between reintroduced steelhead and resident rainbow trout. Specifically, reintroduced Central Valley fall-run and spring-run Chinook salmon and potamodromous Chinook salmon (Klamath River fall-run) may hybridize, and reintroduced Central Valley steelhead may hybridize with resident rainbow trout, which may have originated from various differing strains. Hybridization of different strains of rainbow trout or Chinook salmon can have unanticipated genetic effects on hybrid progeny and subsequent effects to the resident and introduced populations. Generally, hybridization can result in the loss of unique genetic composition of the parental taxa, outbreeding depression (i.e., relative reduction in fitness of hybrid), gametic wastage, or a combination of these (Allendorf et al. 2001). Intraspecific hybridization specifically can be harmful to locally adapted populations due to the potential loss of local adaptations. The loss of such adaptations can be difficult to detect because local adaptation of native populations might only be essential during periodic episodes of extreme environmental conditions (e.g. storms, drought, fire, etc.) (Allendorf et al. 2001). Negus (1996) found that hybridization of two different strains of rainbow trout stocked in Lake Superior may compromise the genetic integrity of the naturalized population, and that hybrid progeny would likely have reduced fitness relative to the naturalized rainbow trout.

Similarly, Johnson and Abrahams (1991) found that hybrid juvenile progeny of steelhead and domesticated rainbow trout were more willing to risk exposure to predation than the wild steelhead juveniles. Araki et al. (2008) indicate that negative effects of intraspecific hybridization between wild and hatchery salmonids can happen rapidly (i.e., over one generation).

Intraspecific hybridization may have unanticipated effects on the genetics and life histories of anadromous salmonids in the upper Tuolumne River Watershed, and may conflict with the genetic, viability, and population goals of a reintroduction program.

Juvenile Rearing Competition

As shown in Table 5.3-4, there is substantial overlap in temporal distributions of reintroduced juvenile salmonids and juveniles of stocked fish species, particularly between year-round rearing re-introduced spring-run Chinook salmon and steelhead and year-round rearing brown trout, brook trout, rainbow trout, and smallmouth bass. Juvenile reintroduced fall-run Chinook salmon also would be rearing with the same stocked fish species until they emigrated to Don Pedro Reservoir. Although the potamodromous kokanee and Chinook salmon offspring would be expected to be rearing for shorter durations than the other species in the upper Tuolumne River, they also would be competing for resources during portions of the year, particularly during the spring.

Table 5.3-4. Juvenile rearing temporal distributions in the upper Tuolumne River and its tributaries.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fall-run Chinook Salmon												
Spring-run Chinook Salmon												
Steelhead												
Brown Trout												
Rainbow Trout												
Brook Trout												
Kokanee												
Chinook Salmon												
Smallmouth Bass												

Juveniles of reintroduced species would likely compete for rearing habitat (or territories) as well as prey resources with resident stocked fishes in the upper Tuolumne River watershed. Interspecific competition between salmonid species has been documented in various types of environments under varying situations. Some relevant examples are summarized below, primarily relating to interactions of brown trout and other anadromous and resident salmonid species. In addition to competition between species, competition would occur between juveniles of the same species, such as between resident rainbow trout and introduced steelhead, and between progeny of resident potamodromous Chinook salmon and introduced Chinook salmon.

A study of subyearling Chinook salmon and brown trout in a simulated stream (where both species are non-native) found that during the spring, Chinook salmon were larger due to earlier emergence and were socially dominant, but they did not dominate when brown trout had prior residence (Glova and Field-Dodgson 1995). During the summer, interspecific differences in size between Chinook salmon and brown trout no longer existed, and brown trout were apparently always socially dominant. Glova and Field-Dodgson (1995) concluded that brown trout could adversely affect juvenile Chinook salmon populations, and that brown trout should not be added to streams with Chinook salmon.

In the Chitiose River system (Hokkaido, Japan), brown trout were found to be competitively superior to rainbow trout, resulting in non-native brown trout replacing the non-native rainbow trout due to interspecific competition (Hasegawa 2016).

Van Zwol et al. (2012) examined competition and growth of juvenile Atlantic salmon, brown trout and rainbow trout in semi-natural streams, and found that brown trout were the most dominant and had the greatest growth rate regardless of what other species were present. In the presence of brown trout, rainbow trout reportedly fed less frequently and exhibited negative growth as compared to when rainbow trout were only present with Atlantic salmon (Van Zwol et al. 2012).

Houde et al. (2015) assessed juvenile Atlantic salmon placed into artificial stream tanks with combinations of juvenile brown trout, rainbow trout, Chinook salmon and coho salmon. Survival of all three Atlantic salmon populations was lower in the presence of brown trout. Growth also was lower in the brown trout treatment, but survival and growth were not negatively impacted by the presence of Chinook salmon, rainbow trout, or coho salmon. Houde et al. (2015) suggest that tributaries containing brown trout should be avoided during Atlantic salmon reintroduction into Lake Ontario.

Smallmouth bass presumably may also have a potential impact on juvenile anadromous salmonids due to competition for food in areas where smallmouth bass persist (e.g., in the North Fork Tuolumne River or near its confluence with the upper Tuolumne River). Smallmouth bass have been found to affect native fish populations in some areas through limiting the distribution of native species, and competing for resources (reviewed by Valois et al. 2009).

Predation

Predation of juvenile reintroduced fall-run and spring-run Chinook salmon and steelhead may occur by adult brown trout, rainbow trout, brook trout and smallmouth bass year-round (Table 5.3-5). Although potamodromous adult kokanee and Chinook salmon may occur in the upper Tuolumne River during their adult immigration and spawning periods, kokanee salmon and Chinook salmon are not expected to be noteworthy predators of juvenile reintroduced species. Kokanee salmon are known to primarily feed on zooplankton, and anadromous Chinook salmon have generally only been documented to feed on eggs while migrating upstream in freshwater (Garner et al. 2009).

Table 5.3-5. Temporal distributions of juvenile reintroduced species and adult stocked fish species.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fall-run Chinook Salmon (Juvenile)												
Spring-run Chinook Salmon (Juvenile)												
Steelhead (Juvenile)												
Brown Trout (Adult)												
Rainbow Trout (Adult)												
Brook Trout (Adult)												
Smallmouth Bass (Adult)												

Juveniles of reintroduced species are expected to be susceptible to predation by resident stocked fishes in the upper Tuolumne River watershed, particularly brown trout and smallmouth bass in the upper Tuolumne River, and largemouth bass and smallmouth bass in Don Pedro Reservoir. Some relevant studies are summarized below, primarily relating to interactions of brown trout, smallmouth bass or largemouth bass, with anadromous and resident salmonid species.

Krueger et al. (2011) analyzed predator diets and evaluated the relative effect of predation by stocked sport fishes on the variability in survival of Chinook salmon parr in the Muskegon River, MI. Brown trout were found to be a primary predator of Chinook salmon parr, consuming from 15-34 percent of the total number available.

Kuehne and Olden (2012) evaluated whether juvenile Chinook salmon were less able to recognize a non-native predator than a native predator, by evaluating behavioral responses to chemical cues of the invasive smallmouth bass and the native northern pikeminnow in laboratory and field studies. Results indicated that Chinook salmon exhibited anti-predator responses to the northern pikeminnow but not to smallmouth bass. Responses to northern pikeminnow odor resulted in increased flight or absence, reductions in swimming and foraging, and increased time spent near the substrate, compared to responses to the smallmouth bass odor. Results indicate that “naivety” of juvenile Chinook salmon with respect to non-native predators may be an important factor determining the effect of non-native predators on prey populations (Kuehne and Olden 2012).

Smallmouth bass have been found to consume juvenile anadromous salmonids opportunistically when their distributions overlap (e.g., Fritts and Pearsons 2004). For example, in Lake Washington, WA, predation by smallmouth bass increased during spring (50 percent salmon by weight of diet items) when juvenile sockeye salmon utilized littoral areas occupied by smallmouth bass during outmigration (reviewed by Carey et al. 2011). In the Columbia and Snake River basins, the percent of smallmouth bass diets containing salmon has been observed to be highly variable, ranging from 0-65 percent by frequency and 0-89 percent by weight. However, when identified, Chinook salmon was the most frequently consumed salmonid species (Carey et al. 2011).

Predation of juvenile salmon by introduced black bass is considered to be a primary factor limiting survival of juvenile Chinook salmon in the lower Tuolumne River. During 1989 and 1990, TID and MID conducted studies to assess the effects of predation on outmigrant Chinook salmon survival. These studies were prompted by a 1987 CDFG study in which mortality of marked fish released into the Tuolumne River was estimated to be 70 percent during the three days required for the fish to travel downstream from La Grange to the San Joaquin River (TID/MID 2013b). Because water temperatures were less than 64°F (18°C) (i.e., within the range suitable for juvenile salmon), predation was thought to be the most likely source of this mortality. TID and MID (1992) identified 12 fish species that could prey on fry and juvenile Chinook salmon, but largemouth and smallmouth bass were found to be the primary predators.

During 2012, TID and MID (2013c) conducted studies on predation of juvenile Chinook salmon and predatory fish species in the lower Tuolumne River, including estimating abundances of predatory fish species, estimating predation rates of juvenile Chinook salmon, and tracking movements of predatory fish species in relation to juvenile Chinook salmon. The abundance of largemouth bass (>150 mm FL) in the lower Tuolumne River from RM 0 to RM 39.4 was estimated to be 3,796 to 5,843, depending on the method used to expand abundances from sampled areas to non-sampled areas. Largemouth bass were found to occur downstream of RM 34.8, while smallmouth bass (>150 mm FL) were captured throughout the study reach (RM 3.7 to RM 38.4), and striped bass (>150 mm FL) were found throughout most of the study reach (RM 3.7 to RM 35.0). Although only six were sampled, Sacramento pikeminnow (>150 mm FL) were captured at or below RM 25.5.

Stomach sampling conducted during March and May of 2012 of piscivorous fishes identified 30 juvenile Chinook salmon, with eight juvenile Chinook salmon found in smallmouth bass, 11 in largemouth bass, and 11 in striped bass. Average predation rates observed were 0.07 juvenile Chinook salmon per predator per day for largemouth bass, 0.09 per predator per day for smallmouth bass, 0.68 per predator per day for striped bass, and 0.0 per predator per day for Sacramento pikeminnow (TID/MID 2013c).

The estimated number of juvenile Chinook salmon potentially consumed during March 1 – May 31 of 2012 was 15,495 from largemouth bass, 20,501 from smallmouth bass, and 6,193 from striped bass. Based on estimated losses of juvenile Chinook salmon between rotary screw traps in the Tuolumne River during 2007-2011 (74-98 percent), the estimated number of juvenile Chinook salmon estimated to have been lost ranged from 47,000 to 270,000. If the predation rates and predator abundances during 2007-2011 were similar to those documented in the 2012 study, the authors determined that it is plausible that the majority of juvenile Chinook salmon mortality in the Tuolumne River during most years is due to predation (TID/MID 2013c).

Largemouth bass also have been found to be keystone predators of native fish species in the Delta, particularly during spring months (Nobriga and Feyrer 2007).

5.3.4.2 Don Pedro Reservoir

As previously described, the same stocked fish species that occur in the upper Tuolumne River also have the potential to occur in Don Pedro Reservoir, as well as additional stocked fish species, particularly largemouth bass. Although no spawning habitat competition or hybridization interactions would be expected in Don Pedro Reservoir between reintroduced salmonids and stocked fish species, juvenile competition and predation interactions would be expected if progeny of reintroduced salmonids entered Don Pedro Reservoir. Therefore, overlap in temporal distributions of juvenile reintroduced salmonids and juvenile stocked fish species (Table 5.3-4), and overlap in temporal distributions of juvenile reintroduced salmonids and adult stocked fish species (Table 5.3-5) are applicable to Don Pedro Reservoir, except that juvenile and adult largemouth bass also may be present year-round.

5.3.4.3 Tributaries to Don Pedro Reservoir

TID and MID (2013b) identified 20 tributaries with the potential to be accessed by spawning salmonids from Don Pedro Reservoir. All tributaries were assumed to be potentially accessible during the spring, while only perennial tributaries were assumed to be potentially accessible during the fall (Table 5.3-6). TID and MID (2013b) evaluated whether salmonids would be able to access each tributary from the reservoir during the typical spring (i.e., March through June) and fall (i.e., October through November) salmonid spawning periods. Specifically, TID and MID (2013b) evaluated gradient within the inundation zone between the reservoir and each tributary to identify reaches that could become too steep for adult migration associated with reductions in reservoir elevation during the spring and fall spawning periods.

Table 5.3-6. Tributaries to Don Pedro Reservoir (TID/MID 2013b).

Stream	Spring Spawning Evaluated	Fall Spawning Evaluated
Tuolumne River	Yes	Yes
Deer Creek	Yes	No
Moccasin Creek	Yes	Yes
Hatch and First Creeks	Yes	No
Willow Creek	Yes	No
Fleming Creek	Yes	No
Rogers Creek	Yes	Yes
Lucas Gulch	Yes	No
Ranchero Creek	Yes	No
West Fork Creek	Yes	No
Big Creek	Yes	Yes
Fortynine Creek	Yes	No
Sixbit Gulch	Yes	No
Poormans Gulch	Yes	No
Woods Creek	Yes	Yes
Sullivan Creek	Yes	No
Kanaka Creek	Yes	No
Rough and Ready Creek	Yes	No

All tributaries that were evaluated during both the fall and spring were found to be accessible from Don Pedro Reservoir during the evaluated time period, with the exception of Deer Creek, which was found to be too steep (i.e., greater than 10 percent gradient) during the spring (TID/MID 2013b).

Although little information is available on fisheries habitat or fish species community composition in the tributaries to Don Pedro Reservoir, stocked fish species that were identified in the upper Tuolumne River and its tributaries may potentially be present in the tributaries to the reservoir as well, particularly rainbow trout and brown trout. Therefore, if reintroduced anadromous salmonids were able to access the tributaries to Don Pedro Reservoir, some of the same types of hybridization, competition, and predation interactions discussed for the upper Tuolumne River also have the potential to occur in the reservoir tributaries.

5.3.4.4 Disease

Disease is a major threat to the health and success of fisheries and is a critical element in assessing potential risks associated with a reintroduction effort. Dill and Cordone (1997) suggest that some of the fish introduced into California are responsible for the occurrence of a number of major fish parasites, diseases, or nonpathogenic organisms. For example, the introduction of largemouth bass to some areas of the state was also accompanied by the introduction of the bass tapeworm, *Proteocephalus ambloplitis*, which also can infect trout and other fishes. In 2015, an outbreak of whirling disease within the Mount Shasta and Darrah Springs hatcheries occurred, affecting at least 3 million trout (Sabalow 2015). It has been hypothesized that the infection started when an avian predator ate a fish from Battle Creek, a stream near the Darrah Springs hatchery that is known to host the parasite. The bird then moved to the spring that feeds Darrah hatchery holding ponds, where it defecated in the water and spread the spores to aquatic worms, which then spread the spores to fish in the hatchery (Sabalow 2015).

While diseased fish are found among natural populations, the methods in which fish are raised in hatcheries can increase the occurrences of many diseases. Hatchery fish can have reduced health relative to wild fish when they are cultured in high densities, exposed to potential stressors, and provided artificial or unnatural feeds (Walker and Winton 2010). At the same time, anthropogenic stresses on aquatic ecosystems have reduced the suitability of riverine habitat conditions for wild fish populations. These conditions have led to the emergence and spread of an increasing array of new diseases (Walker and Winton 2010).

No comprehensive fish pathogen survey has been conducted on juvenile fall-run Chinook salmon in the San Joaquin River system. However, in 2001 the National Wild Fish Health Survey examined 70 free ranging fish within the San Joaquin River west of Merced. The survey found no clinical signs of disease, and viral or obligate bacterial pathogens were not detected in any of the Chinook salmon that were examined (True 2001). The survey also tested specimens from the Tracy Fish Collection Center which were collected from across the Central Valley. Collected species included striped bass, white catfish, American shad, and threadfin shad. White catfish had clinical signs of bacterial infections that were identified as *Aeromonas hydrophila* in laboratory testing. A large percentage of the striped bass also tested positive for *Aeromonas hydrophila*, but did not exhibit clinical signs of disease. Elevated water temperatures, handling required for the trapping and transport of fishes, and poor water quality were all thought to contribute to the prevalence of *Aeromonas hydrophilia* in the otherwise hardy catfish species (True 2001).

Until the early 1980s, California's hatcheries occasionally used broodstock from other basins or moved fry to other basins. This practice of using out-of-basin stock could have affected the genetics of the fish naturally occurring in the receiving basins or resulted in the transfer of diseases from the hatchery to the wild populations (TID/MID 2013c).

During the early 1990s, a copepod infestation of the trout and salmon fisheries within Don Pedro Reservoir occurred. CDFW refrained from stocking Chinook salmon or rainbow trout to the reservoir, and only stocked brook trout and brown trout during the infestation years, because they are reportedly not susceptible to the parasites. Rainbow trout stocking resumed in 1997 (TID /MID 2013c), while Chinook salmon stocking resumed temporarily in 1999, and has occurred annually since 2005.

PKD (caused by *Tetracapsuloides bryosalmonae)* has been diagnosed in Merced River Hatchery juvenile Chinook salmon for several decades (Hedrick et al. 1986, as cited in Foott et al. 2007). The incidence of *T. bryosalmonae* infection in Merced River Hatchery Chinook salmon prior to and shortly after release has ranged from 4 – 100 percent, with most of the infections rated as early stage and the fish asymptomatic (Foott et al. 2007). The majority of Merced River Hatchery PKD infections have been rated as moderate, with minimal kidney swelling. However, during the spring migration period, water temperatures in the Delta can be in excess of 18°C (~64.4°F), and may promote the rapid expression of PKD (Foott et al. 1986; Baker et al. 1995, as cited in Foott et al. 2007). Therefore, PKD could be a notable mortality factor for Merced River Chinook salmon smolts during their early estuary and ocean entry phase (Foott et al. 2007). The Merced River Hatchery's Chinook salmon yearling production program was discontinued due to high fish losses from PKD (California HSRG 2012).

During March and April of 2013, the California Nevada Fish Health Center conducted a survey of juvenile Chinook salmon smolts within the Stanislaus, Tuolumne, Merced, and San Joaquin rivers. No bacterial or viral pathogens were detected in any of the fish sampled, however, the parasite that causes PKD in salmonids (*Tetracapsuloides bryosalmonae*) was detected in 80 percent of the fish sampled from the Merced River, 7 percent of fish from the Stanislaus River, and 25 percent of the fish from the mainstem San Joaquin River. None of the fish sampled from the Tuolumne River (N=36) had the parasite (Nichols 2013).

A review of CDFW's fish pathology reports for the Moccasin Creek Hatchery from 2010 to 2016 shows that CDFW pathologists routinely observed and treated for *Apiosoma* spp, *Epistylis* spp, *Gyrodactylus* spp, *Trichodina* spp, *Trichophyra* spp, *Flavobacterium brachiophilum* (bacterial gill disease), *Flavobacterium columnare* (columnaris disease), *Flavobacterium psychrophilum* (cold water disease), *Icthyobodo nectar* (costia), *Ichthyophthirius mutlifiliis* (Ich), *Spironucleus salmonis*, and various other ubiquitous motile and non-motile Aeromonad and Pseudomonad bacteria. The most commonly observed pathogens were cold water disease, bacterial gill disease, and costia, respectively (CDFW, unpublished data).

Discussion of disease outbreaks within and outside of the upper Tuolumne River watershed is important because the risk of spreading diseases to new areas or exacerbating existing sub-lethal effects of disease are notable concerns when considering introduction of fish into areas otherwise unaccustomed to the presence of the introduced species/strain. The reintroduction of salmonids into the upper reaches of the Tuolumne River would allow for the potential introduction of pathogens into the upper Tuolumne River watershed that introduced salmonids may have acquired in the lower Tuolumne or San Joaquin rivers. Therefore, fish assemblages in the upper Tuolumne River watershed may be exposed to new pathogens that are not currently or historically were present, potentially resulting in unintended disease-related effects on fisheries in the upper watershed. Because a disease outbreak is more likely to occur under unsuitable environmental conditions (e.g., elevated water temperature, low dissolved oxygen, fish crowding) and/or when fish are under stress, the capture, handling, transport, and release of adult salmonids from the lower Tuolumne River into the upper watershed may exacerbate the potential for a disease outbreak among the introduced fish as well as among the existing fish populations. The exact type and severity of potential impacts of introducing salmonids to the upper watershed are unknown and need to be considered carefully before implementing a reintroduction program.

6.0 DISCUSSION AND FINDINGS

The species of fish that are currently or were historically stocked within the Tuolumne River Basin spawn and rear in habitats that are very similar to habitats preferred by the salmonids species/runs being considered for reintroduction, which could result in a suite of potentially deleterious interactions among stocked species and salmonids reintroduced into the upper watershed.

It is well documented that stocking non-native fishes can impact native fish communities via direct predation, competition for food and habitat, interbreeding/hybridization, and the spread of disease such as whirling disease (Pacific Rivers Council 2006; Kostow 2009; Araki et al. 2008). Specifically, potential interactions between stocked fish species and reintroduced anadromous salmonids may include competition for spawning habitat, hybridization, competition for rearing resources, juvenile predation, and increased incidence of disease. The extent and intensity of potential population-related impacts on reintroduced anadromous salmonids associated with stocked fish species would depend on a multitude of factors and their interactions. Hence, the cumulative population-related impacts of these interactions cannot be predicted at this time, but it is not uncommon for nonnative species to outcompete native species in western Sierra Nevada watersheds, sometimes locally extirpating native species.

Due to similar spawning habitat preferences and overlapping temporal distributions, reintroduced fall-run and spring-run Chinook salmon may need to compete for spawning habitat with brown trout, brook trout, and potamodromous kokanee and Chinook salmon. In addition, reintroduced steelhead may need to compete for spawning habitat with primarily resident rainbow trout. Competition for spawning habitat may result in reintroduced Chinook salmon and steelhead utilizing less suitable spawning areas and/or may result in increased potential for redd superimposition, potentially resulting in relatively lower survival of embryos and subsequent year-class abundance.

In addition to the potential for competition for spawning habitat, reintroduced Central Valley fall-run and spring-run Chinook salmon and potamodromous Chinook salmon (Klamath River fall-run) may hybridize, and reintroduced Central Valley steelhead may hybridize with resident rainbow trout. Hybridization may have unanticipated genetic effects and subsequent effects on the life histories of anadromous salmonids in the upper Tuolumne River watershed, and may conflict with the goals of a reintroduction program.

Juveniles of reintroduced species would likely compete for rearing habitat (or territories) as well as prey resources with resident stocked fishes in the upper Tuolumne River watershed. In general, most studies related to competition among salmonid species have found that brown trout often have an adverse impact on other salmonid species in terms of growth and/or survival, including Chinook salmon and *O. mykiss*. Smallmouth bass also has been found to outcompete anadromous salmonids.

In addition to competitive interactions, juveniles of reintroduced species are expected to be susceptible to predation by resident stocked fishes in the upper Tuolumne River watershed, particularly brown trout and smallmouth bass in the upper Tuolumne River, and largemouth bass and smallmouth bass in Don Pedro Reservoir. Studies demonstrate highly variable levels of predation of anadromous salmonids by non-native predators such as brown trout, smallmouth bass and largemouth bass, with particularly high levels of predation in the lower Tuolumne River, indicating the potential for substantial predation-related impacts to reintroduced anadromous salmonids in the upper Tuolumne River watershed.

In addition to ecological interactions between reintroduced species and existing stocked species, stocked species of salmonids can carry and transmit many of the same diseases (e.g., PKD, whirling disease) that salmonids considered to be introduced into the upper watershed could potentially carry and transmit. As described above, disease outbreaks can be more common under hatchery conditions than in natural settings. Any disease outbreak in the upper Tuolumne River watershed could limit the success of both existing populations and reintroduced populations. In addition, the transport of salmonids from below La Grange Dam to the upper Tuolumne River would effectively connect the upper Tuolumne River Watershed not only to the lower Tuolumne River, but also to the San Joaquin River system and all of its tributaries.

Investigation of the cumulative effects of this connectivity is beyond the scope of this study. However, this increased connectivity could not only result in increased potential for incidence of disease in the upper Tuolumne River watershed, but due to straying that often occurs in anadromous salmonid populations, it could facilitate hybridization between existing salmonid populations in the upper Tuolumne River, reintroduced anadromous salmonids, as well as anadromous salmonids in the other San Joaquin River tributaries. Recent and ongoing hatchery practices, including release of Merced River Hatchery and Mokelumne River Hatchery juvenile salmonids into the San Joaquin River, may further increase the potential for straying among the San Joaquin River tributaries. Other reintroduction programs in the San Joaquin River watershed also may affect a reintroduction program in the Tuolumne River watershed. For example, Feather River Hatchery phenotypic spring-run Chinook salmon introduced into the San Joaquin River may return to the Tuolumne River. Therefore, a reintroduction program could have unforeseen impacts to the genetic diversity of the salmonids not only in the Tuolumne River, but throughout the San Joaquin River watershed. There are also potential genetic management issues related to reintroduced Chinook and steelhead, as they may interact with existing potamodromous Chinook or resident rainbow trout, but these issues cannot be evaluated until more is known about genetic origins of existing populations and the source populations that might be considered to support a reintroduction effort.

Reintroduced salmonids may be affected by competition for spawning and rearing habitat, hybridization, juvenile predation, and increased potential for disease. Although the extent and intensity of potential population-related effects cannot be explicitly determined at this time, potential impacts to reintroduced salmonids associated with historically or currently stocked fish species, and potential impacts of a reintroduction program on existing salmonid populations should be understood prior to attempting a reintroduction program in the upper Tuolumne River watershed.

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