UPPER TUOLUMNE RIVER BASIN WATER TEMPERATURE MONITORING AND MODELING TEMPERATURE INDICES ANALYSIS STUDY REPORT

LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

Prepared for:
Turlock Irrigation District – Turlock, California
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Upper Tuolumne River Basin Water Temperature Monitoring and Modeling Study: Temperature Indices Analysis

Study Report

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List of Acronyms and Abbreviations

CCSF..........................City and County of San Francisco
CDFW........................California Department of Fish and Wildlife
cfs...............................cubic feet per second
Districts......................Turlock Irrigation District and Modesto Irrigation District
FERC..........................Federal Energy Regulatory Commission
GIS.............................Geographic Information System
ILP..............................Integrated Licensing Process
ISR.............................Initial Study Report
LGDD........................La Grange Diversion Dam
LP...............................Licensing Participant
M&I............................municipal and industrial
MAE...........................mean average error
MID............................Modesto Irrigation District
MSAE........................mean squared average error
MWAT………………Maximum Weekly Average Temperature
NMFS.........................National Marine Fisheries Service
NPS............................National Park Service
PAD............................Pre-Application Document
QA/QC.......................quality assurance/quality control
RM.............................river mile
RMSE.........................root mean squared error
RSP............................Revised Study Plan
SD2............................Scoping Document 2
SPD............................Study Plan Determination
TID.............................Turlock Irrigation District
UOWTI......................Upper Optimum Water Temperature Index
USFWS......................United States Fish and Wildlife Service
USGS.........................United States Geological Survey
USR............................Updated Study Report
UTRFT.......................Upper Tuolumne River Flow and Temperature Model
WTI…………………Water Temperature Index

1.0 INTRODUCTION

1.1 Background

The Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) jointly 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 headpond formed by the diversion dam. Under normal river flows, the headpond formed by the diversion dam extends for approximately two miles 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 headpond 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, Cherry Lake (also known as Lake Lloyd), 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) and operated by the San Francisco Public Utilities Commission. Inflow to the La Grange headpond is the sum of releases from the Don Pedro Project, located 2.3 miles upstream, and very minor contributions from two small intermittent drainageways 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 4.7 megawatts (MW). The La Grange Hydroelectric Project (Project; FERC No. 14581) operates in run-of-river mode. The LGDD provides no flood control benefits, and there are no existing recreation facilities associated with the Project or the La Grange headpond.

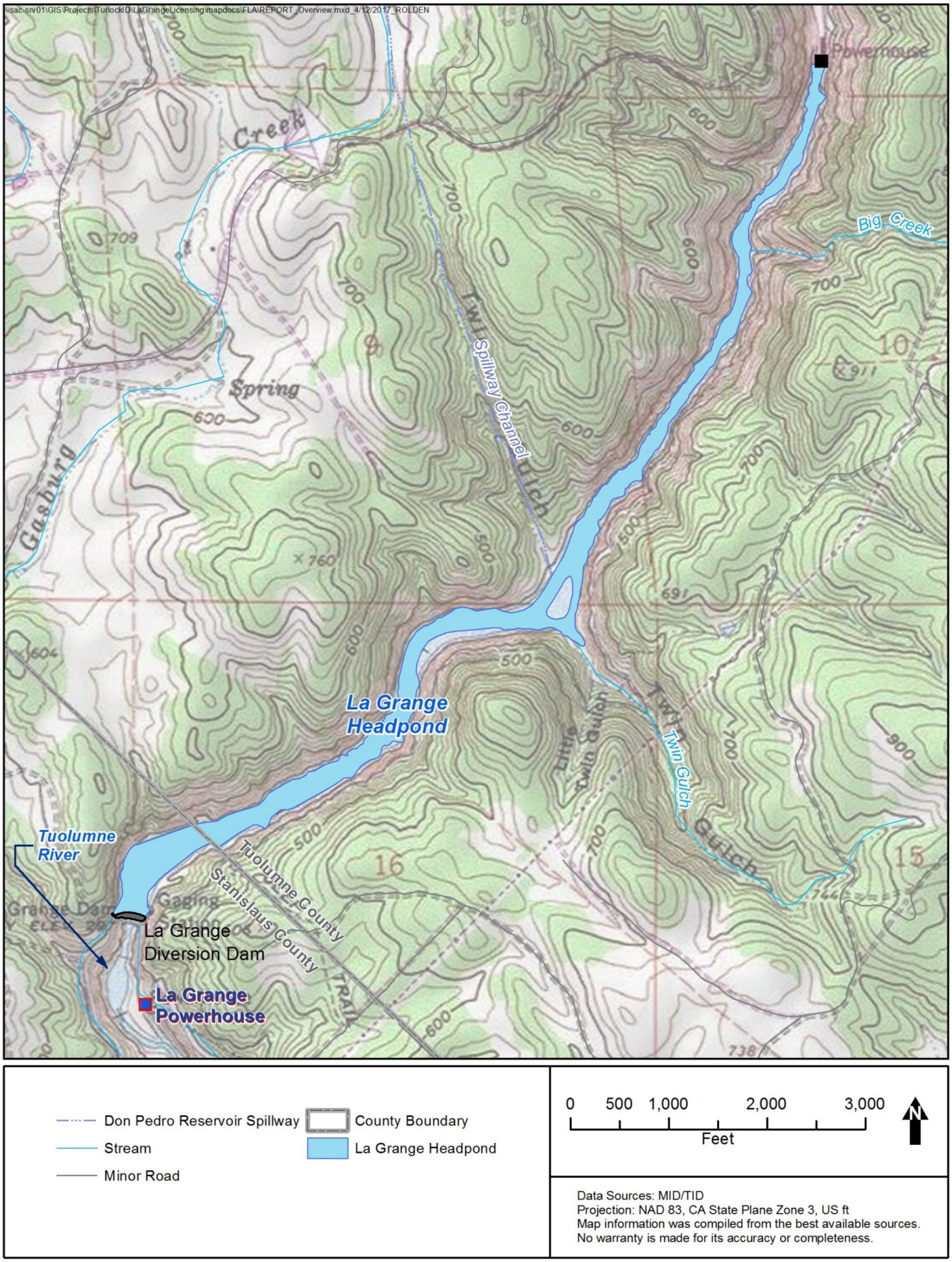


Figure 1.1-1. La Grange Hydroelectric Project location map.

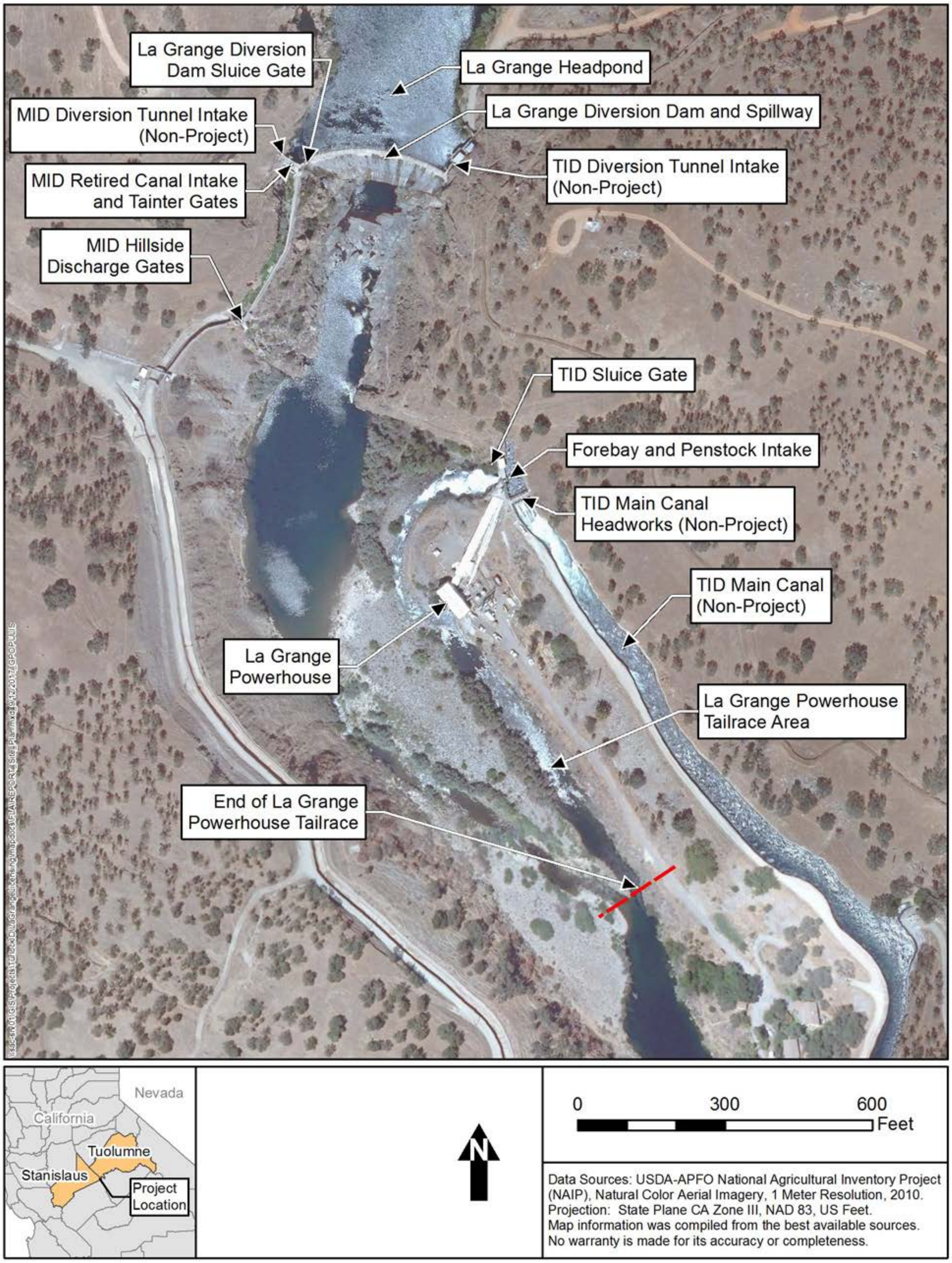


Figure 1.1-2. La Grange Hydroelectric Project site plan.

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 headpond. 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 Hydroelectric 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, 2016. 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, and a revised pre-filing schedule. 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, and accepted the Districts' revised pre-filing schedule.

On February 1, 2017, the Districts filed the Updated Study Report (USR) for the La Grange Hydroelectric Project. The Districts held a USR meeting on February 16, 2017, and on March 3, 2017, 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 3, 2017. Comments on the USR were received from the Central Sierra Environmental Resource Center on February 27, 2017, from NMFS on April 3, 2017, and from CDFW on April 13, 2017. On May 2, 2017, the Districts filed with FERC a response to comments received from licensing participants.

On April 24, 2017, the Districts filed the Draft License Application for the La Grange Hydroelectric Project. Comments on the Draft License Application were received from NMFS on May 12, 2017, from FERC on July 18, 2017, and from CDFW on August 18, 2017. The Districts' response to these comments is included in the La Grange Hydroelectric Project Final License Application (FLA). The FLA was filed with FERC on October 11, 2017, in accordance with the Districts' Request for Extension of Time granted by FERC on September 1, 2017.

This report describes the objectives, methods, and results of the temperature indices analysis component of the Upper Tuolumne River Basin Water Temperature Monitoring and Modeling Study (herein referred to as the Water Temperature Monitoring and Modeling Study). The Water Temperature Monitoring and Modeling Study is one of the three study components of the Upper Tuolumne River Basin Habitat Assessment as described in the RSP and in Section 1.3 below. Documents relating to the Project licensing are publicly available on the Districts' licensing website at www.lagrange-licensing.com/.

1.3 Voluntary Studies

To facilitate the Fish Passage Facilities Alternatives Assessment, the Districts provided to licensing participants Technical Memorandum (TM) No. 1 in September 2015. Information provided in TM No. 1 included a summary of relevant site, hydrologic, and biological background data and suggested design criteria that were to be used as a basis for development of alternative fish passage facility concepts. The purpose of this initial submittal of potential design criteria was to obtain needed input and direction from fisheries resource agencies on essential design parameters necessary to undertake the study.

TM No. 1 identified a number of information gaps critical to informing the biological and associated engineering basis of conceptual designs. When agency input on design parameters was not forthcoming, the Districts proposed in November 2015 to address these critical information gaps through a collaborative process with all licensing participants. Licensing participants and the Districts formed a Plenary Group and adopted a plan to implement the Upper Tuolumne River Fish Reintroduction Assessment Framework (Assessment Framework) intended to develop information needed to complete fish passage conceptual studies and to assess the overall viability of developing and sustaining anadromous salmonid populations in the upper Tuolumne River (TID/MID 2016a, 2017a). In support of the Assessment Framework, licensing participants agreed that site-specific studies of ecological, biological, and socioeconomic issues could help inform decision making regarding fish reintroduction and fish passage. In all, study plans were developed for the conduct of nine voluntary studies (Table 1.3-1), two of which -- Fish Migration Barriers Study and Water Temperature Monitoring and Modeling Study -- had been proposed by the Districts previously in its Revised Study Plan document, but were not required in FERC's Study Plan Determination. The remaining seven study plans were developed in collaboration with licensing participants in early 2016, and field data collection began in mid-2016.

Table 1.3-1. Voluntary studies proposed by the Districts.

No.	Study	Completed	Not Completed
1	Upper Tuolumne River Basin Fish Migration Barriers Study	X	
2	Upper Tuolumne River Basin Water Temperature Monitoring and Modeling Study	X	
3	Upper Tuolumne River Chinook Salmon and Steelhead Spawning Gravel Mapping Study		X
4	Upper Tuolumne River Habitat Mapping Assessment		X
5	Upper Tuolumne River Macroinvertebrate Assessment		X
6	Upper Tuolumne River Instream Flow Study		X
7	Hatchery and Stocking Practices Review	X	

No.	Study	Completed	Not Completed
8	Socioeconomic Scoping Study		X
9	Regulatory Context for Potential Anadromous Salmonid Reintroduction into the Upper Tuolumne River Basin		X

On May 2, 2016, the Districts filed with FERC an updated pre-filing licensing schedule to allow time for the Districts to complete ongoing FERC-approved studies, for NMFS to complete its Upper Tuolumne River Habitat and Carrying Capacity Study and study of Tuolumne River *O. mykiss* genetics, and for the performance of a Fish Transit Study in parallel with the ongoing fish passage engineering study. On May 27, 2016, FERC filed a determination on requests for study modifications and new studies, and approved the revised schedule and Districts' study plan for the Fish Transit Study.

The Districts have since completed the Upper Tuolumne River Basin Fish Migration Barriers Study, the Upper Tuolumne River Basin Water Temperature Monitoring and Modeling Study, and the Hatchery and Stocking Practices Review Study. As explained in Exhibit E of the La Grange Hydroelectric Project FLA (TID/MID 2017b), based on the results of the Fish Passage Facilities Alternatives Assessment and other reintroduction studies and relevant information, the remaining voluntary studies do not require completion at this time.

1.4 Description of the 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 1.5-1).

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

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

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).

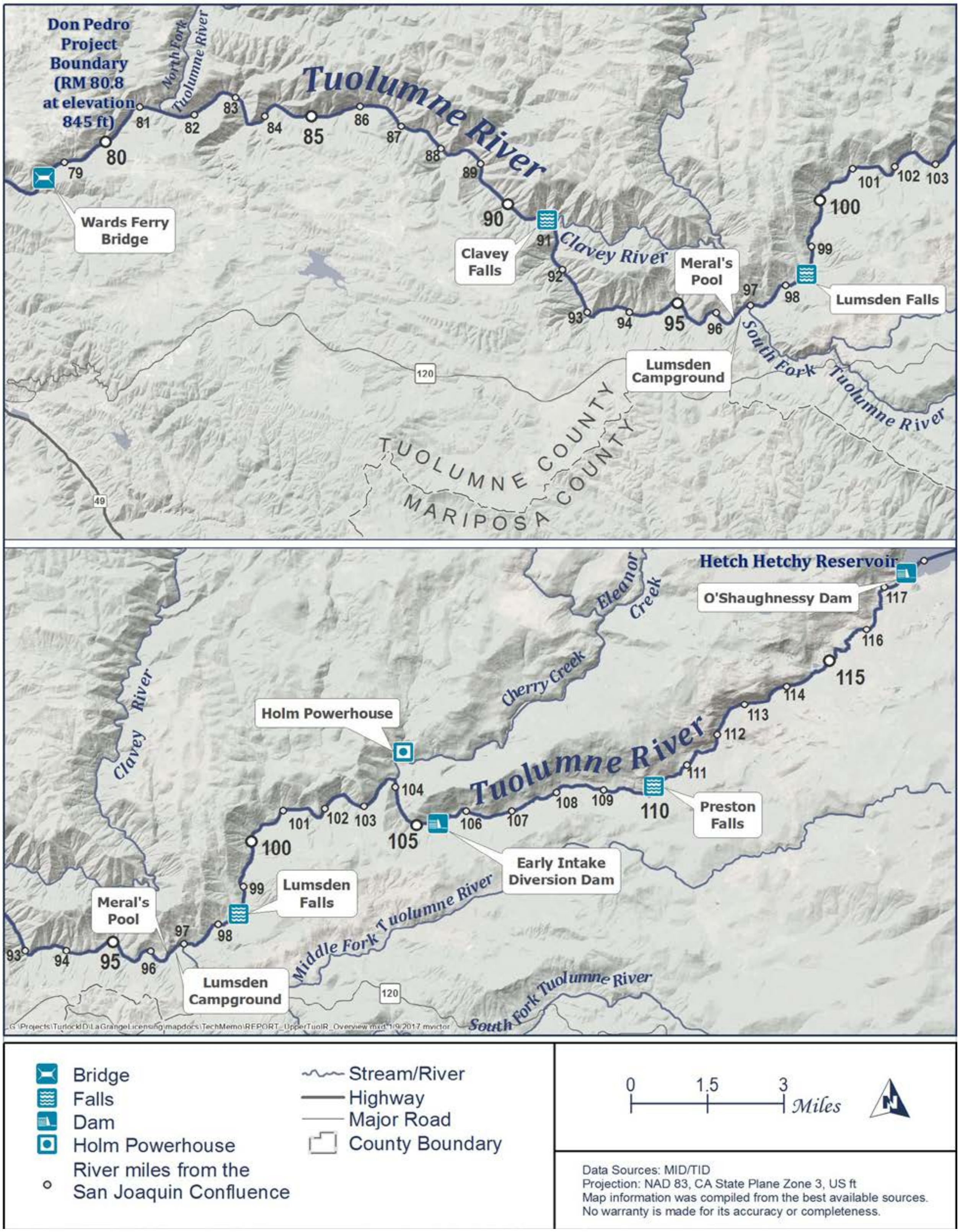


Figure 1.5-1. The Tuolumne River basin upstream of Don Pedro Project. The top map depicts the river from Wards Ferry Bridge to RM 101, and the bottom map depicts the river from RM 94 to RM 118.

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 waterfalls on the upper mainstem Tuolumne River: Clavey Falls (RM 91), Lumsden Falls (RM 98.25), and Preston Falls (RM 110).

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 and 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 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 ac-ft per year 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 ac-ft (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 ac-ft since 1975. The maximum annual unimpaired runoff since 1975 was 4.6 million ac-ft (Water Year [WY] 1983), and the minimum was 0.38 million ac-ft (WY 1977)[4]. 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.

[4] The preliminary estimate on unimpaired runoff at La Grange gage for WY 2017 is 4.8 million AF.

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 Table 1.5-1, 1.5-2, and 1.5-3, 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[5]. This variability is also illustrated in three select water years: 2008, 2009, and 2013 in Figure 1.5-2, Figure 1.5-3, and Figure 1.5-4, respectively. Data illustrated in each year shows how flows downstream of Holm Powerhouse fluctuate from approximately 150 or 200 cubic feet per second (cfs) up to 1,000 or 1,200 cfs on a daily basis most clearly during the late summer months of July through September.

Table 1.5-1. 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 (5th)	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
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 1.5-2. 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 1.5-3. 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

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

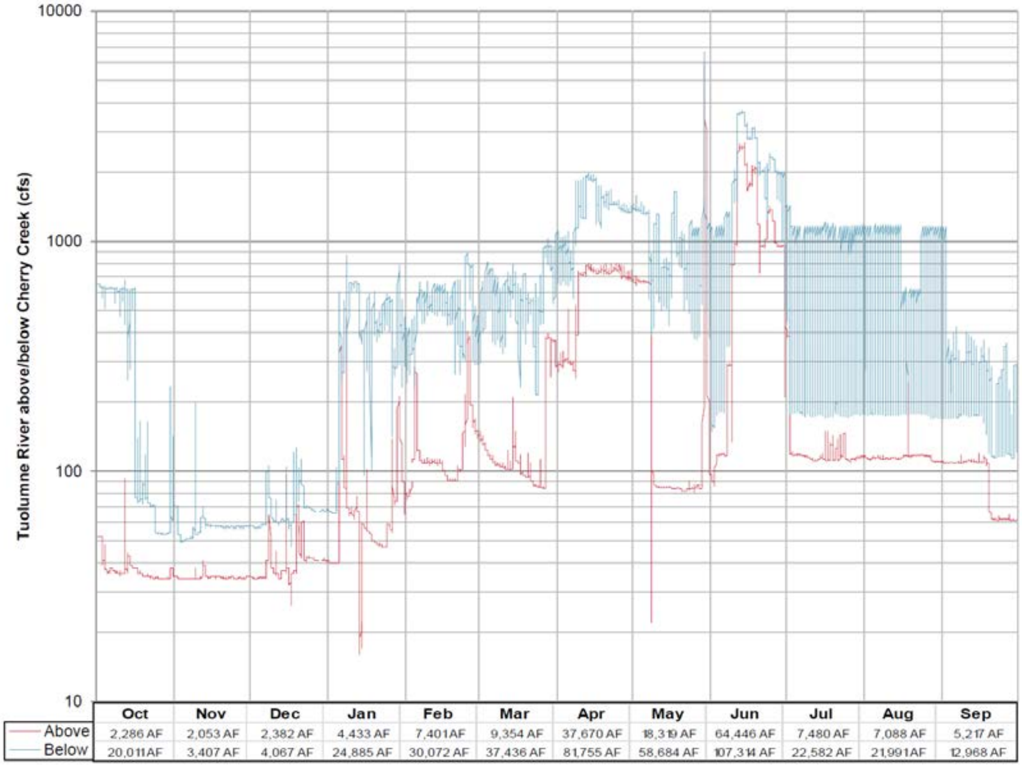


Figure 1.5-2. Tuolumne River Flow above/below Cherry Creek for Water Year 2008.

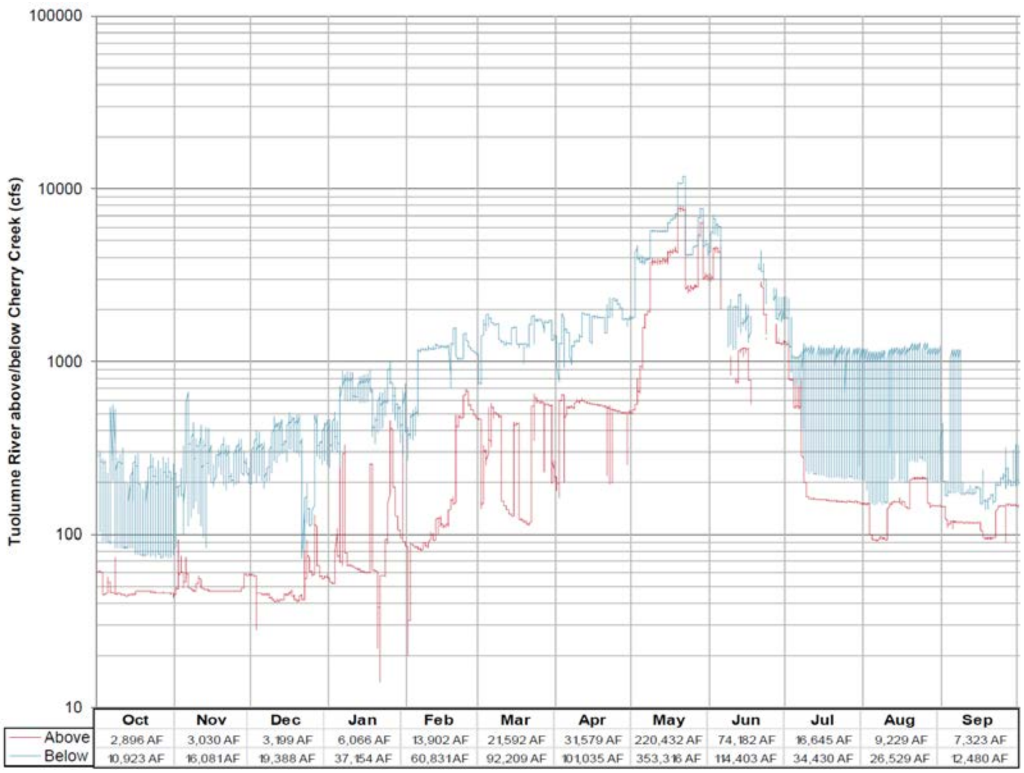


Figure 1.5-3. Tuolumne River Flow above/below Cherry Creek for Water Year 2009.

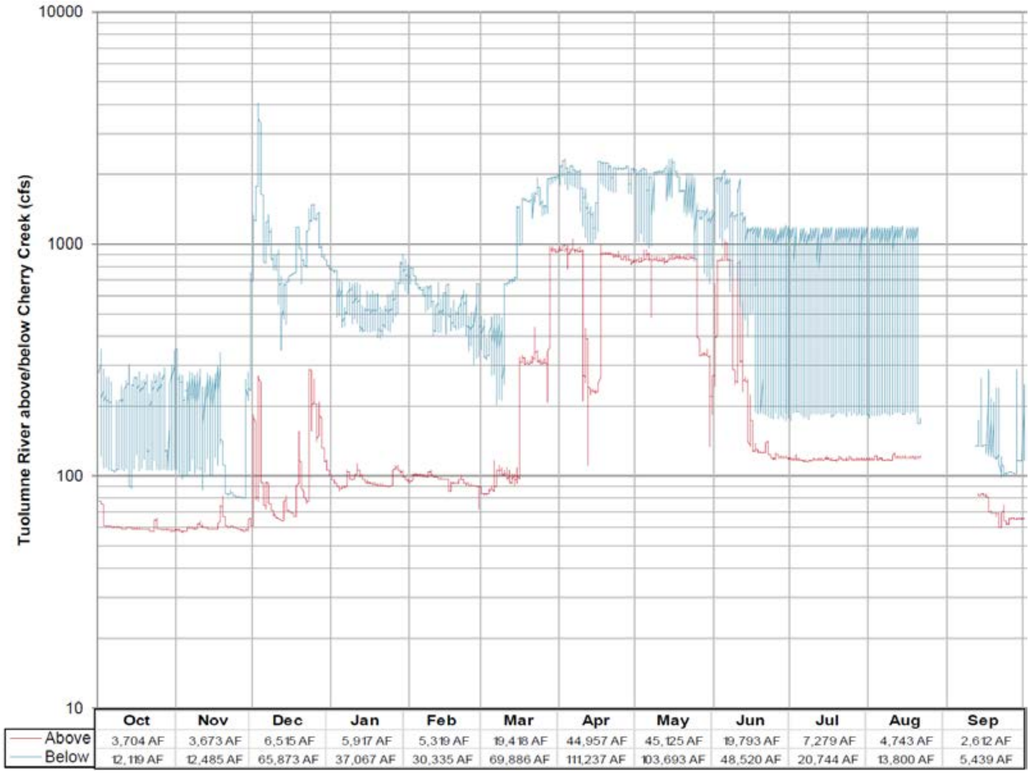


Figure 1.5-4. Tuolumne River Flow above/below Cherry Creek for Water Year 2013.

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 trout (*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 ac-ft, respectively (SFPUC 2008). SFPUC releases 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 remain in the Tuolumne River where they are supplemented by tributary flows and occasional releases at Kirkwood Powerhouse to the Tuolumne River.

The minimum stream flow maintained by SFPUC below Cherry Lake is 5 cfs from October through June and 15.5 cfs from July through September (RMC and McBain and Trush 2007, Revised 2016). In years when no pumping (i.e., water conveyance between Lake Eleanor and Cherry Lake) takes place between Lake Eleanor and Cherry Lake, the minimum flow downstream of Lake Eleanor is 5 cfs from October through June and 15.5 cfs from July through September (RMC and McBain and Trush 2007, Revised 2016). In years when pumping does occur, the minimum 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 and Trush 2007, Revised 2016). There are no specific, regulated minimum flow releases 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 and Trush 2007, Revised 2016). These minimum flows take into consideration the effects of seasonal water temperatures on habitat suitability.

SFPUC owns and operates the 170 MW Holm Powerhouse located near the mouth of Cherry Creek. The Holm Powerhouse generally operates in a peaking mode, except when Cherry Creek river flows are sufficient for the plant to operate at full capacity. Flows in the Tuolumne River downstream of its confluence with Cherry Creek may be significantly influenced by the peaking operation of Holm Powerhouse. The on-peak operation of Holm Powerhouse during summer provides flows for whitewater rafting in the Tuolumne River downstream of Cherry Creek, with most whitewater boating trips starting at the USFS Lumsden Campground near the South Fork confluence.

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, dissolved oxygen 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 water temperatures (June through July) 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 and fall maximum water temperatures in the upper Tuolumne River would be substantially higher, up to 4.5°C, in the absence of the Hetch Hetchy impoundments than they are under existing conditions (Figures 1.5-5 and 1.5-6). During most of the year, 7DADM temperatures are generally similar to or slightly higher, up to 2.5°C, with the dams in place, and can be up to 4°C higher in winter (Figures 1.5-5 and 1.5-6). 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.

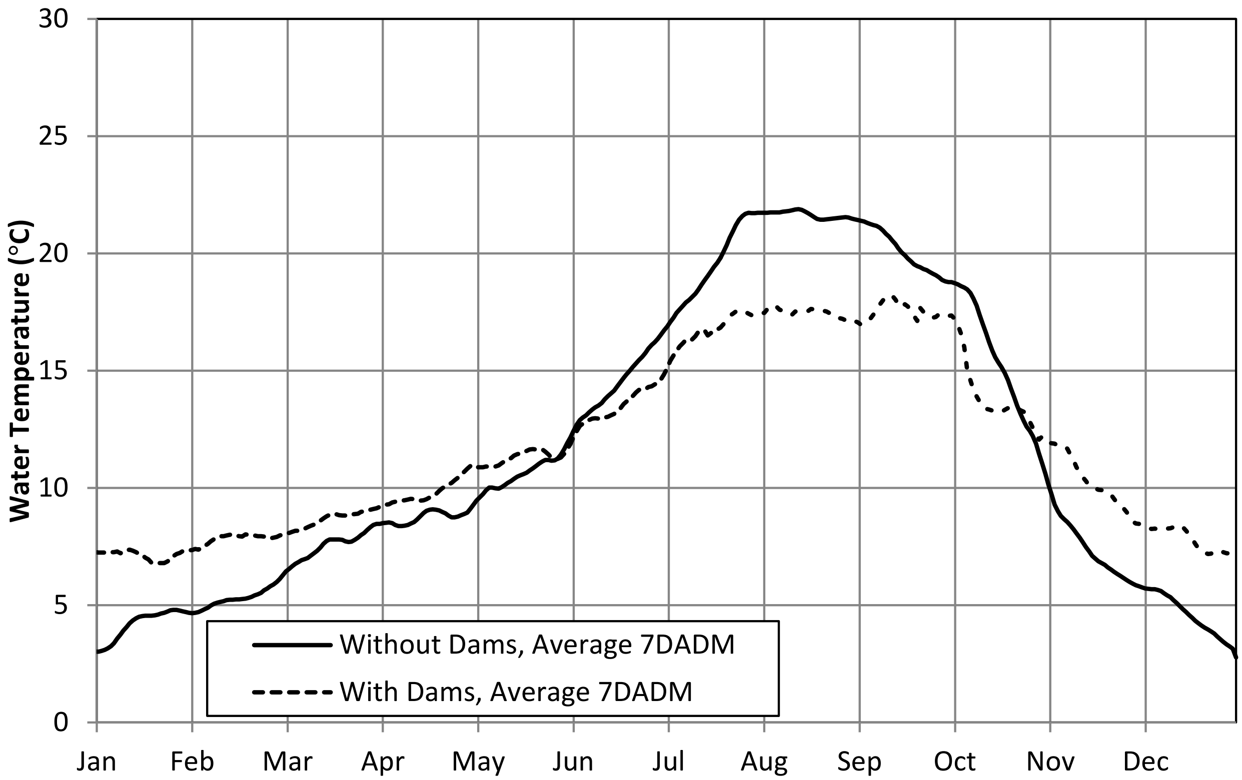


Figure 1.5-5. Comparison of 7DADM water temperatures under with- and without-dams conditions in the Tuolumne River below the South Fork Tuolumne River (≈RM 98). Without-dams temperatures are simulated based on the period 1970–2012 (Jayasundara et al. 2014), and with-dams temperatures are based on data collected by temperature loggers from 2005 to 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]."

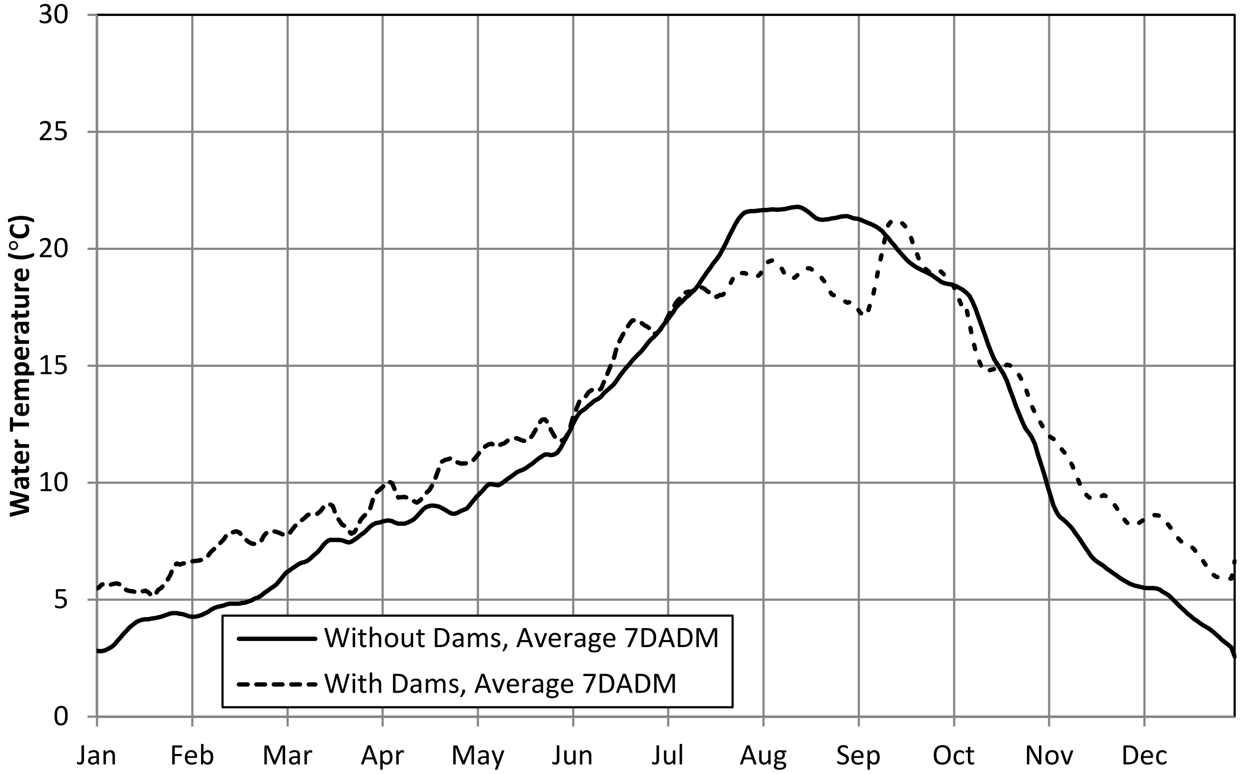


Figure 1.5-6. Comparison of 7DADM water temperatures under with- and without-dams conditions in the Tuolumne River below Indian Creek (≈RM 88). Without-dams temperatures are simulated based on the period 1970–2012 (Jayasundara et al. 2014), and with-dams temperatures are based on data collected by temperature loggers from 2009 to 2012.

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). 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 2015). Although in small numbers (i.e., two to eight), in 2012 juvenile Chinook salmon were collected in the upper Tuolumne River (Perales 2015).

CDFW stocks rainbow trout throughout the upper Tuolumne River watershed (CDFW 2016). CDFW has released, or continues to release, kokanee, brook trout, rainbow trout, coho salmon, Chinook salmon, brown trout, Eagle Lake trout (*Oncorhynchus mykiss aquilarum*), 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 salmon reproducing in the upper Tuolumne River (see preceding paragraph) are the product of CDFW stocking programs conducted in Don Pedro Reservoir (Perales 2015). The planted Chinook salmon are "surplus" juveniles from Iron Gate Hatchery, located on the Klamath River, outside the Central Valley (Perales 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). Flows in the Tuolumne River downstream of its confluence with Cherry Creek are heavily influenced by the peaking operation of the Holm Powerhouse, which provides on-peak energy for SFPUC and supports whitewater rafting. The resulting flow fluctuations in the upper Tuolumne River (see Section 1.4.2) influence resident trout habitat and may affect habitat suitability for trout, other fish species, and macroinvertebrates. 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.

2.0 STUDY GOAL

The Upper Tuolumne River Flow and Temperature (UTRFT) Model was applied to the historical period from 2008-2016, and fish life-stage water temperature index (WTI) values were applied using simulated temperatures at selected locations. The WTI values and associated species periodicities were collaboratively developed and approved by the Framework Plenary Group (La Grange Hydroelectric Project Reintroduction Assessment Framework Plenary Group 2017). This study report provides results of the UTRFT Model application to WTI values in order to assess thermal suitability in the upper Tuolumne River for the reintroduction of spring Chinook (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*).

2.1 Species of Interest

Prior to implementation of this study, three anadromous salmonid species were considered for reintroduction to the upper Tuolumne River above the Don Pedro Project and two were chosen for evaluation -- Central Valley (CV) Spring-Run Salmon (*O. tshawytscha*) and California Central Valley (CCV) Steelhead (anadromous *O. mykiss*). The federal Endangered Species Act (ESA) listing status for both species and additional information on fall-run Chinook is described below.

2.1.1 Central Valley Spring-Run Chinook Salmon

The Central Valley spring-run Chinook salmon Evolutionarily Significant Unit (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. Per the Recovery Plan, both the Tuolumne River (below La Grange Diversion Dam) and the upper Tuolumne River (above the La Grange Diversion Dam) are considered candidate areas for reintroduction (NMFS 2014).

2.1.2 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 Distinct Population Segment (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. Per the Recovery Plan, the Tuolumne River (below La Grange Diversion Dam) is considered a Core 2 population (i.e., meeting or having the potential to meet, the biological recovery standard for moderate risk of extinction). The upper Tuolumne River (above La Grange Diversion Dam) is considered a candidate area for reintroduction (NMFS 2014).

2.1.3 Fall-run Chinook Salmon

At the January 2016 Workshop for the Framework Plenary Group (described in section 1.3 above), NMFS stated an interest in the evaluating the reintroduction of both spring-run and fall-run Chinook and steelhead to the upper Tuolumne River Reach (La Grange Hydroelectric Project Reintroduction Assessment Framework Plenary Group 2016). After evaluation of this request, the Districts did not agree that evaluating reintroduction of fall-run Chinook to the upper Tuolumne River was appropriate.[6] Concerns with fall-run Chinook included the fact that they are not listed and are not consistent with a reintroduction program to advance the Recovery Plan; concerns regarding stress of non-volitional passage; competition, interbreeding and genetic effects with spring-run Chinook, disease transmission given a large proportion of fall-run Chinook are out-of-basin hatchery strays, and adverse impacts to the source population if upper river activities were unsuccessful. Furthermore, the historical distribution of fall-run Chinook is believed to have been confined to lower elevations of the Sacramento and San Joaquin River tributaries (Yoshiyama et al. 2001). Since 1971, California Department of Fish and Wildlife has conducted annual salmon spawning surveys in the lower Tuolumne River. In addition to CDFW's work, the Districts have also studied fall-run Chinook salmon on the lower Tuolumne River through annual seine surveys conducted since 1986, annual snorkel surveys since 1982, adult fish weir counts since 2009, and more recently as part of the Don Pedro Hydroelectric Project relicensing. Historical data obtained through these efforts show that spawner estimates have ranged from 40,300 in 1985 to 77 in 1991 (TID/MID 2010, Report 2009-2). Variation in numbers have been attributed to water quality and water availability in the San Joaquin River system as well as changes in ocean conditions. Studies conducted through the FERC relicensing of Don Pedro Hydroelectric Project have demonstrated that under the current flow regime, there is sufficient spawning gravels available in the lower Tuolumne River to support a spawning population of over 50,000 fall-run Chinook salmon and over 700,000 *O. mykiss* (TID/MID 2013b). As such, fall-run Chinook were not evaluated as part of this study.

[6] At the February 16, 2016 Reintroduction Assessment Framework Technical Committee conference call, the Districts questioned the prudency of including fall-run Chinook and presented their concerns.

3.0 STUDY AREA

The Water Temperature Monitoring and Modeling Study area includes the mainstem Tuolumne River from below Early Intake (RM 105) to above the Don Pedro Project Boundary (approximately RM 80.8) (Figure 1.4-1). Through this reach, the Tuolumne River receives seasonally-varying tributary flow contributions from Cherry Creek, South Fork Tuolumne River, Clavey River, and North Fork Tuolumne River, as well as minor flow contributions from numerous small tributaries.

4.0 UPPER TUOLUMNE RIVER FLOW AND TEMPERATURE MODEL

The UTRFT Model has been updated and calibrated for historical conditions in years 2008 (January 1) through 2016 (September 30) (TID/MID 2017b). For the 2008 to 2016 period, annual average flows as measured at the USGS gage (11274790) above Hetch Hetchy ranged from 64 percent of normal in 2007 to 195 percent of normal in 2011. The model domain extends from Early Intake to the Don Pedro Hydroelectric Project boundary, and the river is represented with 1,307 nodes with node spacing of approximately 100 ft (30 m) (Figure 4.0-1). The computational time step is 15 minutes. The model domain, modeling period (span of 8 years and 9 months), and spatial and temporal steps provides a comprehensive data set that represents a wide range of hydrologic and meteorologic conditions.

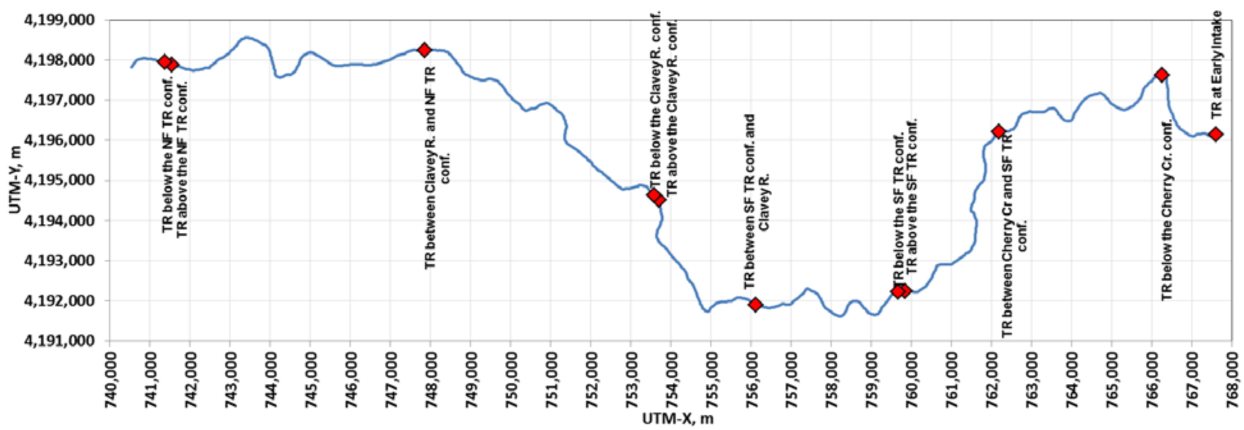


Figure 4.0-1. Schematic of model domain and selected locations for temperature assessment criteria application.

The updated UTRFT Model performed well, replicating hourly hydropower peaking operations throughout the reach and reproducing diurnal variations in water temperature in response to meteorological conditions as well as hydropower peaking operations. Overall, the model simulated seasonal variations and tracked observed data well. For all years, mean bias was typically low and near zero (average bias = -0.04^{o}C (0.08^{o}F)), mean average error (MAE) was under 1^{o}C (1.8^{o}F) the majority of the time (average mean squared average error (MSAE) = 0.86^{o}C (1.6^{o}F)), and root mean squared error (RMSE) was typically under 1.5 ^{o}C (2.7^{o}F) (average RMSE = 1.19^{o}C (2.15^{o}F)). Overall, given the level of available data, these results indicate that the model effectively captures a range of hydrologic and water temperature conditions in the upper Tuolumne River system on an hourly basis.

Herein, the UTRFT Model was applied to the historic period (2008-2016) to simulate flow and water temperature throughout the study reach. Model application provides sub-daily temperature information at approximately 30 m (100 ft) intervals throughout the upper Tuolumne River, effectively interpolating to locations and time periods where or when measured field data are unavailable.

Subsequently, simulated temperatures were used to evaluate WTI values throughout the study reach for spring-run Chinook salmon and steelhead at different lifestages for selected locations (described in Section 5.0 below). Thus, the model provided a means to assess thermal suitability throughout the reach for multiple years representing a wide range of hydrologic year types, operations (e.g., hydropower peaking, hydropower outages), and meteorological conditions.

5.0 TEMPERATURE ASSESSMENT

As part of the Framework process described in Section 1.3 above, technical subcommittees (working in coordination with the larger Plenary Group) comprised of interested LPs (i.e., federal and state resource management agencies, non-governmental organizations and the public) on a voluntary basis were formed to support key reintroduction feasibility assessment activities. In general, technical subcommittee meetings focused on specialized technical topics related to the Framework process and included: (1) the collaborative development of study plans for 2016 voluntary Upper Tuolumne River studies, (2) discussions to define reintroduction goals and objectives to evaluate reintroduction feasibility, and (3) discussions to identify appropriate water temperature criteria to evaluate thermal suitability in the reintroduction reach. In 2016-2017, the Water Temperature Subcommittee (formed to address topic number 3) participated in numerous conference calls to develop and finalize information to support thermal suitability assessments of target species (i.e., steelhead and spring-run Chinook) in the study area. As a starting point, members decided the best path forward was to review and update with additional studies and site-specific information, a literature review already completed for the Yuba Salmon Forum (YSF) in 2012 (Bratovich et al. 2012). This literature review focused on Central Valley temperature experiments and field observations and contains over 100 references. Where data needed to be augmented, the review extended to information collected in the Pacific Northwest. Based upon the information collected, the YSF developed water temperature index values for each life stage for spring-run Chinook and steelhead and used this information to support determination of areas in the Yuba watershed that may be suitable or unsuitable for salmon and steelhead reintroduction. Similar to the Yuba process, the Water Temperature Subcommittee developed a literature review document (TID/MID 2017c) that included up-to-date regional and site specific information regarding the potential biological effects of water temperature to the growth and survival of salmon and steelhead and based upon this information, the subcommittee developed and finalized guidance for which to assess thermal suitability in the upper Tuolumne River. Information included life stage periodicities and water temperature indices (WTIs) for both optimum and tolerable conditions (as defined in Bratovich et al. 2012) for spring-run Chinook and steelhead; and use of Maximum Weekly Average Temperature (MWAT) as the metric of evaluation. Temperatures occurring consistently above the upper tolerable limit may have long-term adverse effects and would be judged to be unlikely to support recovery or reintroduction. Table 5.0-1 below summarizes information developed by the Water Temperature Subcommittee. This information was presented to and approved by the Framework Plenary Group on May 18, 2017 (La Grange Hydroelectric Project Reintroduction Assessment Framework Plenary Group 2017).

Table 5.0-1. Spring-run Chinook and Steelhead Water Temperature Indices for Upper Optimum (UOWTI) and Upper Tolerable (UTWTI) conditions for the UTR reach (Evaluation metric is MWAT (Maximum weekly average of daily average temperature).

Lifestage	UOWTI (MWAT) °F	UTWTI (MWAT) °F	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spring-run Chinook Salmon[1, 2]														
Adult Upstream Migration	64	68												
Adult Holding	61	65												
Adult Spawning	56	58												
Embryo Incubation and Emergence	56	58												
Fry Rearing	65	68												
Juvenile Rearing and Downstream Movement	65	68												
Smolt Outmigration	63	68												
Steelhead[1, 2]														
Adult Upstream Migration	64	68												
Holding	61	65												
Adult Spawning	54	57												
Embryo Incubation and Emergence	54	57												
Fry Rearing	68	72												
Juvenile Rearing and Downstream Movement	68	72												
Smolt Outmigration	55	57												

[1] Dark shaded areas represent known peak periods for the specified lifestage whereas light shaded areas represent presence.
[2] The absence of dark shaded areas for any lifestage indicates that the Technical Committee did not identify any particular peak period based on the available data.

WTIs listed in Table 5.0-1 were evaluated for eleven locations through the study area (Table 5.0-2). These locations were selected to be upstream and downstream of major tributaries, and when reaches between tributaries were more than a few miles, an intermediate point on the mainstem Tuolumne River was added. In general, the suite of locations was intended to provide sufficient spatial representation of the thermal characteristics of the study area and to address the thermal influences of major tributaries. UTRFT model outputs were used to calculate seven-day running averages of the daily average and maximum. The MWAT was computed by calculating the mathematical mean of multiple, equally spaced, daily water temperatures over a 7-day consecutive period. The MWAT is defined as the highest value calculated for all possible seven-day periods over a given time period, in this case, a particular salmonid lifestage. In order to determine whether the maximum weekly temperature standard is attained, the mathematical mean of multiple, equally spaced, daily temperatures over a seven-day consecutive period is compared to the associated WTIs. These statistics were subsequently used to estimate the number of days on which the given WTIs were exceeded in each of the fish life stages identified in Table 5.0-1. All data are available in electronic format and are available upon request.

Table 5.0-2. Temperature assessment criteria generic sites (Abbreviations: TR: Tuolumne River; Cr.: Creek; Conf.: Confluence; SF: South Fork; R.: River; NF: North Fork).

Location Number	Location Name	Approximate River Mile
1	TR at Early Intake	105.0
2	TR below the Cherry Cr. conf.	103.7
3	TR between Cherry Cr and SF TR conf.	100.1
4	TR above the SF TR conf.	97.2
5	TR below the SF TR conf.	96.8
6	TR between SF TR conf. and Clavey R.	93.7
7	TR above the Clavey R. conf.	91.2
8	TR below the Clavey R. conf.	90.8
9	TR between Clavey R. and NF TR conf.	85.9
10	TR above the NF TR conf.	81.1
11	TR below the NF TR conf.	81.5

6.0 APPLICATON OF WATER TEMPERATURE INDICES FOR EVALUATING SIMULATED MODEL APPLICATION RESULTS

WTI values developed from the Framework Water Temperature Subcommittee (La Grange Hydroelectric Project Reintroduction Assessment Framework Plenary Group 2017) were applied to simulated temperatures at the locations presented in Table 5.0-2. In this section, as an example, WTIs were applied to 2008 simulated temperatures for target species' life stages. Tables summarizing this information for all analysis years, 2008 to 2016, can be found in the Appendix A. Hydrology information for the upper Tuolumne River (USGS gage 11274790) above the Hetch Hetchy system (i.e., essentially unimpaired) was acquired for the historic period (2008-2016). Of the nine-year period, the range of annual average flows was 64 percent to 195 percent. However, 2008 was 95 percent of the average and closest to representative of normal annual runoff of the Tuolumne River above the Hetch Hetchy system for this time period[7]. The calculated MWAT values are presented, and percentage of days when index values is exceeded enumerated for spring-run Chinook salmon upper optimum water temperature index (UOWTI) value (Table 6.0-1 and Table 6.0-2), spring-run Chinook salmon upper tolerable water temperature index (UTWTI) value (Table 5.0-3 and Table 5.0-4), steelhead UOWTI (Table 6.0-5 and Table 6.0-6), and steelhead UTWTI (Table 6.0-7 and Table 6.0-8). Highlighted entries (gray) indicate where MWAT exceeds WTIs for each life stage and location.

[7] As described in Section 4.0, 2008-2016 is a drier than average period of time when considering hydrology from 1971 to 2016 based upon the USGS gage (11276900) below Early Intake.

Table 6.0-1. Spring-run Chinook salmon (UOWTI) MWAT for each fish life stage for calendar year 2008.

Fish life stage	Assessment WTI (MWAT)	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], ºF										
Adult Upstream Migration (03/01 – 05/31)	64.0	66.4	52.5	53.5	55.5	55.9	56.4	57.8	58.2	58.9	59.5	59.5
Adult Holding (04/01 – 09/15)	61.0	70.1	64.0	63.8	64.7	65.0	65.0	66.3	66.9	66.7	66.7	66.7
Adult Spawning (08/15 – 10/31)	56.0	66.4	61.5	61.6	62.6	63.0	63.1	64.4	64.8	64.8	65.0	65.2
Embryo Incubation and Emergence (08/15 – 12/31)	56.0	66.4	61.5	61.6	62.6	63.0	63.1	64.4	64.8	64.8	65.0	65.2
Fry Rearing (11/01 – 03/31)	65.0	53.7	50.3	50.8	51.2	51.1	51.6	52.1	52.1	53.3	53.8	53.9
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	65.0	70.1	64.0	63.8	64.7	65.0	65.0	66.3	66.9	66.7	66.7	66.7
Smolt Outmigration (10/01 – 05/31)	63.0	66.4	56.1	56.7	57.4	57.5	57.9	58.6	58.7	59.6	60.2	60.3

[1] Cells which exceed the assessment water temperature index value (MWAT) are highlighted in gray.

Table 6.0-2. Percentages of days when spring-run Chinook salmon UOWTI values are exceeded for calendar year 2008.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (03/01 – 05/31)	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (04/01 – 09/15)	50.6	14.9	17.3	20.8	23.2	25.0	32.7	35.1	34.5	35.1	35.7
Adult Spawning (08/15 – 10/31)	76.9	52.6	57.7	65.4	66.7	67.9	69.2	70.5	71.8	71.8	71.8
Embryo Incubation and Emergence (08/15 – 12/31)	43.2	29.5	32.4	36.7	37.4	38.1	38.8	39.6	40.3	40.3	40.3
Fry Rearing (11/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	16.7	0.0	0.0	0.0	0.0	0.3	3.6	3.8	3.8	4.1	4.9
Smolt Outmigration (10/01 – 05/31)	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6.0-3. Spring-run Chinook salmon (UTWTI) MWAT for each fish life stage for calendar year 2008.

Fish life stage	Assessment WTI (MWAT)	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], ºF										
Adult Upstream Migration (03/01 – 05/31)	68.0	66.4	52.5	53.5	55.5	55.9	56.4	57.8	58.2	58.9	59.5	59.5
Adult Holding (04/01 – 09/15)	65.0	70.1	64.0	63.8	64.7	65.0	65.0	66.3	66.9	66.7	66.7	66.7
Adult Spawning (08/15 – 10/31)	58.0	66.4	61.5	61.6	62.6	63.0	63.1	64.4	64.8	64.8	65.0	65.2
Embryo Incubation and Emergence (08/15 – 12/31)	58.0	66.4	61.5	61.6	62.6	63.0	63.1	64.4	64.8	64.8	65.0	65.2
Fry Rearing (11/01 – 03/31)	68.0	53.7	50.3	50.8	51.2	51.1	51.6	52.1	52.1	53.3	53.8	53.9
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	68.0	70.1	64.0	63.8	64.7	65.0	65.0	66.3	66.9	66.7	66.7	66.7
Smolt Outmigration (10/01 – 05/31)	68.0	66.4	56.1	56.7	57.4	57.5	57.9	58.6	58.7	59.6	60.2	60.3

[1] Cells which exceed the assessment water temperature index value (MWAT) are highlighted in gray.

Table 6.0-4. Percentages of days when spring-run Chinook salmon UTWTI values are exceeded for calendar year 2008.

Fish life stage	Location No. 1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (03/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (04/01 – 09/15)	36.3	0.0	0.0	0.0	0.0	0.6	7.7	8.3	8.3	8.9	10.7
Adult Spawning (08/15 – 10/31)	74.4	26.9	32.1	33.3	34.6	38.5	53.8	56.4	64.1	70.5	70.5
Embryo Incubation and Emergence (08/15 – 12/31)	41.7	15.1	18.0	18.7	19.4	21.6	30.2	31.7	36.0	39.6	39.6
Fry Rearing (11/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (10/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6.0-5. Steelhead (UOWTI) MWAT for each fish life stage for calendar year 2008.

Fish life stage	Assessment WTI (MWAT)	Location No. 1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], ºF										
Adult Upstream Migration (10/01 – 03/31)	64.0	62.5	56.1	56.7	57.4	57.5	57.9	58.6	58.7	59.6	60.2	60.3
Adult Holding (10/01 –12/15)	61.0	62.5	56.1	56.7	57.4	57.5	57.9	58.6	58.7	59.6	60.2	60.3
Adult Spawning (12/15 – 04/30)	54.0	50.7	47.0	47.5	48.1	48.1	48.5	49.0	49.1	49.6	50.2	50.2
Embryo Incubation and Emergence (12/15 – 05/31)	54.0	66.4	52.5	53.5	55.5	55.9	56.4	57.8	58.2	58.9	59.5	59.5
Fry Rearing (02/01 – 07/15)	68.0	70.1	64.0	63.8	64.7	65.0	65.0	66.2	66.8	66.7	66.7	66.7
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	68.0	70.1	64.0	63.8	64.7	65.0	65.0	66.3	66.9	66.7	66.7	66.7
Smolt Outmigration (12/01 – 04/30)	55.0	50.7	47.8	48.3	48.9	48.9	49.4	49.8	49.9	50.6	51.2	51.2

[1] Cells which exceed the assessment water temperature index value (MWAT) are highlighted in gray.

Table 6.0-6. Percentages of days when Steelhead UOWTI values are exceeded for calendar year 2008.

Fish life stage	Location No. 1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (10/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (10/01 –12/15)	9.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Spawning (12/15 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Embryo Incubation and Emergence (12/15 – 05/31)	13.0	0.0	0.0	3.0	3.6	4.1	5.9	5.9	7.1	8.9	8.9
Fry Rearing (02/01 – 07/15)	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (12/01 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6.0-7. Steelhead (UTWTI) MWAT for each fish life stage for calendar year 2008.

Fish life stage	Assessment WTI (MWAT)	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (10/01 – 03/31)	68.0	62.5	56.1	56.7	57.4	57.5	57.9	58.6	58.7	59.6	60.2	60.3
Adult Holding (10/01 –12/15)	65.0	62.5	56.1	56.7	57.4	57.5	57.9	58.6	58.7	59.6	60.2	60.3
Adult Spawning (12/15 – 04/30)	57.0	50.7	47.0	47.5	48.1	48.1	48.5	49.0	49.1	49.6	50.2	50.2
Embryo Incubation and Emergence (12/15 – 05/31)	57.0	66.4	52.5	53.5	55.5	55.9	56.4	57.8	58.2	58.9	59.5	59.5
Fry Rearing (02/01 – 07/15)	72.0	70.1	64.0	63.8	64.7	65.0	65.0	66.2	66.8	66.7	66.7	66.7
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	72.0	70.1	64.0	63.8	64.7	65.0	65.0	66.3	66.9	66.7	66.7	66.7
Smolt Outmigration (12/01 – 04/30)	57.0	50.7	47.8	48.3	48.9	48.9	49.4	49.8	49.9	50.6	51.2	51.2

[1] Cells which exceed the assessment water temperature index value (MWAT) are highlighted in gray.

Table 6.0-8. Percentages of days when Steelhead UTWTI values are exceeded for calendar year 2008.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (10/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (10/01 –12/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Spawning (12/15 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Embryo Incubation and Emergence (12/15 – 05/31)	10.1	0.0	0.0	0.0	0.0	0.0	1.8	3.0	3.6	4.1	4.1
Fry Rearing (02/01 – 07/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (12/01 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

6.1 Graphical Assessment of Water Temperature Indices Application

A graphical representation of index values computed using simulated 2008 temperatures as compared to WTI values (UOWTI and UTWTI) at four locations (below each tributary confluence) in the study reach are shown for spring-run Chinook and steelhead, respectively (Figure 6.1-1 through Figure 6.1-4). Graphical representations for 2008-2016 are included in Appendix B.

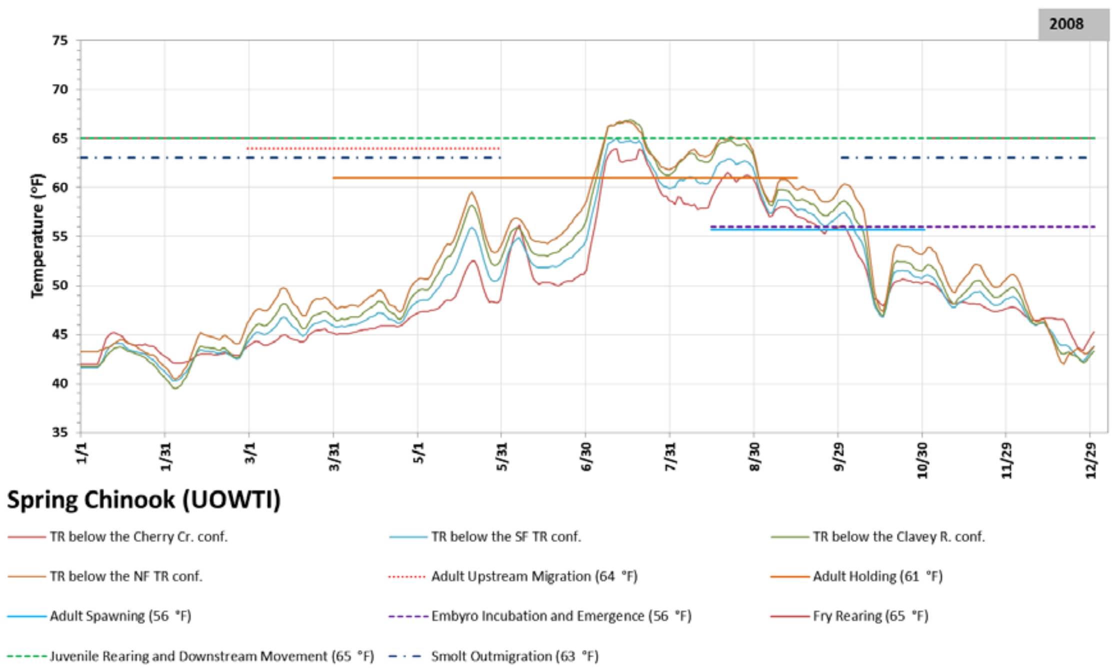


Figure 6.1-1. Upper Optimum Water Temperature Index (UOWTI) values for spring-run Chinook salmon superimposed on the 2008 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.

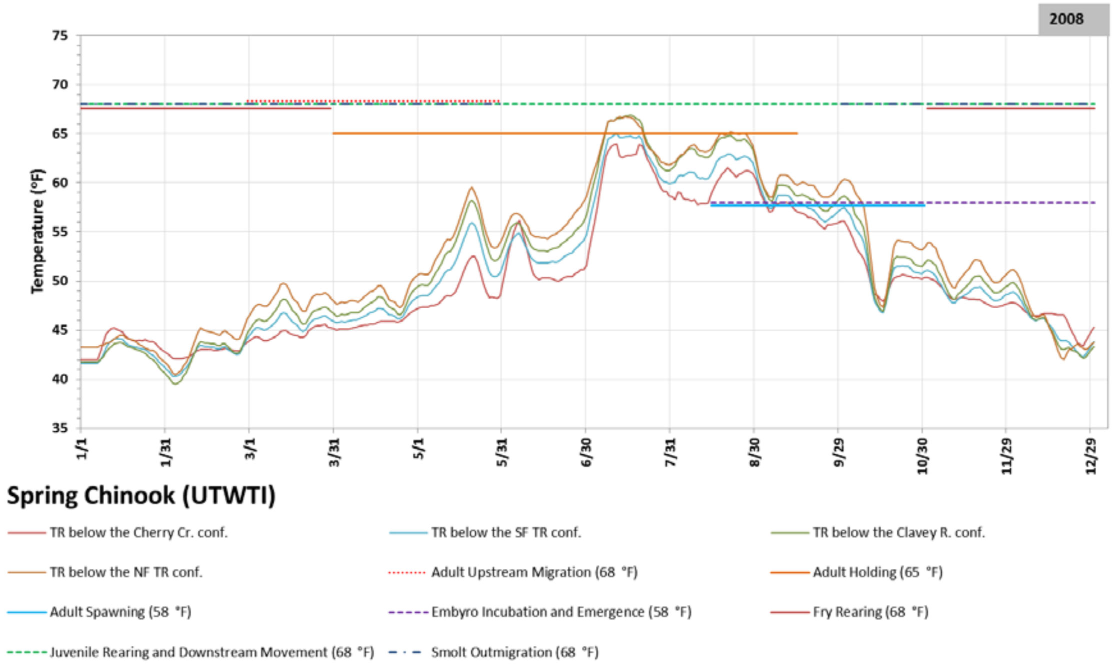


Figure 6.1-2. **Upper Tolerable Water Temperature Index (UTWTI) values for spring-run Chinook salmon superimposed on the 2008 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

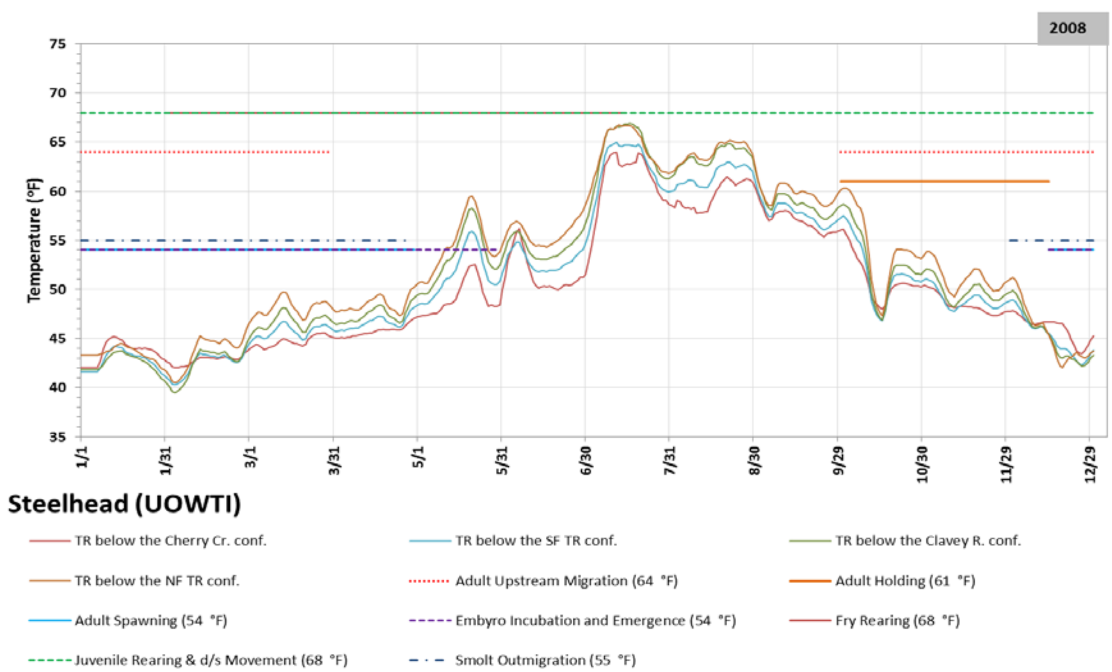


Figure 6.1-3. **Upper Optimum Water Temperature Index (UOWTI) values for Steelhead superimposed on the 2008 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

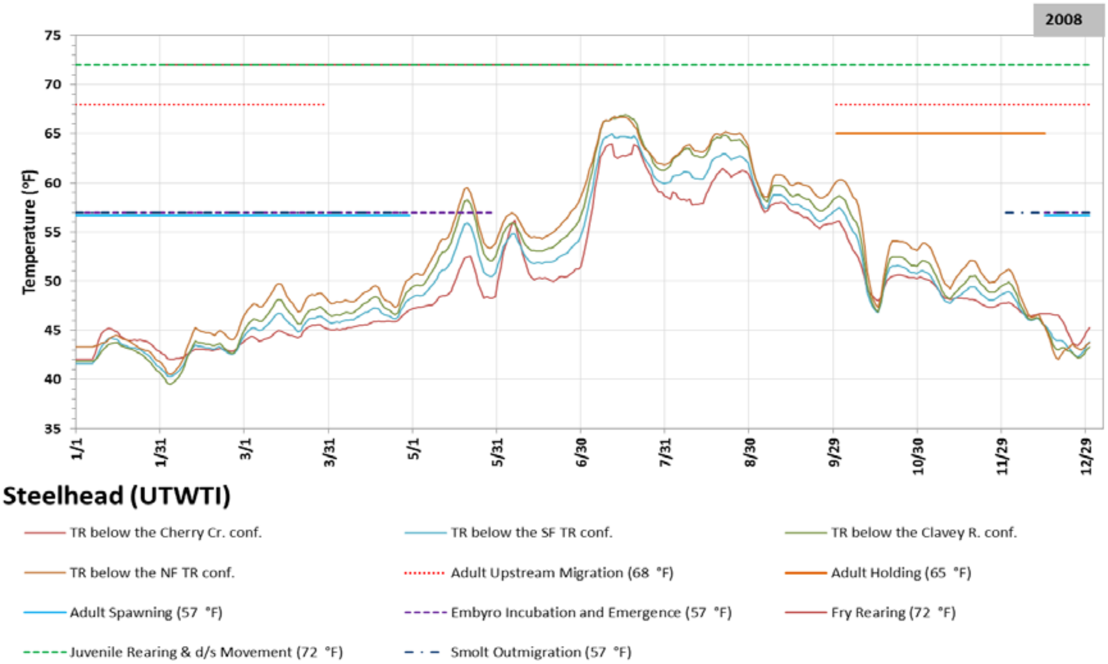


Figure 6.1-4. **Upper Tolerable Water Temperature Index (UTWTI) values for Steelhead superimposed on the 2008 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

7.0 OPERATIONAL IMPACTS

In addition to the application of WTIs to the historical period from 2008-2016, a brief review of hydrologic records was completed to identify any operations that may affect water temperature conditions in the study reach. Specifically, a review of potential planned and unplanned outages of the Holm powerhouse were explored. These include regular scheduled outages (a day or two) and longer duration (on the order of weeks), unplanned outages that, while infrequent, would be typical for operations of a hydroelectric project.

7.1 Regular Scheduled Outages

During typical summer peaking operations, Holm Powerhouse is regularly taken offline approximately every two weeks, and these changes in peaking operations have direct impacts on water temperature. Representative data from 2013 is presented to illustrate these operations (Figure 7.1-1). During peaking operations, daily minimum water temperatures decrease to approximately 48°F to 49°F due to cold water conveyed from Cherry Lake to support hydropower operations, and during non-peaking operations, minimum water temperatures are in the 63°F to 68°F range, reflecting local, upstream Cherry Creek stream temperatures. While daily maximum temperatures in Cherry Creek are similar, the implications of peaking on daily average water temperatures are notable. Fifteen-minute and daily average metrics are presented herein because the 7-day average metric masks these one day events.

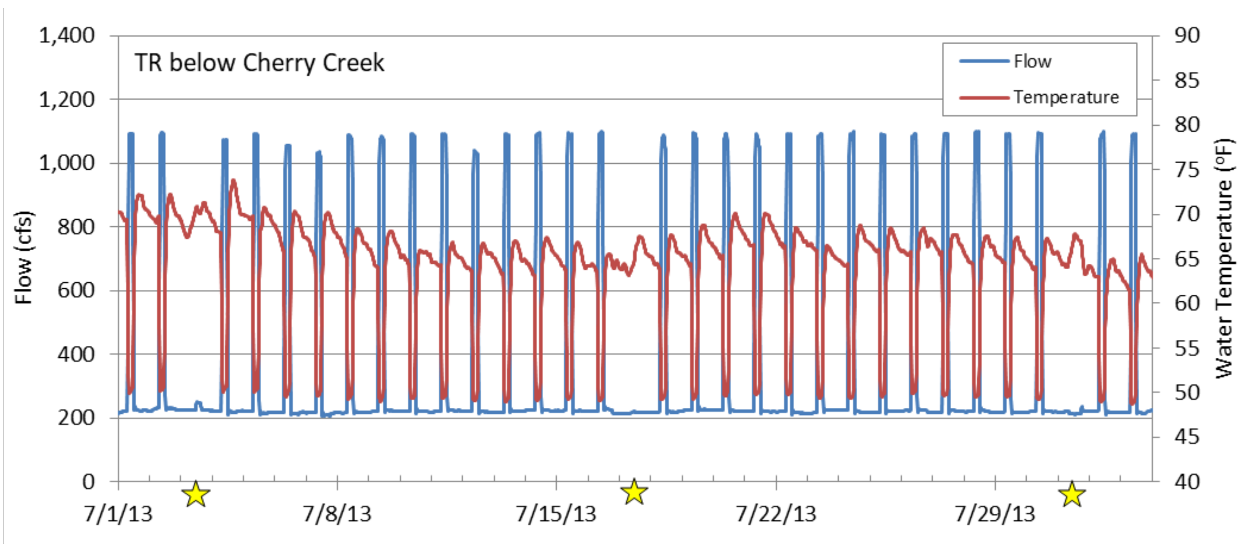


Figure 7.1-1. **15-minute flow and water temperature at for Cherry Creek below Dion R Holm Powerhouse near Mather, CA (USGS 11278400): July 2013 (stars denote days with planned outages).**

The UTRFT Model simulates the effects of the planned outages downstream in the mainstem Tuolumne River. Below the Cherry Creek confluence, daily maximum temperatures were not markedly affected by the changes in flow pattern, but daily average temperatures during planned outages were higher than the adjacent days (Figure 7.1-2). This one-day increase is masked in a 7-day running average metric, but these short-term increases in temperature could have a biological effect, hence they are presented here as supplemental information.

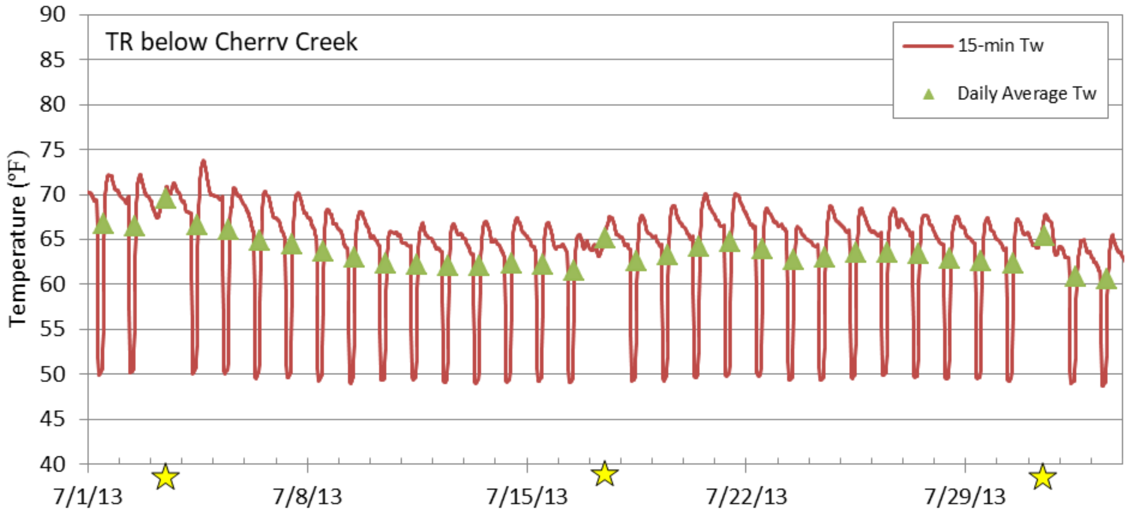


Figure 7.1-2. Simulated water temperature (Tw) at Tuolumne River below Cherry Creek confluence in July 2013 (stars denote days with planned outages).

The temperature implications in daily average water temperature associated with planned outages were less pronounced at locations further downstream due to the influence of tributary flows and the cumulative effect of heating associated with meteorological conditions (Figure 7.1-3 to Figure 7.1-5).

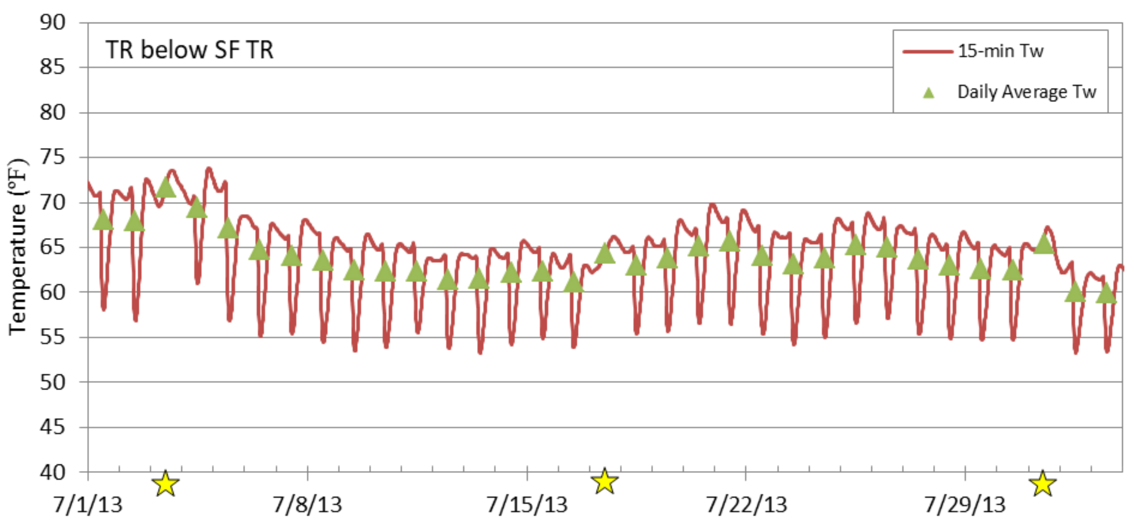


Figure 7.1-3. Simulated water temperature (Tw) at Tuolumne River below South Fork Tuolumne River confluence in July 2013 (stars denote days with planned outages).

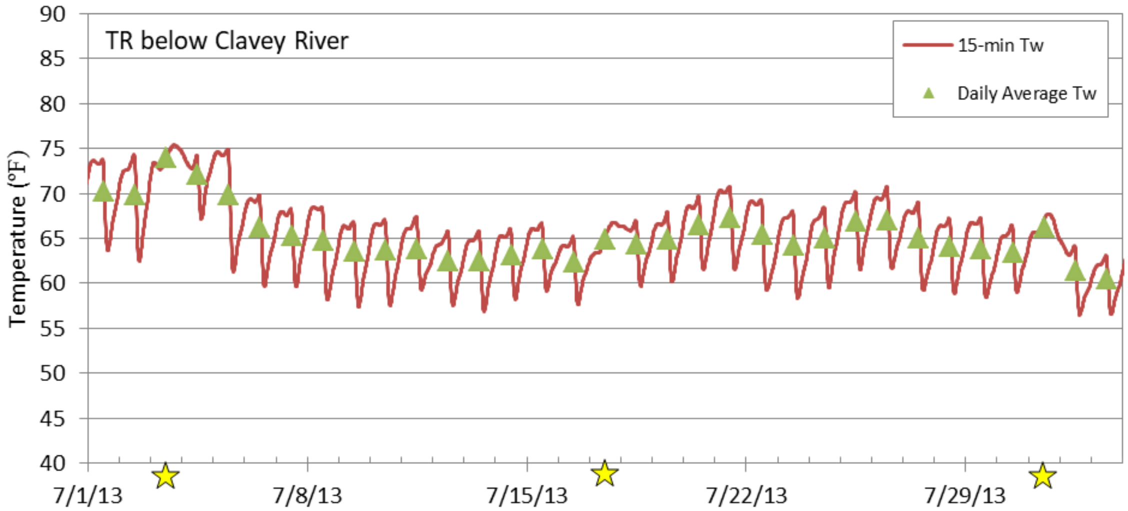


Figure 7.1-4. **Simulated water temperature (Tw) at Tuolumne River below Clavey River confluence in July 2013 (stars denote days with planned outages).**

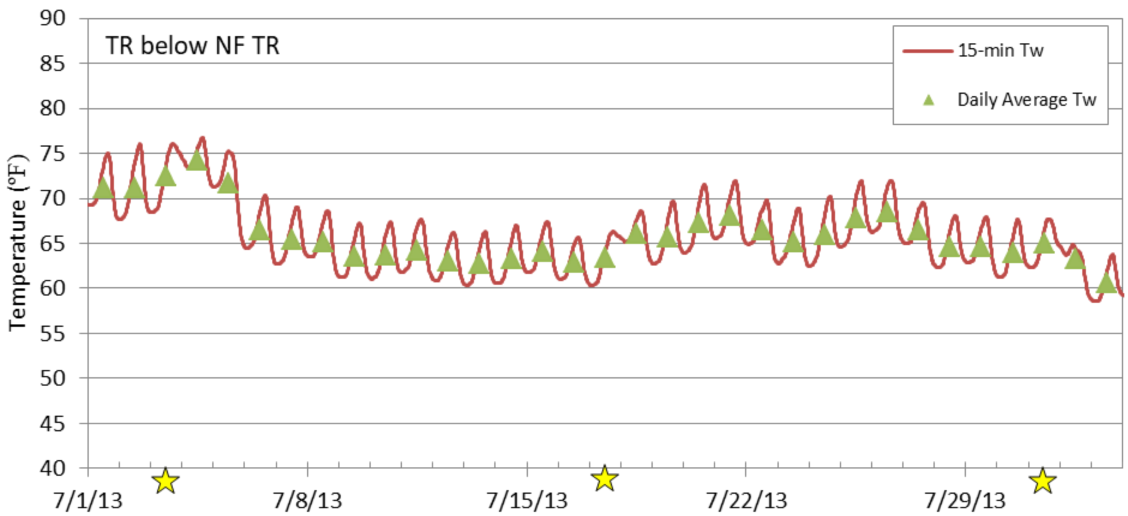


Figure 7.1-5. **Simulated water temperature (Tw) at Tuolumne River below North Fork Tuolumne River confluence in July 2013 (stars denote days with planned outages).**

7.2 Unplanned (Extended) Outages

Occasionally extended, unplanned outages occur at Holm Powerhouse. These unplanned outages are an expected element of hydropower generation facilities and can run for several weeks. One example of an unplanned extended outage was during the Rim Fire in the late summer of 2013, when the powerhouse was taken offline and staff evacuated for safety reasons. Flows in lower Cherry Creek for the period August 1 through September 30, 2013 illustrate the extended outage from approximately August 19 through September 30. There are periods in mid- and late-September when partial operation of the powerhouse is evident.

During peaking operations prior to August 19, daily minimum water temperatures ranged from approximately 46°F to 47°F, and during non-peaking operations, maximum water temperatures were in the 60°F to 65°F range depending on the number of units in service at Holm Powerhouse. When the powerhouse went offline in mid-August, daily minimum water temperatures in Cherry Creek were in the 63°F to 67°F degree range over the next two weeks, and maximum temperatures regularly ranged from 66°F to over 70°F for the same period (Figure 7.2-1). The implications of this outage on downstream river reaches for locations in the Tuolumne River below Cherry Creek, South Fork Tuolumne River, Clavey River and North Fork Tuolumne River are shown in Figure 7.2-2. Water temperatures increase with distance downstream, with temperatures below Cherry Creek ranging from approximately 65°F to 69°F through September 5. Temperatures were 2°F to 3°F warmer below the North Fork Tuolumne River. Fall cooling is reflected in the decreasing temperatures through September. Powerhouse Operations in mid-September (16^{th} to 21^{st}), even at a modest flow rate at about 150 cfs to 200 cfs, have a notable impact (6°F to 10°F decrease) on water temperature in Cherry Creek and the downstream Tuolumne River.

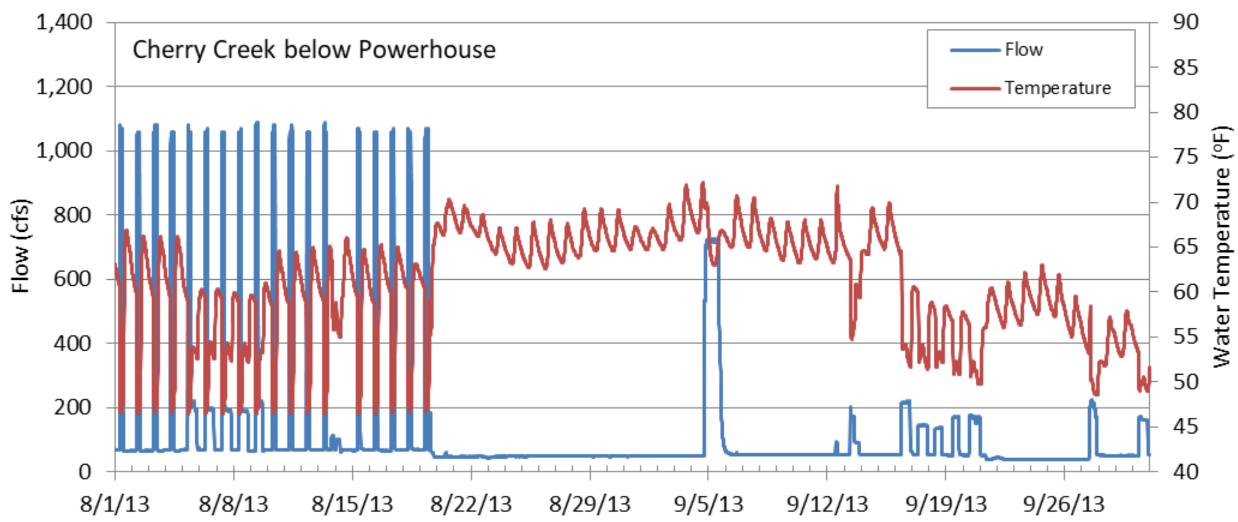


Figure 7.2-1. 15-minute flow and water temperature at for Cherry Creek below Dion R Holm Powerhouse near Mather, CA (USGS 11278400): August and September 2013.

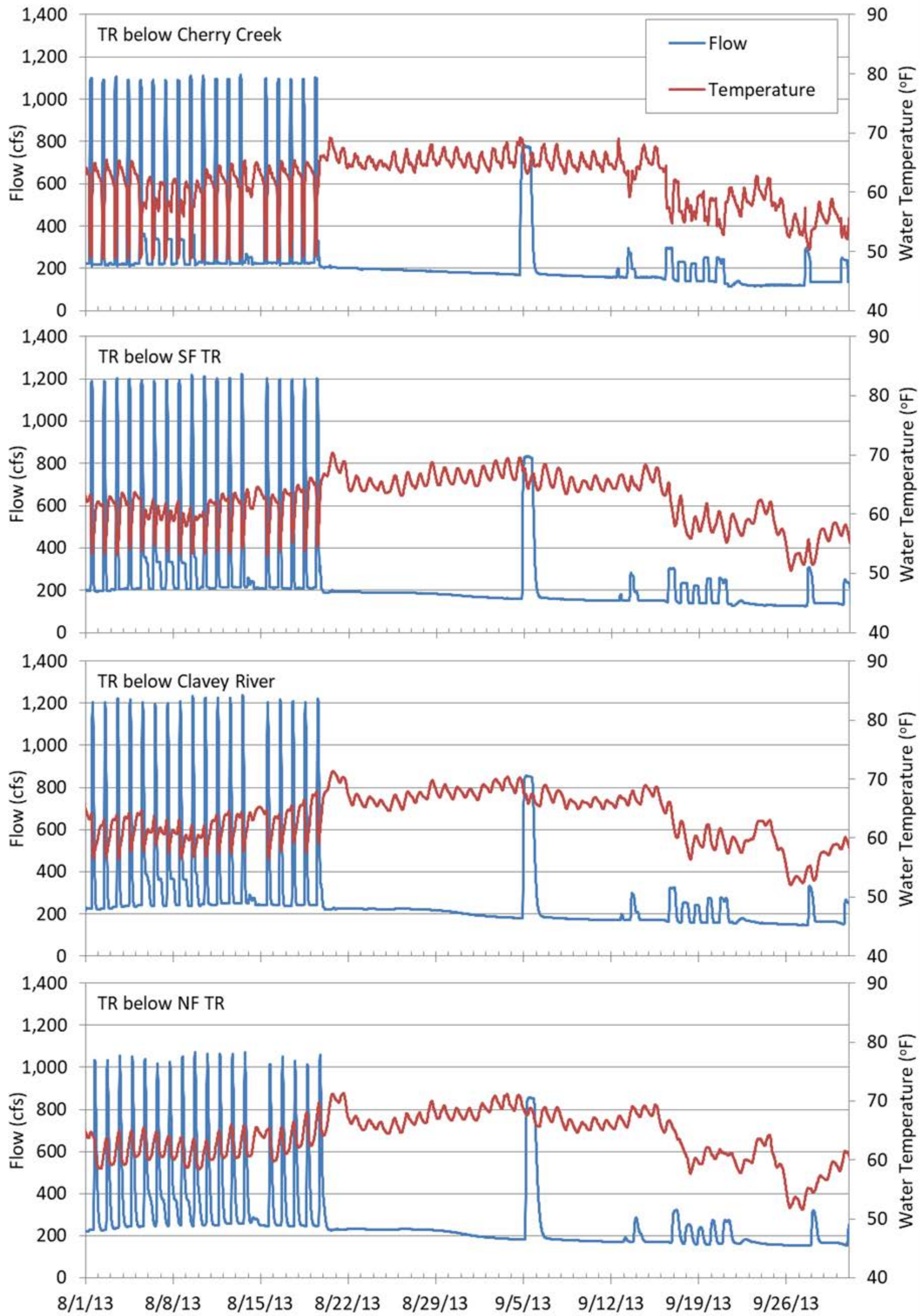
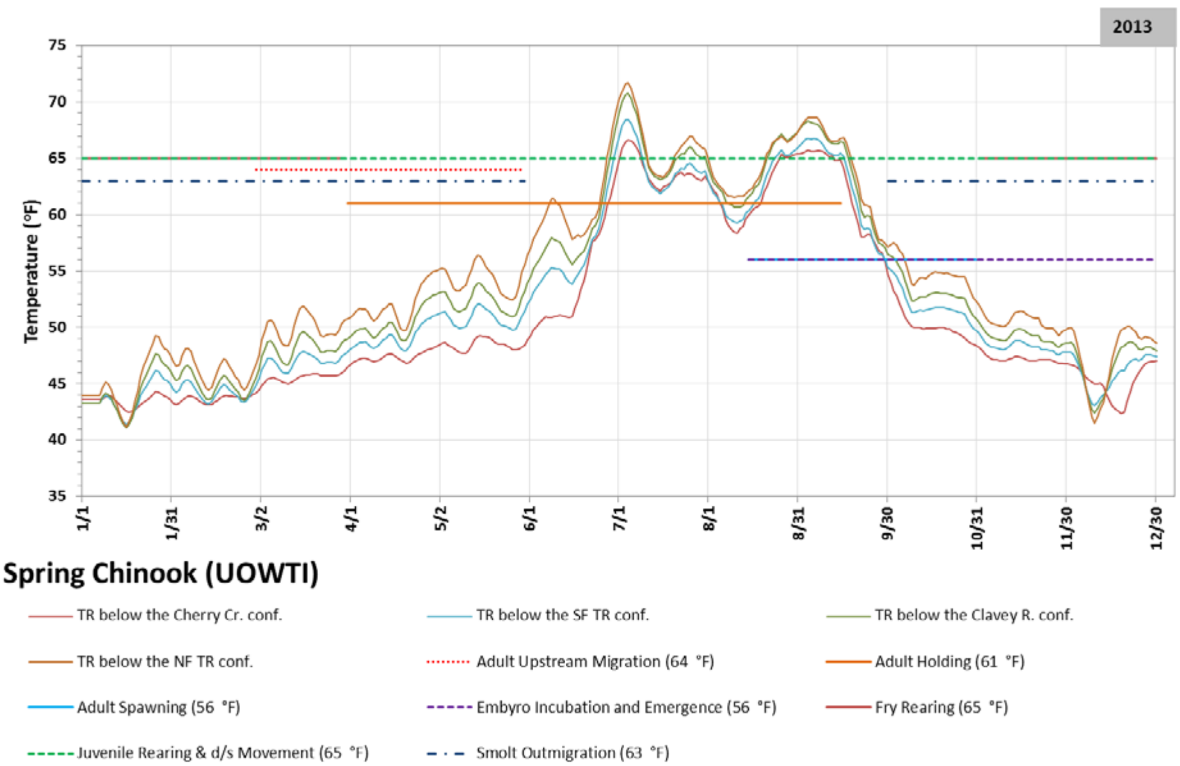


Figure 7.2-2. **15-minute flow and water temperature at for Tuolumne River below Cherry Creek, below South Fork Tuolumne River, below Clavey River, and below North Fork Tuolumne River: August and September 2013.**

In Figure 7.2-3, seven-day average metrics were applied in this case because the extended outage is clearly reflected over several weeks. Water temperatures began to rise starting in mid-August, and continued to be higher than expected for the next month and exceed temperature assessment criteria for juvenile rearing, adult holding, adult spawning, and embryo incubation and emergence for extended periods in July, August, and September.

Examining calculated MWAT values for spring-run Chinook UOWTI values for the simulated 2013 August and September temperatures at the four mainstem Tuolumne River locations presented in Figure 7.2-3 indicates the outage had an impact on water temperature. Because hydropower peaking typically occurs during daytime periods, cold water contributions from Holm Powerhouse moderate daytime maxima. However, during outages these cold water inputs are absent and the impact on daily average water temperatures (and daily maximum temperature) can be considerable. For example, immediately after the start of the outage, mainstem maximum daily water temperatures increased notably, as illustrated in Figure 7.2-3. This impact is reflected in the 7-day metrics as shown in Figure 7.2-3. Following the start of the outage, both the adult holding and juvenile rearing criteria were exceeded (adult spawning, and embryo incubation and emergence metrics were already exceeded) throughout the river. Temperatures remained higher than normal through mid- to late-September, when powerhouse activities resumed and seasonal cooling provided relief. Adult spawning and embryo incubation and emergence WTI values were not met until the last two days of September in the upper reaches. These results indicate that extended power outages can have an impact on thermal conditions in the upper Tuolumne River during summer and early fall.



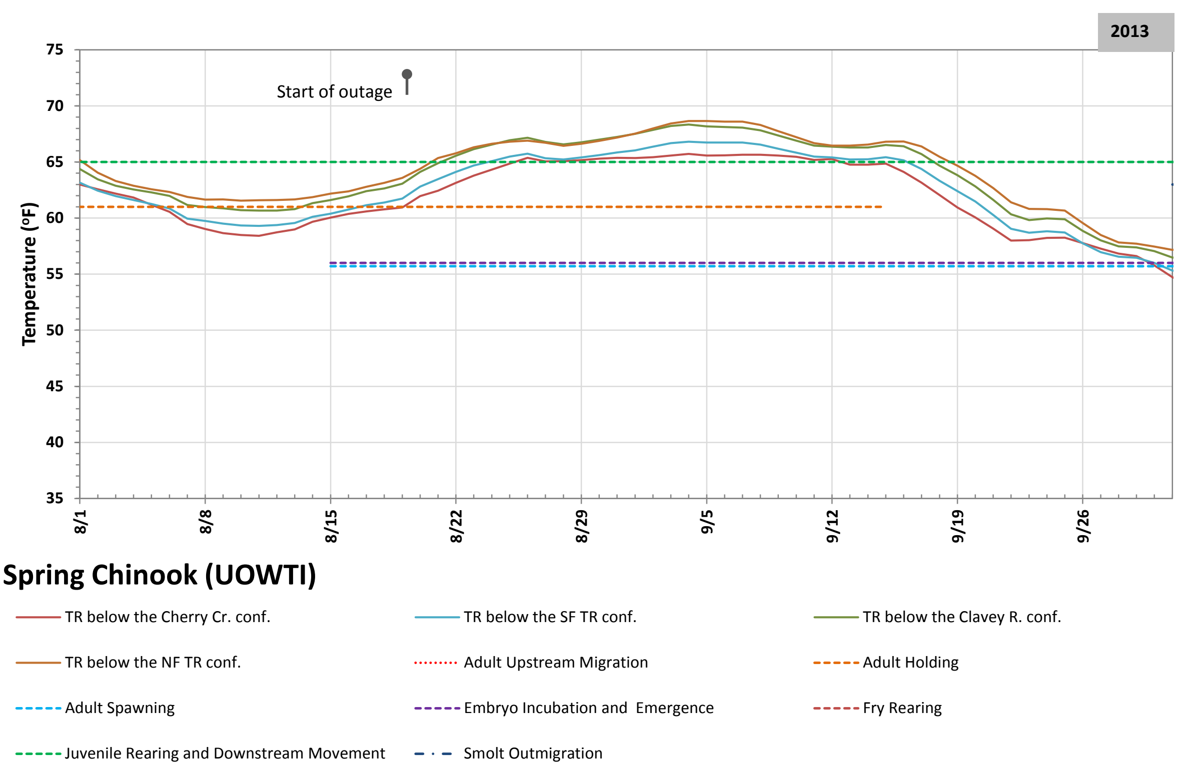


Figure 7.2-3. 2013 Simulated 7-day running average Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River. The Upper Optimum Water Temperature Index (UOWTI) for spring-run Chinook salmon was superimposed onto the figure for reference.

8.0 CONCLUSION

Application of the UTRFT Model provided a means to evaluate WTI values for spring-run Chinook and steelhead life stages for a range of hydrologic, operational, and meteorological conditions. WTI values for both species were based upon a literature review that included up-to-date regional and site specific information regarding the potential biological effects of water temperature to the growth and survival of salmon and steelhead. Findings include:

- Utilizing the WTIs and the simulated model temperatures for each species, WTIs are exceeded in all years for at least one lifestage at one of the investigated locations for spring-run Chinook salmon.
- For steelhead, WTIs are exceeded in many years for at least one lifestage at one of the investigated locations.
- Hydropeaking operations appear to mitigate against warmer thermal conditions in the upper Tuolumne River. Extended power outages (planned or unplanned) can have an impact on thermal conditions in the upper Tuolumne River during summer and early fall.

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TEMPERATURE INDICES ANALYSIS
STUDY REPORT

APPENDIX A

APPLICATION OF WATER TEMPERATURE INDICES FOR EVALUATING SIMULATED MODEL RESULTS: 2008 - 2016

In this appendix, the maximum weekly average temperature (MWAT) at each site during each life stage is presented, followed by the percentage of days when the temperature assessment values at each site during each life stage is exceeded.

A.1 Maximum Weekly Average Temperature (MWAT)

Table A.1-1. Spring-run Chinook salmon UOWTI MWAT for each fish life stage for the calendar year 2008.

Fish life stage	UOWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (03/01 – 05/31)	64	66.4	52.5	53.5	55.5	55.9	56.4	57.8	58.2	58.9	59.5	59.5
Adult Holding (04/01 – 09/15)	61	70.1	64.0	63.8	64.7	65.0	65.0	66.3	66.9	66.7	66.7	66.7
Adult Spawning (08/15 – 10/31)	56	66.4	61.5	61.6	62.6	63.0	63.1	64.4	64.8	64.8	65.0	65.2
Embryo Incubation and Emergence (08/15 – 12/31)	56	66.4	61.5	61.6	62.6	63.0	63.1	64.4	64.8	64.8	65.0	65.2
Fry Rearing (11/01 – 03/31)	65	53.7	50.3	50.8	51.2	51.1	51.6	52.1	52.1	53.3	53.8	53.9
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	65	70.1	64.0	63.8	64.7	65.0	65.0	66.3	66.9	66.7	66.7	66.7
Smolt Outmigration (10/01 – 05/31)	63	66.4	56.1	56.7	57.4	57.5	57.9	58.6	58.7	59.6	60.2	60.3

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-2. Spring-run Chinook salmon UTWTI MWAT for each fish life stage for the calendar year 2008.

Fish life stage	UTWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (03/01 – 05/31)	68	66.4	52.5	53.5	55.5	55.9	56.4	57.8	58.2	58.9	59.5	59.5
Adult Holding (04/01 – 09/15)	65	70.1	64.0	63.8	64.7	65.0	65.0	66.3	66.9	66.7	66.7	66.7
Adult Spawning (08/15 – 10/31)	58	66.4	61.5	61.6	62.6	63.0	63.1	64.4	64.8	64.8	65.0	65.2
Embryo Incubation and Emergence (08/15 – 12/31)	58	66.4	61.5	61.6	62.6	63.0	63.1	64.4	64.8	64.8	65.0	65.2
Fry Rearing (11/01 – 03/31)	68	53.7	50.3	50.8	51.2	51.1	51.6	52.1	52.1	53.3	53.8	53.9
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	68	70.1	64.0	63.8	64.7	65.0	65.0	66.3	66.9	66.7	66.7	66.7
Smolt Outmigration (10/01 – 05/31)	68	66.4	56.1	56.7	57.4	57.5	57.9	58.6	58.7	59.6	60.2	60.3

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-3. Steelhead UOWTI MWAT for each fish life stage for the calendar year 2008.

Fish life stage	UOWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (10/01 – 03/31)	64	62.5	56.1	56.7	57.4	57.5	57.9	58.6	58.7	59.6	60.2	60.3
Adult Holding (10/01 –12/15)	61	62.5	56.1	56.7	57.4	57.5	57.9	58.6	58.7	59.6	60.2	60.3
Adult Spawning (12/15 – 04/30)	54	50.7	47.0	47.5	48.1	48.1	48.5	49.0	49.1	49.6	50.2	50.2
Embryo Incubation and Emergence (12/15 – 05/31)	54	66.4	52.5	53.5	55.5	55.9	56.4	57.8	58.2	58.9	59.5	59.5
Fry Rearing (02/01 – 07/15)	68	70.1	64.0	63.8	64.7	65.0	65.0	66.2	66.8	66.7	66.7	66.7
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	68	70.1	64.0	63.8	64.7	65.0	65.0	66.3	66.9	66.7	66.7	66.7
Smolt Outmigration (12/01 – 04/30)	55	50.7	47.8	48.3	48.9	48.9	49.4	49.8	49.9	50.6	51.2	51.2

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-4. Steelhead UTWTI MWAT for each fish life stage for the calendar year 2008.

Fish life stage	UTWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (10/01 – 03/31)	68	62.5	56.1	56.7	57.4	57.5	57.9	58.6	58.7	59.6	60.2	60.3
Adult Holding (10/01 –12/15)	65	62.5	56.1	56.7	57.4	57.5	57.9	58.6	58.7	59.6	60.2	60.3
Adult Spawning (12/15 – 04/30)	57	50.7	47.0	47.5	48.1	48.1	48.5	49.0	49.1	49.6	50.2	50.2
Embryo Incubation and Emergence (12/15 – 05/31)	57	66.4	52.5	53.5	55.5	55.9	56.4	57.8	58.2	58.9	59.5	59.5
Fry Rearing (02/01 – 07/15)	72	70.1	64.0	63.8	64.7	65.0	65.0	66.2	66.8	66.7	66.7	66.7
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	72	70.1	64.0	63.8	64.7	65.0	65.0	66.3	66.9	66.7	66.7	66.7
Smolt Outmigration (12/01 – 04/30)	57	50.7	47.8	48.3	48.9	48.9	49.4	49.8	49.9	50.6	51.2	51.2

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-5. Spring-run Chinook salmon UOWTI MWAT for each fish life stage for the calendar year 2009.

Fish life stage	UOWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (03/01 – 05/31)	64	50.5	51.3	52.0	52.9	53.1	53.6	54.3	54.5	55.3	56.0	56.1
Adult Holding (04/01 – 09/15)	61	70.0	62.2	62.5	63.4	63.6	63.8	64.8	65.1	65.6	66.1	66.3
Adult Spawning (08/15 – 10/31)	56	67.3	61.5	61.7	62.3	62.4	62.8	63.5	63.8	64.1	64.5	64.6
Embryo Incubation and Emergence (08/15 – 12/31)	56	67.3	61.5	61.7	62.3	62.4	62.8	63.5	63.8	64.1	64.5	64.6
Fry Rearing (11/01 – 03/31)	65	51.3	50.9	51.3	51.7	51.7	52.1	52.5	52.5	53.2	53.5	53.5
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	65	70.0	62.2	62.5	63.4	63.6	63.8	64.8	65.1	65.6	66.1	66.3
Smolt Outmigration (10/01 – 05/31)	63	58.6	56.7	56.9	56.6	56.6	56.8	57.4	57.4	58.5	59.2	59.3

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-6. Spring-run Chinook salmon UTWTI MWAT for each fish life stage for the calendar year 2009.

Fish life stage	UTWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (03/01 – 05/31)	68	50.5	51.3	52.0	52.9	53.1	53.6	54.3	54.5	55.3	56.0	56.1
Adult Holding (04/01 – 09/15)	65	70.0	62.2	62.5	63.4	63.6	63.8	64.8	65.1	65.6	66.1	66.3
Adult Spawning (08/15 – 10/31)	58	67.3	61.5	61.7	62.3	62.4	62.8	63.5	63.8	64.1	64.5	64.6
Embryo Incubation and Emergence (08/15 – 12/31)	58	67.3	61.5	61.7	62.3	62.4	62.8	63.5	63.8	64.1	64.5	64.6
Fry Rearing (11/01 – 03/31)	68	51.3	50.9	51.3	51.7	51.7	52.1	52.5	52.5	53.2	53.5	53.5
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	68	70.0	62.2	62.5	63.4	63.6	63.8	64.8	65.1	65.6	66.1	66.3
Smolt Outmigration (10/01 – 05/31)	68	58.6	56.7	56.9	56.6	56.6	56.8	57.4	57.4	58.5	59.2	59.3

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-7. Steelhead UOWTI MWAT for each fish life stage for the calendar year 2009.

Fish life stage	UOWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (10/01 – 03/31)	64	58.6	56.7	56.9	56.6	56.6	56.8	57.4	57.4	58.5	59.2	59.3
Adult Holding (10/01 –12/15)	61	58.6	56.7	56.9	56.6	56.6	56.8	57.4	57.4	58.5	59.2	59.3
Adult Spawning (12/15 – 04/30)	54	50.4	48.4	48.9	49.3	49.2	49.7	50.3	50.5	51.2	51.9	52.1
Embryo Incubation and Emergence (12/15 – 05/31)	54	50.5	51.3	52.0	52.9	53.1	53.6	54.3	54.5	55.3	56.0	56.1
Fry Rearing (02/01 – 07/15)	68	66.1	59.8	59.8	60.4	60.7	60.7	61.6	61.9	62.0	62.4	62.6
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	68	70.0	62.2	62.5	63.4	63.6	63.8	64.8	65.1	65.6	66.1	66.3
Smolt Outmigration (12/01 – 04/30)	55	50.4	48.4	48.9	49.3	49.2	49.7	50.3	50.5	51.2	51.9	52.1

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-8. Steelhead UTWTI MWAT for each fish life stage for the calendar year 2009.

Fish life stage	UTWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (10/01 – 03/31)	68	58.6	56.7	56.9	56.6	56.6	56.8	57.4	57.4	58.5	59.2	59.3
Adult Holding (10/01 –12/15)	65	58.6	56.7	56.9	56.6	56.6	56.8	57.4	57.4	58.5	59.2	59.3
Adult Spawning (12/15 – 04/30)	57	50.4	48.4	48.9	49.3	49.2	49.7	50.3	50.5	51.2	51.9	52.1
Embryo Incubation and Emergence (12/15 – 05/31)	57	50.5	51.3	52.0	52.9	53.1	53.6	54.3	54.5	55.3	56.0	56.1
Fry Rearing (02/01 – 07/15)	72	66.1	59.8	59.8	60.4	60.7	60.7	61.6	61.9	62.0	62.4	62.6
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	72	70.0	62.2	62.5	63.4	63.6	63.8	64.8	65.1	65.6	66.1	66.3
Smolt Outmigration (12/01 – 04/30)	57	50.4	48.4	48.9	49.3	49.2	49.7	50.3	50.5	51.2	51.9	52.1

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-9. Spring-run Chinook salmon UOWTI MWAT for each fish life stage for the calendar year 2010.

Fish life stage	UOWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (03/01 – 05/31)	64	48.9	48.7	49.0	49.3	49.3	49.6	49.9	50.0	50.4	50.9	51.0
Adult Holding (04/01 – 09/15)	61	65.9	62.4	62.2	62.7	62.8	63.0	63.9	64.2	64.6	65.0	65.2
Adult Spawning (08/15 – 10/31)	56	64.4	62.5	62.8	63.3	63.4	63.8	64.5	64.7	64.9	65.2	65.3
Embryo Incubation and Emergence (08/15 – 12/31)	56	64.4	62.5	62.8	63.3	63.4	63.8	64.5	64.7	64.9	65.2	65.3
Fry Rearing (11/01 – 03/31)	65	52.4	49.7	50.3	51.0	51.1	51.6	52.2	52.3	53.2	53.8	53.9
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	65	65.9	62.5	62.8	63.3	63.4	63.8	64.5	64.7	64.9	65.2	65.3
Smolt Outmigration (10/01 – 05/31)	63	61.9	62.5	62.8	63.3	63.4	63.8	64.5	64.7	64.9	65.2	65.3

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-10. Spring-run Chinook salmon UTWTI MWAT for each fish life stage for the calendar year 2010.

Fish life stage	UTWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (03/01 – 05/31)	68	48.9	48.7	49.0	49.3	49.3	49.6	49.9	50.0	50.4	50.9	51.0
Adult Holding (04/01 – 09/15)	65	65.9	62.4	62.2	62.7	62.8	63.0	63.9	64.2	64.6	65.0	65.2
Adult Spawning (08/15 – 10/31)	58	64.4	62.5	62.8	63.3	63.4	63.8	64.5	64.7	64.9	65.2	65.3
Embryo Incubation and Emergence (08/15 – 12/31)	58	64.4	62.5	62.8	63.3	63.4	63.8	64.5	64.7	64.9	65.2	65.3
Fry Rearing (11/01 – 03/31)	68	52.4	49.7	50.3	51.0	51.1	51.6	52.2	52.3	53.2	53.8	53.9
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	68	65.9	62.5	62.8	63.3	63.4	63.8	64.5	64.7	64.9	65.2	65.3
Smolt Outmigration (10/01 – 05/31)	68	61.9	62.5	62.8	63.3	63.4	63.8	64.5	64.7	64.9	65.2	65.3

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-11. Steelhead UOWTI MWAT for each fish life stage for the calendar year 2010.

Fish life stage	UOWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (10/01 – 03/31)	64	61.9	62.5	62.8	63.3	63.4	63.8	64.5	64.7	64.9	65.2	65.3
Adult Holding (10/01 –12/15)	61	61.9	62.5	62.8	63.3	63.4	63.8	64.5	64.7	64.9	65.2	65.3
Adult Spawning (12/15 – 04/30)	54	49.5	48.1	48.2	48.5	48.5	48.7	49.1	49.1	49.5	49.9	50.1
Embryo Incubation and Emergence (12/15 – 05/31)	54	49.5	48.7	49.0	49.3	49.3	49.6	49.9	50.0	50.4	50.9	51.0
Fry Rearing (02/01 – 07/15)	68	57.7	55.7	56.8	58.2	58.3	59.0	60.0	60.2	61.4	62.3	62.4
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	68	65.9	62.5	62.8	63.3	63.4	63.8	64.5	64.7	64.9	65.2	65.3
Smolt Outmigration (12/01 – 04/30)	55	49.5	48.4	48.6	48.7	48.6	48.9	49.2	49.3	49.7	50.2	50.4

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-12. Steelhead UTWTI MWAT for each fish life stage for the calendar year 2010.

Fish life stage	UTWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (10/01 – 03/31)	68	61.9	62.5	62.8	63.3	63.4	63.8	64.5	64.7	64.9	65.2	65.3
Adult Holding (10/01 –12/15)	65	61.9	62.5	62.8	63.3	63.4	63.8	64.5	64.7	64.9	65.2	65.3
Adult Spawning (12/15 – 04/30)	57	49.5	48.1	48.2	48.5	48.5	48.7	49.1	49.1	49.5	49.9	50.1
Embryo Incubation and Emergence (12/15 – 05/31)	57	49.5	48.7	49.0	49.3	49.3	49.6	49.9	50.0	50.4	50.9	51.0
Fry Rearing (02/01 – 07/15)	72	57.7	55.7	56.8	58.2	58.3	59.0	60.0	60.2	61.4	62.3	62.4
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	72	65.9	62.5	62.8	63.3	63.4	63.8	64.5	64.7	64.9	65.2	65.3
Smolt Outmigration (12/01 – 04/30)	57	49.5	48.4	48.6	48.7	48.6	48.9	49.2	49.3	49.7	50.2	50.4

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-13. Spring-run Chinook salmon UOWTI MWAT for each fish life stage for the calendar year 2011.

Fish life stage	UOWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (03/01 – 05/31)	64	47.5	48.1	48.6	48.9	48.8	49.2	49.6	49.6	50.3	50.9	51.0
Adult Holding (04/01 – 09/15)	61	66.1	64.4	64.1	64.3	64.4	64.5	65.3	65.6	65.6	65.8	66.0
Adult Spawning (08/15 – 10/31)	56	66.1	64.4	64.1	64.3	64.4	64.5	65.3	65.6	65.6	65.8	66.0
Embryo Incubation and Emergence (08/15 – 12/31)	56	66.1	64.4	64.1	64.3	64.4	64.5	65.3	65.6	65.6	65.8	66.0
Fry Rearing (11/01 – 03/31)	65	52.9	53.4	53.2	53.1	53.0	53.1	53.2	53.2	53.3	53.5	53.5
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	65	66.1	64.4	64.1	64.3	64.4	64.5	65.3	65.6	65.6	65.8	66.0
Smolt Outmigration (10/01 – 05/31)	63	62.5	59.2	59.4	59.9	59.9	60.4	61.3	61.4	62.1	62.7	62.8

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-14. Spring-run Chinook salmon UTWTI MWAT for each fish life stage for the calendar year 2011.

Fish life stage	UTWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (03/01 – 05/31)	68	47.5	48.1	48.6	48.9	48.8	49.2	49.6	49.6	50.3	50.9	51.0
Adult Holding (04/01 – 09/15)	65	66.1	64.4	64.1	64.3	64.4	64.5	65.3	65.6	65.6	65.8	66.0
Adult Spawning (08/15 – 10/31)	58	66.1	64.4	64.1	64.3	64.4	64.5	65.3	65.6	65.6	65.8	66.0
Embryo Incubation and Emergence (08/15 – 12/31)	58	66.1	64.4	64.1	64.3	64.4	64.5	65.3	65.6	65.6	65.8	66.0
Fry Rearing (11/01 – 03/31)	68	52.9	53.4	53.2	53.1	53.0	53.1	53.2	53.2	53.3	53.5	53.5
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	68	66.1	64.4	64.1	64.3	64.4	64.5	65.3	65.6	65.6	65.8	66.0
Smolt Outmigration (10/01 – 05/31)	68	62.5	59.2	59.4	59.9	59.9	60.4	61.3	61.4	62.1	62.7	62.8

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-15. Steelhead UOWTI MWAT for each fish life stage for the calendar year 2011.

Fish life stage	UOWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (10/01 – 03/31)	64	62.5	59.2	59.4	59.9	59.9	60.4	61.3	61.4	62.1	62.7	62.8
Adult Holding (10/01 –12/15)	61	62.5	59.2	59.4	59.9	59.9	60.4	61.3	61.4	62.1	62.7	62.8
Adult Spawning (12/15 – 04/30)	54	46.3	46.6	47.2	47.9	47.9	48.3	48.9	49.0	49.7	50.4	50.6
Embryo Incubation and Emergence (12/15 – 05/31)	54	47.5	48.1	48.6	48.9	48.8	49.2	49.6	49.6	50.3	50.9	51.0
Fry Rearing (02/01 – 07/15)	68	53.3	53.3	53.9	54.7	54.9	55.4	56.0	56.2	56.9	57.8	57.8
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	68	66.1	64.4	64.1	64.3	64.4	64.5	65.3	65.6	65.6	65.8	66.0
Smolt Outmigration (12/01 – 04/30)	55	46.3	46.6	47.2	47.9	47.9	48.3	48.9	49.0	49.7	50.4	50.6

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-16. Steelhead UTWTI MWAT for each fish life stage for the calendar year 2011.

Fish life stage	UTWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (10/01 – 03/31)	68	62.5	59.2	59.4	59.9	59.9	60.4	61.3	61.4	62.1	62.7	62.8
Adult Holding (10/01 –12/15)	65	62.5	59.2	59.4	59.9	59.9	60.4	61.3	61.4	62.1	62.7	62.8
Adult Spawning (12/15 – 04/30)	57	46.3	46.6	47.2	47.9	47.9	48.3	48.9	49.0	49.7	50.4	50.6
Embryo Incubation and Emergence (12/15 – 05/31)	57	47.5	48.1	48.6	48.9	48.8	49.2	49.6	49.6	50.3	50.9	51.0
Fry Rearing (02/01 – 07/15)	72	53.3	53.3	53.9	54.7	54.9	55.4	56.0	56.2	56.9	57.8	57.8
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	72	66.1	64.4	64.1	64.3	64.4	64.5	65.3	65.6	65.6	65.8	66.0
Smolt Outmigration (12/01 – 04/30)	57	46.3	46.6	47.2	47.9	47.9	48.3	48.9	49.0	49.7	50.4	50.6

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-17. Spring-run Chinook salmon UOWTI MWAT for each fish life stage for the calendar year 2012.

Fish life stage	UOWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (03/01 – 05/31)	64	53.7	52.8	53.4	54.1	54.2	54.6	55.2	55.3	55.9	56.5	56.6
Adult Holding (04/01 – 09/15)	61	67.9	63.6	64.2	65.4	65.6	66.0	67.0	67.3	67.8	68.4	68.6
Adult Spawning (08/15 – 10/31)	56	67.3	63.6	64.2	65.4	65.6	66.0	67.0	67.3	67.8	68.4	68.6
Embryo Incubation and Emergence (08/15 – 12/31)	56	67.3	63.6	64.2	65.4	65.6	66.0	67.0	67.3	67.8	68.4	68.6
Fry Rearing (11/01 – 03/31)	65	52.0	49.7	50.7	51.7	51.7	52.4	53.1	53.1	54.5	55.3	55.3
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	65	67.9	63.6	64.2	65.4	65.6	66.0	67.0	67.3	67.8	68.4	68.6
Smolt Outmigration (10/01 – 05/31)	63	62.1	56.1	57.2	58.7	59.0	59.6	60.6	60.9	62.0	62.7	62.8

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-18. Spring-run Chinook salmon UTWTI MWAT for each fish life stage for the calendar year 2012.

Fish life stage	UTWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (03/01 – 05/31)	68	53.7	52.8	53.4	54.1	54.2	54.6	55.2	55.3	55.9	56.5	56.6
Adult Holding (04/01 – 09/15)	65	67.9	63.6	64.2	65.4	65.6	66.0	67.0	67.3	67.8	68.4	68.6
Adult Spawning (08/15 – 10/31)	58	67.3	63.6	64.2	65.4	65.6	66.0	67.0	67.3	67.8	68.4	68.6
Embryo Incubation and Emergence (08/15 – 12/31)	58	67.3	63.6	64.2	65.4	65.6	66.0	67.0	67.3	67.8	68.4	68.6
Fry Rearing (11/01 – 03/31)	68	52.0	49.7	50.7	51.7	51.7	52.4	53.1	53.1	54.5	55.3	55.3
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	68	67.9	63.6	64.2	65.4	65.6	66.0	67.0	67.3	67.8	68.4	68.6
Smolt Outmigration (10/01 – 05/31)	68	62.1	56.1	57.2	58.7	59.0	59.6	60.6	60.9	62.0	62.7	62.8

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-19. Steelhead UOWTI MWAT for each fish life stage for the calendar year 2012.

Fish life stage	UOWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (10/01 – 03/31)	64	62.1	56.1	57.2	58.7	59.0	59.6	60.6	60.9	62.0	62.7	62.8
Adult Holding (10/01 –12/15)	61	62.1	56.1	57.2	58.7	59.0	59.6	60.6	60.9	62.0	62.7	62.8
Adult Spawning (12/15 – 04/30)	54	51.8	50.5	51.2	52.4	52.7	53.2	54.1	54.4	55.2	56.0	56.2
Embryo Incubation and Emergence (12/15 – 05/31)	54	53.7	52.8	53.4	54.1	54.2	54.6	55.2	55.3	55.9	56.5	56.6
Fry Rearing (02/01 – 07/15)	68	67.9	63.3	63.2	64.3	64.7	64.8	66.0	66.5	66.3	66.8	67.1
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	68	67.9	63.6	64.2	65.4	65.6	66.0	67.0	67.3	67.8	68.4	68.6
Smolt Outmigration (12/01 – 04/30)	55	51.8	50.5	51.2	52.4	52.7	53.2	54.1	54.4	55.2	56.0	56.2

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-20. Steelhead UTWTI MWAT for each fish life stage for the calendar year 2012.

Fish life stage	UTWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (10/01 – 03/31)	68	62.1	56.1	57.2	58.7	59.0	59.6	60.6	60.9	62.0	62.7	62.8
Adult Holding (10/01 –12/15)	65	62.1	56.1	57.2	58.7	59.0	59.6	60.6	60.9	62.0	62.7	62.8
Adult Spawning (12/15 – 04/30)	57	51.8	50.5	51.2	52.4	52.7	53.2	54.1	54.4	55.2	56.0	56.2
Embryo Incubation and Emergence (12/15 – 05/31)	57	53.7	52.8	53.4	54.1	54.2	54.6	55.2	55.3	55.9	56.5	56.6
Fry Rearing (02/01 – 07/15)	72	67.9	63.3	63.2	64.3	64.7	64.8	66.0	66.5	66.3	66.8	67.1
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	72	67.9	63.6	64.2	65.4	65.6	66.0	67.0	67.3	67.8	68.4	68.6
Smolt Outmigration (12/01 – 04/30)	57	51.8	50.5	51.2	52.4	52.7	53.2	54.1	54.4	55.2	56.0	56.2

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-21. Spring-run Chinook salmon UOWTI MWAT for each fish life stage for the calendar year 2013.

Fish life stage	UOWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (03/01 – 05/31)	64	52.2	49.3	50.4	51.9	52.1	52.9	53.8	53.9	55.2	56.3	56.4
Adult Holding (04/01 – 09/15)	61	72.3	66.6	66.9	68.1	68.4	68.7	70.1	70.7	70.8	71.4	71.7
Adult Spawning (08/15 – 10/31)	56	65.9	65.7	66.0	66.6	66.8	67.1	68.0	68.3	68.4	68.5	68.7
Embryo Incubation and Emergence (08/15 – 12/31)	56	65.9	65.7	66.0	66.6	66.8	67.1	68.0	68.3	68.4	68.5	68.7
Fry Rearing (11/01 – 03/31)	65	51.6	48.2	48.8	49.4	49.5	49.9	50.4	50.5	51.4	51.9	52.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	65	72.3	66.6	66.9	68.1	68.4	68.7	70.1	70.7	70.8	71.4	71.7
Smolt Outmigration (10/01 – 05/31)	63	58.0	54.7	54.7	55.2	55.3	55.6	56.3	56.5	56.9	57.4	57.5

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-22. Spring-run Chinook salmon UTWTI MWAT for each fish life stage for the calendar year 2013.

Fish life stage	UTWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (03/01 – 05/31)	68	52.2	49.3	50.4	51.9	52.1	52.9	53.8	53.9	55.2	56.3	56.4
Adult Holding (04/01 – 09/15)	65	72.3	66.6	66.9	68.1	68.4	68.7	70.1	70.7	70.8	71.4	71.7
Adult Spawning (08/15 – 10/31)	58	65.9	65.7	66.0	66.6	66.8	67.1	68.0	68.3	68.4	68.5	68.7
Embryo Incubation and Emergence (08/15 – 12/31)	58	65.9	65.7	66.0	66.6	66.8	67.1	68.0	68.3	68.4	68.5	68.7
Fry Rearing (11/01 – 03/31)	68	51.6	48.2	48.8	49.4	49.5	49.9	50.4	50.5	51.4	51.9	52.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	68	72.3	66.6	66.9	68.1	68.4	68.7	70.1	70.7	70.8	71.4	71.7
Smolt Outmigration (10/01 – 05/31)	68	58.0	54.7	54.7	55.2	55.3	55.6	56.3	56.5	56.9	57.4	57.5

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-23. Steelhead UOWTI MWAT for each fish life stage for the calendar year 2013.

Fish life stage	UOWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (10/01 – 03/31)	64	58.0	54.7	54.7	55.2	55.3	55.6	56.3	56.5	56.9	57.4	57.5
Adult Holding (10/01 –12/15)	61	58.0	54.7	54.7	55.2	55.3	55.6	56.3	56.5	56.9	57.4	57.5
Adult Spawning (12/15 – 04/30)	54	49.6	48.1	49.2	50.7	51.0	51.7	52.6	52.9	53.9	54.8	54.9
Embryo Incubation and Emergence (12/15 – 05/31)	54	52.2	49.3	50.4	51.9	52.1	52.9	53.8	53.9	55.2	56.3	56.4
Fry Rearing (02/01 – 07/15)	68	72.3	66.6	66.9	68.1	68.4	68.7	70.1	70.7	70.8	71.4	71.7
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	68	72.3	66.6	66.9	68.1	68.4	68.7	70.1	70.7	70.8	71.4	71.7
Smolt Outmigration (12/01 – 04/30)	55	49.6	48.1	49.2	50.7	51.0	51.7	52.6	52.9	53.9	54.8	54.9

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-24. Steelhead UTWTI MWAT for each fish life stage for the calendar year 2013.

Fish life stage	UTWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (10/01 – 03/31)	68	58.0	54.7	54.7	55.2	55.3	55.6	56.3	56.5	56.9	57.4	57.5
Adult Holding (10/01 –12/15)	65	58.0	54.7	54.7	55.2	55.3	55.6	56.3	56.5	56.9	57.4	57.5
Adult Spawning (12/15 – 04/30)	57	49.6	48.1	49.2	50.7	51.0	51.7	52.6	52.9	53.9	54.8	54.9
Embryo Incubation and Emergence (12/15 – 05/31)	57	52.2	49.3	50.4	51.9	52.1	52.9	53.8	53.9	55.2	56.3	56.4
Fry Rearing (02/01 – 07/15)	72	72.3	66.6	66.9	68.1	68.4	68.7	70.1	70.7	70.8	71.4	71.7
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	72	72.3	66.6	66.9	68.1	68.4	68.7	70.1	70.7	70.8	71.4	71.7
Smolt Outmigration (12/01 – 04/30)	57	49.6	48.1	49.2	50.7	51.0	51.7	52.6	52.9	53.9	54.8	54.9

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-25. Spring-run Chinook salmon UOWTI MWAT for each fish life stage for the calendar year 2014.

Fish life stage	UOWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (03/01 – 05/31)	64	66.1	52.3	52.7	54.0	54.2	54.7	55.7	56.0	56.9	58.0	58.1
Adult Holding (04/01 – 09/15)	61	74.4	64.3	64.2	64.7	64.8	64.9	65.4	65.5	66.3	67.0	67.1
Adult Spawning (08/15 – 10/31)	56	70.0	57.5	58.4	59.3	59.5	60.1	61.5	61.8	63.3	64.2	64.4
Embryo Incubation and Emergence (08/15 – 12/31)	56	70.0	57.5	58.4	59.3	59.5	60.1	61.5	61.8	63.3	64.2	64.4
Fry Rearing (11/01 – 03/31)	65	56.3	51.1	51.6	52.3	52.3	53.0	53.6	53.6	55.0	55.7	55.8
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	65	74.4	64.3	64.2	64.7	64.8	64.9	65.4	65.5	66.3	67.0	67.1
Smolt Outmigration (10/01 – 05/31)	63	66.1	55.9	56.5	57.2	57.2	57.7	58.3	58.3	59.3	59.9	60.0

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-26. Spring-run Chinook salmon UTWTI MWAT for each fish life stage for the calendar year 2014.

Fish life stage	UTWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (03/01 – 05/31)	68	66.1	52.3	52.7	54.0	54.2	54.7	55.7	56.0	56.9	58.0	58.1
Adult Holding (04/01 – 09/15)	65	74.4	64.3	64.2	64.7	64.8	64.9	65.4	65.5	66.3	67.0	67.1
Adult Spawning (08/15 – 10/31)	58	70.0	57.5	58.4	59.3	59.5	60.1	61.5	61.8	63.3	64.2	64.4
Embryo Incubation and Emergence (08/15 – 12/31)	58	70.0	57.5	58.4	59.3	59.5	60.1	61.5	61.8	63.3	64.2	64.4
Fry Rearing (11/01 – 03/31)	68	56.3	51.1	51.6	52.3	52.3	53.0	53.6	53.6	55.0	55.7	55.8
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	68	74.4	64.3	64.2	64.7	64.8	64.9	65.4	65.5	66.3	67.0	67.1
Smolt Outmigration (10/01 – 05/31)	68	66.1	55.9	56.5	57.2	57.2	57.7	58.3	58.3	59.3	59.9	60.0

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-27. Steelhead UOWTI MWAT for each fish life stage for the calendar year 2014.

Fish life stage	UOWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (10/01 – 03/31)	64	62.0	55.9	56.5	57.2	57.2	57.7	58.3	58.3	59.3	59.9	60.0
Adult Holding (10/01 –12/15)	61	62.0	55.9	56.5	57.2	57.2	57.7	58.3	58.3	59.3	59.9	60.0
Adult Spawning (12/15 – 04/30)	54	64.2	51.9	52.7	54.0	54.2	54.7	55.7	56.0	56.7	57.5	57.6
Embryo Incubation and Emergence (12/15 – 05/31)	54	66.1	52.3	52.7	54.0	54.2	54.7	55.7	56.0	56.9	58.0	58.1
Fry Rearing (02/01 – 07/15)	68	74.0	63.8	63.2	63.6	63.6	63.8	64.2	64.3	65.1	65.7	65.8
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	68	74.4	64.3	64.2	64.7	64.8	64.9	65.4	65.5	66.3	67.0	67.1
Smolt Outmigration (12/01 – 04/30)	55	64.2	51.9	52.7	54.0	54.2	54.7	55.7	56.0	56.7	57.5	57.6

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-28. Steelhead UTWTI MWAT for each fish life stage for the calendar year 2014.

Fish life stage	UTWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (10/01 – 03/31)	68	62.0	55.9	56.5	57.2	57.2	57.7	58.3	58.3	59.3	59.9	60.0
Adult Holding (10/01 –12/15)	65	62.0	55.9	56.5	57.2	57.2	57.7	58.3	58.3	59.3	59.9	60.0
Adult Spawning (12/15 – 04/30)	57	64.2	51.9	52.7	54.0	54.2	54.7	55.7	56.0	56.7	57.5	57.6
Embryo Incubation and Emergence (12/15 – 05/31)	57	66.1	52.3	52.7	54.0	54.2	54.7	55.7	56.0	56.9	58.0	58.1
Fry Rearing (02/01 – 07/15)	72	74.0	63.8	63.2	63.6	63.6	63.8	64.2	64.3	65.1	65.7	65.8
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	72	74.4	64.3	64.2	64.7	64.8	64.9	65.4	65.5	66.3	67.0	67.1
Smolt Outmigration (12/01 – 04/30)	57	64.2	51.9	52.7	54.0	54.2	54.7	55.7	56.0	56.7	57.5	57.6

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-29. Spring-run Chinook salmon UOWTI MWAT for each fish life stage for the calendar year 2015.

Fish life stage	UOWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (03/01 – 05/31)	64	66.5	55.0	55.0	55.4	55.4	55.9	56.8	57.0	58.4	59.5	59.6
Adult Holding (04/01 – 09/15)	61	73.3	61.9	61.8	63.1	63.3	63.9	64.7	64.9	65.8	66.8	66.9
Adult Spawning (08/15 – 10/31)	56	69.4	63.7	63.7	63.8	63.8	64.1	64.3	64.4	64.8	65.1	65.1
Embryo Incubation and Emergence (08/15 – 12/31)	56	69.4	63.7	63.7	63.8	63.8	64.1	64.3	64.4	64.8	65.1	65.1
Fry Rearing (11/01 – 03/31)	65	60.2	59.2	58.7	58.2	58.1	58.1	58.1	58.1	58.0	57.9	57.9
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	65	73.3	63.7	63.7	63.8	63.8	64.1	64.7	64.9	65.8	66.8	66.9
Smolt Outmigration (10/01 – 05/31)	63	66.5	63.7	63.7	63.8	63.8	64.1	64.3	64.4	64.8	65.1	65.1

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-30. Spring-run Chinook salmon UTWTI MWAT for each fish life stage for the calendar year 2015.

Fish life stage	UTWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (03/01 – 05/31)	68	66.5	55.0	55.0	55.4	55.4	55.9	56.8	57.0	58.4	59.5	59.6
Adult Holding (04/01 – 09/15)	65	73.3	61.9	61.8	63.1	63.3	63.9	64.7	64.9	65.8	66.8	66.9
Adult Spawning (08/15 – 10/31)	58	69.4	63.7	63.7	63.8	63.8	64.1	64.3	64.4	64.8	65.1	65.1
Embryo Incubation and Emergence (08/15 – 12/31)	58	69.4	63.7	63.7	63.8	63.8	64.1	64.3	64.4	64.8	65.1	65.1
Fry Rearing (11/01 – 03/31)	68	60.2	59.2	58.7	58.2	58.1	58.1	58.1	58.1	58.0	57.9	57.9
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	68	73.3	63.7	63.7	63.8	63.8	64.1	64.7	64.9	65.8	66.8	66.9
Smolt Outmigration (10/01 – 05/31)	68	66.5	63.7	63.7	63.8	63.8	64.1	64.3	64.4	64.8	65.1	65.1

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-31. Steelhead UOWTI MWAT for each fish life stage for the calendar year 2015.

Fish life stage	UOWTI (MWAT) °F	Location No. 1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (10/01 – 03/31)	64	64.4	63.7	63.7	63.8	63.8	64.1	64.3	64.4	64.8	65.1	65.1
Adult Holding (10/01 –12/15)	61	64.4	63.7	63.7	63.8	63.8	64.1	64.3	64.4	64.8	65.1	65.1
Adult Spawning (12/15 – 04/30)	54	62.0	52.4	52.9	53.5	53.5	54.1	54.9	55.1	56.0	56.7	56.8
Embryo Incubation and Emergence (12/15 – 05/31)	54	66.5	55.0	55.0	55.4	55.4	55.9	56.8	57.0	58.4	59.5	59.6
Fry Rearing (02/01 – 07/15)	68	73.3	61.9	61.8	63.1	63.3	63.9	64.7	64.9	65.8	66.8	66.9
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	68	73.3	63.7	63.7	63.8	63.8	64.1	64.7	64.9	65.8	66.8	66.9
Smolt Outmigration (12/01 – 04/30)	55	62.0	52.4	52.9	53.5	53.5	54.1	54.9	55.1	56.0	56.7	56.8

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-32. Steelhead UTWTI MWAT for each fish life stage for the calendar year 2015.

Fish life stage	UTWTI (MWAT) °F	Location No. 1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (10/01 – 03/31)	68	64.4	63.7	63.7	63.8	63.8	64.1	64.3	64.4	64.8	65.1	65.1
Adult Holding (10/01 –12/15)	65	64.4	63.7	63.7	63.8	63.8	64.1	64.3	64.4	64.8	65.1	65.1
Adult Spawning (12/15 – 04/30)	57	62.0	52.4	52.9	53.5	53.5	54.1	54.9	55.1	56.0	56.7	56.8
Embryo Incubation and Emergence (12/15 – 05/31)	57	66.5	55.0	55.0	55.4	55.4	55.9	56.8	57.0	58.4	59.5	59.6
Fry Rearing (02/01 – 07/15)	72	73.3	61.9	61.8	63.1	63.3	63.9	64.7	64.9	65.8	66.8	66.9
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	72	73.3	63.7	63.7	63.8	63.8	64.1	64.7	64.9	65.8	66.8	66.9
Smolt Outmigration (12/01 – 04/30)	57	62.0	52.4	52.9	53.5	53.5	54.1	54.9	55.1	56.0	56.7	56.8

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-33. Spring-run Chinook salmon UOWTI MWAT for each fish life stage for the calendar year 2016.

Fish life stage	UOWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (03/01 – 05/31)	64	50.7	51.0	51.9	54.4	55.2	55.7	57.4	39.4	58.6	59.5	59.9
Adult Holding (04/01 – 09/15)	61	68.2	57.4	58.4	60.4	60.9	61.4	62.6	39.4	63.7	64.6	64.9
Adult Spawning (08/15 – 10/31)	56	64.8	54.9	56.2	57.8	57.9	58.8	59.8	39.4	61.4	62.5	62.6
Embryo Incubation and Emergence (08/15 – 12/31)	56	64.8	54.9	56.2	57.8	57.9	58.8	59.8	39.4	61.4	62.5	62.6
Fry Rearing (11/01 – 03/31)	65	47.2	45.9	46.7	48.2	48.6	49.0	50.1	39.4	51.0	51.7	52.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	65	68.2	57.4	58.4	60.4	60.9	61.4	62.6	39.4	63.7	64.6	64.9
Smolt Outmigration (10/01 – 05/31)	63	50.7	51.0	51.9	54.4	55.2	55.7	57.4	39.4	58.6	59.5	59.9

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-34. Spring-run Chinook salmon UTWTI MWAT for each fish life stage for the calendar year 2016.

Fish life stage	UTWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (03/01 – 05/31)	68	50.7	51.0	51.9	54.4	55.2	55.7	57.4	39.4	58.6	59.5	59.9
Adult Holding (04/01 – 09/15)	65	68.2	57.4	58.4	60.4	60.9	61.4	62.6	39.4	63.7	64.6	64.9
Adult Spawning (08/15 – 10/31)	58	64.8	54.9	56.2	57.8	57.9	58.8	59.8	39.4	61.4	62.5	62.6
Embryo Incubation and Emergence (08/15 – 12/31)	58	64.8	54.9	56.2	57.8	57.9	58.8	59.8	39.4	61.4	62.5	62.6
Fry Rearing (11/01 – 03/31)	68	47.2	45.9	46.7	48.2	48.6	49.0	50.1	39.4	51.0	51.7	52.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	68	68.2	57.4	58.4	60.4	60.9	61.4	62.6	39.4	63.7	64.6	64.9
Smolt Outmigration (10/01 – 05/31)	68	50.7	51.0	51.9	54.4	55.2	55.7	57.4	39.4	58.6	59.5	59.9

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-35. Steelhead UOWTI MWAT for each fish life stage for the calendar year 2016.

Fish life stage	UOWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (10/01 – 03/31)	64	47.2	45.9	46.7	48.2	48.6	49.0	50.1	39.4	51.0	51.7	52.0
Adult Holding (10/01 –12/15)	61	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Adult Spawning (12/15 – 04/30)	54	47.9	47.2	47.7	48.9	49.3	49.8	51.0	39.4	52.1	53.0	53.2
Embryo Incubation and Emergence (12/15 – 05/31)	54	50.7	51.0	51.9	54.4	55.2	55.7	57.4	39.4	58.6	59.5	59.9
Fry Rearing (02/01 – 07/15)	68	66.0	57.4	58.4	60.4	60.9	61.4	62.6	39.4	63.7	64.6	64.9
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	68	68.2	57.4	58.4	60.4	60.9	61.4	62.6	39.4	63.7	64.6	64.9
Smolt Outmigration (12/01 – 04/30)	55	47.9	47.2	47.7	48.9	49.3	49.8	51.0	39.4	52.1	53.0	53.2

[1] MWATS which exceed the temperature limits are listed in gray cells.

Table A.1-36. Steelhead UTWTI MWAT for each fish life stage for the calendar year 2016.

Fish life stage	UTWTI (MWAT) °F	Location No.										
		1	2	3	4	5	6	7	8	9	10	11
		MWAT[1], °F										
Adult Upstream Migration (10/01 – 03/31)	68	47.2	45.9	46.7	48.2	48.6	49.0	50.1	39.4	51.0	51.7	52.0
Adult Holding (10/01 –12/15)	65	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Adult Spawning (12/15 – 04/30)	57	47.9	47.2	47.7	48.9	49.3	49.8	51.0	39.4	52.1	53.0	53.2
Embryo Incubation and Emergence (12/15 – 05/31)	57	50.7	51.0	51.9	54.4	55.2	55.7	57.4	39.4	58.6	59.5	59.9
Fry Rearing (02/01 – 07/15)	72	66.0	57.4	58.4	60.4	60.9	61.4	62.6	39.4	63.7	64.6	64.9
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	72	68.2	57.4	58.4	60.4	60.9	61.4	62.6	39.4	63.7	64.6	64.9
Smolt Outmigration (12/01 – 04/30)	57	47.9	47.2	47.7	48.9	49.3	49.8	51.0	39.4	52.1	53.0	53.2

[1] MWATS which exceed the temperature limits are listed in gray cells.

A.2. Percentage of Days When Temperature Assessment Values were Exceeded

Table A.2-1. Percentages of days when spring-run Chinook salmon UOWTI values are exceeded for the calendar year 2008.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (03/01 – 05/31)	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (04/01 – 09/15)	50.6	14.9	17.3	20.8	23.2	25.0	32.7	35.1	34.5	35.1	35.7
Adult Spawning (08/15 – 10/31)	76.9	52.6	57.7	65.4	66.7	67.9	69.2	70.5	71.8	71.8	71.8
Embryo Incubation and Emergence (08/15 – 12/31)	43.2	29.5	32.4	36.7	37.4	38.1	38.8	39.6	40.3	40.3	40.3
Fry Rearing (11/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	16.7	0.0	0.0	0.0	0.0	0.3	3.6	3.8	3.8	4.1	4.9
Smolt Outmigration (10/01 – 05/31)	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-2. Percentages of days when spring-run Chinook salmon UTWTI values are exceeded for the calendar year 2008.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (03/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (04/01 – 09/15)	36.3	0.0	0.0	0.0	0.0	0.6	7.7	8.3	8.3	8.9	10.7
Adult Spawning (08/15 – 10/31)	74.4	26.9	32.1	33.3	34.6	38.5	53.8	56.4	64.1	70.5	70.5
Embryo Incubation and Emergence (08/15 – 12/31)	41.7	15.1	18.0	18.7	19.4	21.6	30.2	31.7	36.0	39.6	39.6
Fry Rearing (11/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (10/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-3. Percentages of days when Steelhead UOWTI values are exceeded for the calendar year 2008.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (10/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (10/01 –12/15)	9.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Spawning (12/15 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Embryo Incubation and Emergence (12/15 – 05/31)	13.0	0.0	0.0	3.0	3.6	4.1	5.9	5.9	7.1	8.9	8.9
Fry Rearing (02/01 – 07/15)	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (12/01 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-4. Percentages of days when Steelhead UTWTI values are exceeded for the calendar year 2008.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (10/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (10/01 –12/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Spawning (12/15 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Embryo Incubation and Emergence (12/15 – 05/31)	10.1	0.0	0.0	0.0	0.0	0.0	1.8	3.0	3.6	4.1	4.1
Fry Rearing (02/01 – 07/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (12/01 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-5. Percentages of days when spring-run Chinook salmon UOWTI values are exceeded for the calendar year 2009.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (03/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (04/01 – 09/15)	39.9	13.1	13.1	14.3	16.1	17.3	26.8	29.8	32.1	36.3	38.7
Adult Spawning (08/15 – 10/31)	73.1	65.4	67.9	66.7	65.4	69.2	73.1	73.1	76.9	78.2	79.5
Embryo Incubation and Emergence (08/15 – 12/31)	41.0	36.7	38.1	37.4	36.7	38.8	41.0	41.0	43.2	43.9	44.6
Fry Rearing (11/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	9.9	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.1	3.6	3.8
Smolt Outmigration (10/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-6. Percentages of days when spring-run Chinook salmon UTWTI values are exceeded for the calendar year 2009.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (03/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (04/01 – 09/15)	21.4	0.0	0.0	0.0	0.0	0.0	0.0	0.6	2.4	7.7	8.3
Adult Spawning (08/15 – 10/31)	61.5	38.5	42.3	56.4	57.7	60.3	60.3	60.3	65.4	66.7	66.7
Embryo Incubation and Emergence (08/15 – 12/31)	34.5	21.6	23.7	31.7	32.4	33.8	33.8	33.8	36.7	37.4	37.4
Fry Rearing (11/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (10/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-7. Percentages of days when Steelhead UOWTI values are exceeded for the calendar year 2009.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (10/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (10/01 –12/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Spawning (12/15 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Embryo Incubation and Emergence (12/15 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6	2.4	3.6	3.6
Fry Rearing (02/01 – 07/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (12/01 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-8. Percentages of days when Steelhead UTWTI values are exceeded for the calendar year 2009.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (10/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (10/01 –12/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Spawning (12/15 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Embryo Incubation and Emergence (12/15 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fry Rearing (02/01 – 07/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (12/01 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-9. Percentages of days when spring-run Chinook salmon UOWTI values are exceeded for the calendar year 2010.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (03/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (04/01 – 09/15)	24.4	9.5	7.7	11.3	12.5	13.1	19.0	20.8	26.2	28.0	28.6
Adult Spawning (08/15 – 10/31)	92.3	47.4	48.7	52.6	53.8	62.8	73.1	75.6	83.3	87.2	87.2
Embryo Incubation and Emergence (08/15 – 12/31)	51.8	26.6	27.3	29.5	30.2	35.3	41.0	42.4	46.8	48.9	48.9
Fry Rearing (11/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.1
Smolt Outmigration (10/01 – 05/31)	0.0	0.0	0.0	0.8	0.8	0.8	1.6	1.6	2.1	2.1	2.1

Table A.2-10. Percentages of days when spring-run Chinook salmon UTWTI values are exceeded for the calendar year 2010.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (03/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (04/01 – 09/15)	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.2
Adult Spawning (08/15 – 10/31)	78.2	30.8	33.3	38.5	41.0	42.3	50.0	55.1	71.8	79.5	79.5
Embryo Incubation and Emergence (08/15 – 12/31)	43.9	17.3	18.7	21.6	23.0	23.7	28.1	30.9	40.3	44.6	44.6
Fry Rearing (11/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (10/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-11. Percentages of days when Steelhead UOWTI values are exceeded for the calendar year 2010.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (10/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	1.1	1.6	1.6	1.6	1.6
Adult Holding (10/01 –12/15)	6.6	5.3	5.3	6.6	7.9	7.9	9.2	9.2	9.2	9.2	10.5
Adult Spawning (12/15 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Embryo Incubation and Emergence (12/15 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fry Rearing (02/01 – 07/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (12/01 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-12. Percentages of days when Steelhead UTWTI values are exceeded for the calendar year 2010.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (10/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (10/01 –12/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	2.6
Adult Spawning (12/15 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Embryo Incubation and Emergence (12/15 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fry Rearing (02/01 – 07/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (12/01 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-13. Percentages of days when spring-run Chinook salmon UOWTI values are exceeded for the calendar year 2011.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (03/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (04/01 – 09/15)	19.0	3.6	3.6	4.2	4.2	4.2	6.5	7.1	8.9	13.1	13.7
Adult Spawning (08/15 – 10/31)	91.0	57.7	59.0	59.0	64.1	74.4	89.7	89.7	91.0	93.6	93.6
Embryo Incubation and Emergence (08/15 – 12/31)	51.1	32.4	33.1	33.1	36.0	41.7	50.4	50.4	51.1	52.5	52.5
Fry Rearing (11/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	4.7	0.0	0.0	0.0	0.0	0.0	0.8	1.1	1.4	1.4	1.9
Smolt Outmigration (10/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-14. Percentages of days when spring-run Chinook salmon UTWTI values are exceeded for the calendar year 2011.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (03/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (04/01 – 09/15)	10.1	0.0	0.0	0.0	0.0	0.0	1.8	2.4	2.4	2.4	3.0
Adult Spawning (08/15 – 10/31)	78.2	37.2	43.6	50.0	50.0	50.0	59.0	61.5	84.6	85.9	85.9
Embryo Incubation and Emergence (08/15 – 12/31)	43.9	20.9	24.5	28.1	28.1	28.1	33.1	34.5	47.5	48.2	48.2
Fry Rearing (11/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (10/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-15. Percentages of days when Steelhead UOWTI values are exceeded for the calendar year 2011.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (10/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (10/01 –12/15)	5.3	0.0	0.0	0.0	0.0	0.0	5.3	9.2	13.2	17.1	17.1
Adult Spawning (12/15 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Embryo Incubation and Emergence (12/15 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fry Rearing (02/01 – 07/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (12/01 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-16. Percentages of days when Steelhead UTWTI values are exceeded for the calendar year 2011.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (10/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (10/01 –12/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Spawning (12/15 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Embryo Incubation and Emergence (12/15 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fry Rearing (02/01 – 07/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (12/01 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-17. Percentages of days when spring-run Chinook salmon UOWTI values are exceeded for the calendar year 2012.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (03/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (04/01 – 09/15)	56.0	34.5	35.7	41.7	43.5	44.6	50.0	51.8	53.0	53.6	53.6
Adult Spawning (08/15 – 10/31)	89.7	61.5	70.5	73.1	73.1	80.8	85.9	85.9	89.7	89.7	89.7
Embryo Incubation and Emergence (08/15 – 12/31)	50.4	34.5	39.6	41.0	41.0	45.3	48.2	48.2	50.4	50.4	50.4
Fry Rearing (11/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	17.5	0.0	0.0	1.1	1.4	1.4	4.4	6.8	7.7	11.2	12.3
Smolt Outmigration (10/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-18. Percentages of days when spring-run Chinook salmon UTWTI values are exceeded for the calendar year 2012.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (03/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (04/01 – 09/15)	37.5	0.0	0.0	2.4	3.0	3.0	9.5	14.9	16.7	23.8	26.2
Adult Spawning (08/15 – 10/31)	75.6	44.9	52.6	66.7	66.7	69.2	73.1	73.1	80.8	88.5	88.5
Embryo Incubation and Emergence (08/15 – 12/31)	42.4	25.2	29.5	37.4	37.4	38.8	41.0	41.0	45.3	49.6	49.6
Fry Rearing (11/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.4
Smolt Outmigration (10/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-19. Percentages of days when Steelhead UOWTI values are exceeded for the calendar year 2012.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (10/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (10/01 –12/15)	10.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.9	9.2	10.5
Adult Spawning (12/15 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	1.4	2.2	4.3	5.8	5.8
Embryo Incubation and Emergence (12/15 – 05/31)	0.0	0.0	0.0	0.6	1.2	2.4	5.3	5.9	10.7	13.6	13.6
Fry Rearing (02/01 – 07/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.4
Smolt Outmigration (12/01 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	3.3	3.9

Table A.2-20. Percentages of days when Steelhead UTWTI values are exceeded for the calendar year 2012.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (10/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (10/01 –12/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Spawning (12/15 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Embryo Incubation and Emergence (12/15 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fry Rearing (02/01 – 07/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (12/01 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-21. Percentages of days when spring-run Chinook salmon UOWTI values are exceeded for the calendar year 2013.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (03/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (04/01 – 09/15)	53.6	38.7	38.7	40.5	41.1	41.7	43.5	44.6	45.8	50.0	50.0
Adult Spawning (08/15 – 10/31)	73.1	59.0	59.0	59.0	60.3	60.3	64.1	64.1	66.7	67.9	67.9
Embryo Incubation and Emergence (08/15 – 12/31)	41.0	33.1	33.1	33.1	33.8	33.8	36.0	36.0	37.4	38.1	38.1
Fry Rearing (11/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	15.9	6.8	6.3	8.8	9.0	9.0	11.2	13.7	13.7	14.5	15.1
Smolt Outmigration (10/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-22. Percentages of days when spring-run Chinook salmon UTWTI values are exceeded for the calendar year 2013.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (03/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (04/01 – 09/15)	34.5	14.9	13.7	18.5	19.0	19.0	23.2	28.6	28.0	29.8	31.0
Adult Spawning (08/15 – 10/31)	61.5	53.8	53.8	53.8	53.8	55.1	55.1	56.4	56.4	56.4	56.4
Embryo Incubation and Emergence (08/15 – 12/31)	34.5	30.2	30.2	30.2	30.2	30.9	30.9	31.7	31.7	31.7	31.7
Fry Rearing (11/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	7.7	0.0	0.0	0.5	0.8	1.1	2.2	3.3	3.8	4.1	4.1
Smolt Outmigration (10/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-23. Percentages of days when Steelhead UOWTI values are exceeded for the calendar year 2013.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (10/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (10/01 –12/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Spawning (12/15 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	2.9
Embryo Incubation and Emergence (12/15 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	12.5	13.1
Fry Rearing (02/01 – 07/15)	9.1	0.0	0.0	1.2	1.8	2.4	4.2	4.2	4.8	5.5	5.5
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	7.7	0.0	0.0	0.5	0.8	1.1	2.2	3.3	3.8	4.1	4.1
Smolt Outmigration (12/01 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-24. Percentages of days when Steelhead UTWTI values are exceeded for the calendar year 2013.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (10/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (10/01 –12/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Spawning (12/15 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Embryo Incubation and Emergence (12/15 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fry Rearing (02/01 – 07/15)	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (12/01 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-25. Percentages of days when spring-run Chinook salmon UOWTI values are exceeded for the calendar year 2014.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (03/01 – 05/31)	7.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (04/01 – 09/15)	83.9	16.1	17.3	17.9	19.0	23.8	28.6	29.8	48.8	50.6	50.6
Adult Spawning (08/15 – 10/31)	94.9	42.3	61.5	71.8	71.8	82.1	88.5	88.5	92.3	97.4	97.4
Embryo Incubation and Emergence (08/15 – 12/31)	53.2	23.7	34.5	40.3	40.3	46.0	49.6	49.6	51.8	54.7	54.7
Fry Rearing (11/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	33.4	0.0	0.0	0.0	0.0	0.0	1.1	1.4	3.0	3.8	3.8
Smolt Outmigration (10/01 – 05/31)	6.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-26. Percentages of days when spring-run Chinook salmon UTWTI values are exceeded for the calendar year.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (03/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (04/01 – 09/15)	65.5	0.0	0.0	0.0	0.0	0.0	2.4	3.0	6.5	8.3	8.3
Adult Spawning (08/15 – 10/31)	88.5	0.0	12.8	55.1	55.1	56.4	61.5	64.1	84.6	88.5	88.5
Embryo Incubation and Emergence (08/15 – 12/31)	49.6	0.0	7.2	30.9	30.9	31.7	34.5	36.0	47.5	49.6	49.6
Fry Rearing (11/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	22.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (10/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-27. Percentages of days when Steelhead UOWTI values are exceeded for the calendar year 2014.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (10/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (10/01 –12/15)	17.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Spawning (12/15 – 04/30)	24.1	0.0	0.0	0.7	2.2	5.1	7.3	7.3	8.8	10.2	10.2
Embryo Incubation and Emergence (12/15 – 05/31)	38.1	0.0	0.0	0.6	1.8	6.0	10.1	10.1	12.5	19.6	19.6
Fry Rearing (02/01 – 07/15)	23.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	22.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (12/01 – 04/30)	19.9	0.0	0.0	0.0	0.0	0.0	4.0	4.6	6.6	7.9	7.9

Table A.2-28. Percentages of days when Steelhead UTWTI values are exceeded for the calendar year 2014.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (10/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (10/01 –12/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Spawning (12/15 – 04/30)	13.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	3.6
Embryo Incubation and Emergence (12/15 – 05/31)	29.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	6.0
Fry Rearing (02/01 – 07/15)	7.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (12/01 – 04/30)	12.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	3.3

Table A.2-29. Percentages of days when spring-run Chinook salmon UOWTI values are exceeded for the calendar year 2015.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (03/01 – 05/31)	9.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (04/01 – 09/15)	78.0	4.2	3.0	4.2	4.8	6.0	8.3	10.1	20.8	48.2	48.8
Adult Spawning (08/15 – 10/31)	98.7	64.1	94.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Embryo Incubation and Emergence (08/15 – 12/31)	55.4	38.1	55.4	57.6	57.6	57.6	58.3	58.3	58.3	58.3	58.3
Fry Rearing (11/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	29.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	2.5	2.5
Smolt Outmigration (10/01 – 05/31)	8.2	4.1	3.7	3.3	3.3	3.3	3.7	3.7	4.1	4.5	4.5

Table A.2-30. Percentages of days when spring-run Chinook salmon UTWTI values are exceeded for the calendar year.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (03/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (04/01 – 09/15)	61.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	4.8	4.8
Adult Spawning (08/15 – 10/31)	92.3	48.7	50.0	57.7	60.3	91.0	93.6	94.9	100.0	100.0	100.0
Embryo Incubation and Emergence (08/15 – 12/31)	51.8	28.1	28.8	33.1	34.5	51.8	53.2	54.0	56.1	56.1	56.1
Fry Rearing (11/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	22.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (10/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-31. Percentages of days when Steelhead UOWTI values are exceeded for the calendar year 2015.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (10/01 – 03/31)	0.5	0.0	0.0	0.0	0.0	1.1	2.7	3.3	3.8	3.8	3.8
Adult Holding (10/01 –12/15)	27.6	32.9	30.3	27.6	26.3	28.9	27.6	27.6	30.3	30.3	30.3
Adult Spawning (12/15 – 04/30)	34.3	0.0	0.0	0.0	0.0	0.7	3.6	5.8	8.8	16.8	18.2
Embryo Incubation and Emergence (12/15 – 05/31)	46.4	3.0	3.0	4.8	4.8	7.1	11.3	13.1	18.5	26.8	28.6
Fry Rearing (02/01 – 07/15)	20.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	22.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (12/01 – 04/30)	30.5	0.0	0.0	0.0	0.0	0.0	0.0	0.7	4.0	7.3	9.3

Table A.2-32. Percentages of days when Steelhead UTWTI values are exceeded for the calendar year 2015.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (10/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (10/01 –12/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	1.3
Adult Spawning (12/15 – 04/30)	27.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Embryo Incubation and Emergence (12/15 – 05/31)	40.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	6.5	6.5
Fry Rearing (02/01 – 07/15)	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (12/01 – 04/30)	24.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-33. Percentages of days when spring-run Chinook salmon UOWTI values are exceeded for the calendar year 2016.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (03/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (04/01 – 09/15)	41.1	0.0	0.0	0.0	0.0	3.6	10.7	0.0	31.0	48.2	48.8
Adult Spawning (08/15 – 10/31)	100.0	0.0	14.9	48.9	51.1	68.1	85.1	0.0	97.9	100.0	100.0
Embryo Incubation and Emergence (08/15 – 12/31)	100.0	0.0	14.9	48.9	51.1	68.1	85.1	0.0	97.9	100.0	100.0
Fry Rearing (11/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	10.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (10/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-34. Percentages of days when spring-run Chinook salmon UTWTI values are exceeded for the calendar year.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (03/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (04/01 – 09/15)	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Spawning (08/15 – 10/31)	100.0	0.0	0.0	0.0	0.0	25.5	48.9	0.0	74.5	85.1	89.4
Embryo Incubation and Emergence (08/15 – 12/31)	100.0	0.0	0.0	0.0	0.0	25.5	48.9	0.0	74.5	85.1	89.4
Fry Rearing (11/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (10/01 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-35. Percentages of days when Steelhead UOWTI values are exceeded for the calendar year 2016.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (10/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (10/01 –12/15)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Adult Spawning (12/15 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Embryo Incubation and Emergence (12/15 – 05/31)	0.0	0.0	0.0	0.7	2.0	3.3	7.9	0.0	11.2	12.5	12.5
Fry Rearing (02/01 – 07/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (12/01 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2-36. Percentages of days when Steelhead UTWTI values are exceeded for the calendar year 2016.

Fish life stage	Location No.										
	1	2	3	4	5	6	7	8	9	10	11
	% of days exceeded										
Adult Upstream Migration (10/01 – 03/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Holding (10/01 –12/15)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Adult Spawning (12/15 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Embryo Incubation and Emergence (12/15 – 05/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	2.0	3.9	4.6
Fry Rearing (02/01 – 07/15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Rearing and Downstream Movement (01/01 – 12/31)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smolt Outmigration (12/01 – 04/30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TEMPERATURE INDICES ANALYSIS
STUDY REPORT

APPENDIX B

GRAPHICAL ASSESSMENT OF WATER TEMPERATURE INDICES APPLICATION: 2008 - 2016

In this appendix, graphical representations of index values computed using simulated temperatures as compared to WTI (UOWTI and UTWTI) at four locations (below each tributary confluence) in the study reach are shown for spring-run Chinook and steelhead for 2008 to 2016.

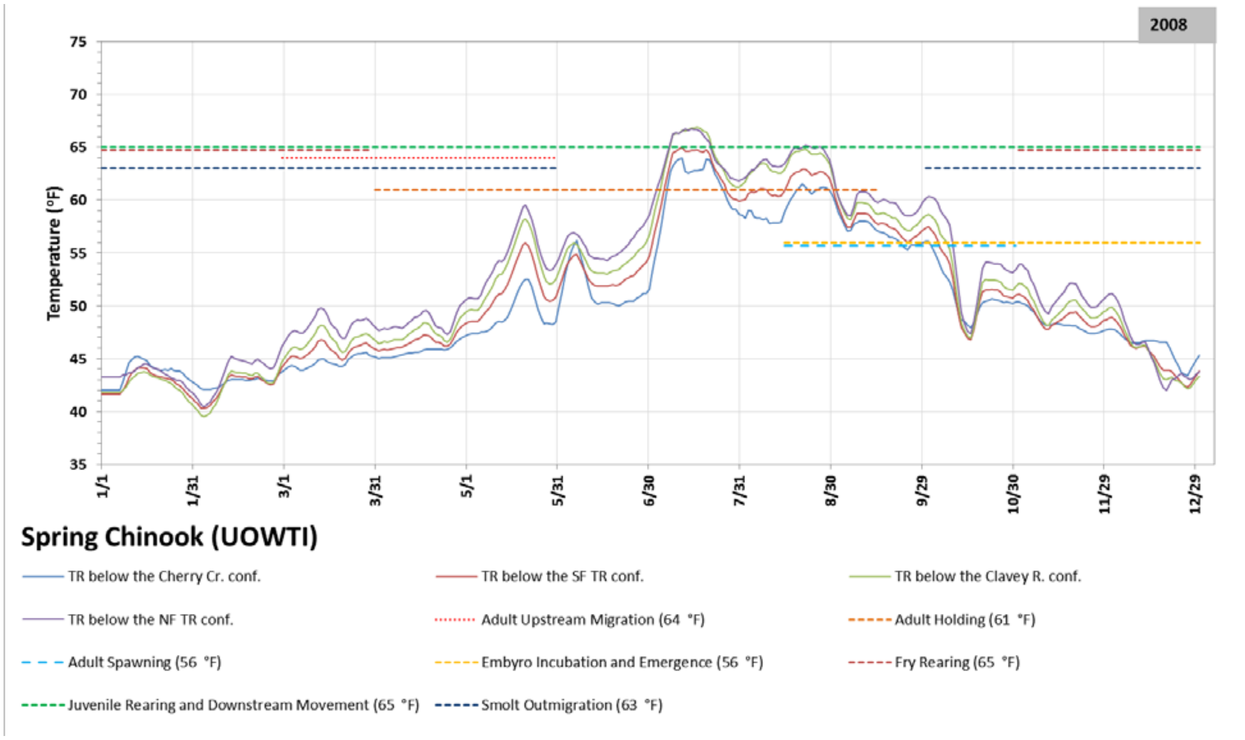

Figure B-1. **Upper Optimum Water Temperature Index (UOWTI) for spring-run Chinook salmon superimposed on the 2008 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

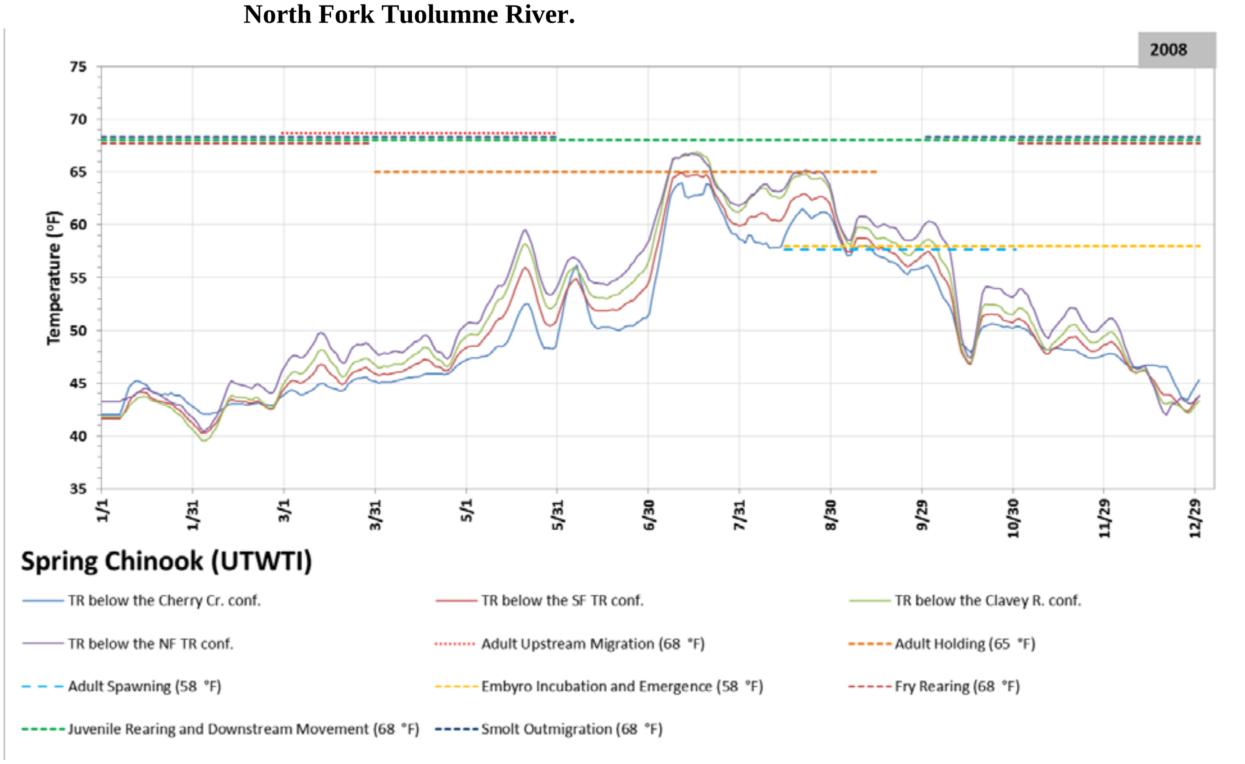

Figure B-2. **Upper Tolerable Water Temperature Index (UTWTI) for spring-run Chinook salmon superimposed on the 2008 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

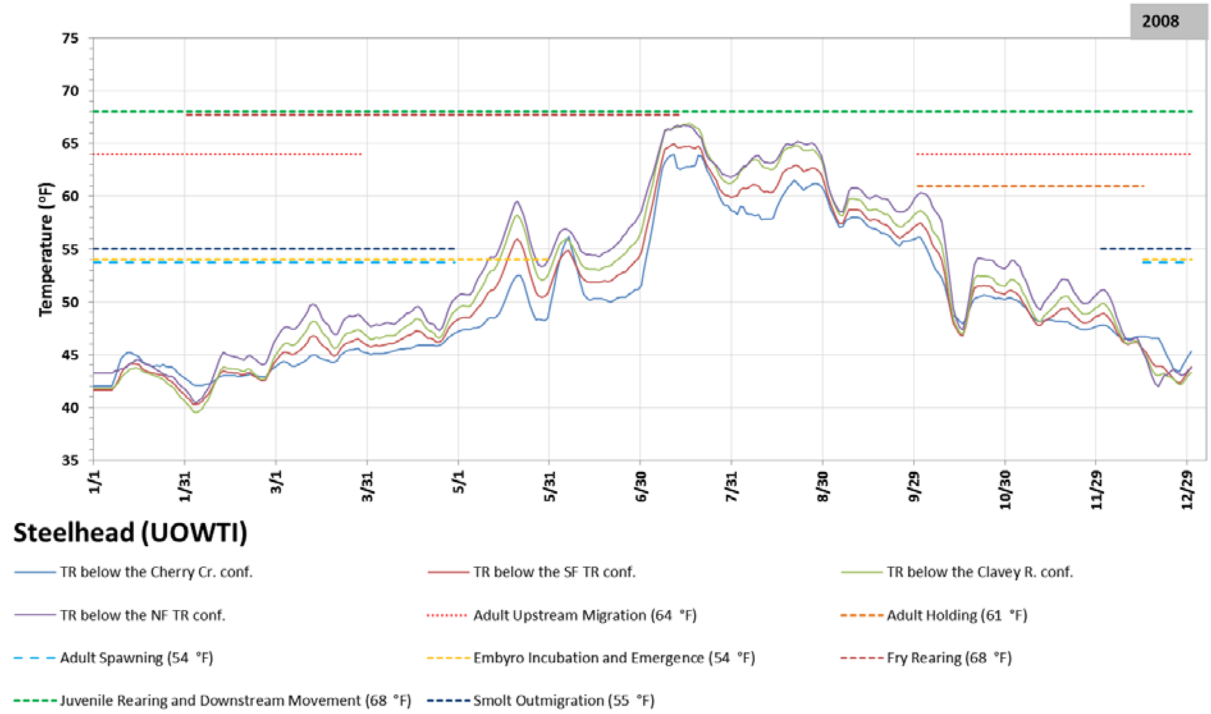

Figure B-3. **Upper Optimum Water Temperature Index (UOWTI) for Steelhead superimposed on the 2008 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

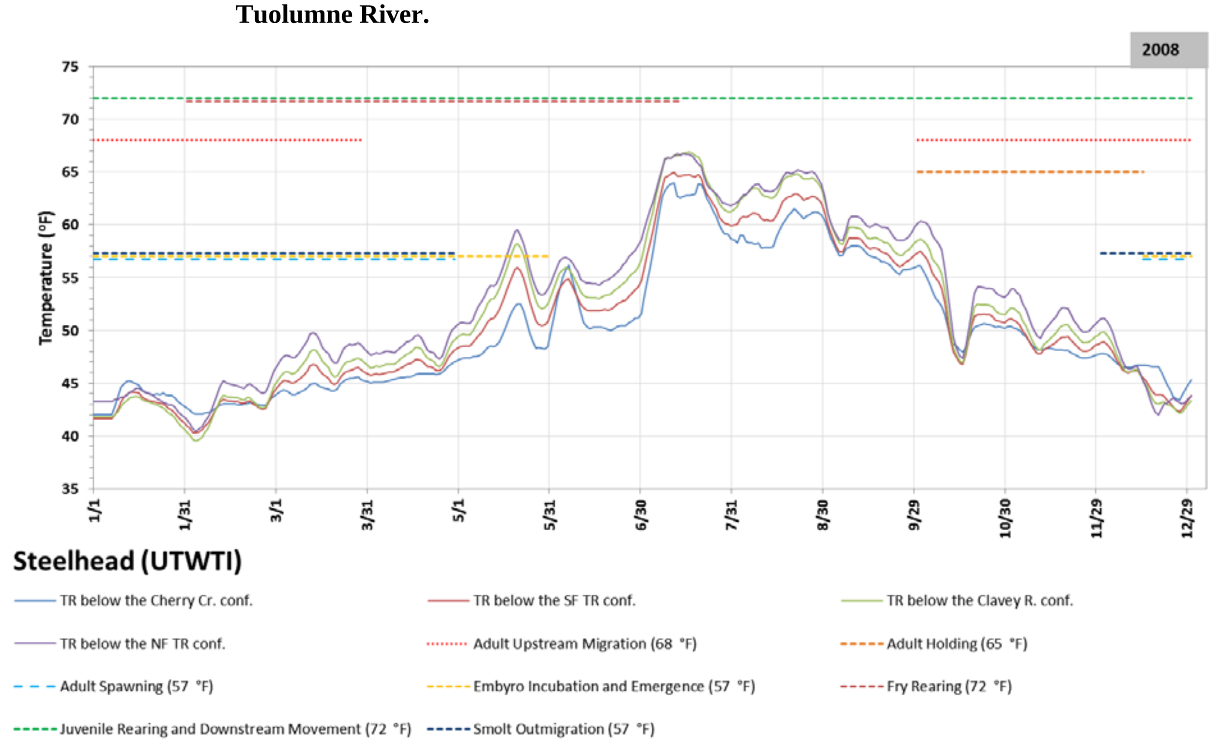

Figure B-4. **Upper Tolerable Water Temperature Index (UTWTI) for Steelhead superimposed on the 2008 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

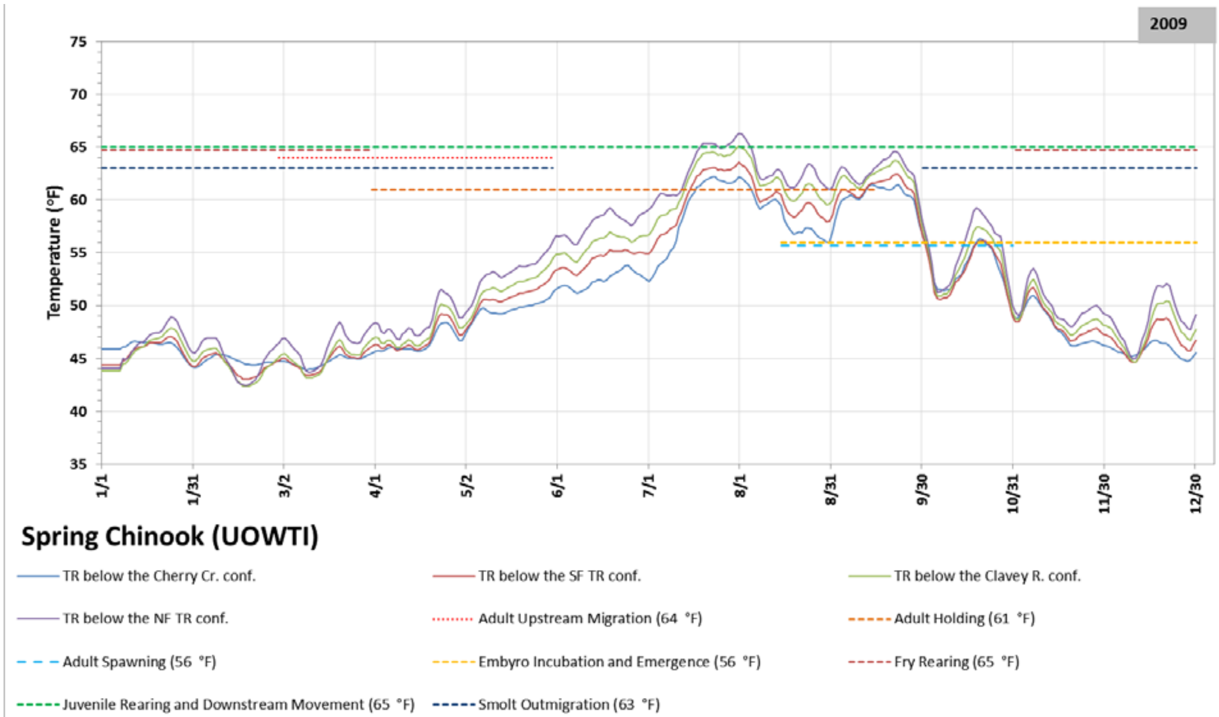

Figure B-5. **Upper Optimum Water Temperature Index (UOWTI) for spring-run Chinook salmon superimposed on the 2009 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

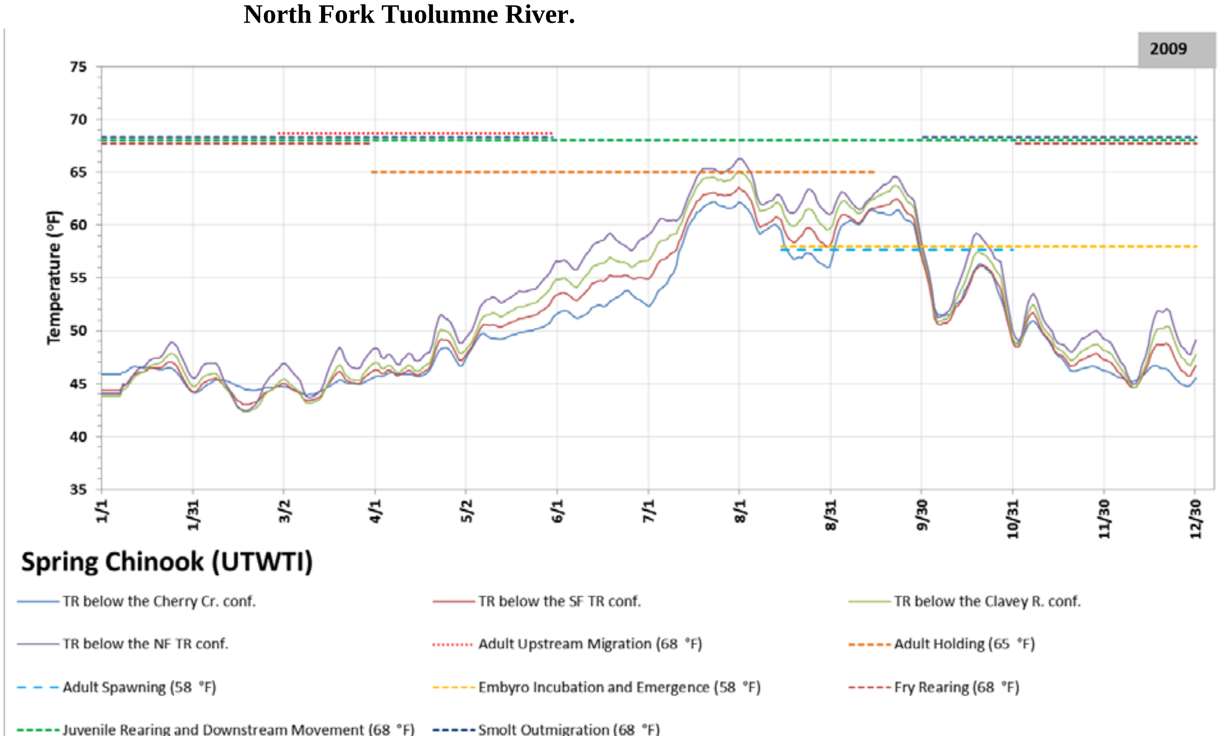

Figure B-6. **Upper Tolerable Water Temperature Index (UTWTI) for spring-run Chinook salmon superimposed on the 2009 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

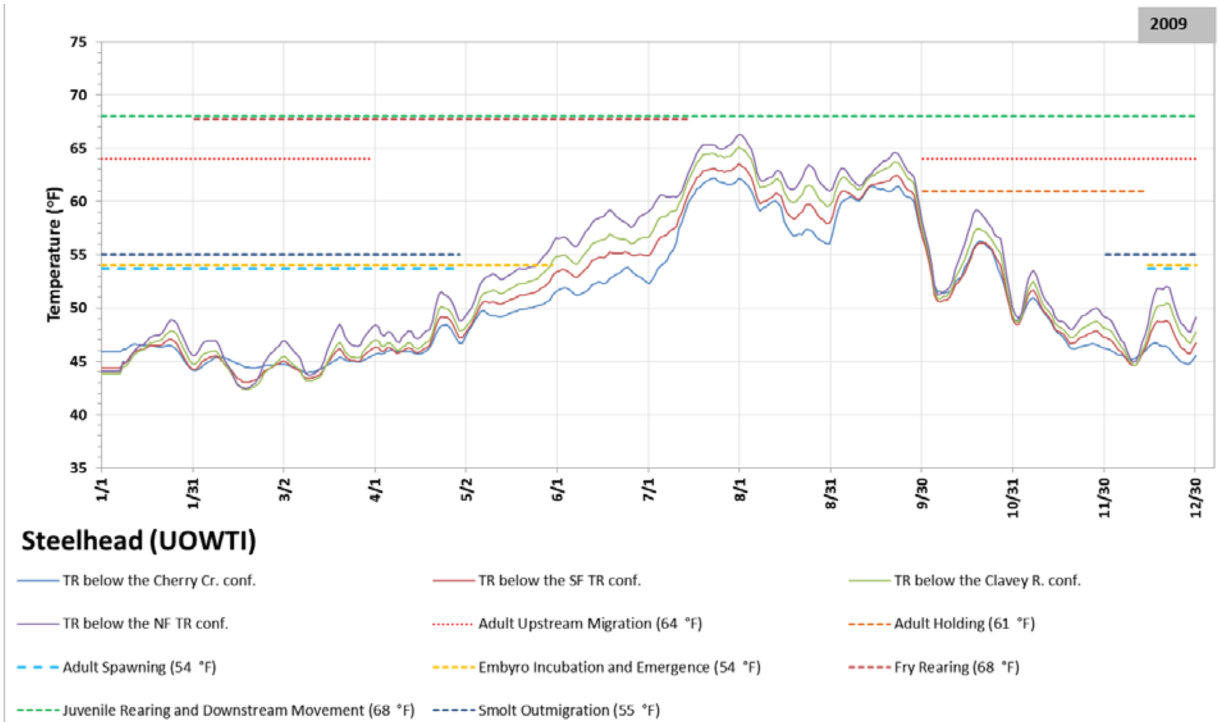

Figure B-7. **Upper Optimum Water Temperature Index (UOWTI) for Steelhead superimposed on the 2009 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

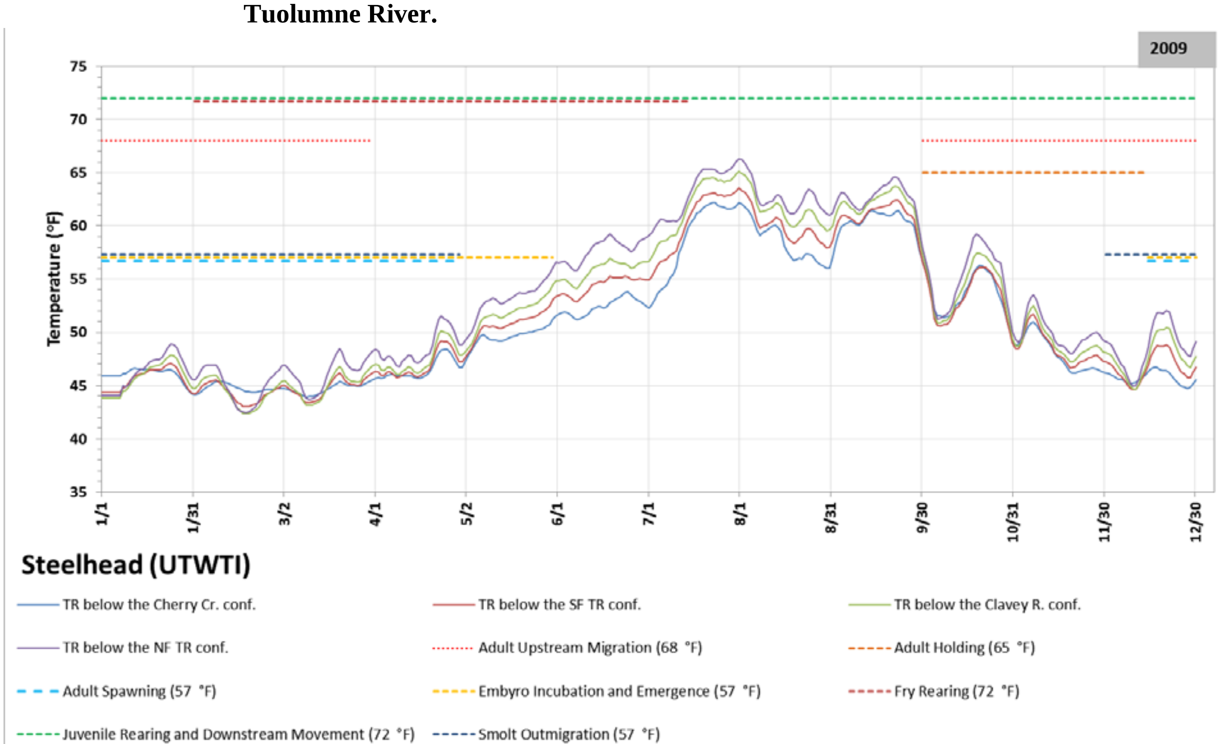

Figure B-8. **Upper Tolerable Water Temperature Index (UTWTI) for Steelhead superimposed on the 2009 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

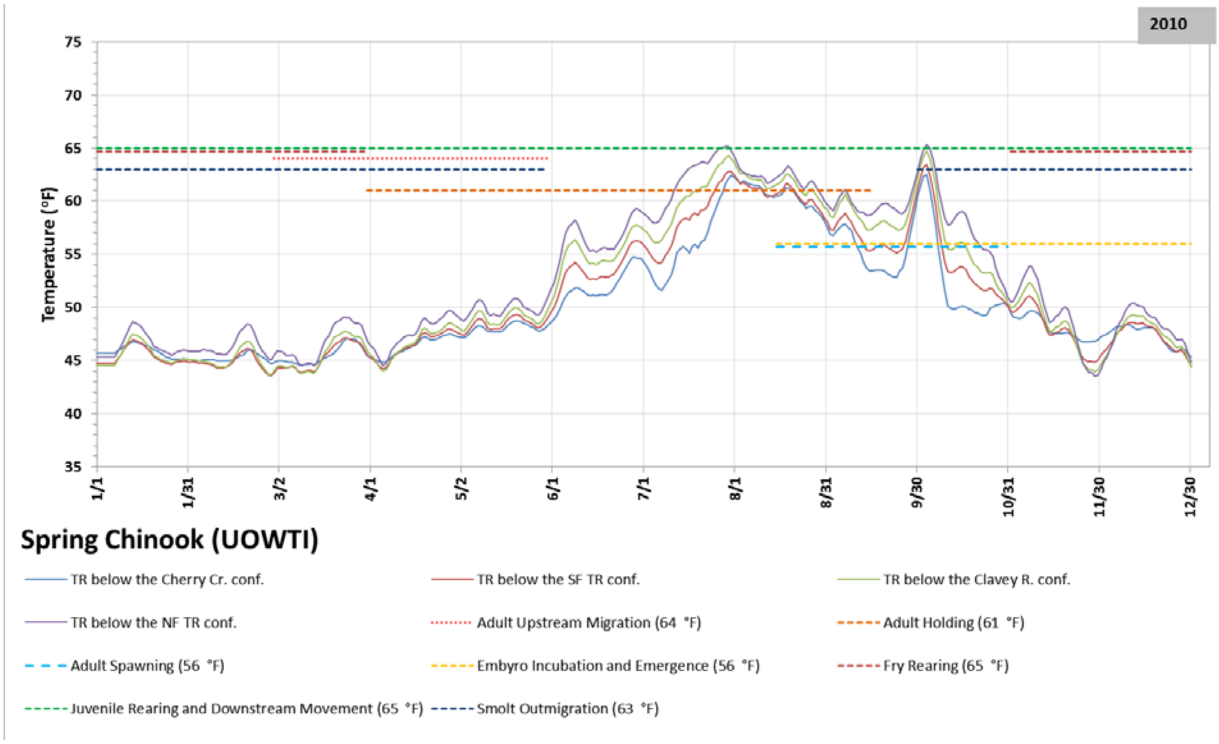

Figure B-9. **Upper Optimum Water Temperature Index (UOWTI) for spring-run Chinook salmon superimposed on the 2010 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

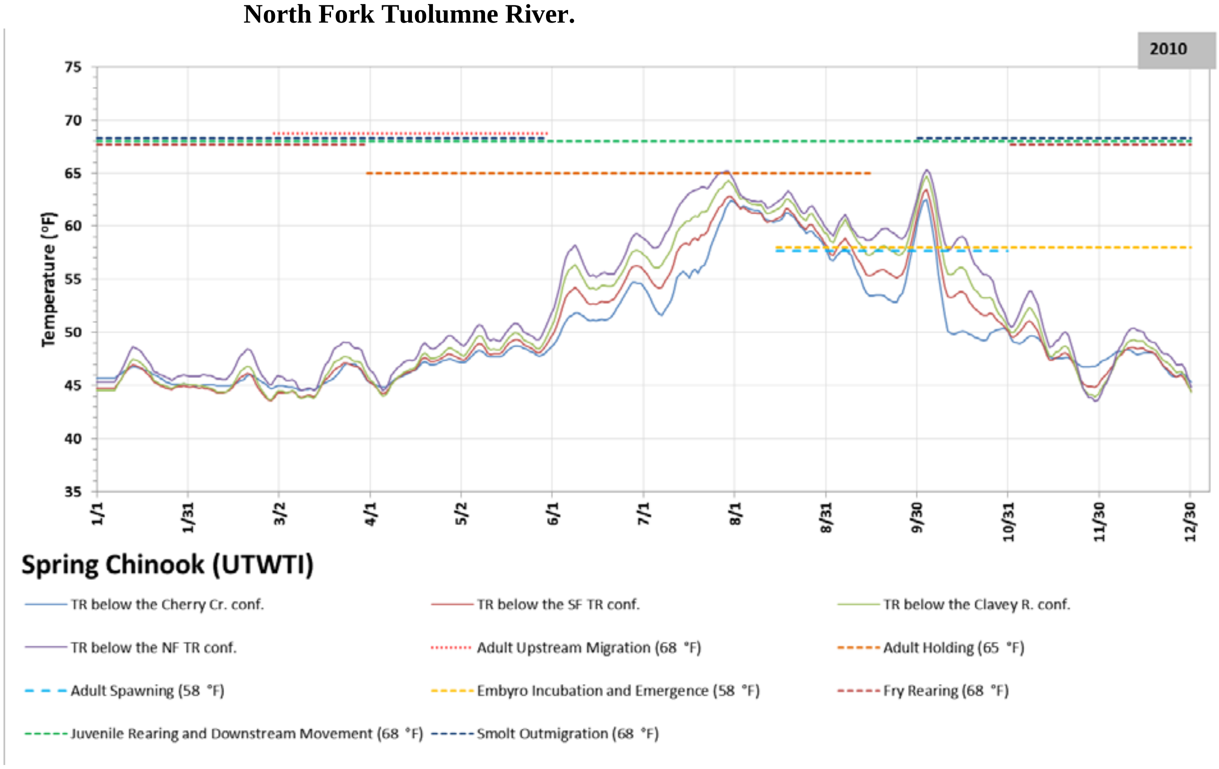

Figure B-10. **Upper Tolerable Water Temperature Index (UTWTI) for spring-run Chinook salmon superimposed on the 2010 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

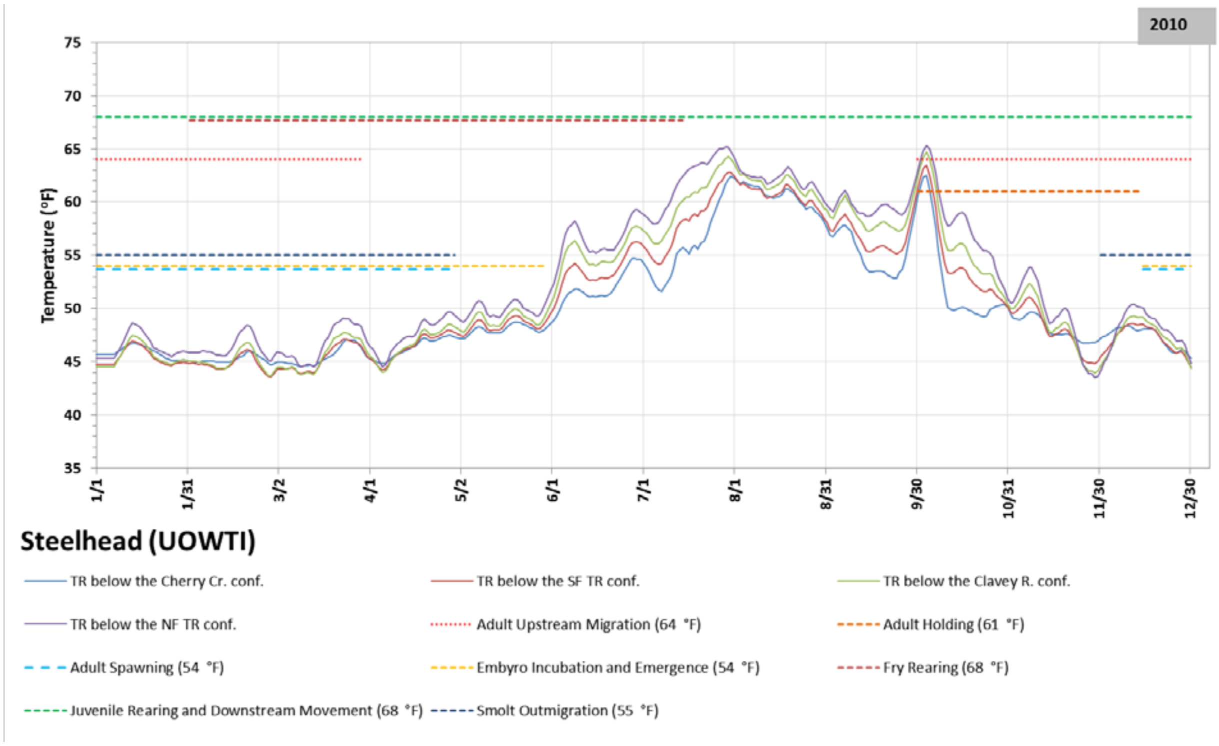

Figure B-11. **Upper Optimum Water Temperature Index (UOWTI) for Steelhead superimposed on the 2010 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

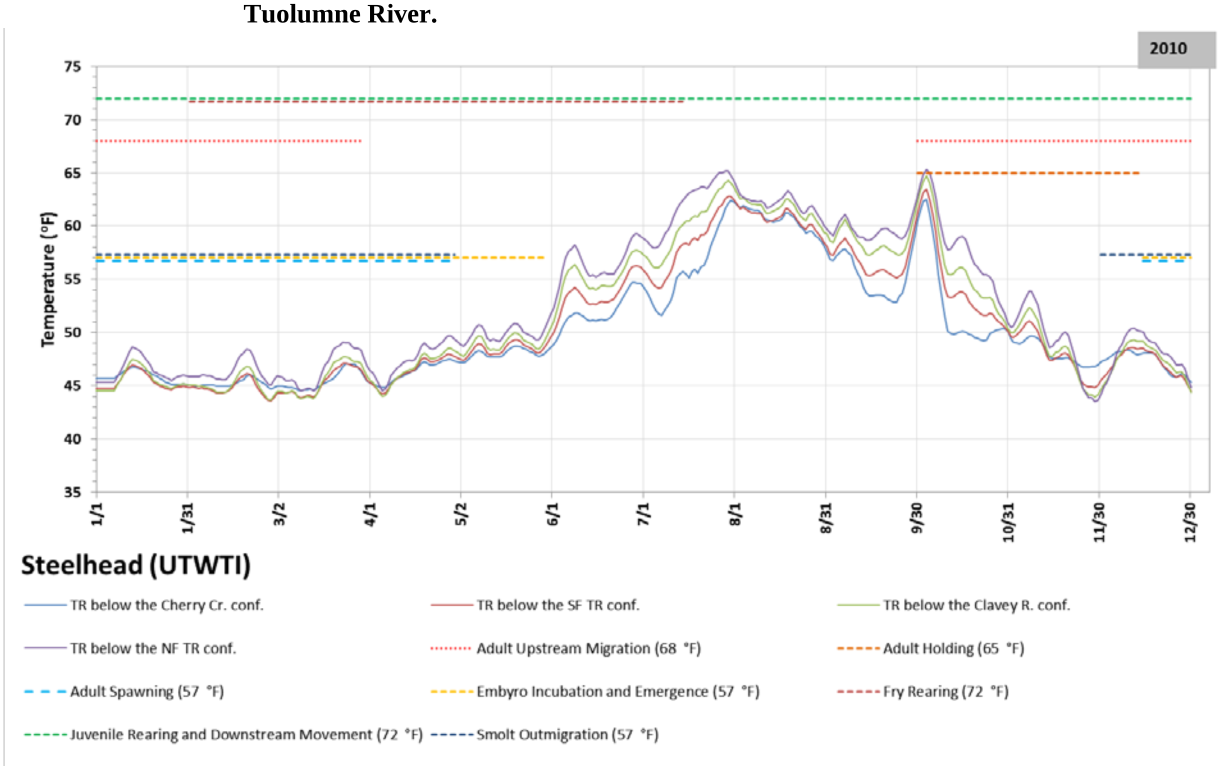

Figure B-12. **Upper Tolerable Water Temperature Index (UTWTI) for Steelhead superimposed on the 2010 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

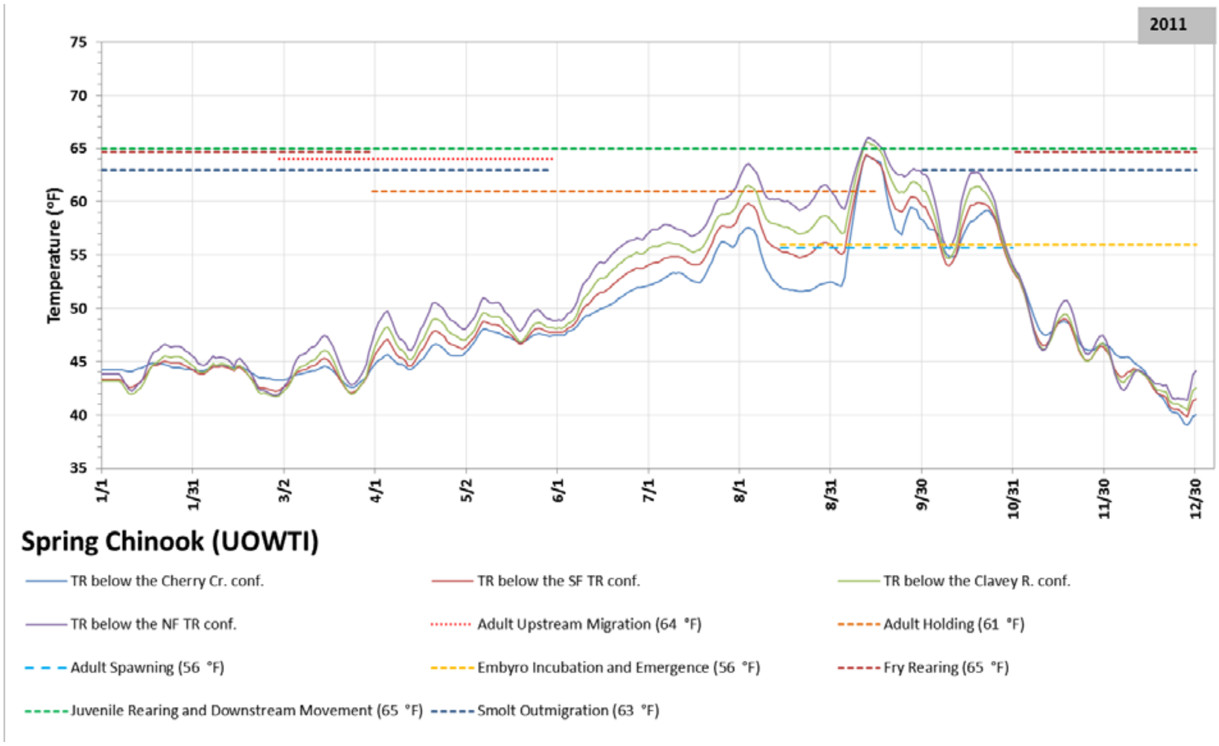

Figure B-13. **Upper Optimum Water Temperature Index (UOWTI) for spring-run Chinook salmon superimposed on the 2011 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

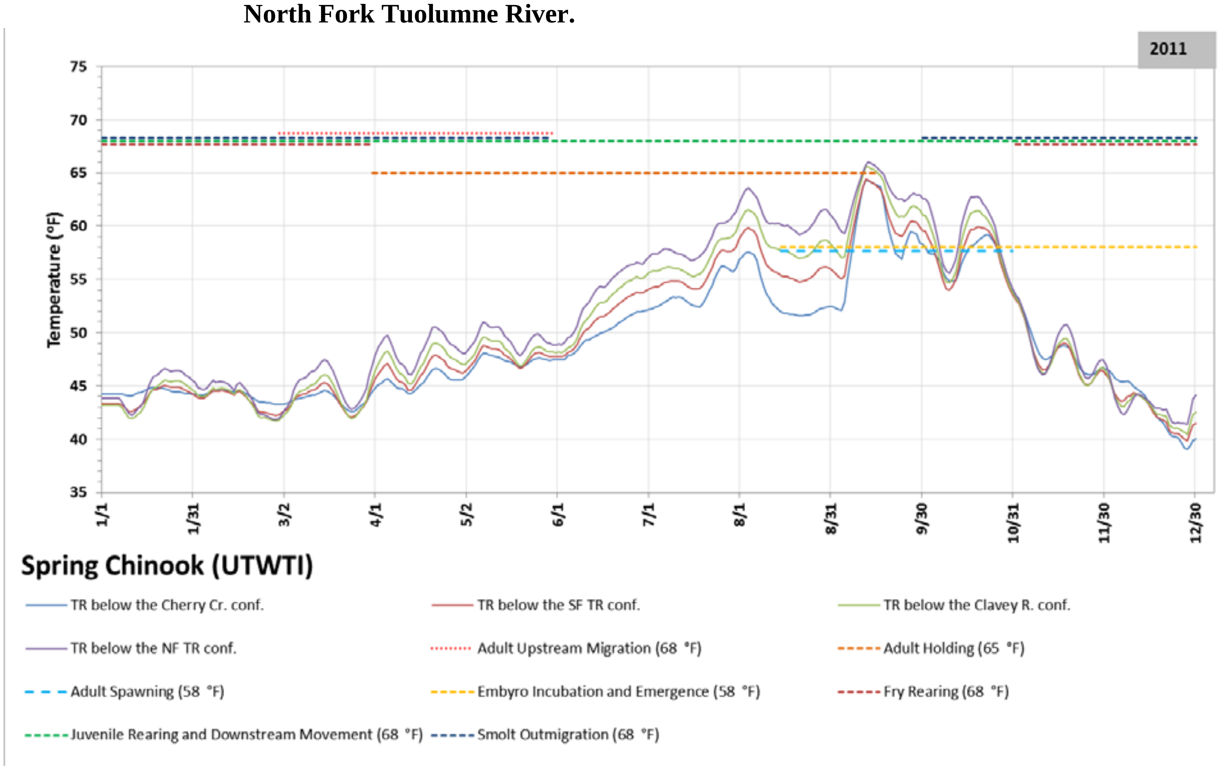

Figure B-14. **Upper Tolerable Water Temperature Index (UTWTI) for spring-run Chinook salmon superimposed on the 2011 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

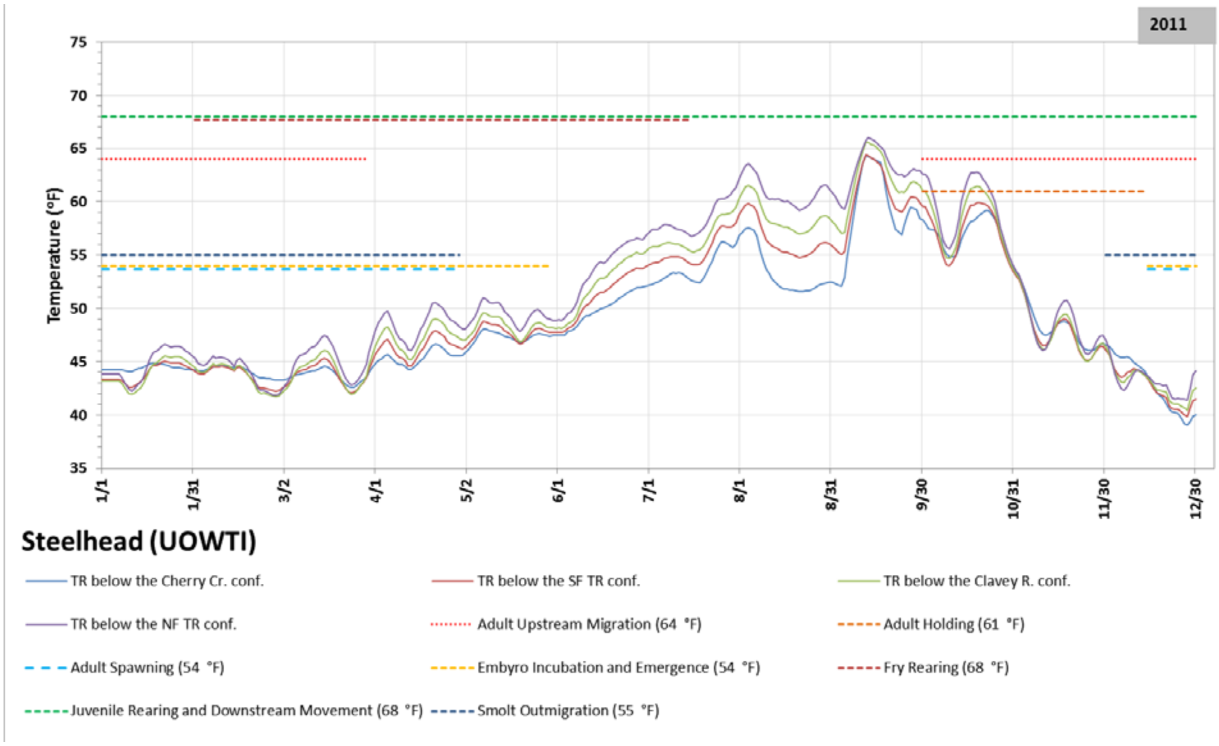

Figure B-15. **Upper Optimum Water Temperature Index (UOWTI) for Steelhead superimposed on the 2011 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

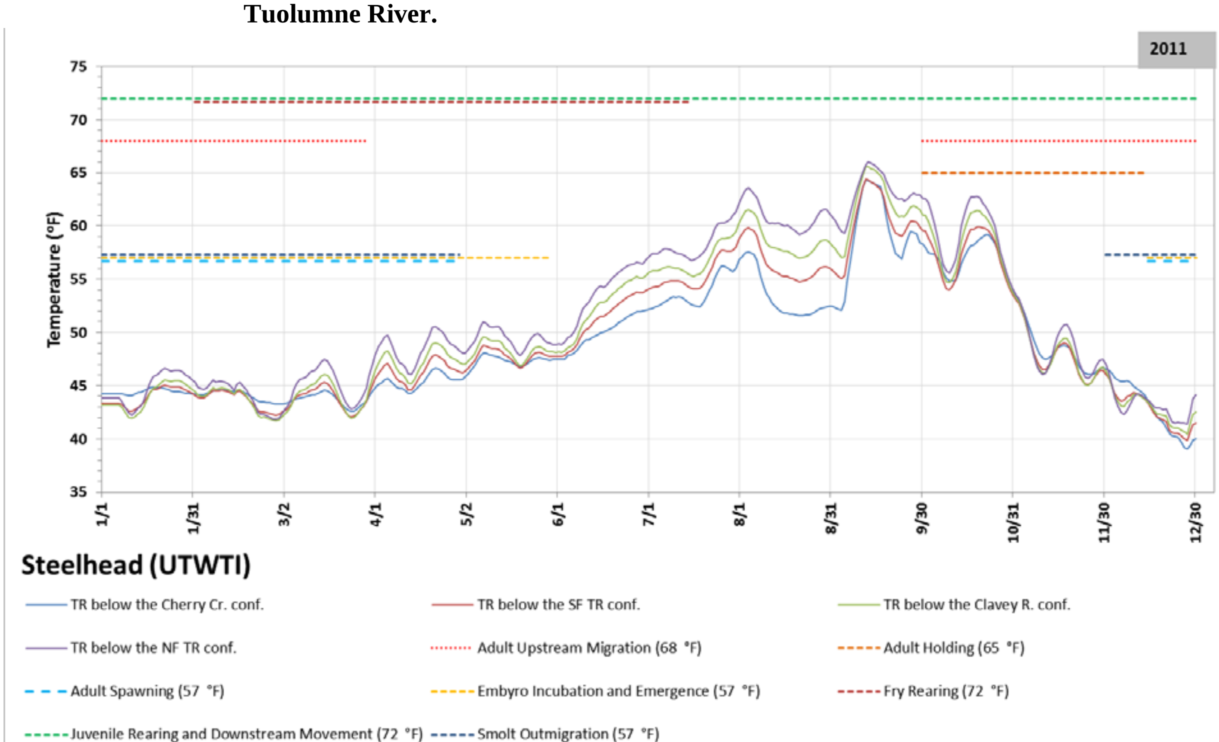

Figure B-16. **Upper Tolerable Water Temperature Index (UTWTI) for Steelhead superimposed on the 2011 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

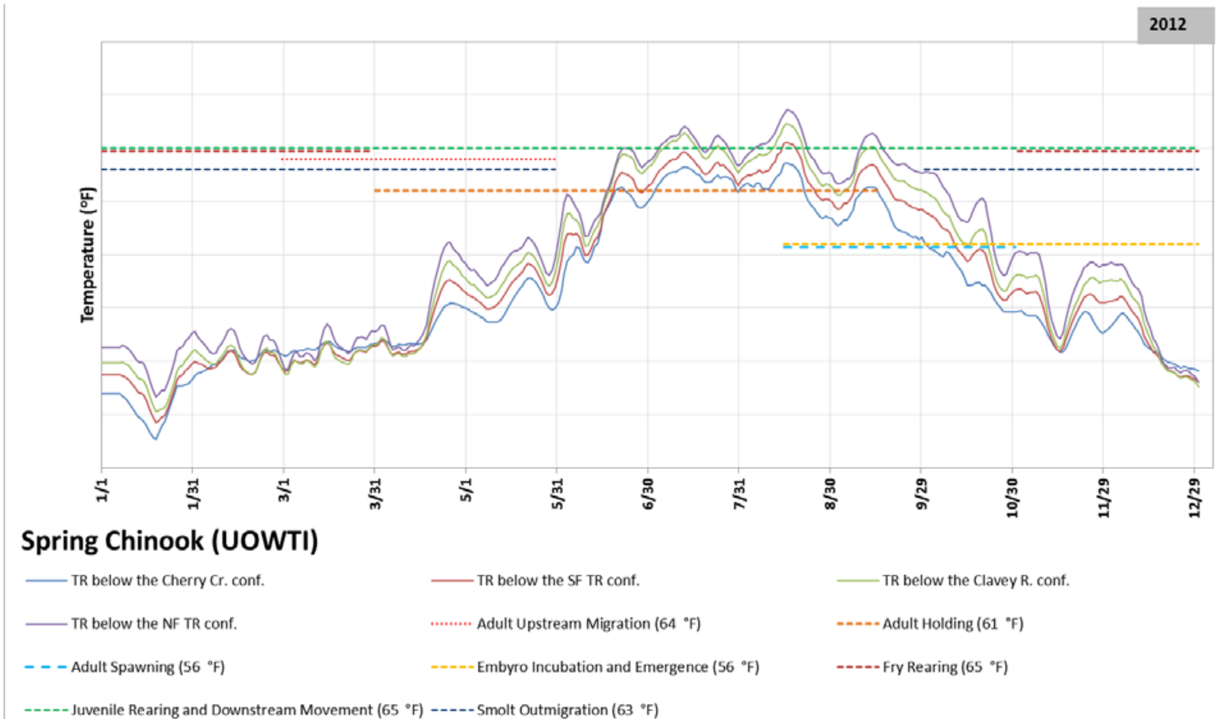

Figure B-17. Upper Optimum Water Temperature Index (UOWTI) for spring-run Chinook salmon superimposed on the 2012 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.

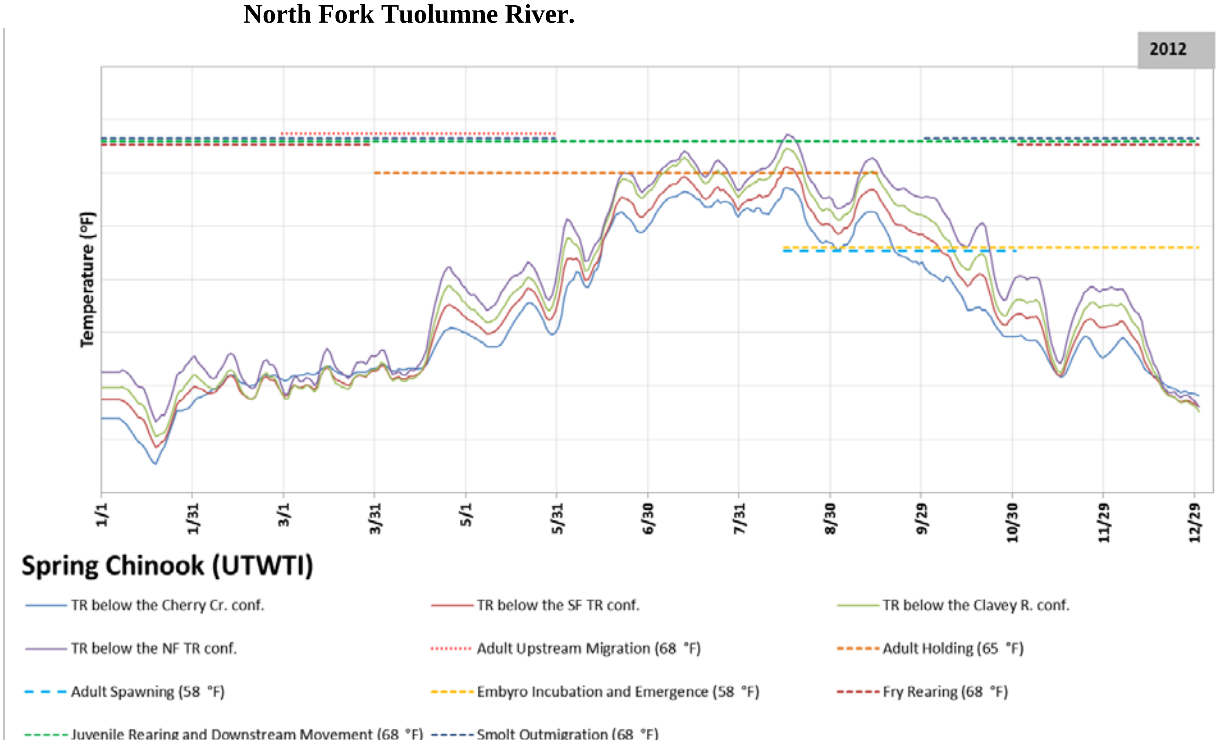

Figure B-18. Upper Tolerable Water Temperature Index (UTWTI) for spring-run Chinook salmon superimposed on the 2012 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.

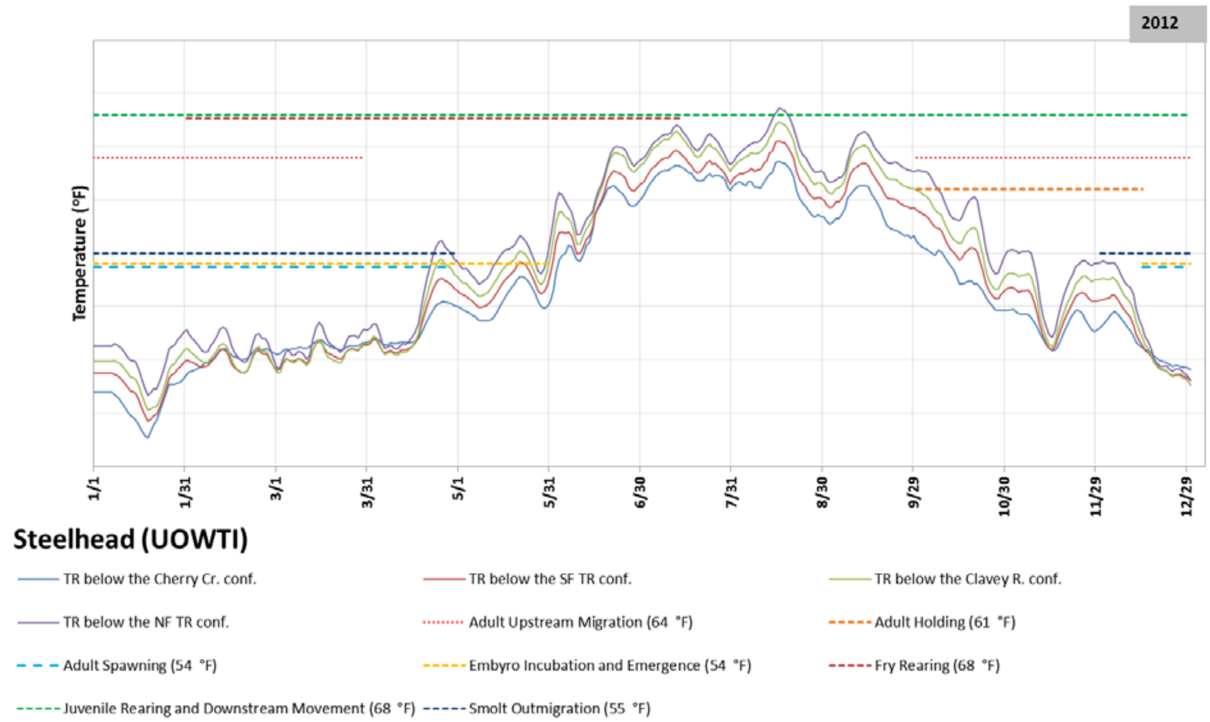

Figure B-19. **Upper Optimum Water Temperature Index (UOWTI) for Steelhead superimposed on the 2012 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

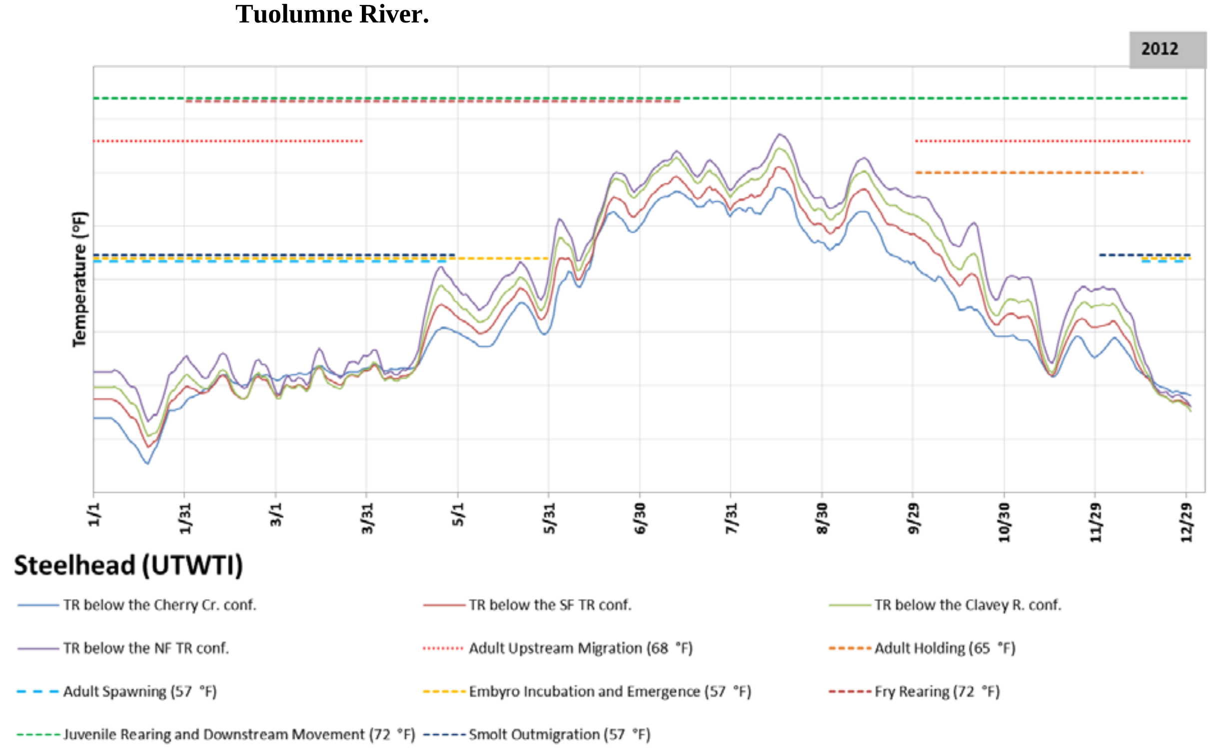

Figure B-20. **Upper Tolerable Water Temperature Index (UTWTI) for Steelhead superimposed on the 2012 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

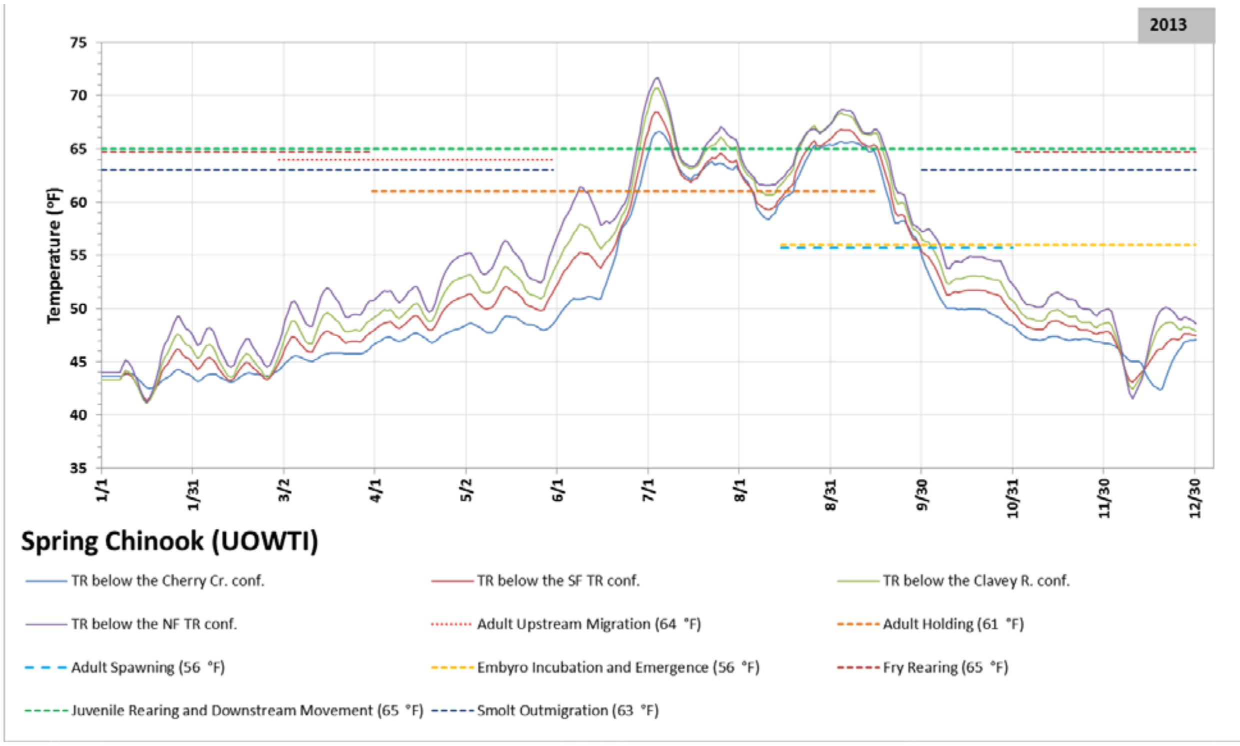

Figure B-21. **Upper Optimum Water Temperature Index (UOWTI) for spring-run Chinook salmon superimposed on the 2013 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

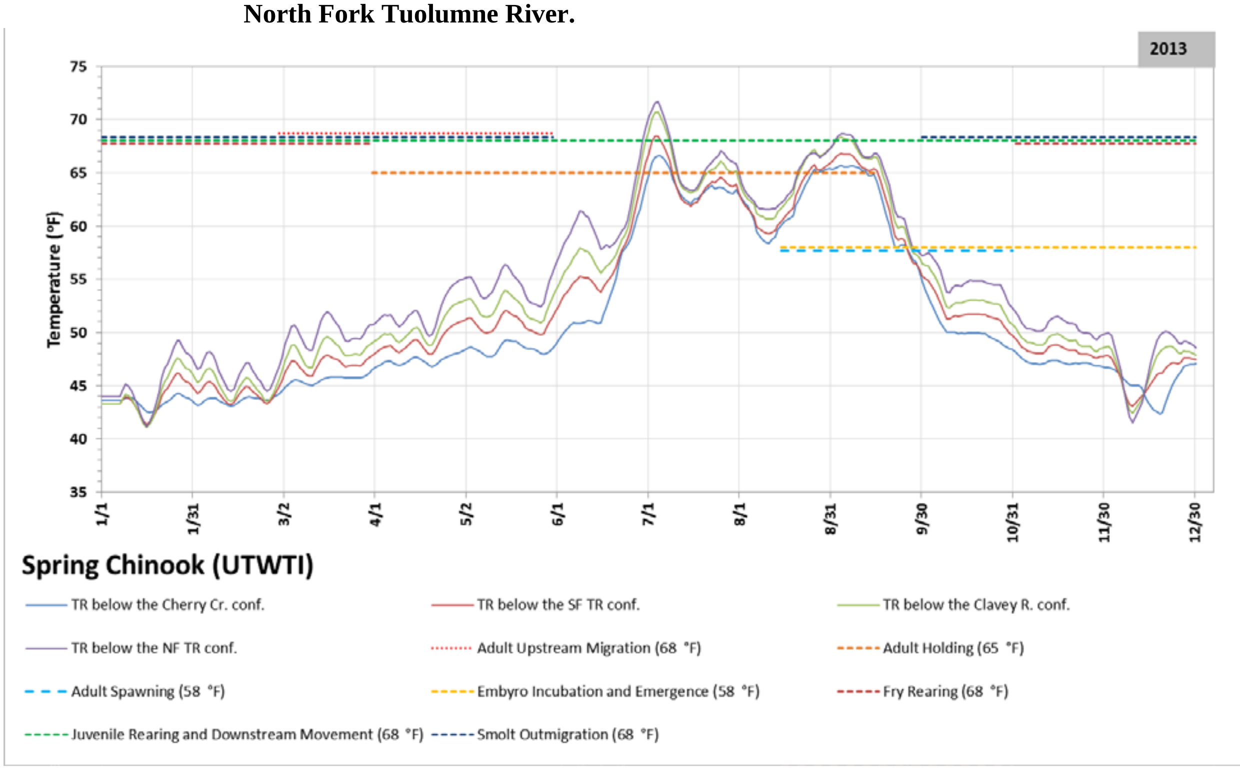

Figure B-22. **Upper Tolerable Water Temperature Index (UTWTI) for spring-run Chinook salmon superimposed on the 2013 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

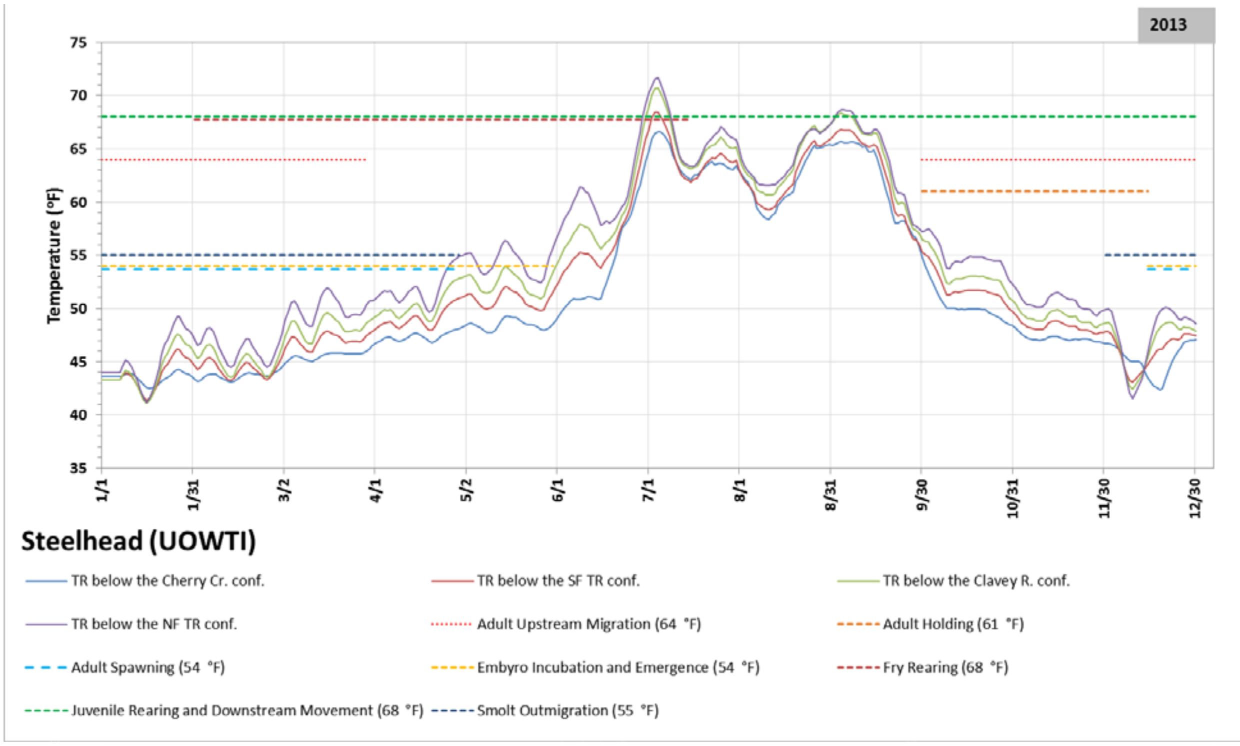

Figure B-23. **Upper Optimum Water Temperature Index (UOWTI) for Steelhead superimposed on the 2013 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

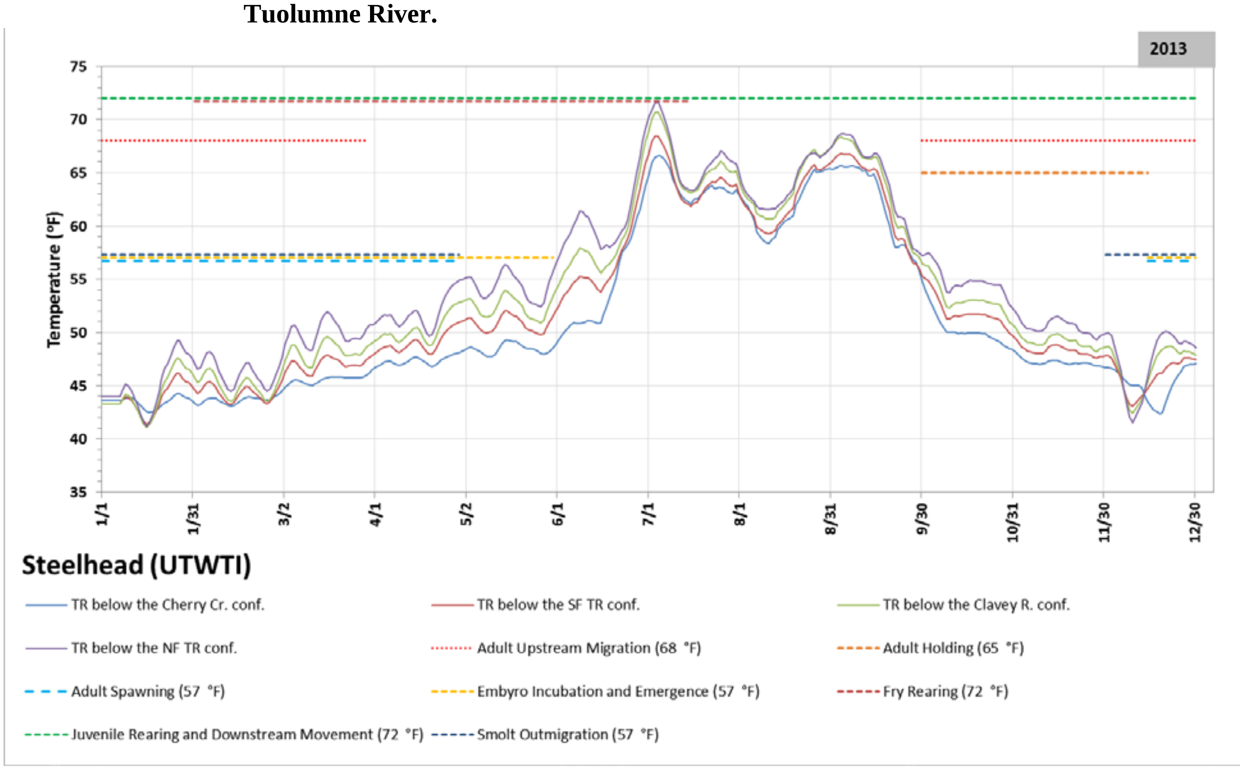

Figure B-24. **Upper Tolerable Water Temperature Index (UTWTI) for Steelhead superimposed on the 2013 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

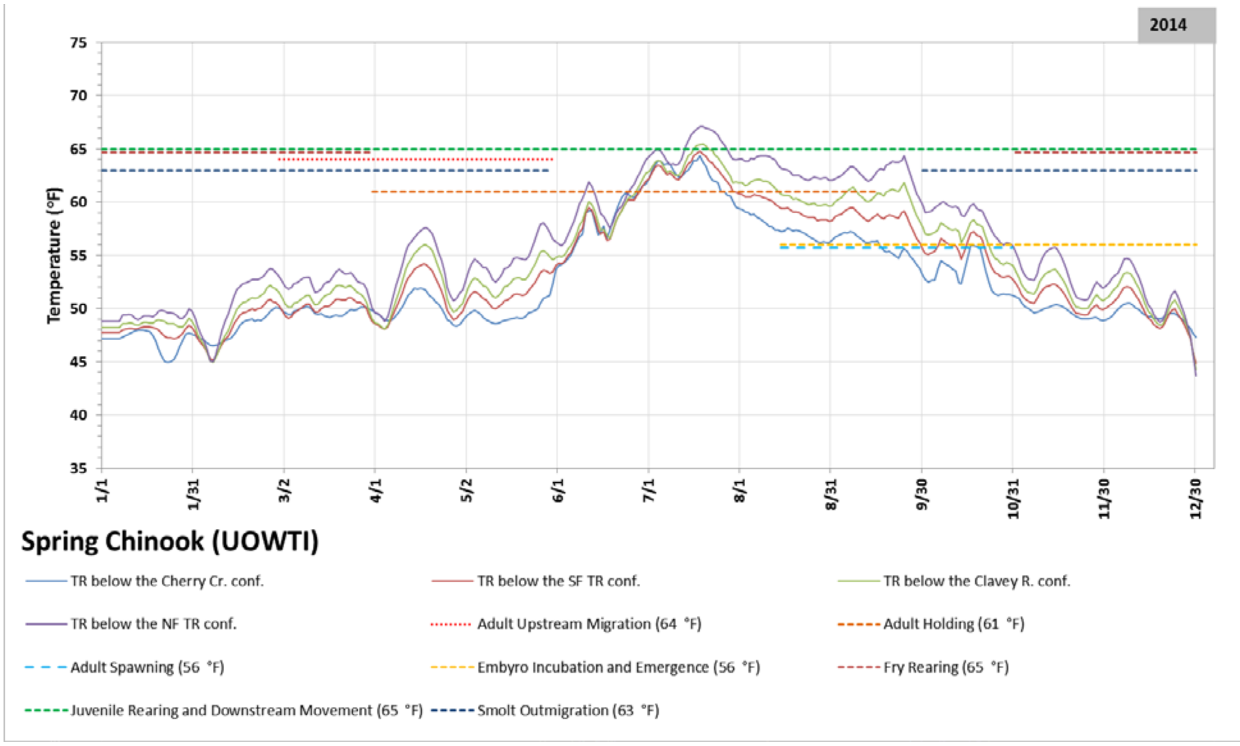

Figure B-25. **Upper Optimum Water Temperature Index (UOWTI) for spring-run Chinook salmon superimposed on the 2014 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

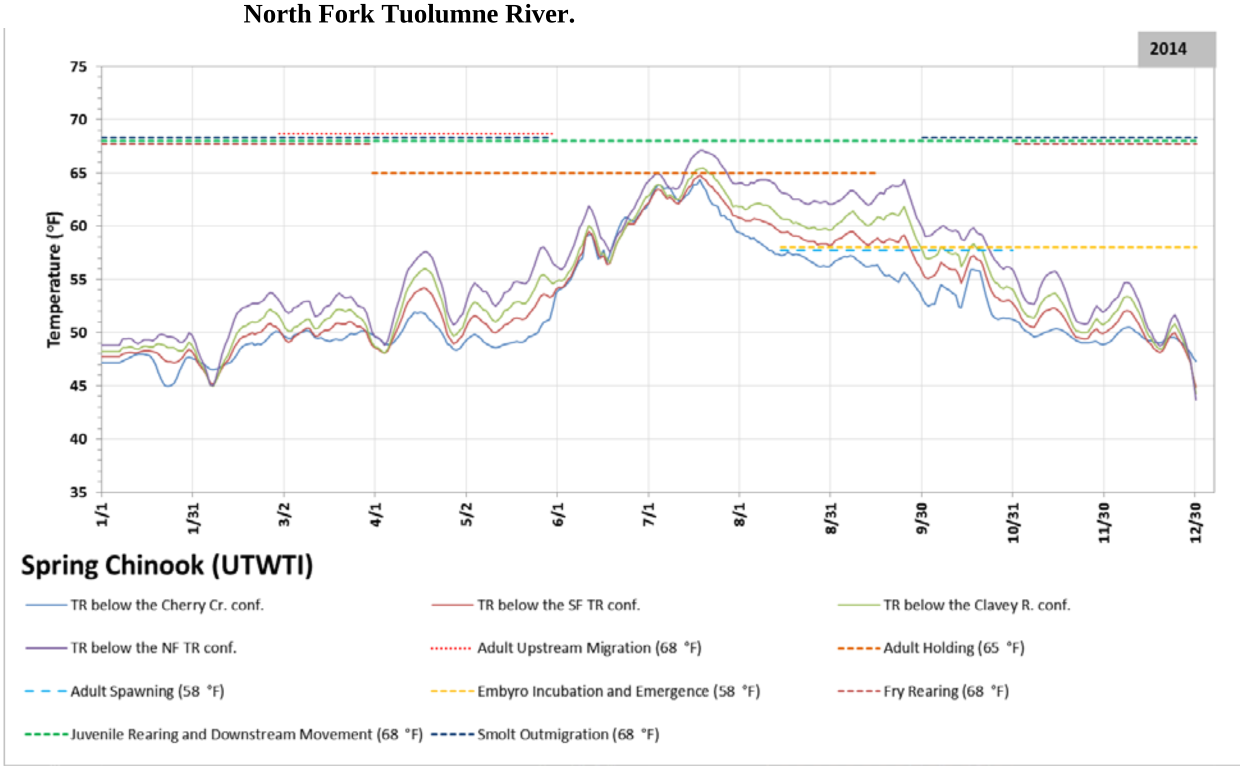

Figure B-26. **Upper Tolerable Water Temperature Index (UTWTI) for spring-run Chinook salmon superimposed on the 2014 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

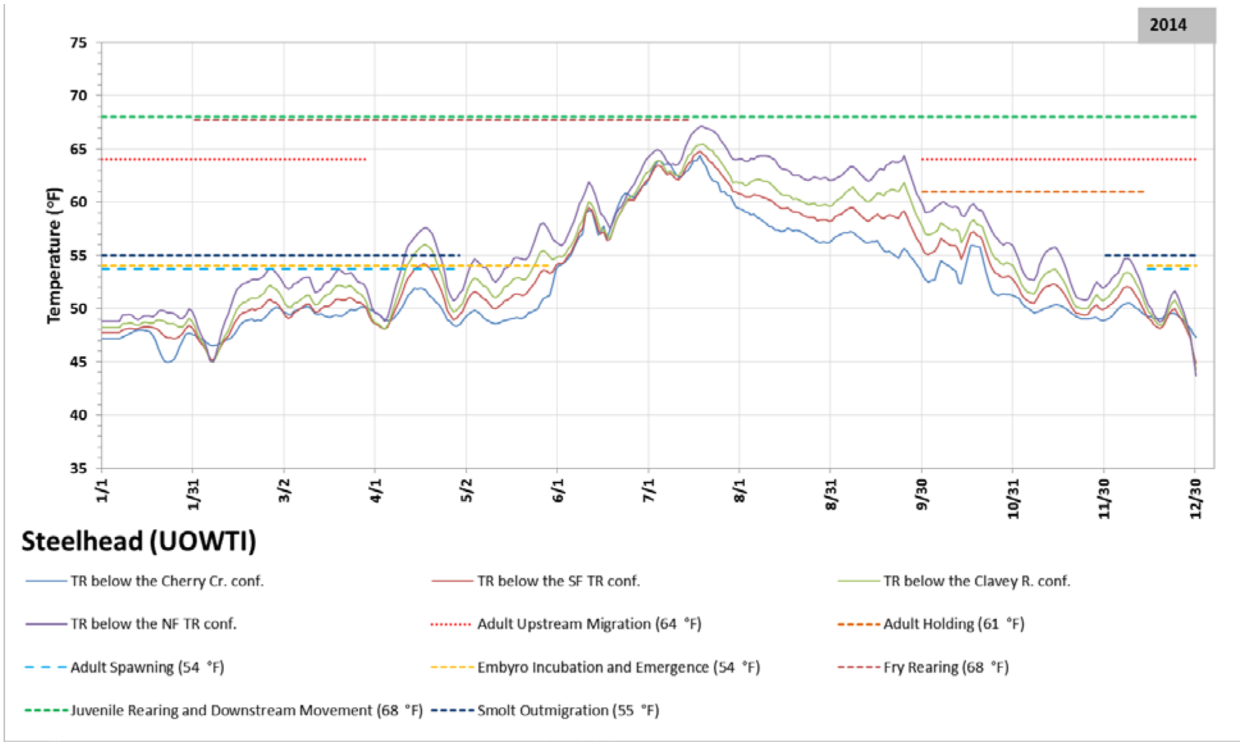

Figure B-27. **Upper Optimum Water Temperature Index (UOWTI) for Steelhead superimposed on the 2014 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

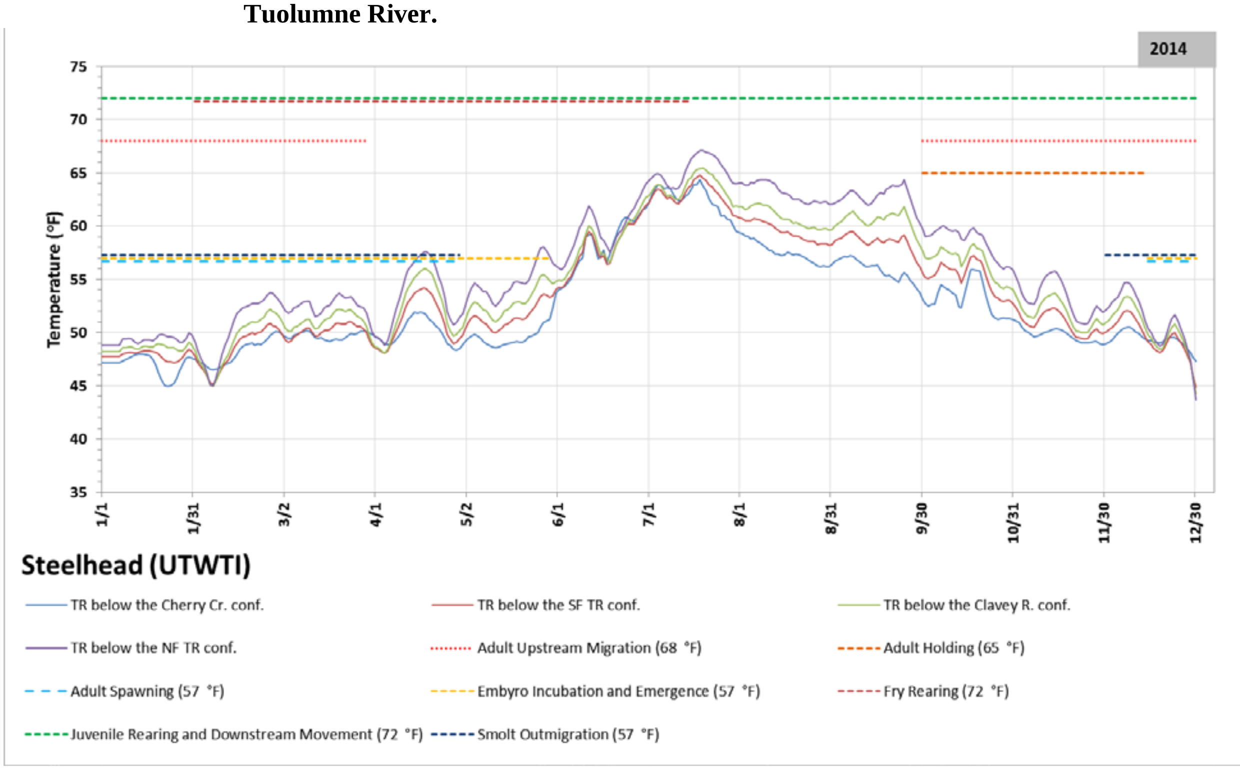

Figure B-28. **Upper Tolerable Water Temperature Index (UTWTI) for Steelhead superimposed on the 2014 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

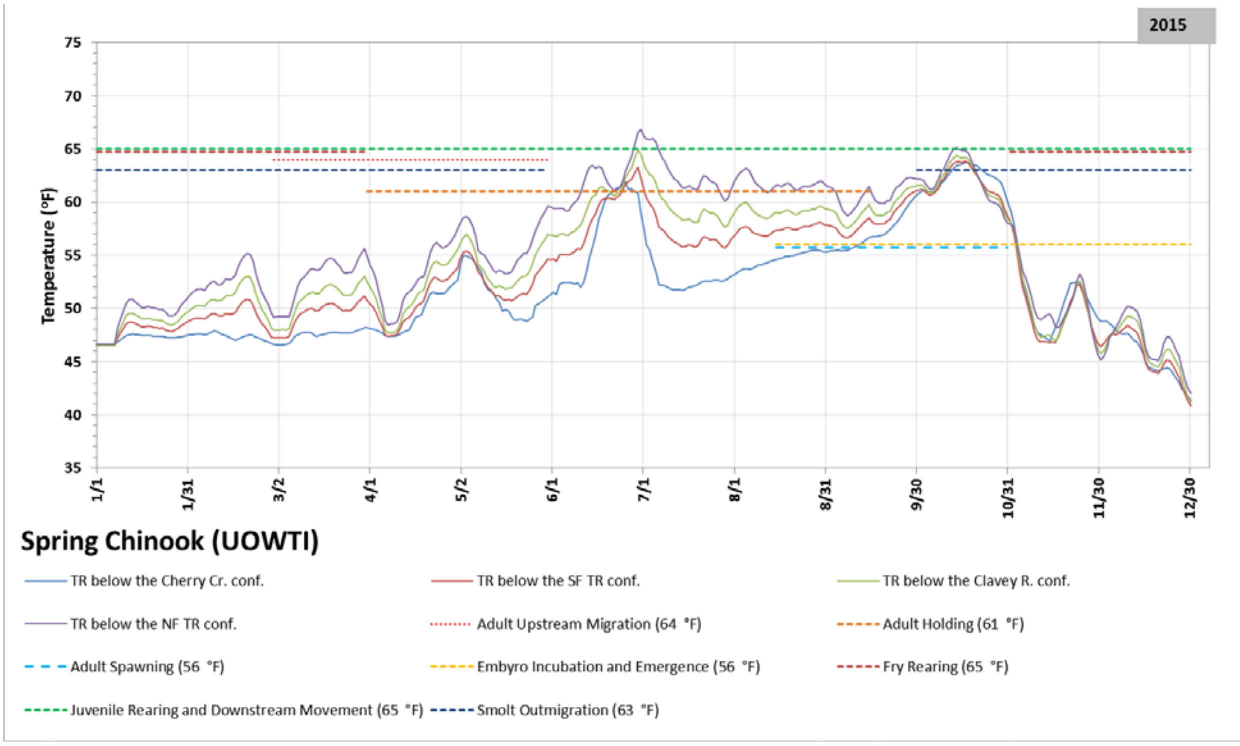

Figure B-29. **Upper Optimum Water Temperature Index (UOWTI) for spring-run Chinook salmon superimposed on the 2015 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

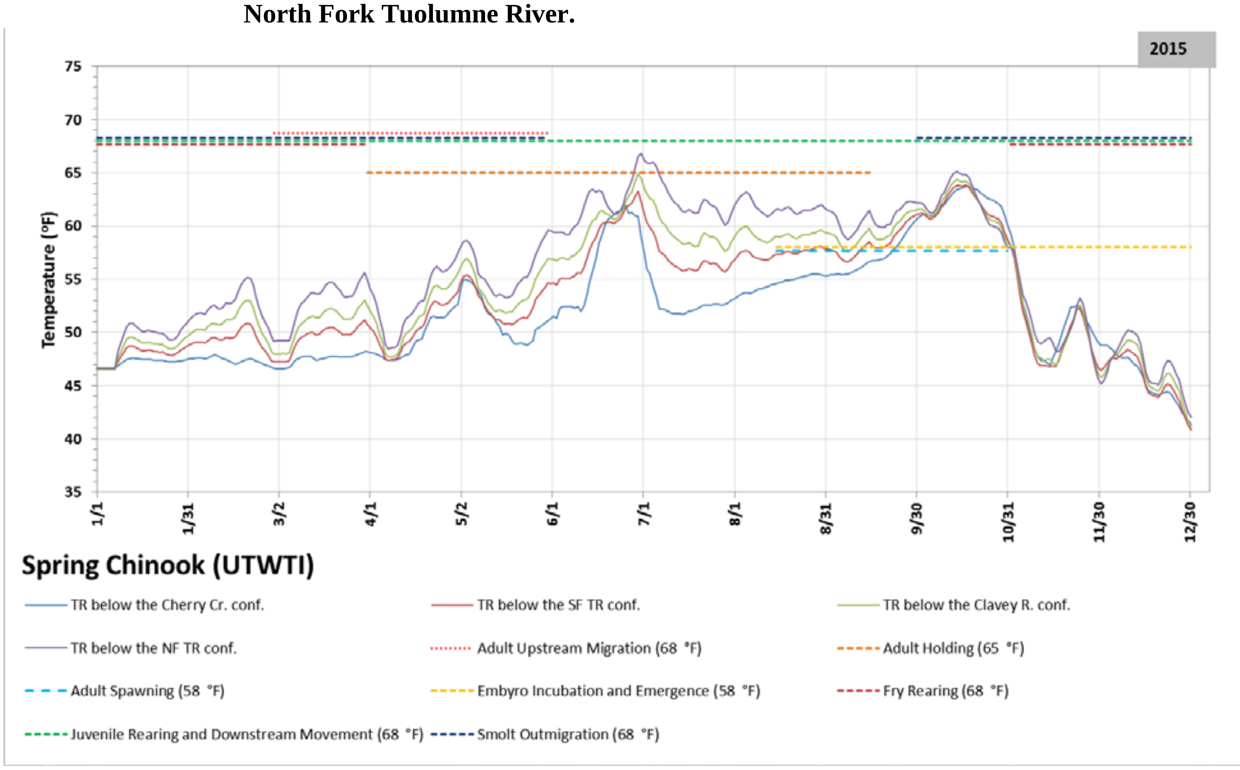

Figure B-30. **Upper Tolerable Water Temperature Index (UTWTI) for spring-run Chinook salmon superimposed on the 2015 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

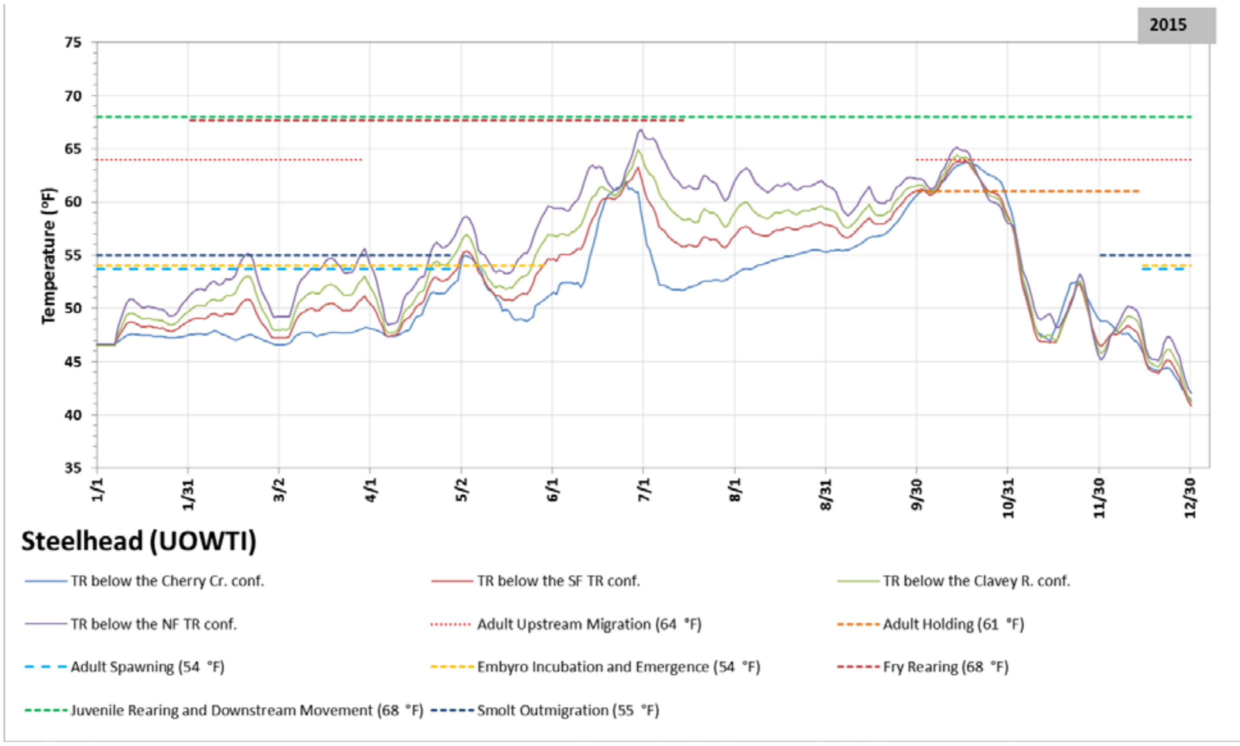

Figure B-31. Upper Optimum Water Temperature Index (UOWTI) for Steelhead superimposed on the 2015 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.

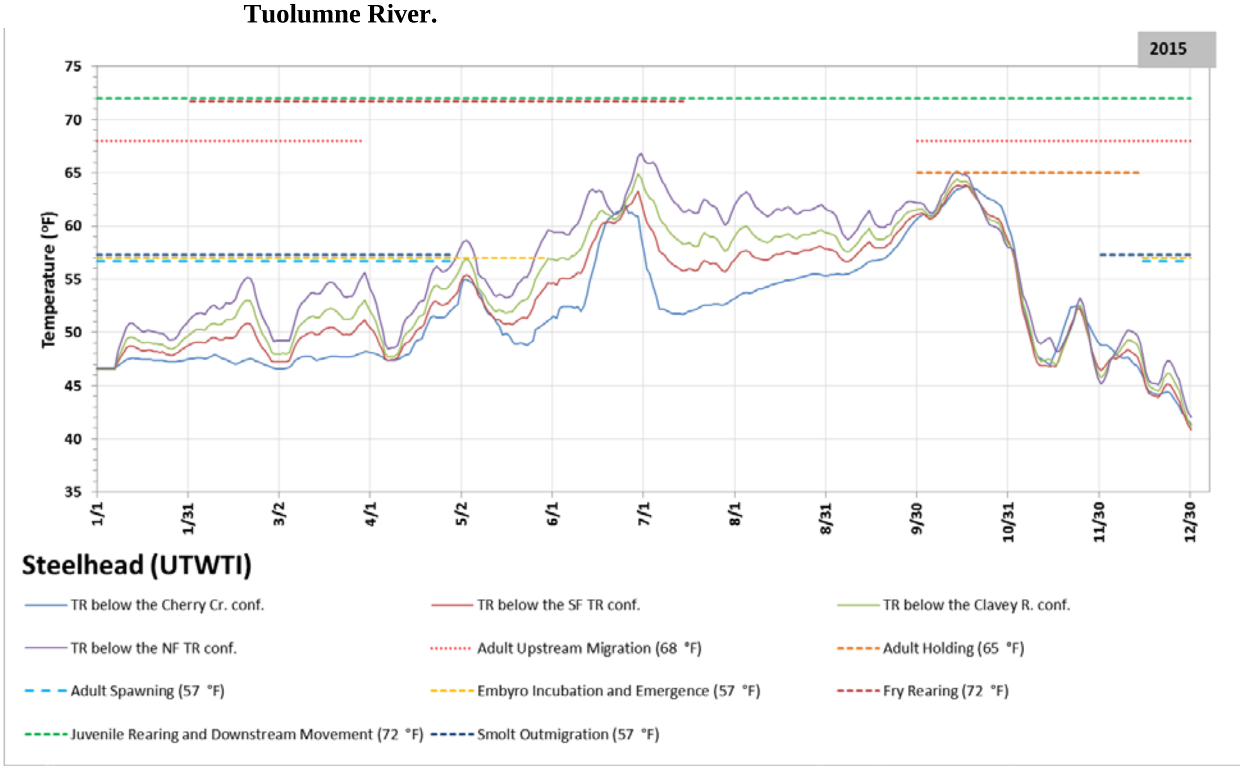

Figure B-32. Upper Tolerable Water Temperature Index (UTWTI) for Steelhead superimposed on the 2015 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.

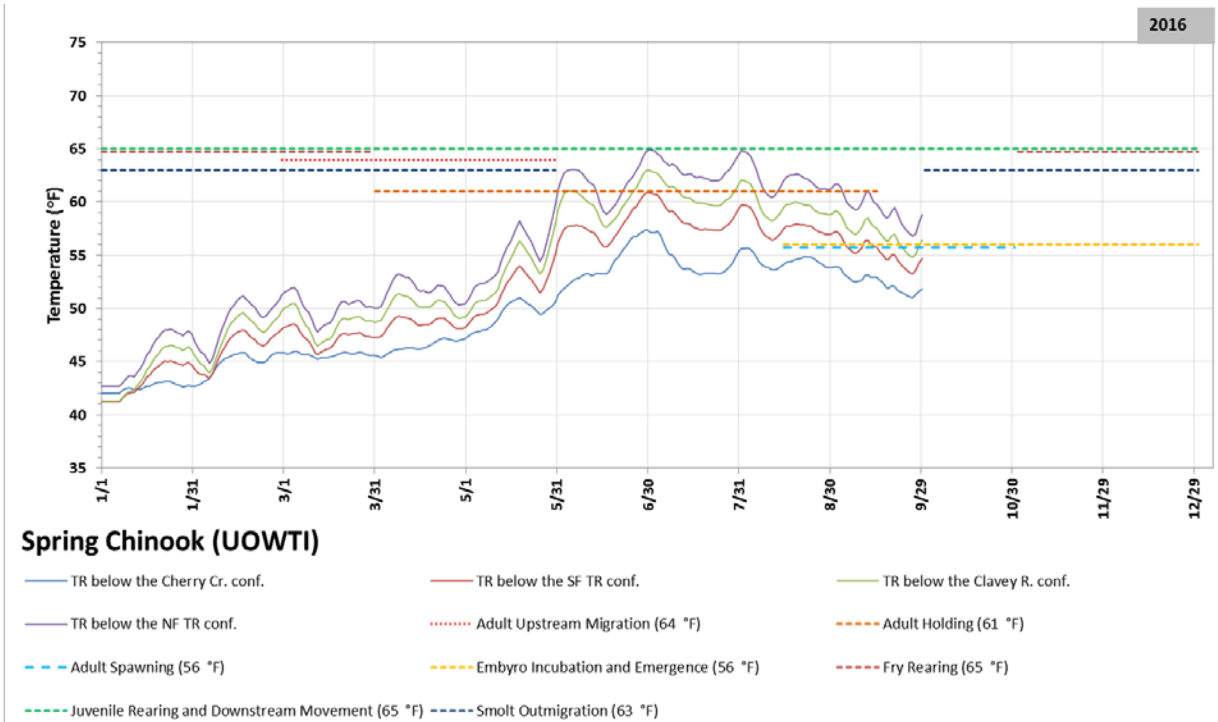

Figure B-33. **Upper Optimum Water Temperature Index (UOWTI) for spring-run Chinook salmon superimposed on the 2016 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

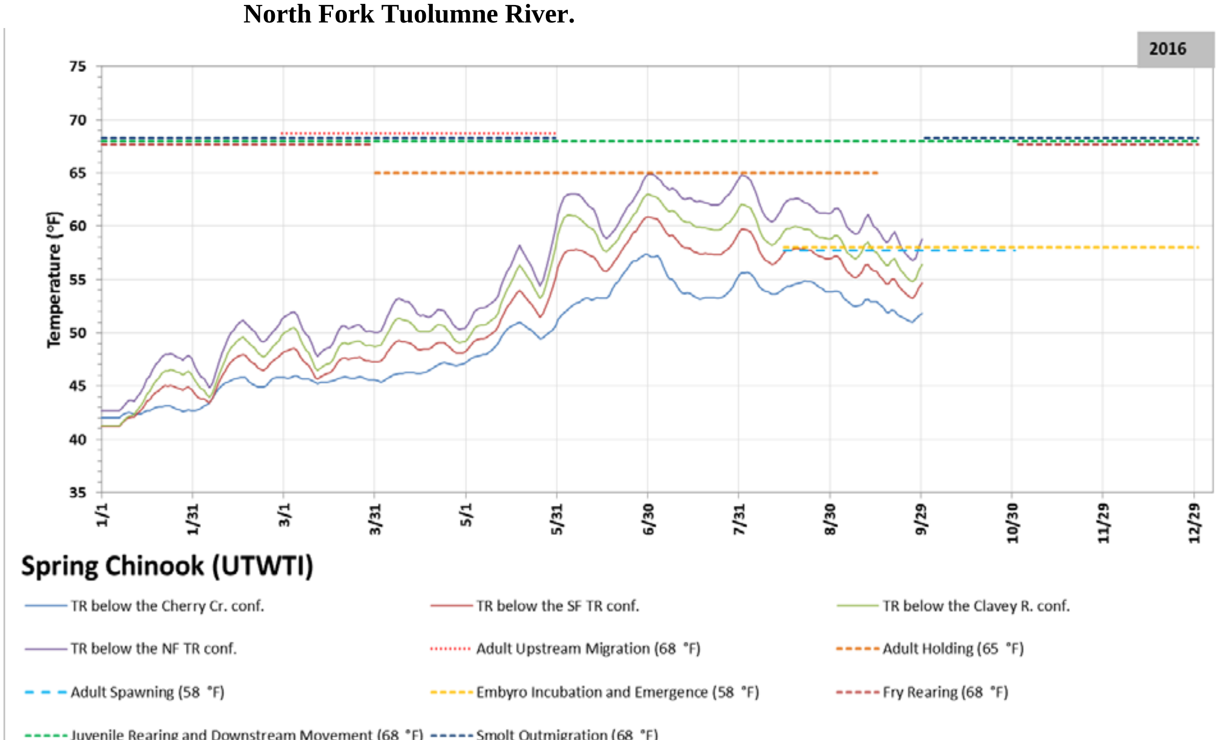

Figure B-34. **Upper Tolerable Water Temperature Index (UTWTI) for spring-run Chinook salmon superimposed on the 2016 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

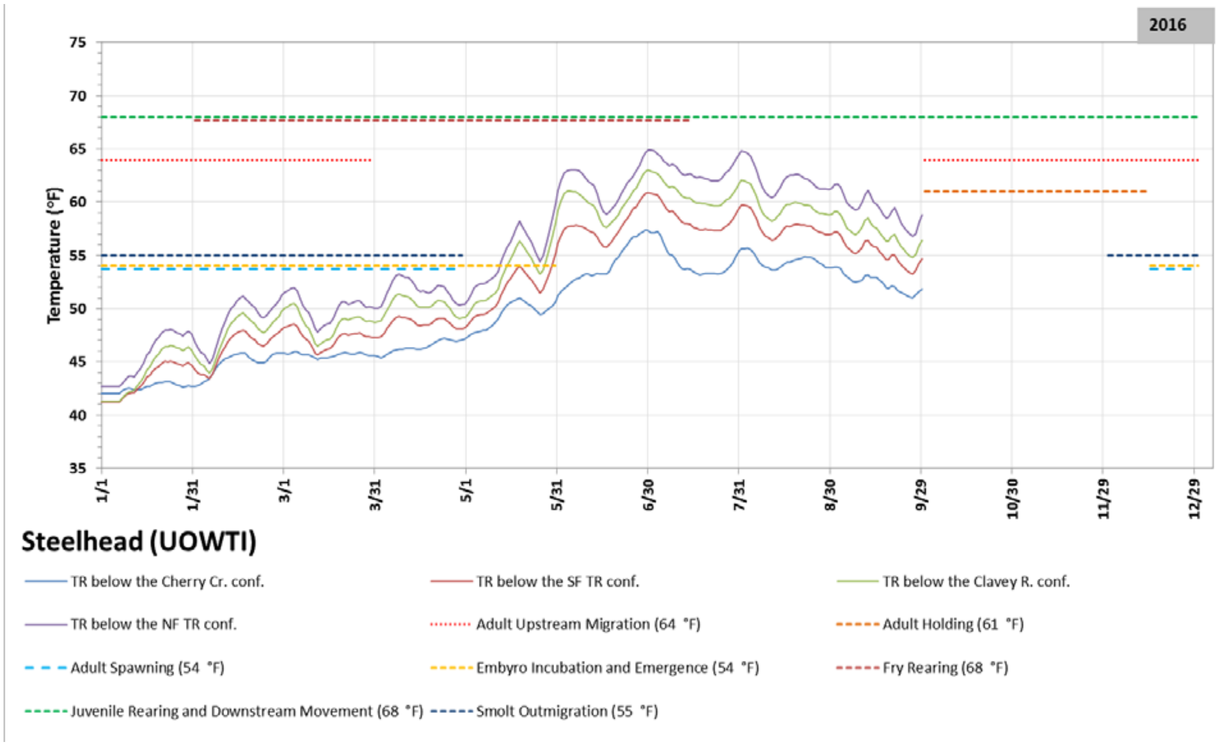

Figure B-35. **Upper Optimum Water Temperature Index (UOWTI) for Steelhead superimposed on the 2016 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**

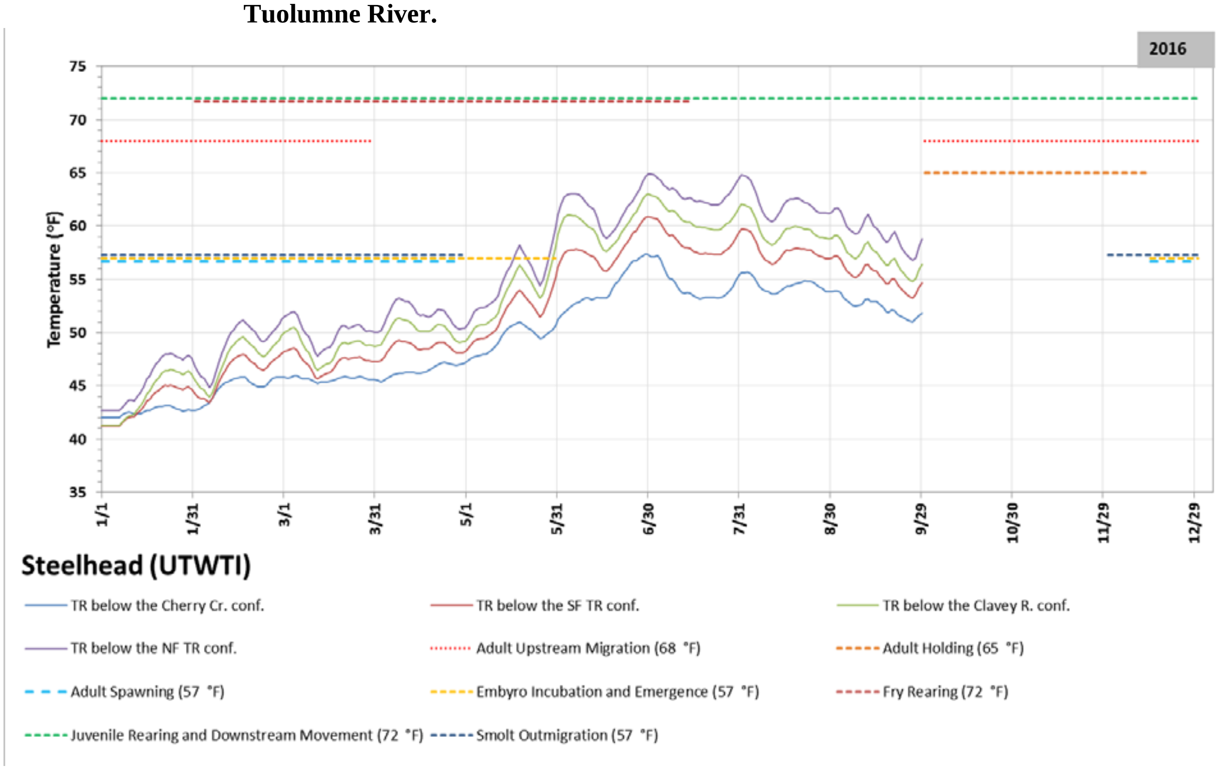

Figure B-36. **Upper Tolerable Water Temperature Index (UTWTI) for Steelhead superimposed on the 2016 Simulated Tuolumne River Temperatures below Cherry Creek Confluence, below South Fork Tuolumne River, below Clavey River and below North Fork Tuolumne River.**