

**SALMONID REDD MAPPING
2014/2015 AND 2015/2016 MONITORING REPORT
DON PEDRO PROJECT
FERC NO. 2299**



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

Prepared by:
FISHBIO

September 2017

This Page Intentionally Left Blank.

Salmonid Redd Mapping 2014/2015 and 2015/2016 Monitoring Report

TABLE OF CONTENTS

Section No.	Description	Page No.
1.0	Study Goals and Objectives	1-1
2.0	Study Area	2-1
3.0	Methodology	3-1
3.1	Redd Mapping.....	3-1
3.2	River Conditions	3-3
3.3	Comparison of Redd Counts and Densities Between Gravel Augmentation and Control Sites.....	3-4
4.0	Results	4-1
4.1	Redd Counts.....	4-1
4.1.1	2014/2015 Monitoring Season.....	4-1
4.1.2	2015/2016 Monitoring Season.....	4-3
4.2	River Conditions	4-6
4.2.1	2014/2015 Monitoring Season.....	4-6
4.2.2	2015/2016 Monitoring Season.....	4-7
4.3	Redd Characteristics	4-8
4.3.1	2014/2015 Monitoring Season.....	4-8
4.3.2	2015/2016 Monitoring Season.....	4-9
4.4	Spawning Distribution and Use of Gravel Augmentation Sites	4-11
4.4.1	2014/2015 Monitoring Season.....	4-11
4.4.2	2015/2016 Monitoring Season.....	4-13
5.0	Discussion and Findings	5-1
5.1	Chinook Salmon.....	5-1
5.2	<i>O. mykiss</i>	5-3
6.0	References.....	6-1

List of Figures

Figure No.	Description	Page No.
Figure 2.0-1.	Map of the study area.....	2-2
Figure 3.1-1.	Schematic of the redd measurement locations.....	3-3
Figure 4.1-1.	Weekly number of observed new Chinook salmon redds in the surveyed reaches of the lower Tuolumne River during 2014/2015.	4-2
Figure 4.1-2.	Weekly number of observed new <i>O. mykiss</i> redds in the surveyed reaches of the lower Tuolumne River during 2014/2015.	4-3
Figure 4.1-3.	Weekly number of observed new Chinook salmon redds in the surveyed reaches of the lower Tuolumne River during 2015/2016.	4-4
Figure 4.1-4.	Weekly number of observed new <i>O. mykiss</i> redds in the surveyed reaches of the lower Tuolumne River during 2015/2016.	4-6
Figure 4.2-1.	Daily mean water temperatures in the lower Tuolumne River and mean daily flow (cfs) at La Grange (LGN) during the 2014/2015 survey period.....	4-7
Figure 4.2-2.	Daily mean water temperatures in the lower Tuolumne River and mean daily flow (cfs) at La Grange (LGN) during the 2015/2016 survey period.....	4-8
Figure 4.3-1.	Total redd area for Chinook and <i>O. mykiss</i> during the 2015/2016 monitoring season.	4-11
Figure 4.4-1.	Chinook salmon redd distribution by river mile on the lower Tuolumne River during 2014/2015.	4-12
Figure 4.4-2.	Areal densities of Chinook salmon redds in the 88 riffles on the lower Tuolumne River during 2014/2015.....	4-12
Figure 4.4-3.	Chinook salmon redd distribution by river mile on the lower Tuolumne River during 2015/2016. Reach 4 was not surveyed due to excessive water hyacinth that blocked access.	4-13
Figure 4.4-4.	Areal densities of Chinook salmon redds in the 88 riffles on the lower Tuolumne River during 2015/2016.....	4-14
Figure 5.1-1.	Total new Chinook redds observed in relation to previous years.	5-1
Figure 5.1-2.	Percent redd distribution by reach and year. Reach 4 was not surveyed in 2015 due to excessive water hyacinth growth that blocked access.	5-2
Figure 5.1-3.	Percentage of Chinook salmon redd superimposition in relation to previous years.	5-2
Figure 5.2-1.	Cumulative <i>O. mykiss</i> redd timing during years sampled from 2012-2015.	5-3

List of Tables

Table No.	Description	Page No.
Table 3.1-1.	Data collected to describe each identified redd.	3-1
Table 3.3-1.	Gravel augmentation projects in the lower Tuolumne River, 2002–2011.....	3-4
Table 4.1-1.	New Chinook salmon redds identified by reach and date during the 2014/2015 survey period.....	4-1

Table 4.1-2.	New <i>O. mykiss</i> redds identified by reach and date during the 2014/2015 survey period.....	4-2
Table 4.1-3.	New Chinook salmon redds identified by reach and date during the 2015/2016 survey period.....	4-4
Table 4.1-4.	New <i>O. mykiss</i> redds identified by reach and date during the 2015/2016 survey period.....	4-5
Table 4.3-1.	Physical size measurements of sampled Chinook salmon redds during the 2014/2015 survey period.....	4-8
Table 4.3-2.	Physical size measurements of sampled <i>O. mykiss</i> redds during the 2014/2015 survey period.....	4-9
Table 4.3-3.	Physical size measurements of sampled Chinook salmon redds during the 2015/2016 survey period.....	4-10
Table 4.3-4.	Physical size measurements of sampled <i>O. mykiss</i> redds during the 2015/2016 survey period.....	4-10

List of Attachments

Attachment A	Daily Mean Water Temperatures in the Tuolumne River during the 2014/2015 and 2015/2016 Monitoring Seasons
Attachment B	Chinook Salmon and <i>O. mykiss</i> Spawning Distribution on the Tuolumne River during the 2014/2015 and 2015/2016 Monitoring Seasons

1.0 STUDY GOALS AND OBJECTIVES

The purpose of this redd mapping study is to document the spatial distribution of fall-run Chinook salmon and *O. mykiss* redds in order to assist with quantifying the current spawning capacity and redd/recruit relationships of the lower Tuolumne River. This survey is not a FERC required study; however, the Districts voluntarily continued data collection in 2013-2015 in order to supplement data presented in the Don Pedro Hydroelectric Project amended Final License Application. The study effort utilized the same methodology as the FERC-approved 2012 Salmonid Redd Mapping Study (W&AR-08) (TID/MID 2013a).

2.0 STUDY AREA

The study area includes the Tuolumne River from La Grange Diversion Dam (RM 52) downstream to Santa Fe Bridge (RM 21.6), which encompasses the same area surveyed annually by the California Department of Fish and Wildlife (CDFW) to document Chinook salmon spawning. The study area was divided into four reaches (Figure 2.0-1), which correspond to the same reach designations used by CDFW:

- Reach 1: La Grange Diversion Dam (RM 52.0) to Basso Bridge (RM 47.5)
- Reach 2: Basso Bridge (RM 47.5) to Turlock Lake State Recreation Area (TLSRA) (RM 42.0)
- Reach 3: TLSRA (RM 42.0) to Hickman Bridge (RM 31.6)
- Reach 4: Hickman Bridge (RM 31.6) to Santa Fe Bridge (RM 21.6)¹

Downstream of RM 21.6, general habitat characteristics are not favorable to salmonid spawning as the river gradient decreases and the river bed becomes dominated by sand substrates.

¹ During the 2014/2015 sample period, Reach 4 was not regularly surveyed due to excessive water hyacinth growth that blocked boat passage at various locations throughout the reach. Surveys of this reach were only conducted opportunistically between October 18 and December 30, 2014 (weeks 7-13). During the 2015/2016 sample period, Reach 4 was not surveyed due to excessive water hyacinth growth that blocked boat passage at various locations throughout the reach.

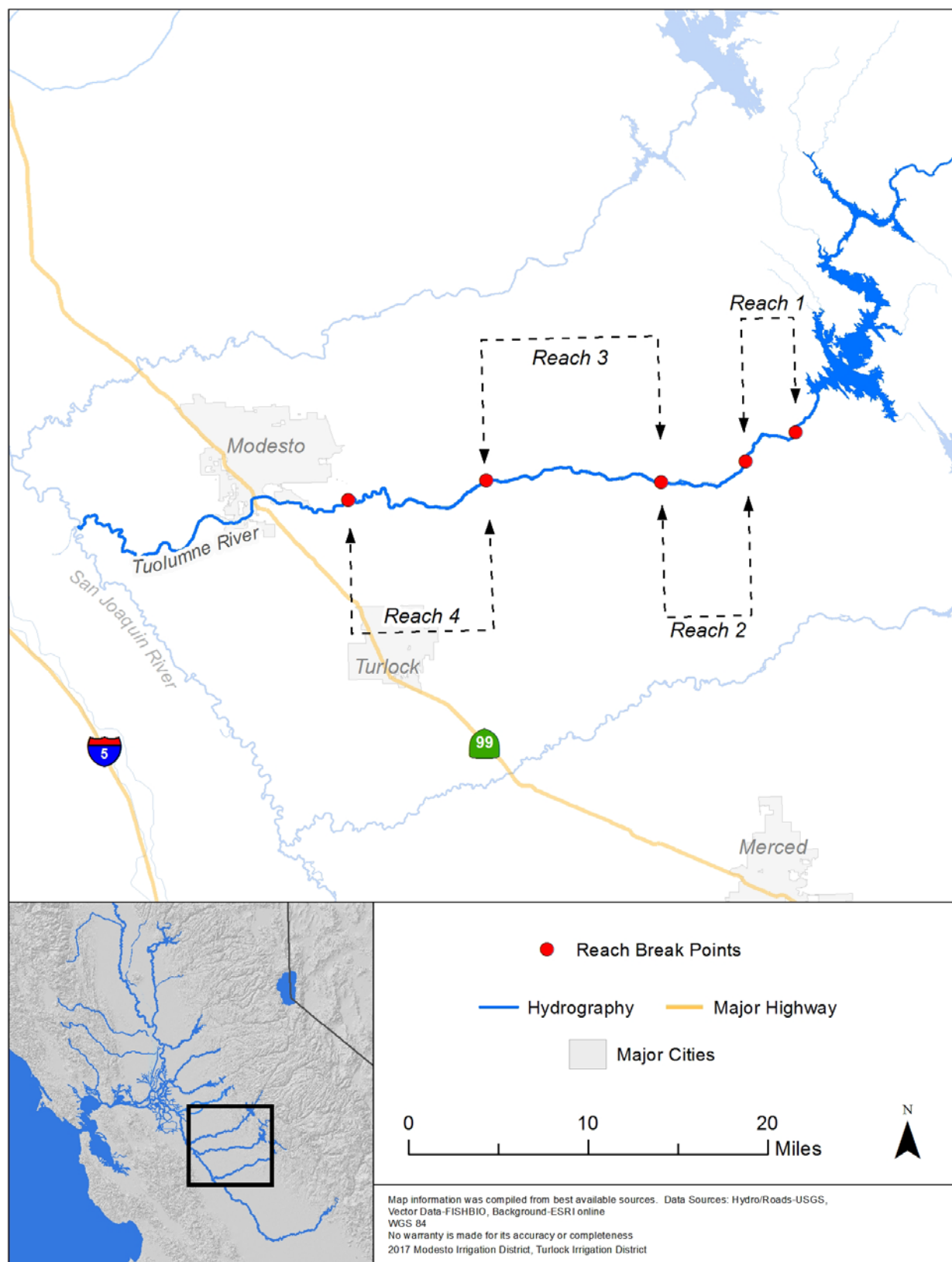


Figure 2.0-1. Map of the study area.

3.0 METHODOLOGY

3.1 Redd Mapping

Each survey was conducted from a 12-foot inflatable raft equipped with a rowing frame. One crew member stood at the front of the boat and surveyed for spawning activity as the boat maneuvered downstream. When the observer could not view the entire river width, the boat was stopped and both crew members surveyed by wading the riffle areas.

All visible redds were georeferenced (marked) using a GPS (Trimble; Geo-XH 6000) equipped with an external antenna (Trimble; Tornado), for sub-meter precision. The external antenna improved satellite reception and accuracy potential of post-processed data. GPS coordinates for each redd were recorded at the estimated egg pocket location. Care was taken to avoid impacting redds during the survey. Surveyors also documented redd status, presence of fish, and evidence of superimposition (Table 3.1-1).

To ensure consistency in field data collection, data dictionaries were constructed using GPS Pathfinder Office software (Trimble; Sunnyvale, CA), with fields outlining each required redd parameter. Data dictionaries were transferred to the GPS unit and opened within TerraSync Software (Trimble; Sunnyvale, CA). A minimum of 10 GPS points were required to record each redd position. GPS data were downloaded from the GPS unit to a desktop computer and post-processed using GPS Pathfinder Office software. To account for positional error due to various sources (e.g., atmospheric conditions, satellite distributions, GPS clock errors), GPS data were differentially corrected using the nearest reliable base data provider (CORS, Modesto COOP (CMOD), California). The GPS files were then exported to shapefile format and opened within ArcGIS software (ESRI; Redlands, CA), where data from previous events were appended to a single master file and stored within a File-Geodatabase. Mapped redd locations were overlaid onto mapped riffle habitats from the 2012 Spawning Gravel in the Lower Tuolumne River Study (W&AR-04) (TID/MID 2013b).

For each new redd marked, physical dimensions were recorded as described in Gallagher et al. (2009) (Figure 3.1-1). Redd measurements included pot length, pot width, tail spill length, and tail spill width. Measurements were recorded to the nearest 0.1 foot using a stadia rod. Measurements were not recorded for redds that were classified as “old” since most had already been measured when recorded as “new.” Older redds are often difficult to delineate due to aging and sediment transport, which tends to cause blending with surrounding substrate over time.

Table 3.1-1. Data collected to describe each identified redd.

Parameter	Attribute	Description
Redd Status	New	Signs of fresh digging activity, well developed pot and tail spill.
	Old	Redd fading, algae and/or redd flattening out but still visible.
	Incomplete	Not well developed, no defined pot or tail spill.
Superimposition	Yes	Evidence of superimposition with adjacent redd(s)
	No	No evidence of superimposition

Parameter	Attribute	Description
Fish Presence	Species	Chinook or <i>O. mykiss</i>
	Count	Number of fish observed actively guarding or constructing the identified redd.
Redd Characteristics	Depth	Water depth immediately upstream of the pot
	Velocity	Water velocity at 60% of depth immediately upstream of the pot.
	Substrate	Estimated median grain-size immediately upstream of the pot.
	Pot Length (P_L)	Total length of the pot parallel to streamflow, measured from the top to bottom edge.
	Pot Width (P_W)	Maximum width of the pot perpendicular to the stream flow or pot length. When the pot is irregularly shaped, estimate the total width as accurately as possible.
	Tail Spill Length (TS_L)	Total length of the tail spill parallel to the stream flow. Measured from the top edge of the middle of the pot to the bottom edge of the tail spill.
	Tail Spill Width 1 (TS_{W1})	Maximum width of the tail spill perpendicular to the stream flow or pot length; measured about one-third of the distance down from the top edge of the tail spill.
	Tail Spill Width 2 (TS_{W2})	Maximum width of the tail spill perpendicular to the stream flow or pot length; measured about two-thirds of the distance down from the top edge of the tail spill.

Total redd area was calculated as the horizontal plane of an ellipsoid encompassing the pot and tail spill areas.

$$Total\ Redd\ Area = \pi \frac{2(\sqrt{P_L \times TS_L})(P_L + TS_L)}{(\sqrt{P_L} + \sqrt{TS_L})} \left(\frac{P_W}{2} \right)$$

Disturbed redd area was calculated as the ellipsoidal area of the pot width and pot length.

$$Disturbed\ Redd\ Area = \frac{\pi (P_L \times P_W)}{4}$$

Depth and velocity measurements were recorded immediately upstream of the pot. Velocity measurements were taken using a FH950 portable velocity meter (Hach Company; Loveland, CO) at 60 percent of the depth and recorded in feet per second (ft/sec). Median grain size was visually estimated on the substrate immediately upstream of the pot.

The following criteria were used to determine whether redds were constructed by Chinook salmon or *O. mykiss*:

- Fish presence: Chinook salmon generally defend their redds for 1-2 weeks after building them, whereas *O. mykiss* do not defend their redds.
- Redd construction timing: Chinook salmon typically construct redds between November and January, whereas *O. mykiss* typically construct redds between January and March (McEwan 2001).

- Redd location: Chinook salmon usually construct redds in the middle of the channel, whereas *O. mykiss* redds are usually closer to cover such as cut banks and overhanging trees (Giovannetti et.al 2013).
- Gravel size: Chinook salmon construct redds in larger gravel sizes than *O. mykiss* (Giovannetti et al. 2013).
- Redd size: Chinook salmon redds are larger than *O. mykiss* redds (Reynolds et al. 1990).

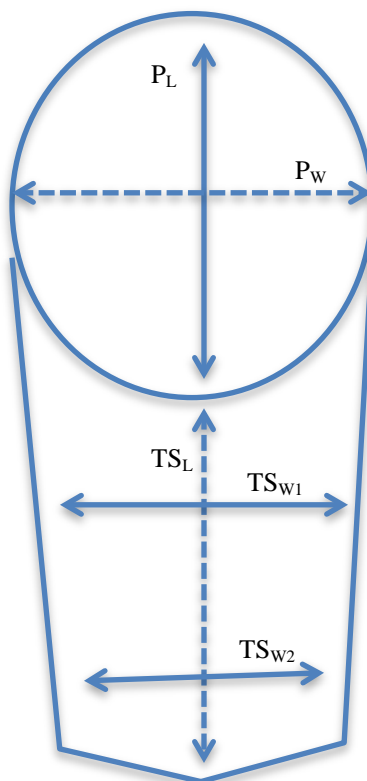


Figure 3.1-1. Schematic of the redd measurement locations.

River miles used in calculations (RMC) of mileage were produced by creating a line feature that traced the river's path from the most current ESRI online stock imagery available when this report was produced. The line feature was then split into 1/10th of mile increments, and numbered starting at the confluence of the San Joaquin River. It should be noted that U.S. Department of the Interior, Geological Survey (USGS) river miles generally are not indicative of actual mileage, and are typically used to reference locations rather than actual distance. USGS river miles are only available in whole numbers; any fractional references have been estimated by splitting the distance between mile markers into 10 equal segments, rather than actual 1/10th of a mile increments.

3.2 River Conditions

Provisional daily average flow data for the Tuolumne River at La Grange were obtained from USGS at http://waterdata.usgs.gov/ca/nwis/uv/?site_no=11289650&agency_cd=USGS. Water temperature data were obtained from hourly-recording Hobo Pro v2 water temperature data

loggers (Onset Computer Corporation) at eight sites from La Grange powerhouse (RM 52) to Santa Fe Bridge (RM 21.6), which are maintained by the Districts under their real-time monitoring program. Daily mean water temperatures for these eight sites from October 2014 through April 2015 and October 2015 through April 2016 are included in Attachment A.

3.3 Comparison of Redd Counts and Densities Between Gravel Augmentation and Control Sites

As directed under the 1995 Tuolumne River Settlement Agreement and 1996 FERC Order, the Tuolumne River Technical Advisory Committee (TRTAC) developed 10 priority habitat restoration projects separated into three classes based on the individual project goals and type of restoration activity: (1) channel and riparian restoration, (2) predator isolation, and (3) sediment management (TID/MID 2005). Gravel augmentation projects aimed at improving spawning gravel availability and quality in the lower Tuolumne River began in 1999. Approximately 73,250 yds³ of spawning gravel were added through projects implemented by CDFW, United States Fish and Wildlife Service, and Friends of the Tuolumne from 2002 to 2011 (CDWR 2004, TID/MID 2005, 2006, 2007, McBain and Trush 2013) (Table 3.3-1).

Table 3.3-1. Gravel augmentation projects in the lower Tuolumne River, 2002–2011.

Location (RM)	Year	Volume, yd ³
50.0 to 50.7	2002	9,600
50.0 to 50.7	2003	5,330
43	2005	11,000
51	2005	10,820
43	2011	17,500
51	2011	19,000

During the present study, 88 riffles were identified from river mile 52.0 to 23.6, and Chinook redd densities were calculated for each riffle throughout the entire study period (sum of all unique redds). Redd densities were calculated using the total number of redds observed on each riffle divided by the area (in square feet) of the riffle. Redd densities in the six restored riffles were compared with densities of redds in unrestored riffles. Unrestored riffles were selected for comparison if they were located within 1 river mile of any restored riffle, which resulted in 10 unique riffles used for this comparison.

4.0 RESULTS

A summary of all data collected during the 2014/2015 and 2015/2016 monitoring seasons is presented below.

4.1 Redd Counts

4.1.1 2014/2015 Monitoring Season

Bi-weekly redd mapping surveys were conducted in Reaches 1 through 3 between October 7, 2014, and April 16, 2015. Surveys in Reach 4 were conducted opportunistically between October 18 and December 30, 2014, and were expected to capture the peak of Chinook spawning activity. A total of 337 completed Chinook salmon redds were documented, of which 307 (91.1 percent) were observed between November 2 and December 30, and only 5 redds (1.5 percent) were observed prior to November 2 (Table 4.1-1). An additional 70 Chinook salmon redds were classified as incomplete. Peak spawning in all survey reaches occurred during the week of November 16, when 142 new Chinook salmon redds were identified (Figure 4.1-1). Twenty-five new Chinook redds were identified during the January to April time period. These redds were classified as Chinook redds based on either the presence of fish or similar size to redds identified earlier in the spawning season.

Table 4.1-1. New Chinook salmon redds identified by reach and date during the 2014/2015 survey period.

Survey Week ¹	Survey Dates	Reach				Grand Total	Percent
		1 (52.0-47.4)	2 (47.4-42.0)	3 (42.0-31.6)	4 (31.6-22.0)		
6	10/7	2	--	--	--	2	0.6%
8	10/22-10/23	3	0	--	--	3	0.9%
10	11/3-11/6	13	6	7	--	26	7.7%
12	11/18-11/21	57	40	43	2	142	42.1%
14	12/1-12/5	15	19	34	10	78	23.1%
16	12/15-12/18	19	6	20	7	52	15.4%
18	12/28-12/30	7	1	0	1	9	2.7%
20	1/13-1/15	2	1	6	--	9	2.7%
23	1/26-1/28	0	1	5	--	6	1.8%
24	2/9-2/11	2	0	0	--	2	0.6%
26	2/24-2/26	1	0	0	--	1	0.3%
28	3/10-3/13	2	0	0	--	2	0.6%
30	3/24-3/26	0	0	2	--	2	1.6%
33	4/14-4/16	2	0	1	--	3	0.9%
Grand Total		125	74	118	20	337	--
Percent		37.1%	22.0%	35.0%	5.9%	--	--

¹ Survey week refers to the number of weeks starting the first full week of September (Week of September 7, 2014).

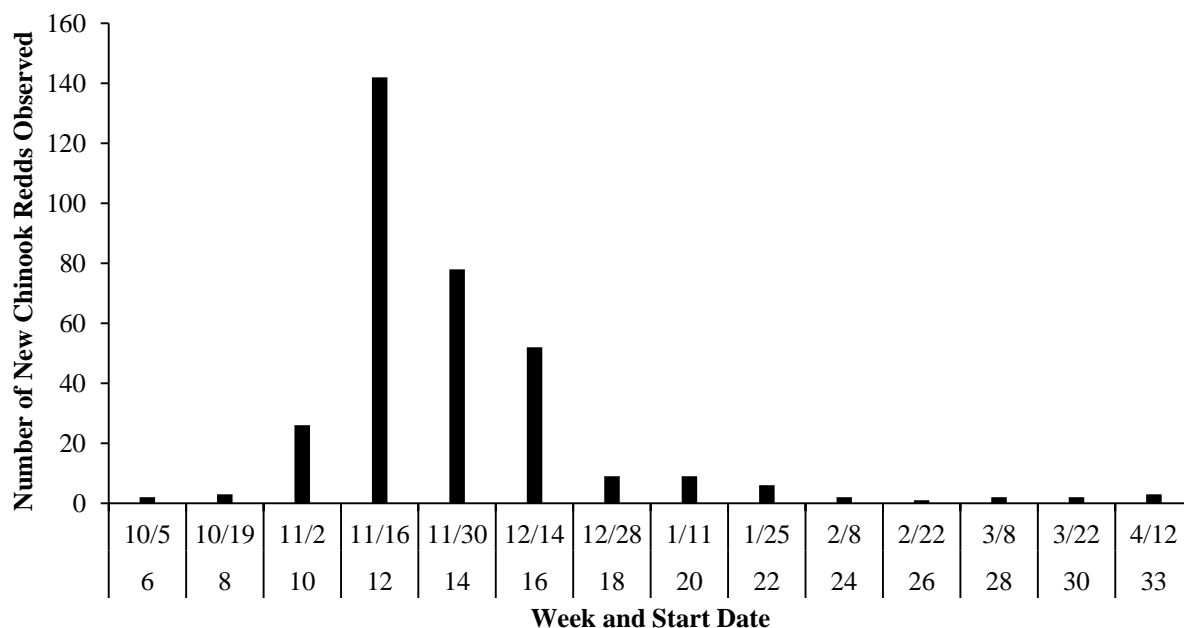


Figure 4.1-1. Weekly number of observed new Chinook salmon redds in the surveyed reaches of the lower Tuolumne River during 2014/2015.

A total of 41 *O. mykiss* redds were observed between October 7, 2014, and April 16, 2015. The first *O. mykiss* redds were observed on December 29, and peak observations occurred during the week of February 22, when 11 new redds were identified (Figure 4.1-2). *O. mykiss* spawning activity declined rapidly after mid-March, and the last redd was documented on March 26.

The highest abundance of observed *O. mykiss* redds occurred in Reach 2 (RM 47.4 to RM 42.0), accounting for 56.1 percent of the *O. mykiss* redds identified (Table 4.1-2). Seventy-six percent of *O. mykiss* redds were observed above RM 42. *O. mykiss* were observed to be actively constructing only three of the identified redds. No *O. mykiss* redds were identified below RM 34 during the 2014/2015 study period.

Table 4.1-2. New *O. mykiss* redds identified by reach and date during the 2014/2015 survey period.

Survey Week ¹	Survey Dates	Reach				Grand Total	Percent
		1 (52.0-47.4)	2 (47.4-42.0)	3 (42.0-31.6)	4 (31.6-22.0)		
6	10/7	0	--	--	--	0	0.0%
8	10/22–10/23	0	0	--	--	0	0.0%
10	11/3–11/6	0	0	0	--	0	0.0%
12	11/18–11/21	0	0	0	0	0	0.0%
14	12/1–12/5	0	0	0	0	0	0.0%
16	12/15–12/18	0	0	0	0	0	0.0%
18	12/28–12/30	0	3	0	0	3	7.3%
20	1/13–1/15	4	3	2	--	9	22.0%
23	1/26–1/28	0	1	1	--	2	4.9%
24	2/9–2/11	0	5	3	--	8	19.5%
26	2/24–2/26	2	8	1	--	11	26.8%

Survey Week ¹	Survey Dates	Reach				Grand Total	Percent
		1 (52.0-47.4)	2 (47.4-42.0)	3 (42.0-31.6)	4 (31.6-22.0)		
28	3/10–3/13	2	3	0	--	5	12.2%
30	3/24–3/26	0	0	3	--	3	7.3%
33	4/14–4/16	0	0	0	--	0	0.0%
Grand Total		8	23	10	--	41	--
Percent		19.5%	56.1%	24.4%	--	--	--

¹ Survey week refers to the number of weeks starting the first full week of September (Week of September 7, 2014).

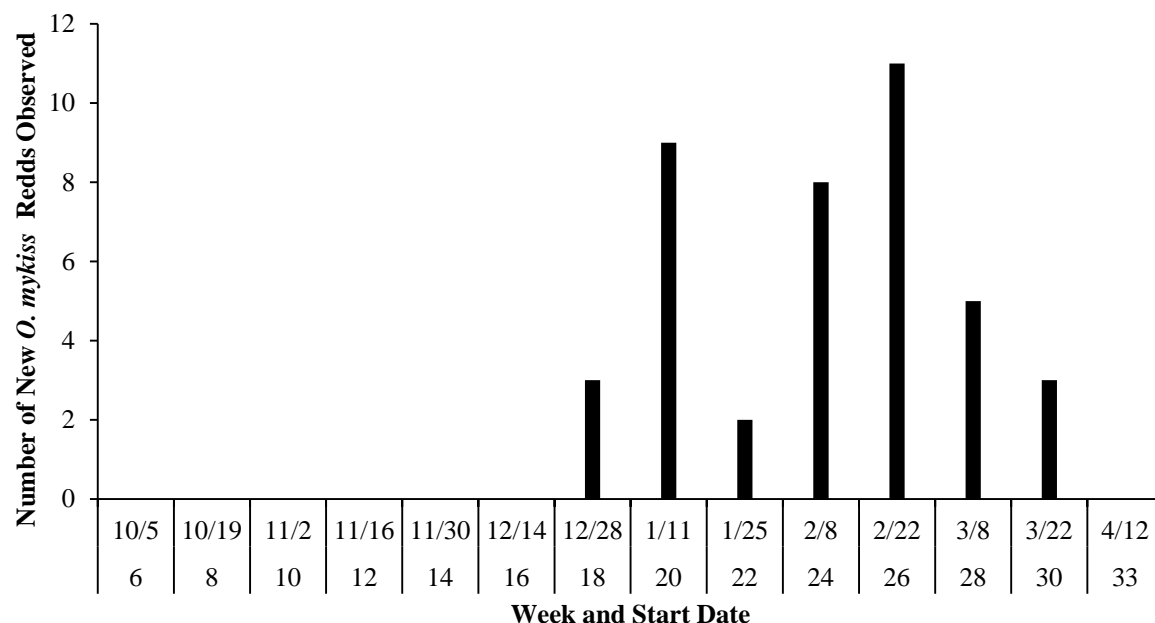


Figure 4.1-2. Weekly number of observed new *O. mykiss* redds in the surveyed reaches of the lower Tuolumne River during 2014/2015.

4.1.2 2015/2016 Monitoring Season

Bi-weekly redd mapping surveys were conducted in Reaches 1 through 3 between October 14, 2015, and April 6, 2016.

A total of 106 completed Chinook salmon redds were documented between October 14, 2015, and April 6, 2016, of which 101 (95.3 percent) were observed between November 3 and December 31, and no redds were observed prior to November 2, 2015 (Table 4.1-3). An additional 23 Chinook salmon redds were classified as incomplete. Peak spawning in all survey reaches occurred during the week of November 30, when 37 new Chinook salmon redds were identified (Figure 4.1-3). The highest abundance of observed salmon redds (45.3 percent) occurred in Reach 3 (RM 31.6 to RM 42.0); however, overall redd density was 4.6 redds/RM. Reach 1 (RM 47.5 to 52.0) had the second highest abundance (37.7 percent), but had higher density at 8.7 redds/RM. Five additional new Chinook redds were identified in January, and no Chinook redds were marked after January 26. Chinook redds marked after December 31 were

classified as Chinook redds based on either the presence of fish or similar size to redds identified earlier in the spawning season.

Table 4.1-3. New Chinook salmon redds identified by reach and date during the 2015/2016 survey period.

Survey Week ¹	Survey Dates	Reach				Grand Total	Percent
		1 (52.0-47.4)	2 (47.5-42.0)	3 (42.0-31.6)	4 ² (31.6-21.6)		
7	10/14	0	--	--	--	0	0.0%
9	10/27–10/28	0	0	--	--	0	0.0%
10	11/3–11/5	2	1	3	--	6	5.7%
12	11/16–11/18	14	7	7	--	28	26.4%
14	11/30–12/2	15	8	14	--	37	34.9%
16	12/14–12/16	3	0	14	--	17	16.0%
18	12/30–12/31	3	2	8	--	13	12.3%
20	1/11–1/15	1	0	2	--	3	2.8%
22	1/26–1/28	2	0	0	--	2	1.9%
24	2/8–2/9	0	0	0	--	0	0.0%
26	2/22–2/23	0	0	0	--	0	0.0%
28	3/9–3/10	0	0	0	--	0	0.0%
30	3/21–3/22	0	0	0	--	0	0.0%
32	4/5–4/6	0	0	0	--	0	0.0%
Grand Total		40	18	48	0	106	--
Redd Density		8.7	3.33	4.6	--	--	--
Percent		37.7%	17.0%	45.3%	0.0%	--	--

¹ Survey week refers to the number of weeks starting the first full week of September (Week of September 6, 2015).

² Reach 4 was not surveyed due to excessive water hyacinth growth that blocked boat passage at various locations throughout the reach.

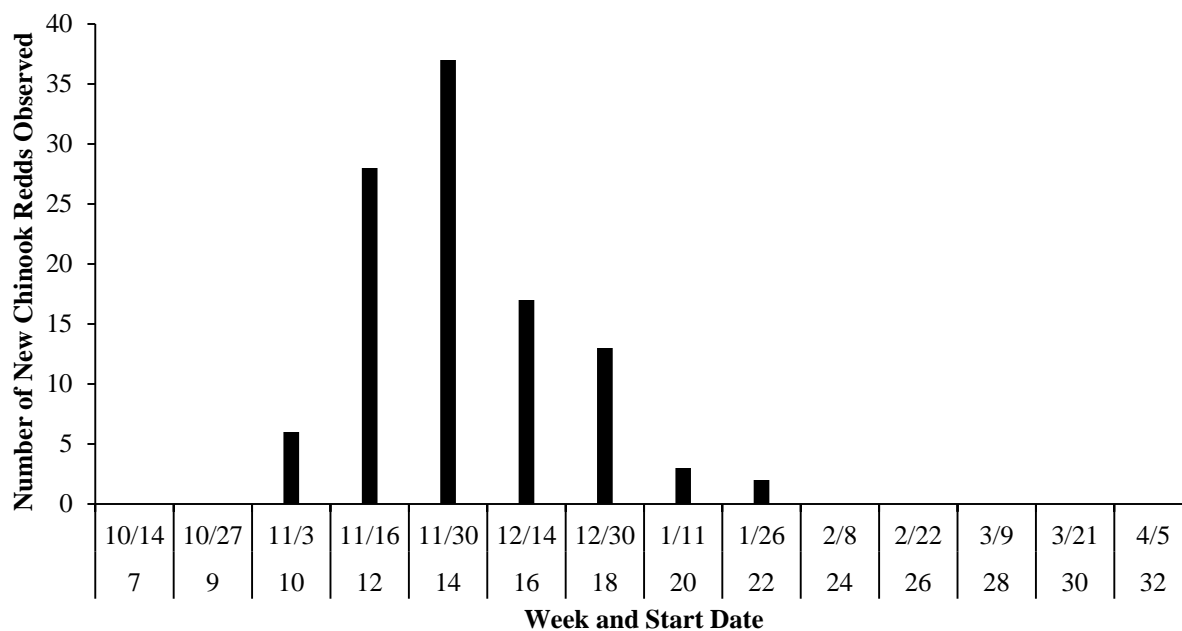


Figure 4.1-3. Weekly number of observed new Chinook salmon redds in the surveyed reaches of the lower Tuolumne River during 2015/2016.

A total of 36 *O. mykiss* redds were observed between October 14, 2015, and April 6, 2016. The first *O. mykiss* redds were observed on December 30, and peak observations occurred during the week of March 9, when nine new redds were identified (Figure 4.1-4). *O. mykiss* spawning activity declined after mid-March, and the last redd was documented on April 5. Spring pulse flow operations began the following week and continued through June, which prevented further redd surveys.

The highest abundance of observed *O. mykiss* redds occurred in Reach 2 (RM 47.5 to RM 42.0), accounting for 52.8 percent of the *O. mykiss* redds identified (Table 4.1-4). Seventy-seven percent of *O. mykiss* redds were observed above RM 42. *O. mykiss* were observed to be actively constructing only one redd during the season. No *O. mykiss* redds were identified below RM 34 during the 2015/2016 study period.

Table 4.1-4. New *O. mykiss* redds identified by reach and date during the 2015/2016 survey period.

Survey Week ¹	Survey Dates	Reach				Grand Total	Percent
		1 (52.0-47.5)	2 (47.5-42.0)	3 (42.0-31.6)	4 ² (31.6-22.0)		
7	10/14	0	--	--	--	0	0.0%
9	10/27-10/28	0	0	--	--	0	0.0%
10	11/3-11/5	0	0	0	--	0	0.0%
12	11/16-11/18	0	0	0	--	0	0.0%
14	11/30-12/2	0	0	0	--	0	0.0%
16	12/14-12/16	0	0	0	--	0	0.0%
18	12/30-12/31	0	1	0	--	1	2.8%
20	1/11-1/15	1	2	2	--	5	13.9%
22	1/26-1/28	0	0	2	--	2	5.6%
24	2/8-2/9	1	1	3	--	5	13.9%
26	2/22-2/23	1	6	1	--	8	22.2%
28	3/9-3/10	4	5	0	--	9	25.0%
30	3/21-3/22	2	2	0	--	4	11.1%
32	4/5-4/6	0	2	0	--	2	5.6%
Grand Total		9	19	8		36	
Percent		25.0%	52.8%	22.2%	0.0%	--	--

¹ Survey week refers to the number of weeks starting the first full week of September (Week of September 6, 2015)

² Reach 4 was not surveyed due to excessive water hyacinth growth that blocked boat passage at various locations throughout the reach

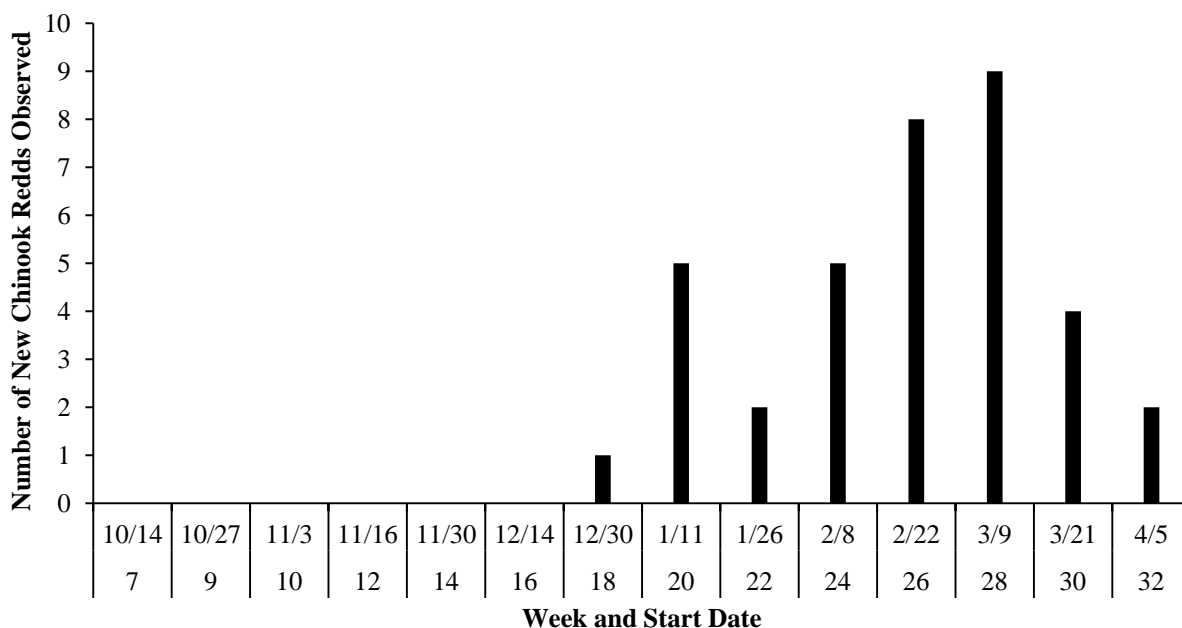


Figure 4.1-4. Weekly number of observed new *O. mykiss* redds in the surveyed reaches of the lower Tuolumne River during 2015/2016.

4.2 River Conditions

4.2.1 2014/2015 Monitoring Season

During the study period (October 7, 2014, through April 16, 2015), average daily flow recorded at the USGS gage at La Grange ranged from 105 to 1,420 cfs (Figure 4.2-1). Except for an early-April pulse flow period, flow at the La Grange gage was relatively constant at approximately 165 cfs throughout the entire study period. During the study period, average daily water temperatures near the bottom of Reach 1 (RM 49) ranged from 47.1° to 58.8°F (Figure 4.2-1). During the time period when the majority of salmon redds were detected (November 2, 2014, through December 18, 2014), mean daily water temperatures in Reach 1 ranged from 48.7° to 53.5°F, and averaged 51.8°F. Mean daily water temperatures at the bottom of Reach 3 (RM 31.6) between November 2, 2014, and December 2, 2014, (time period when majority of salmon redds were detected) ranged from 51.9° to 58.5°F, and averaged 55.5°F.

Mean daily water temperatures in Reach 1 during the *O. mykiss* study period (12/28/14–4/16/15) ranged from 47.1° to 55.3°F, and averaged 51.3°F. Mean daily water temperatures at the bottom of Reach 3 (RM 31.6) ranged from 45.2° to 66.0°F and averaged 55.9°F (Figure 4.2-1).

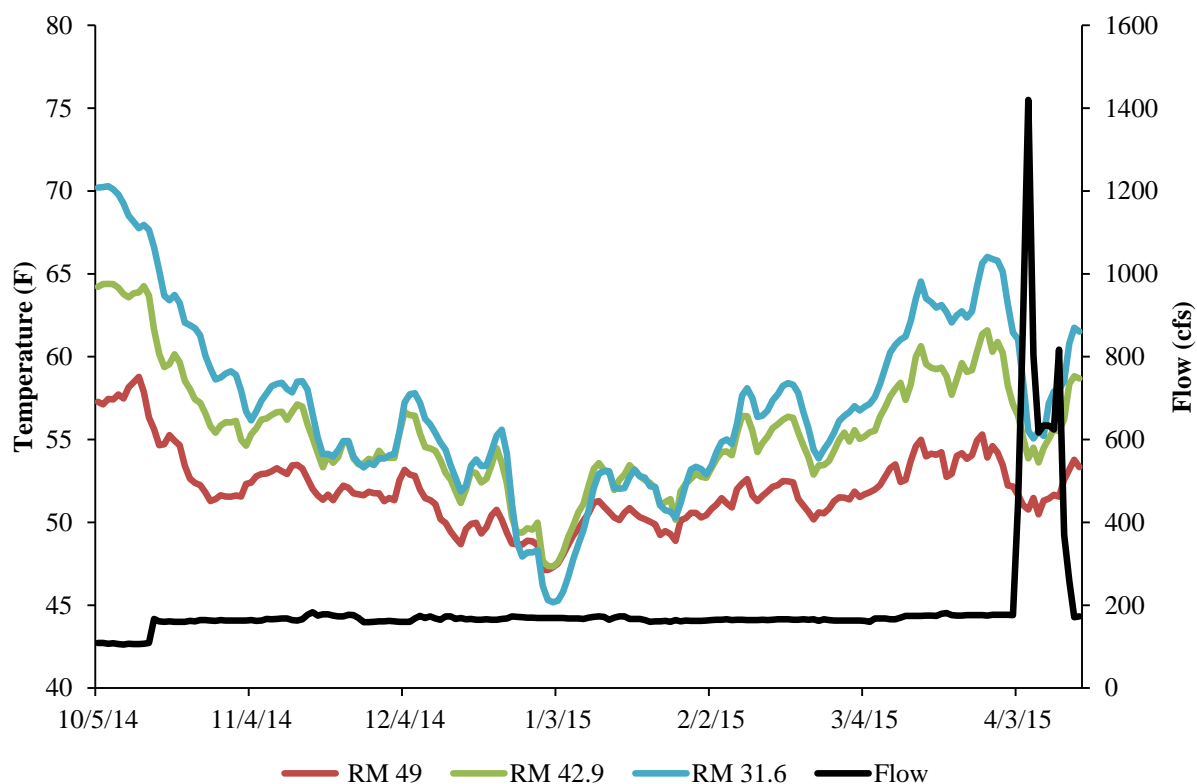


Figure 4.2-1. Daily mean water temperatures in the lower Tuolumne River and mean daily flow (cfs) at La Grange (LGN) during the 2014/2015 survey period.

4.2.2 2015/2016 Monitoring Season

During the study period (10/14/15–4/6/16) average daily flow recorded at the USGS gage at La Grange ranged from 116 to 186 cfs (Figure 4.2-2). Flow at the La Grange gauge was relatively constant at approximately 167 cfs throughout the entire study period. During the study period, average daily water temperatures near the bottom of Reach 1 (RM 42) ranged from 48.6° to 68.5°F (Figure 4.2-1). During the time period when the majority of salmon redds were detected in Reach 1 (November 16, 2015, through December 5, 2015), mean daily water temperatures in that area ranged from 50.5° to 55.1°F, and averaged 52.3°F. During the period when the majority of salmon redds were detected in Reach 3 (from November 30, 2015, through December 16, 2015), mean daily water temperatures at the bottom of the reach (RM 31.6) ranged from 47.5° to 54.1°F, and averaged 51.0°F near Hickman Bridge.

During the *O. mykiss* study period (December 30, 2015, through April 5, 2016), mean daily water temperatures near the bottom of Reach 1 (RM 42) ranged from 48.8° to 58.9°F, and averaged 54.2°F. Mean daily water temperatures at the bottom of Reach 3 (RM 31.6) ranged from 47.0° to 65.0°F and averaged 55.9°F (Figure 4.2-2).

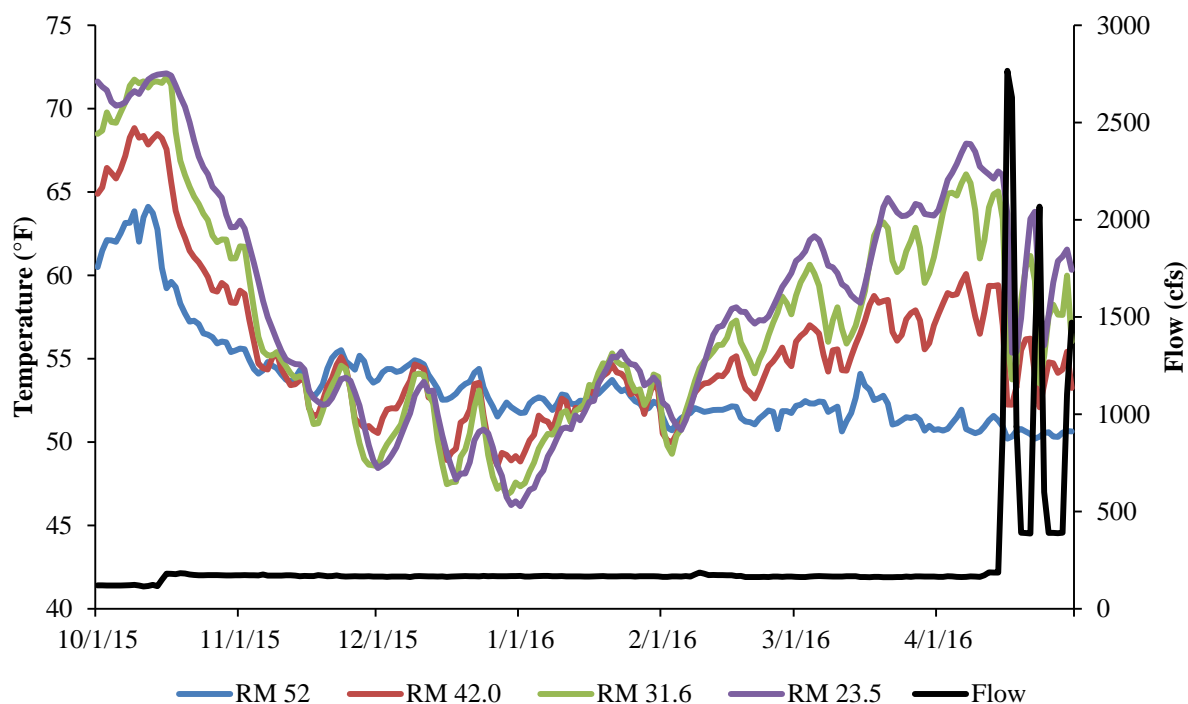


Figure 4.2-2. Daily mean water temperatures in the lower Tuolumne River and mean daily flow (cfs) at La Grange (LGN) during the 2015/2016 survey period.

4.3 Redd Characteristics

4.3.1 2014/2015 Monitoring Season

Redd characteristics were recorded for a sub-sample of identified Chinook salmon redds. Mean depth at Chinook salmon redd locations was 1.7 ft (range, 0.7–2.8 ft). Mean velocity was 1.8 ft/sec, (range 1.1–2.8 ft/sec). Median grain size (+1 S.D.) of identified *O. mykiss* redds was estimated to be 2.0 in \pm 0.5 in. Chinook salmon redd measurements indicated that the mean pot length was 5.3 ft \pm 1.6 ft and the mean pot width was 5.8 ft \pm 2.6 ft. The mean tail spill length was 7.3 ft \pm 2.8 ft, the mean tail spill width #1 was 5.8 ft \pm 1.7 ft, and the mean tail spill width #2 was 4.3 ft \pm 1.7 ft (Table 4.3-1).

Table 4.3-1. Physical size measurements of sampled Chinook salmon redds during the 2014/2015 survey period.

	Gravel Median Size (in)	Depth (ft)	Flow (ft/s)	Pot Depth (ft)	Pot Length (ft)	Pot Width (ft)	Tail Length (ft)	Tail Width #1 (ft)	Tail Width #2 (ft)
Sample Size	8	19	19	18	18	177	17	17	17
Max	2.5	2.8	2.8	2.9	8.0	14.0	13.0	11.0	8.0
Min	1.0	0.7	1.1	1.2	3.3	2.0	3.0	4.0	2.0
Avg	1.9	1.7	1.8	2.0	5.3	5.8	7.3	5.8	4.3
Median	2.0	1.6	1.8	2.0	4.9	5.5	6.0	5.0	3.8
Variance	0.2	0.3	0.3	0.2	2.5	6.8	7.5	3.7	2.8
Std Dev	0.5	0.6	0.5	0.5	1.6	2.6	2.8	2.0	1.7

Mean depth at *O. mykiss* redd locations was 1.0 ft, (range, 0.5–1.8 ft). Mean velocity was 2.1 ft/sec, (range 1.0–3.8 ft/sec). Median grain size (+1 S.D.) of identified *O. mykiss* redds was estimated to be 0.8 in \pm 0.4 in.

O. mykiss redd measurements indicated the mean pot length was 1.8 ft \pm 0.6 ft and the mean pot width was 1.7 ft \pm 0.6 ft. The mean tail spill length was 2.5 ft \pm 1.0 ft, the mean tail spill width #1 was 1.7 ft \pm 0.6 ft, and the mean tail spill width #2 was 1.1 ft \pm 0.5 ft (Table 4.3-2).

Table 4.3-2. Physical size measurements of sampled *O. mykiss* redds during the 2014/2015 survey period.

	Gravel Median Size (in)	Depth (ft)	Flow (ft/s)	Pot Depth (ft)	Pot Length (ft)	Pot Width (ft)	Tail Length (ft)	Tail Width #1 (ft)	Tail Width #2 (ft)
Sample Size	35	34	35	34	33	34	29	29	21
Max	2.3	1.8	3.8	1.9	3.4	3.0	6.0	3.3	2.3
Min	0.3	0.5	1.0	0.6	0.8	0.7	1.1	0.6	0.4
Avg	0.9	1.0	2.1	1.2	1.8	1.7	2.5	1.7	1.2
Median	0.8	1.0	1.9	1.1	2.0	1.6	2.5	1.7	1.1
Variance	0.2	0.1	0.5	0.1	0.4	0.4	0.9	0.4	0.2
Std Dev	0.4	0.3	0.7	0.3	0.6	0.6	1.0	0.6	0.5

The total redd areas for *O. mykiss* ranged from 2.17 ft² to 20.03 ft². Based on this range in *O. mykiss* redd size, it is likely that all spawning was by resident rather than anadromous *O. mykiss*, as average redd sizes for anadromous *O. mykiss* range from 57 ft² to 74.3 ft² (Shapovalov and Taft 1954; Wilson and Collins 1992). This is supported by weir monitoring on the Tuolumne River, which did not detect any *O. mykiss* passing upstream during the 2014/2015 monitoring season (Becker et al. 2015).

4.3.2 2015/2016 Monitoring Season

Redd characteristics were recorded for a sub-sample of identified Chinook salmon redds. Mean depth at Chinook salmon redd locations was 1.4 ft, (range, 0.5–3.2 ft). Mean velocity was 2.08 ft/sec, (range 0.99–3.9 ft/sec). Median grain size (+1 S.D.) of identified redds was estimated to be 1.75 in \pm 0.46 in.

Chinook salmon redd measurements indicated that the mean pot length was 5.4 ft \pm 2.6 ft and the mean pot width was 6.0 ft \pm 3.0 ft. The mean tail spill length was 6.6 ft \pm 2.7 ft, the mean tail spill width #1 was 5.4 ft \pm 2.3 ft, and the mean tail spill width #2 was 4.0 ft \pm 1.5 ft. The combined mean tail width was 4.5 ft \pm 1.8 ft (Table 4.3-3). Mean total redd area for Chinook salmon was 134.2 ft² \pm 113.5 ft², and mean disturbed redd area was 28.8 ft² \pm 3.3 ft².

Table 4.3-3. Physical size measurements of sampled Chinook salmon redds during the 2015/2016 survey period.

	Gravel Median Size (in)	Depth (ft)	Flow (ft/s)	Pot Depth (ft)	Pot Length (ft)	Pot Width (ft)	Tail Length (ft)	Tail Width #1 (ft)	Tail Width #2 (ft)
Sample Size	69	59	59	59	55	60	56	62	56
Max	2.8	3.7	3.9	3.7	14.0	14.0	12.0	12.0	9.0
Min	1.0	0.8	1.0	0.8	2.0	2.0	1.5	1.8	1.2
Avg	1.7	1.8	2.1	1.8	5.4	6.1	6.6	5.4	4.0
Median	1.8	1.7	2	1.7	5.0	5.5	6.5	4.8	3.6
Variance	0.2	0.3	0.5	0.3	6.7	9.4	7.5	5.2	2.1
Std Dev	0.5	0.5	07	0.5	2.6	3.1	2.7	2.3	1.5

Mean depth at *O. mykiss* redd locations was 1.0 ft, (range, 0.7–1.7 ft). Mean velocity was 2.2 ft/sec, (range 1.6–3.4 ft/sec). Median grain size (+1 S.D.) of identified *O. mykiss* redds was estimated to be 0.9 in \pm 0.3 in.

O. mykiss redd measurements indicated the mean pot length was 1.7 ft \pm 0.6 ft and the mean pot width was 1.7 ft \pm 0.7 ft. The mean tail spill length was 2.5 ft \pm 1.0 ft, the mean tail spill width #1 was 1.8 ft \pm 0.8 ft and the mean tail spill width #2 was 1.4 ft \pm 0.6 ft, the combined mean tail width was 1.6 ft \pm 0.7 ft (Table 4.3-4). Mean total redd area for *O. mykiss* was 20.1 ft² \pm 4.2 ft², and mean disturbed redd area was 2.6 ft² \pm 0.4 ft².

Table 4.3-4. Physical size measurements of sampled *O. mykiss* redds during the 2015/2016 survey period.

	Gravel Median Size (in)	Depth (ft)	Flow (ft/s)	Pot Depth (ft)	Pot Length (ft)	Pot Width (ft)	Tail Length (ft)	Tail Width #1 (ft)	Tail Width #2 (ft)
Sample Size	30	25	18	26	25	27	23	23	23
Max	1.3	1.7	3.4	1.9	3.3	4.0	5.0	4.2	3.5
Min	0.5	0.7	1.6	0.8	1.0	1.0	1.0	0.9	0.6
Avg	0.9	1.0	2.2	1.2	1.7	1.7	2.5	1.8	1.4
Median	0.9	0.9	2.2	1.1	1.8	1.5	2.2	1.7	1.3
Variance	0.1	0.1	0.2	0.1	0.4	0.5	1.0	0.6	0.4
Std Dev	0.3	0.3	0.5	0.3	0.6	0.7	1.0	0.8	0.6

The total redd areas for Chinook and *O. mykiss* (Figure 4.3-1) overlapped on a total of six *O. mykiss* redds. *O. mykiss* redd areas ranged from 3.1 ft² to 41.7 ft². Based on this range in *O. mykiss* redd size, it is likely that all spawning was by resident rather than anadromous *O. mykiss*, as average redd sizes for anadromous *O. mykiss* range from 57 ft² to 74.3 ft² (Shapovalov and Taft 1954; Wilson and Collins 1992). The weir monitoring on the Tuolumne River detected three *O. mykiss* passing upstream during the 2015/2016 monitoring season. No passages of potential anadromous *O. mykiss* (>40 cm) were recorded prior to January 27, 2016 (Becker et al. 2016).

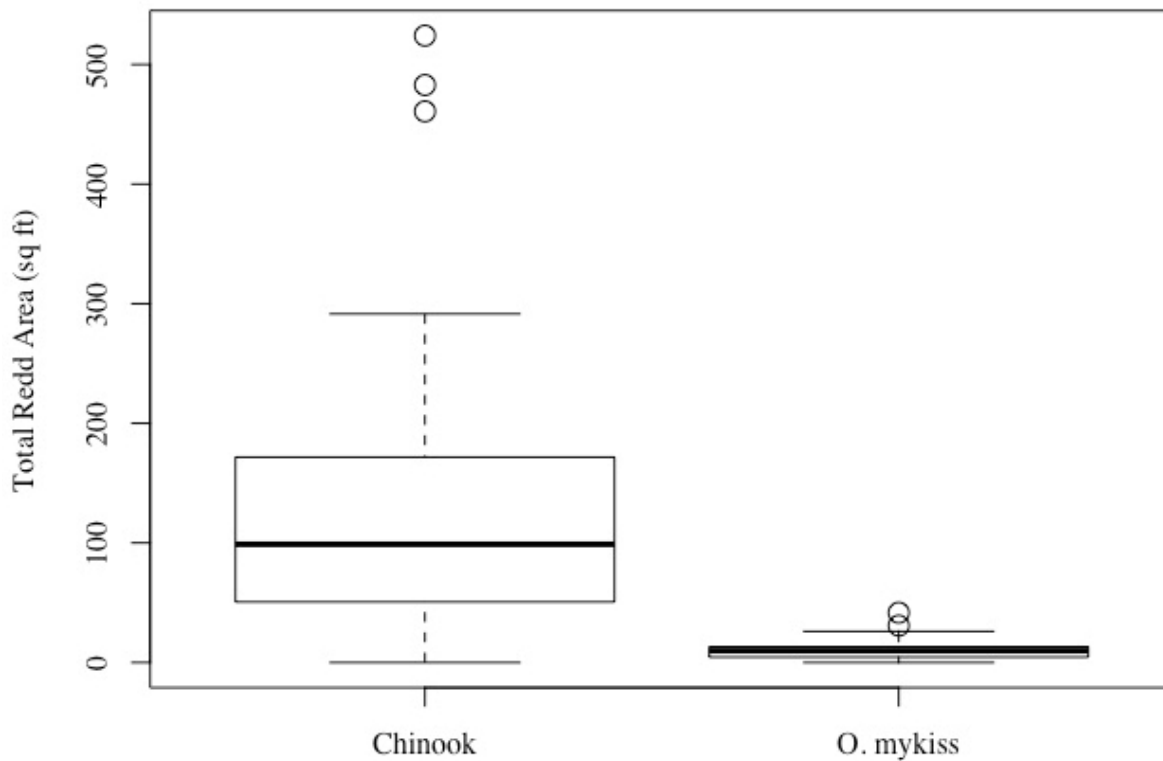


Figure 4.3-1. Total redd area for Chinook and *O. mykiss* during the 2015/2016 monitoring season.

4.4 Spawning Distribution and Use of Gravel Augmentation Sites

4.4.1 2014/2015 Monitoring Season

In general, Chinook salmon spawning activity (by absolute number of redds and densities) increased as river mile increased (Figure 4.4-1). The highest abundance of observed redds occurred in Reach 1 (RM 52.0 to RM 47.4), accounting for 37.1 percent of redds identified. Reaches 2 and 3 accounted for 22.0 percent and 35.0 percent of redds, respectively, with Reach 4 accounting for 5.9 percent of the Chinook spawning activity.

Redd superimposition was identified at 9.5 percent (32 of 337 total) of Chinook salmon redds. The highest number of observed superimposition occurred in Reach 1, accounting for 59.4 percent of superimposition events. There was no evidence of *O. mykiss* redd superimposition during the 2014/2015 study period.

Spawning activity at recent gravel augmentation sites accounted for 16.3 percent (55 of 337 total) of the new Chinook salmon redds observed on the Tuolumne River during 2014/2015. The majority of these redds were observed at the CDFW augmentation sites near La Grange (RM 50.6 to 51). Spawning densities at these sites ranged from 0.030 to 0.127 redds/100 ft². Redd densities throughout the spawning reach ranged from 0 to 0.127 redds/100 ft² (mean = 0.012 redds/100 ft²) during the 2014/2015 spawning season (Figure 4.4-2, Attachment B-1).

O. mykiss spawning activity at recent gravel augmentation sites accounted for 19.5 percent (8 of 41 total) of the redds observed during the 2014/2015 spawning season. All of these redds were observed at the CDFW augmentation sites near La Grange (RMs 50 and 51). Due to the low number of *O. mykiss* redds, no comparison was made between use of restored and unrestored riffles.

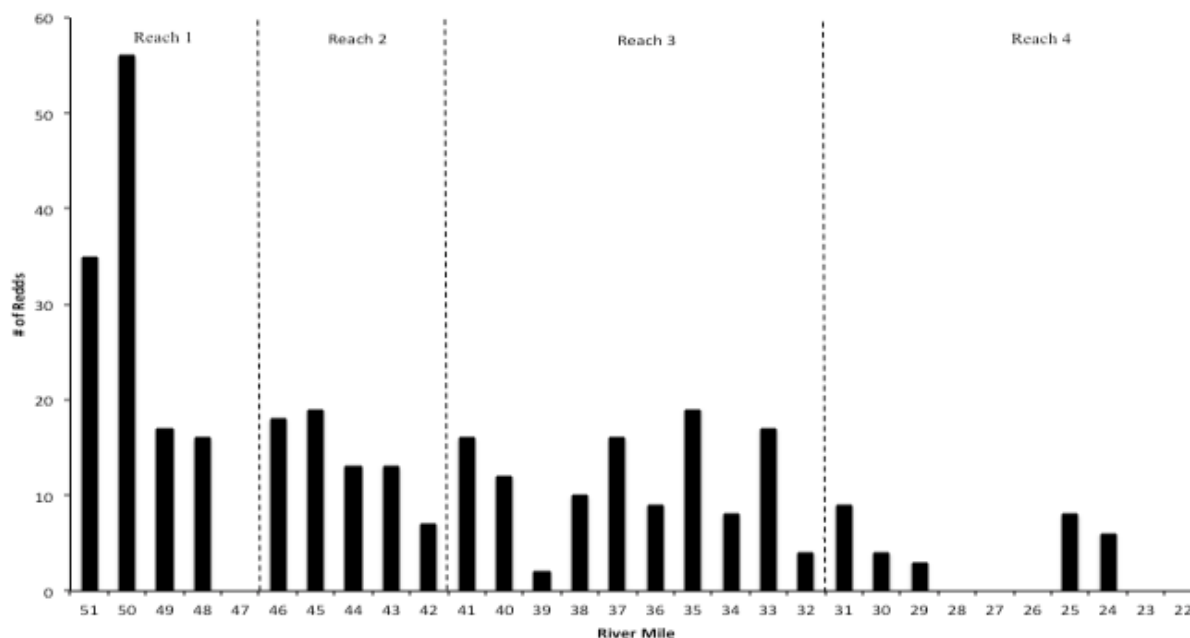


Figure 4.4-1. Chinook salmon redd distribution by river mile on the lower Tuolumne River during 2014/2015.

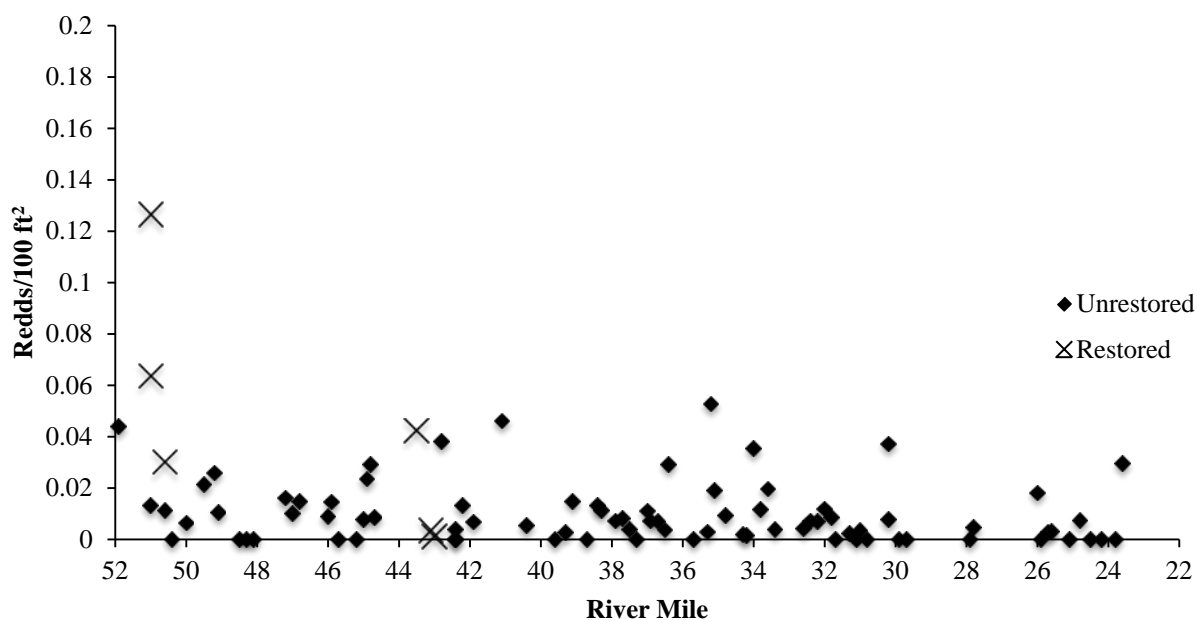


Figure 4.4-2. Areal densities of Chinook salmon redds in the 88 riffles on the lower Tuolumne River during 2014/2015.

4.4.2 2015/2016 Monitoring Season

In general, Chinook salmon spawning activity (by absolute number of redds and densities) increased as river mile increased (Figure 4.4-3). The highest abundance of observed redds occurred in Reach 1 (RM 52.0 to RM 47.5), accounting for 37.7 percent of redds identified. Reaches 2 and 3 accounted for 17.0 percent and 45.3 percent of redds, respectively, with no surveys conducted in Reach 4 during the 2015/2016 monitoring season.

Redd superimposition was identified at 4.7 percent (5 of 106 total) of Chinook salmon redds. Although there was a low sample size, 80 percent (n=4) of superimposition was observed in Reach 4. There was no evidence of *O. mykiss* redd superimposition during the 2015/2016 study period.

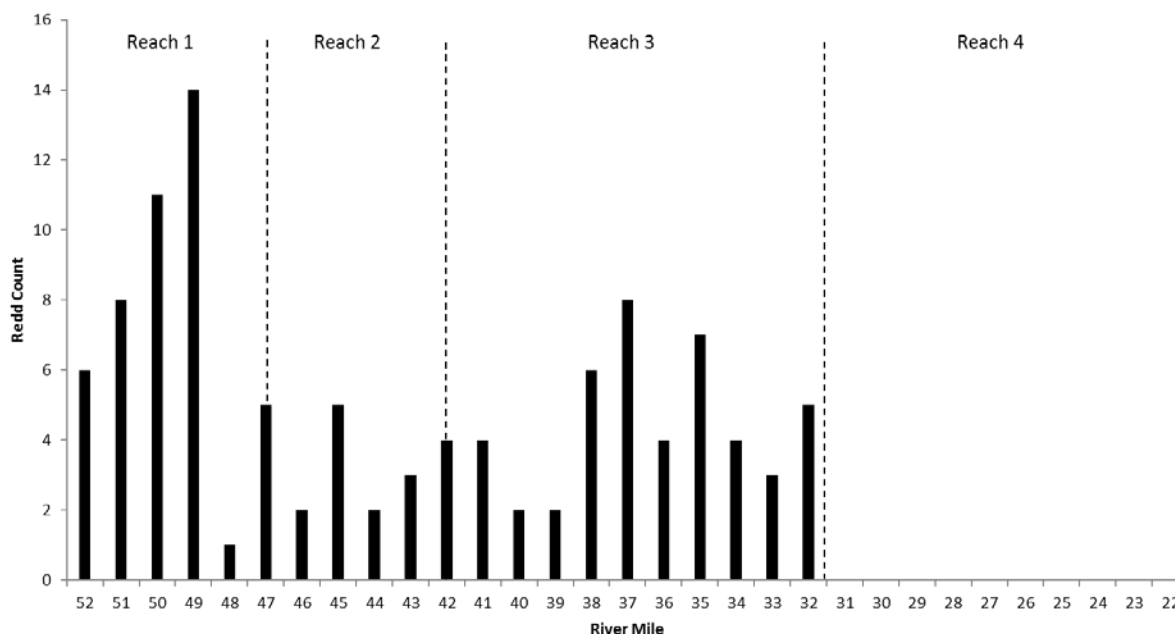


Figure 4.4-3. Chinook salmon redd distribution by river mile on the lower Tuolumne River during 2015/2016. Reach 4 was not surveyed due to excessive water hyacinth that blocked access.

Spawning activity was recorded at 57.2 percent (4 of 7) recent gravel augmentation sites accounting for 12.3 percent (13 of 106 total) of the new Chinook salmon redds observed on the Tuolumne River during 2015/2016. The majority of these redds were observed at the CDFW augmentation sites near La Grange (USGS RM 50). Spawning densities at restored riffles ranged from 0 to 0.028 redds/100 ft². Two augmentation sites had zero redds recorded (11-FW Riffle and 91 BC Riffle-Bobcat M, Appendix B). New redds were identified on 51.2 percent (42 of 82) of non-restored riffles with redd densities ranging from 0.001 to 0.029 redds/100 ft² (mean = 0.009 redds/100 ft²) during the 2015/2016 spawning season (Figure 4.4-4, Attachment B-2).

No *O. mykiss* spawning activity was recorded at recent gravel augmentation sites in 2015. *O. mykiss* spawning was observed at 14.6 percent (12 of 82 total) of non-restored riffles during the 2015/2016 spawning season. *O. mykiss* spawning densities ranged from 0.002 to 0.021 redds/100 ft² during the 2015/2016 spawning season.

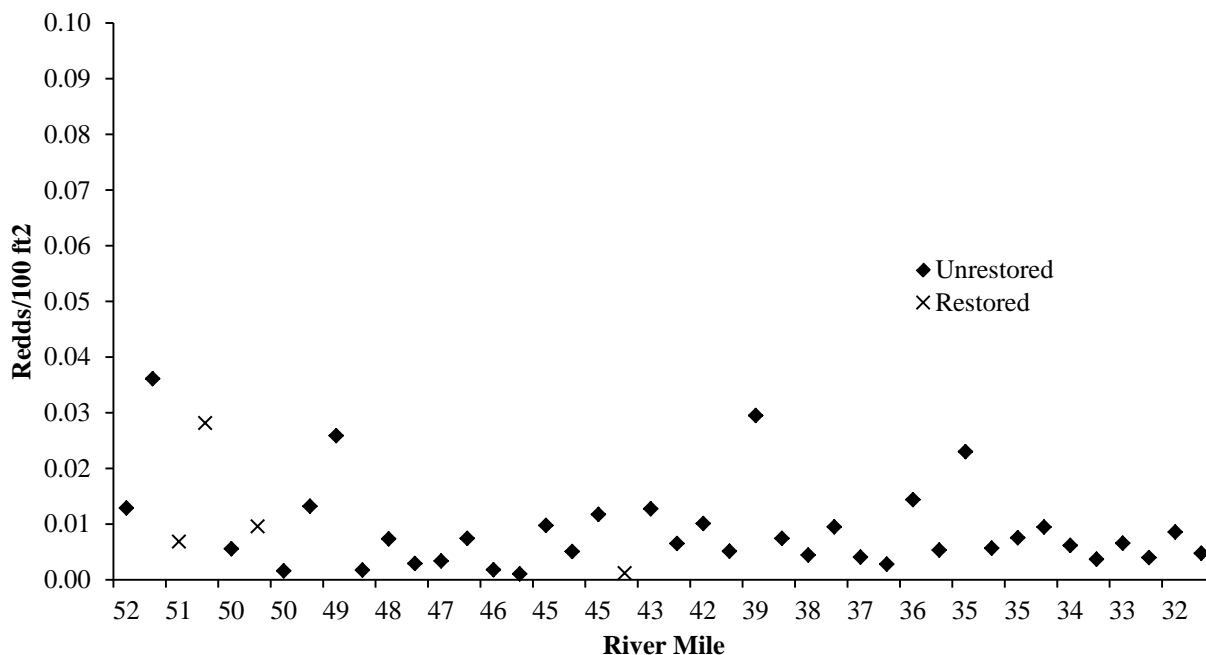


Figure 4.4-4. Areal densities of Chinook salmon redds in the 88 riffles on the lower Tuolumne River during 2015/2016.

5.0 DISCUSSION AND FINDINGS

5.1 Chinook Salmon

The low escapement and subsequent new redds observed during 2015/2016 provided few results to compare to previous years. New redds recorded during the 2015/2016 season represent the second straight year of declining numbers since redd surveys began in 2012/2013 (Figure 5.1-1).

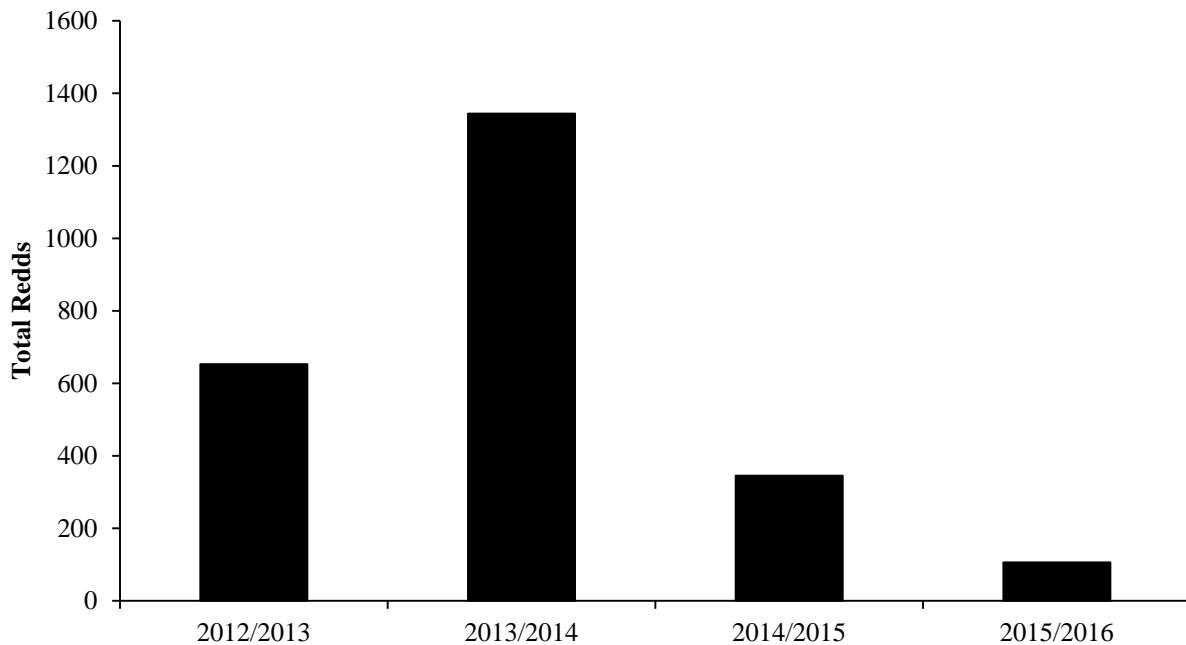


Figure 5.1-1. Total new Chinook redds observed in relation to previous years.

During the 2015/2016 monitoring season, there was a not a clear relationship between river location (i.e., increased river mile) and Chinook spawning. In previous Tuolumne River studies (TID/MID 1992; TID/MID 2013a), Reach 1 (RM 52 to RM 47.5) typically contained a higher portion of the Chinook salmon spawning activity; however, during 2015/2016 monitoring season more redd activity was recorded in Reach 3 than all other reaches (Figure 5.1.-2). This downstream shift in spawning activity was first observed in the 2014/2015 monitoring season, although to a lesser extent.



Figure 5.1-2. Percent redd distribution by reach and year. Reach 4 was not surveyed in 2015 due to excessive water hyacinth growth that blocked access.

Even with a low number of redds and a large amount of available habitat, superimposition was still observed in both seasons, although the frequency was reduced from 2014/2015 to 2015/2016 (Figure 5.1-3).

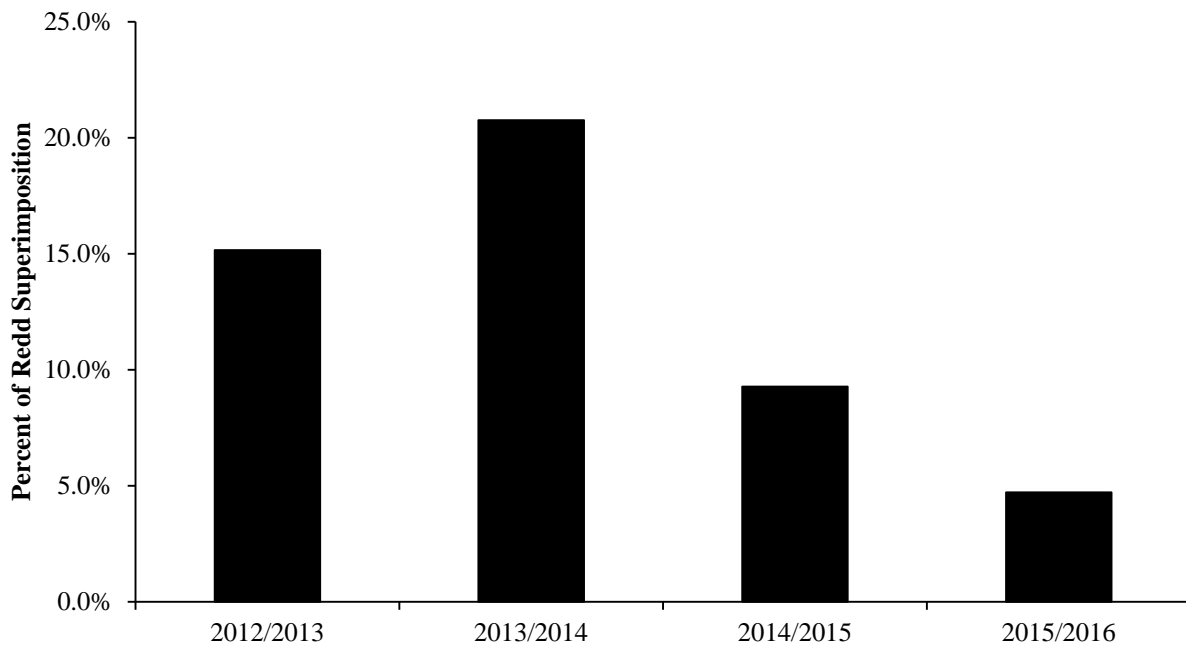


Figure 5.1-3. Percentage of Chinook salmon redd superimposition in relation to previous years.

5.2 *O. mykiss*

The 2015/2016 season represents the third year of documenting and mapping *O. mykiss* redds on the lower Tuolumne River, with previous sampling conducted in 2012/2013 (TID/MID 2013a) and 2014/2015. The number of *O. mykiss* redds was relatively constant with 38, 33, and 36 redds identified during the three years, respectively. The relative timing of *O. mykiss* redds was also similar across monitoring seasons (Figure 5.2-1). In all years, the initial onset of spawning was detected in late-December/early-January. Cumulatively, 50 percent of *O. mykiss* redds were detected by mid to late February, and no redds have been documented after the first week of April.

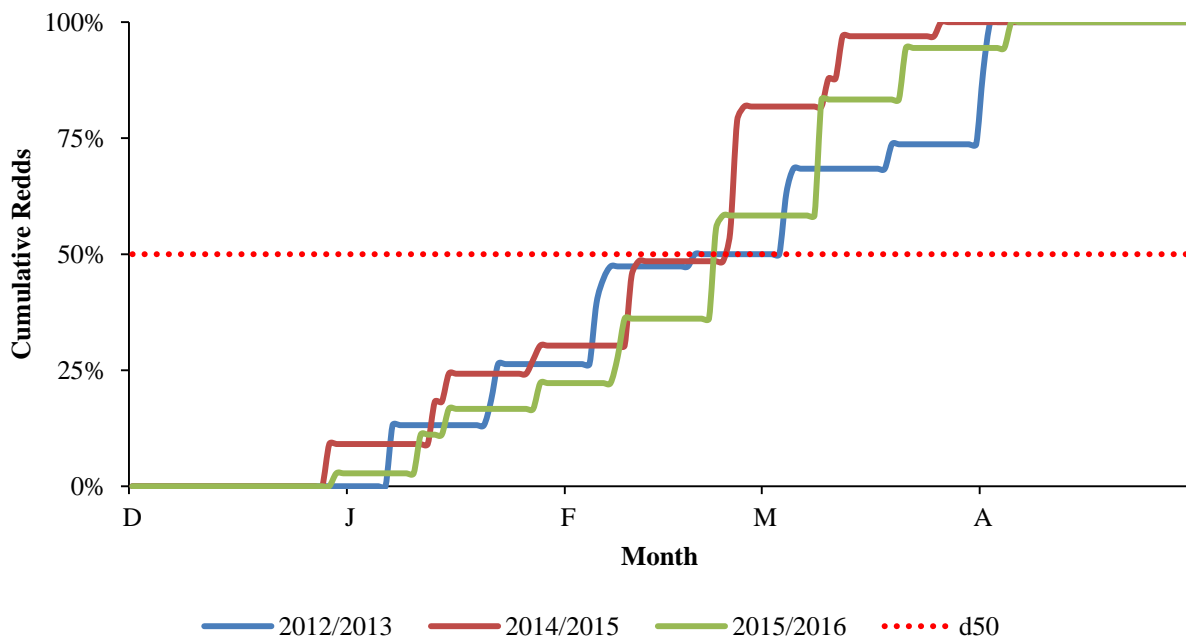


Figure 5.2-1. Cumulative *O. mykiss* redd timing during years sampled from 2012-2015.

Based on relative *O. mykiss* redd size and limited detections of large individuals (>40 cm) passing the fish counting weir operated by the Districts at RM 24.5 (Becker et al. 2016), it is likely that the majority of spawning was by resident rather than anadromous *O. mykiss* during all years of monitoring. Summer snorkel surveys (Stillwater 2010, Stillwater 2012) on the lower Tuolumne River have regularly identified adult *O. mykiss* (30-50 cm) in the upper reaches of the lower Tuolumne River.

6.0 REFERENCES

- Becker, C., J. Guignard, A. Fuller. 2015. Fall Migration Monitoring at the Tuolumne River Weir- 2014 Annual Report. Submitted to Turlock Irrigation District and Modesto Irrigation District. March 2015.
- _____. 2016. Fall Migration Monitoring at the Tuolumne River Weir- 2015 Annual Report. Submitted to Turlock Irrigation District and Modesto Irrigation District. March 2016.
- California Department of Water Resources (CDWR). 2004. Tuolumne River La Grange gravel addition project, Phase II geomorphic monitoring report. Prepared by California Department of Water Resources, San Joaquin District, River Management Section. Report funded by Delta Pumping Plant Fish Protection Agreement and monitoring funded by U.S. Fish and Wildlife Service, Anadromous Fish Restoration Program.
- Gallagher, S.P., P.K.J. Hahn, and D.H. Johnson. 2009. Redd counts. American Fisheries Society Protocols 1953: 197-234.
- Giovannetti, S.L., RJ Bottaro, and M.R. Brown. 2013. Adult steelhead and late-fall Chinook salmon monitoring on Clear Creek, California: 2011 Annual report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, CA.
- McBain and Trush. 2013. Bobcat Flat RM 43 Phase II As-Built Monitoring Final Report. Prepared for: Friends of the Tuolumne, Inc.
- McEwan, D. 2001. Central Valley Steelhead. In R.L. Brown, ed., Fish Bulletin 179, Contributions to the Biology of Central Valley Salmonids, pp. 1-45.
- Reynolds, F.L, Reavis, R. L., and J. Schuler. 1990. Central Valley salmon and steelhead restoration and enhancement plan. Final. Calif. Dept. of Fish and Game. Sacramento CA. 115 p.
- Shapovalov, L. and A. C. Taft. 1954. The life histories of the steelhead rainbow trout (*Salmo gairdneri*) and silver salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California, and recommendations regarding their management. Calif. Dept. Fish and Game, Fish Bull. No. 98. 373 pp.
- Stillwater Sciences. 2010. March and August 2010 population size estimates of *Oncorhynchus mykiss* in the Lower Tuolumne River. Prepared for the Turlock Irrigation District and the Modesto Irrigation District by Stillwater Sciences, Berkeley, CA. November 2010.
- _____. 2012. September 2011 population size estimates of *Oncorhynchus mykiss* in the Lower Tuolumne River. Draft. Prepared by Stillwater Sciences, Berkeley, California for the Turlock Irrigation District and the Modesto Irrigation Districts, California. January 2012.

- Turlock Irrigation District and Modesto Irrigation District (TID/MID). 1992. Report of Turlock Irrigation District and Modesto Irrigation District pursuant to Article 39 of the license for the Don Pedro Project. Turlock, California. 8 Volumes. April.
- _____. 2005. 2005 Ten year summary report. Pursuant to paragraph (G) of the 1996 FERC order issued July 31, 1996. Don Pedro Project, No. 2299.
- _____. 2006. Bobcat Flat/river mile 43, Phase I project completion report. Report 2005-7 in 2005 Lower Tuolumne River annual report of Turlock Irrigation District and Modesto Irrigation District Pursuant to Article 39 of the License for the Don Pedro Project, No. 2299. Prepared by McBain and Trush, Arcata, California.
- _____. 2007. 2006 Report of Turlock Irrigation District and Modesto Irrigation District Pursuant to Article 39 of the License for the Don Pedro Project, No. 2299. 2 Volumes. March.
- _____. 2013a. Salmonid Redd Mapping Study Report (W&AR-08). Prepared by FISHBIO. December 2013.
- _____. 2013b. Spawning Gravel in the Lower Tuolumne River Study Report (W&AR-04). Prepared by Stillwater Sciences. December 2013.
- Wilson, C. E. and Collins, B. W. 1992. Life history, distribution, run-size and angler harvest of steelhead in the South Fork Trinity River basin. Chapter III Job III p. 51-90. In: Kevin Urquhart and Ralph Carpenter (ed.), Annual Report of the Trinity River Basin Salmon and Steelhead Monitoring Project, 1990-1991 Season. December 1992. 186 p.

**STUDY REPORT
SALMONID REDD MAPPING
2014/2015 AND 2015/2016 MONITORING REPORT**

ATTACHMENT A

**DAILY MEAN WATER TEMPERATURES IN THE TUOLUMNE RIVER
DURING THE 2014/2015 AND 2015/2016 MONITORING SEASONS**

This Page Intentionally Left Blank.

Table A-1. Daily mean water temperatures in the Tuolumne River during December 2014 through April 2015.

Date	Hughson Sewer (RM 23.6) Temperature (F)	Waterford (RM 29.8) Temperature (F)	Hickman Bridge (RM 31.6) Temperature (F)	Roberts Ferry (RM 39.6) Temperature (F)	Riffle 21 (RM 42.9) Temperature (F)	Riffle 13B (RM 45.5) Temperature (F)	Riffle 3B (RM 49.0) Temperature (F)	Riffle A7 (RM 50.8) Temperature (F)
10/5/14	-- ¹	69.8	70.2	65.9	64.2	62.4	57.3	57.9
10/6/14	-- ¹	70.0	70.2	65.9	64.4	62.6	57.1	57.7
10/6/14	-- ¹	70.0	70.2	65.9	64.4	62.6	57.4	58.1
10/7/14	-- ¹	70.1	70.3	65.9	64.4	62.6	57.4	58.4
10/8/14	-- ¹	70.0	70.1	65.9	64.2	62.7	57.7	58.3
10/9/14	-- ¹	69.7	69.8	65.8	63.8	62.5	57.5	58.8
10/10/14	-- ¹	69.0	69.2	65.3	63.6	62.2	58.2	59.4
10/11/14	-- ¹	68.4	68.5	65.0	63.8	62.4	58.5	59.8
10/12/14	-- ¹	68.2	68.1	64.9	63.9	62.7	58.8	60.0
10/13/14	-- ¹	67.8	67.8	64.7	64.3	62.7	57.9	57.9
10/14/14	-- ¹	67.9	68.0	65.0	63.7	63.1	56.3	57.2
10/15/14	-- ¹	67.8	67.7	64.9	61.6	62.0	55.6	57.0
10/16/14	-- ¹	66.9	66.6	64.1	60.2	60.1	54.7	56.1
10/17/14	-- ¹	66.1	65.2	62.7	59.4	59.0	54.7	56.4
10/18/14	-- ¹	64.8	63.7	61.6	59.6	58.4	55.3	56.8
10/19/14	-- ¹	64.2	63.4	61.1	60.1	58.8	54.9	56.1
10/20/14	-- ¹	64.4	63.7	61.5	59.7	59.2	54.7	56.4
10/21/14	-- ¹	63.7	63.2	61.5	58.6	58.6	53.4	54.7
10/22/14	-- ¹	62.5	62.1	60.4	58.0	57.6	52.6	53.9
10/23/14	-- ¹	62.5	61.9	60.1	57.4	56.9	52.4	53.7
10/24/14	-- ¹	62.5	61.7	59.6	57.2	56.4	52.3	53.8
10/25/14	-- ¹	62.1	61.3	59.2	56.6	56.2	51.8	53.3
10/26/14	-- ¹	61.0	60.1	58.6	55.8	55.7	51.3	53.0
10/27/14	-- ¹	60.0	59.3	57.8	55.4	54.9	51.4	53.0
10/28/14	-- ¹	59.3	58.6	57.1	55.8	54.8	51.6	53.1
10/29/14	-- ¹	59.3	58.7	57.2	56.1	55.2	51.6	53.1
10/30/14	-- ¹	59.2	59.0	57.4	56.0	55.2	51.5	53.1
10/31/14	-- ¹	59.3	59.1	57.6	56.1	55.1	51.6	53.1
11/1/14	-- ¹	59.4	58.9	57.6	55.0	55.4	51.6	53.9
11/2/14	-- ¹	58.6	57.9	56.7	54.6	54.4	52.3	54.5
11/3/14	-- ¹	57.4	56.7	55.7	55.3	54.7	52.4	54.5
11/4/14	-- ¹	56.7	56.2	55.7	55.7	55.2	52.8	54.8
11/5/14	-- ¹	57.0	56.7	55.6	56.2	55.4	52.9	54.8

Date	Hughson Sewer (RM 23.6) Temperature (F)	Waterford (RM 29.8) Temperature (F)	Hickman Bridge (RM 31.6) Temperature (F)	Roberts Ferry (RM 39.6) Temperature (F)	Riffle 21 (RM 42.9) Temperature (F)	Riffle 13B (RM 45.5) Temperature (F)	Riffle 3B (RM 49.0) Temperature (F)	Riffle A7 (RM 50.8) Temperature (F)
11/6/14	-- ¹	57.6	57.3	56.1	56.3	55.9	53.0	54.9
11/7/14	-- ¹	58.1	57.8	56.5	56.5	55.9	53.1	55.0
11/8/14	-- ¹	58.6	58.2	56.6	56.7	56.1	53.3	55.2
11/9/14	-- ¹	58.9	58.4	56.8	56.7	56.3	53.1	55.0
11/10/14	-- ¹	58.9	58.4	56.8	56.2	56.3	52.9	55.0
11/11/14	-- ¹	58.5	58.0	56.6	56.7	55.7	53.4	55.4
11/12/14	-- ¹	58.3	57.8	56.9	57.1	56.4	53.5	55.2
11/13/14	-- ¹	58.8	58.5	57.5	57.0	56.7	53.2	55.1
11/14/14	-- ¹	58.9	58.5	57.5	55.9	56.5	52.6	54.8
11/15/14	-- ¹	58.6	58.0	56.4	55.1	55.5	52.0	54.4
11/16/14	-- ¹	57.3	56.5	55.6	54.2	54.7	51.6	54.0
11/17/14	-- ¹	55.9	55.1	54.5	53.3	54.1	51.4	53.8
11/18/14	-- ¹	54.9	54.1	53.4	54.0	53.4	51.7	54.0
11/19/14	-- ¹	54.6	54.1	54.0	53.6	54.1	51.3	53.8
11/20/14	-- ¹	54.4	54.0	53.9	54.0	53.5	51.8	54.2
11/21/14	-- ¹	54.8	54.4	54.0	54.9	54.0	52.2	54.4
11/22/14	-- ¹	54.9	54.9	54.8	54.8	54.8	52.1	54.4
11/23/14	-- ¹	54.8	54.9	54.8	53.9	54.6	51.7	54.2
11/24/14	-- ¹	54.0	54.0	53.7	53.5	54.0	51.7	54.1
11/25/14	-- ¹	53.7	53.6	53.0	53.5	53.7	51.6	54.0
11/26/14	-- ¹	53.4	53.3	52.9	53.8	53.8	51.9	54.1
11/27/14	-- ¹	53.6	53.6	53.2	53.7	54.1	51.8	54.1
11/28/14	-- ¹	53.6	53.5	53.0	54.3	53.9	51.8	54.0
11/29/14	-- ¹	53.8	53.9	53.8	53.9	54.3	51.3	53.6
11/30/14	-- ¹	53.8	53.8	54.1	53.9	53.7	51.5	53.6
12/1/14	-- ¹	54.1	54.0	53.8	53.9	53.9	51.3	53.6
12/2/14	-- ¹	54.2	54.1	53.9	55.4	53.7	52.5	54.2
12/3/14	-- ¹	55.3	55.5	55.1	56.7	55.3	53.2	55.0
12/4/14	-- ¹	57.2	57.2	56.5	56.5	56.2	52.9	54.8
12/5/14	-- ¹	57.7	57.7	56.7	56.4	55.9	52.8	54.6
12/6/14	-- ¹	57.9	57.8	56.9	55.4	56.0	52.0	54.1
12/7/14	-- ¹	57.5	57.2	56.0	54.5	54.8	51.5	53.6
12/8/14	-- ¹	56.6	56.3	55.3	54.5	54.2	51.3	53.4
12/9/14	-- ¹	56.1	55.9	55.3	54.3	54.1	51.1	52.9

Date	Hughson Sewer (RM 23.6) Temperature (F)	Waterford (RM 29.8) Temperature (F)	Hickman Bridge (RM 31.6) Temperature (F)	Roberts Ferry (RM 39.6) Temperature (F)	Riffle 21 (RM 42.9) Temperature (F)	Riffle 13B (RM 45.5) Temperature (F)	Riffle 3B (RM 49.0) Temperature (F)	Riffle A7 (RM 50.8) Temperature (F)
12/10/14	-- ¹	55.5	55.4	55.0	53.8	54.1	50.2	52.2
12/11/14	-- ¹	55.0	54.8	54.7	53.0	53.2	50.0	51.9
12/12/14	-- ¹	54.7	54.4	54.0	52.6	52.7	49.4	51.4
12/13/14	-- ¹	54.0	53.4	53.4	51.9	52.3	49.0	51.1
12/14/14	-- ¹	53.2	52.7	52.8	64.2	51.7	57.3	57.9
12/15/14	53.2	52.5	51.9	52.0	51.2	51.1	48.7	50.8
12/16/14	53.3	52.6	52.2	52.3	52.0	52.1	49.6	51.4
12/17/14	53.4	53.5	53.4	53.3	53.1	52.7	49.9	51.8
12/18/14	53.5	54.0	53.8	53.5	53.0	52.8	50.0	51.9
12/19/14	53.6	53.6	53.4	53.1	52.4	52.0	49.3	51.4
12/20/14	54.4	53.5	53.4	53.3	52.6	52.4	49.7	51.6
12/21/14	55.0	54.4	54.3	53.9	53.5	53.2	50.4	52.2
12/22/14	55.1	55.2	55.2	54.8	54.5	53.9	50.8	52.5
12/23/14	55.2	55.7	55.6	54.5	53.6	53.2	50.2	52.1
12/24/14	55.0	54.6	54.1	53.4	52.4	52.0	49.4	51.6
12/25/14	53.5	51.7	51.1	51.3	50.3	50.6	48.7	51.6
12/26/14	52.3	49.2	48.8	49.7	49.4	50.0	48.7	51.4
12/27/14	50.8	48.1	47.9	49.3	49.4	50.1	48.7	51.4
12/28/14	49.5	48.2	48.2	49.4	49.6	50.3	48.9	51.6
12/29/14	48.3	48.2	48.2	49.2	49.6	50.2	48.8	51.5
12/30/14	47.7	48.3	48.3	49.5	50.0	50.5	48.6	51.4
12/31/14	46.3	46.4	46.2	47.8	47.7	48.3	47.1	50.2
1/1/15	45.9	45.4	45.3	47.3	47.4	48.2	47.1	50.0
1/2/15	45.3	45.2	45.2	47.1	47.3	48.2	47.3	50.2
1/3/15	44.8	45.3	45.3	47.1	47.6	48.5	47.5	50.4
1/4/15	44.8	45.8	45.8	47.4	48.2	49.1	48.0	50.9
1/5/15	45.2	46.6	46.7	48.1	49.1	49.9	48.6	51.4
1/6/15	45.8	47.6	47.8	48.8	49.8	50.6	49.2	51.9
1/7/15	46.5	48.6	48.7	49.4	50.6	51.3	49.6	52.1
1/8/15	47.5	49.4	49.5	50.0	51.1	51.6	50.1	52.7
1/9/15	48.9	50.6	50.7	50.8	52.2	52.5	50.6	52.9
1/10/15	50.1	51.9	52.1	51.9	53.2	53.4	51.2	53.4
1/11/15	50.8	52.8	52.9	52.5	53.6	53.6	51.3	53.6
1/12/15	51.6	53.1	53.1	52.5	53.2	53.2	51.0	53.3

Date	Hughson Sewer (RM 23.6) Temperature (F)	Waterford (RM 29.8) Temperature (F)	Hickman Bridge (RM 31.6) Temperature (F)	Roberts Ferry (RM 39.6) Temperature (F)	Riffle 21 (RM 42.9) Temperature (F)	Riffle 13B (RM 45.5) Temperature (F)	Riffle 3B (RM 49.0) Temperature (F)	Riffle A7 (RM 50.8) Temperature (F)
1/13/15	52.4	53.2	53.1	52.6	53.1	53.0	50.6	53.1
1/14/15	52.6	52.1	52.1	51.9	52.0	52.2	50.3	52.7
1/15/15	52.4	52.0	52.0	52.1	52.6	52.6	50.1	52.4
1/16/15	52.2	51.9	52.1	52.5	52.9	53.0	50.6	52.7
1/17/15	52.2	52.6	52.7	52.9	53.4	53.4	50.9	53.0
1/18/15	52.1	53.1	53.2	53.1	53.1	53.0	50.6	52.9
1/19/15	52.4	52.9	52.8	52.9	52.8	52.7	50.3	52.6
1/20/15	52.7	52.7	52.7	52.9	52.6	52.5	50.2	52.4
1/21/15	52.6	52.2	52.2	52.5	52.4	52.3	50.0	52.3
1/22/15	52.3	52.1	52.1	52.5	52.1	52.1	49.9	52.2
1/23/15	51.5	51.1	51.0	51.6	51.0	51.1	49.2	51.8
1/24/15	51.4	50.8	50.7	51.5	51.2	51.5	49.5	51.7
1/25/15	51.0	50.7	50.7	51.5	51.4	51.5	49.3	51.7
1/26/15	50.8	50.4	50.3	50.6	50.2	50.4	48.9	51.5
1/27/15	51.7	51.2	51.2	51.1	51.9	52.3	50.1	52.3
1/28/15	51.7	52.3	52.3	51.9	52.3	52.3	50.3	52.6
1/29/15	52.3	53.3	53.2	52.2	52.6	52.8	50.6	52.7
1/30/15	52.8	53.6	53.4	52.4	52.9	52.9	50.6	52.8
1/31/15	53.3	53.5	53.2	52.4	52.8	52.9	50.3	52.5
2/1/15	53.7	53.1	52.9	52.3	52.7	52.7	50.4	52.6
2/2/15	53.9	53.5	53.4	52.7	53.3	53.3	50.8	52.9
2/3/15	54.1	54.4	54.2	53.2	53.8	53.7	51.1	53.1
2/4/15	54.5	55.0	54.9	53.6	54.3	54.1	51.5	53.4
2/5/15	54.7	55.2	55.0	54.0	54.3	53.9	51.2	53.3
2/6/15	55.1	54.9	54.7	54.2	54.0	53.8	50.9	53.0
2/7/15	56.3	56.0	55.9	54.6	55.4	55.0	52.0	53.5
2/8/15	56.9	57.6	57.6	55.8	56.4	55.5	52.3	54.1
2/9/15	57.6	58.3	58.1	56.1	56.4	56.0	52.6	54.2
2/10/15	57.7	57.8	57.5	55.8	55.5	54.9	51.6	53.7
2/11/15	57.9	56.6	56.4	54.9	54.2	54.0	51.3	53.2
2/12/15	58.2	56.7	56.4	54.8	54.8	54.5	51.6	53.4
2/13/15	58.2	56.9	56.7	54.9	55.2	54.8	51.9	53.7
2/14/15	58.3	57.5	57.4	55.3	55.7	55.3	52.1	53.9
2/15/15	58.4	57.9	57.7	55.6	55.9	55.4	52.2	54.0

Date	Hughson Sewer (RM 23.6) Temperature (F)	Waterford (RM 29.8) Temperature (F)	Hickman Bridge (RM 31.6) Temperature (F)	Roberts Ferry (RM 39.6) Temperature (F)	Riffle 21 (RM 42.9) Temperature (F)	Riffle 13B (RM 45.5) Temperature (F)	Riffle 3B (RM 49.0) Temperature (F)	Riffle A7 (RM 50.8) Temperature (F)
2/16/15	59.0	58.5	58.2	55.9	56.2	55.7	52.5	54.2
2/17/15	59.0	58.6	58.4	56.2	56.4	55.8	52.5	54.2
2/18/15	59.1	58.7	58.3	56.3	56.3	55.9	52.4	54.2
2/19/15	58.9	58.2	57.8	56.2	55.4	55.0	51.4	53.3
2/20/15	58.7	57.1	56.7	55.8	54.6	54.3	51.0	53.0
2/21/15	58.2	56.1	55.7	55.3	53.9	53.6	50.6	52.7
2/22/15	57.2	54.8	54.4	54.3	52.9	52.8	50.2	52.3
2/23/15	55.9	54.1	53.9	53.8	53.4	53.4	50.6	52.5
2/24/15	55.2	54.6	54.4	53.7	53.5	53.3	50.5	52.5
2/25/15	55.1	55.1	54.8	53.7	53.7	53.6	50.8	52.8
2/26/15	55.5	55.8	55.4	54.0	54.3	54.1	51.3	53.2
2/27/15	56.1	56.5	56.1	54.7	55.0	54.6	51.5	53.3
2/28/15	56.5	56.9	56.4	55.2	55.4	54.9	51.5	53.2
3/1/15	56.5	57.0	56.7	55.1	54.9	54.4	51.4	53.2
3/2/15	57.0	57.5	57.0	55.3	55.6	55.1	51.9	53.6
3/3/15	57.2	57.2	56.8	55.3	55.0	54.6	51.5	53.4
3/4/15	57.6	57.3	57.0	55.1	55.2	54.8	51.7	53.5
3/5/15	57.9	57.4	57.2	55.2	55.4	55.0	51.8	53.5
3/6/15	58.2	57.8	57.6	55.3	55.5	55.1	52.0	53.7
3/7/15	58.9	58.7	58.3	55.8	56.4	55.7	52.2	53.7
3/8/15	59.7	59.6	59.3	56.5	56.9	56.1	52.8	54.3
3/9/15	60.4	60.7	60.3	57.0	57.6	56.7	53.3	54.7
3/10/15	61.4	61.1	60.7	57.6	58.1	57.1	53.5	54.8
3/11/15	62.0	61.4	61.0	58.3	58.4	57.2	52.4	53.6
3/12/15	62.5	61.6	61.2	58.3	57.4	56.2	52.6	54.1
3/13/15	63.3	61.3	62.1	58.3	58.3	57.3	53.7	54.8
3/14/15	64.7	-- ¹	63.5	59.3	60.0	58.5	54.6	55.7
3/15/15	65.5	-- ¹	64.5	60.2	60.6	59.1	55.0	56.0
3/16/15	65.3	-- ¹	63.5	60.2	59.6	58.3	54.0	55.5
3/17/15	65.7	-- ¹	63.3	59.9	59.3	58.2	54.2	55.4
3/18/15	65.3	-- ¹	63.0	59.8	59.2	58.1	54.1	55.4
3/19/15	65.3	-- ¹	63.1	59.6	59.3	58.2	54.2	55.3
3/20/15	65.1	-- ¹	62.7	59.6	58.8	57.6	52.7	53.8
3/21/15	64.9	-- ¹	62.1	59.2	57.7	56.6	52.9	54.4

Date	Hughson Sewer (RM 23.6) Temperature (F)	Waterford (RM 29.8) Temperature (F)	Hickman Bridge (RM 31.6) Temperature (F)	Roberts Ferry (RM 39.6) Temperature (F)	Riffle 21 (RM 42.9) Temperature (F)	Riffle 13B (RM 45.5) Temperature (F)	Riffle 3B (RM 49.0) Temperature (F)	Riffle A7 (RM 50.8) Temperature (F)
3/22/15	65.1	-- ¹	62.5	59.2	58.6	57.6	54.0	55.2
3/23/15	64.8	-- ¹	62.7	59.8	59.6	58.4	54.2	55.5
3/24/15	64.3	-- ¹	62.4	59.8	59.1	57.9	53.8	55.3
3/25/15	64.5	-- ¹	62.7	59.7	59.2	58.0	54.1	55.1
3/26/15	65.2	-- ¹	64.3	60.3	60.3	58.9	54.9	55.9
3/27/15	66.4	-- ¹	65.6	61.1	61.4	59.6	55.3	56.1
3/28/15	66.7	66.7	66.0	61.8	61.6	59.6	53.9	54.5
3/29/15	67.2	66.5	65.9	61.6	60.3	58.7	54.6	55.7
3/30/15	67.8	66.6	65.8	61.3	60.9	59.3	54.2	54.7
3/31/15	67.5	65.9	65.1	61.6	60.2	58.5	53.5	54.4
4/1/15	66.2	56.9	63.2	60.3	58.2	57.2	52.2	53.5
4/2/15	65.1	62.2	61.5	59.1	57.1	56.3	52.2	53.6
4/3/15	64.5	61.6	61.0	58.5	56.4	55.9	51.6	53.2
4/4/15	63.7	59.1	58.4	57.2	55.1	54.6	51.0	53.1
4/5/15	59.4	55.7	55.5	56.0	53.9	53.5	50.8	53.0
4/6/15	55.8	55.2	55.1	55.5	54.5	54.3	51.5	53.4
4/7/15	56.0	55.7	55.5	55.8	53.6	53.2	50.5	52.8
4/8/15	56.6	55.4	55.2	55.1	54.5	54.2	51.3	53.2
4/9/15	57.3	57.4	57.2	56.0	55.0	54.4	51.4	53.4
4/10/15	59.2	58.2	57.9	56.3	55.6	54.9	51.7	53.5
4/11/15	59.9	58.4	58.0	56.6	55.5	54.7	51.5	53.5
4/12/15	60.1	58.7	58.5	56.7	56.2	55.8	52.6	54.1
4/13/15	60.9	61.0	60.8	58.0	58.4	57.1	53.2	54.5
4/14/15	61.7	62.1	61.7	58.7	58.8	57.7	53.8	55.1
4/15/15	62.1	61.7	61.5	58.6	58.7	57.4	53.3	54.6

Table A-2. Daily mean water temperatures in the Tuolumne River during December 2015 through April 2016.

Date	Hughson Sewer (RM 23.6) Temperature (F)	Waterford (RM 29.8) Temperature (F)	Hickman Bridge (RM 31.6) Temperature (F)	Roberts Ferry (RM 39.6) Temperature (F)	Riffle 21 (RM 42.9) Temperature (F)	Riffle 13B (RM 45.5) Temperature (F)	Riffle 3B (RM 49.0) Temperature (F)	Riffle A7 (RM 50.8) Temperature (F)
10/5/15	70.2	68.6	69.2	66.9	65.8	64.8	61.2	62.8
10/6/15	70.2	68.9	69.8	67.1	66.4	65.4	61.6	63.2
10/7/15	70.4	69.5	70.4	67.7	67.2	66.1	62.3	63.8
10/8/15	70.8	70.6	71.4	68.6	68.3	67.2	63.1	64.2
10/9/15	71.1	70.8	71.7	69.2	68.9	67.5	63.4	65.0
10/10/15	70.9	70.5	71.5	68.9	68.3	67.2	62.6	63.4
10/11/15	71.3	70.6	71.6	69.0	68.4	66.9	62.4	64.0
10/12/15	71.7	69.6	71.3	68.7	67.8	66.7	63.2	64.9
10/13/15	71.9	70.7	71.6	68.7	68.3	67.3	63.4	64.9
10/14/15	72.0	71.1	71.6	69.0	68.5	67.4	62.8	64.0
10/15/15	72.1	71.3	71.5	69.1	68.1	66.7	61.6	62.2
10/16/15	72.1	71.8	71.9	69.0	67.2	64.9	59.2	59.9
10/17/15	72.0	71.6	71.4	68.1	65.2	63.6	59.0	60.3
10/18/15	71.4	69.2	68.6	66.2	63.7	62.4	58.4	60.0
10/19/15	70.7	67.1	66.9	65.0	62.8	61.7	57.7	59.1
10/20/15	70.1	66.2	66.0	64.3	62.1	60.9	56.9	58.4
10/21/15	69.2	65.4	65.3	63.5	61.3	60.4	56.5	57.9
10/22/15	68.1	64.8	64.7	63.0	60.9	59.9	56.2	57.8
10/23/15	67.1	64.3	64.3	62.5	60.6	59.7	56.0	57.7
10/24/15	66.5	63.7	63.7	62.1	60.2	59.2	55.5	57.1
10/25/15	66.1	63.4	63.3	61.8	59.7	58.8	55.1	56.8
10/26/15	65.3	62.5	62.4	60.9	59.0	58.2	55.0	56.7
10/27/15	65.0	62.1	62.0	60.4	58.8	58.0	54.3	56.1
10/28/15	64.7	62.2	62.2	60.4	59.4	58.6	54.9	56.3
10/29/15	63.6	62.2	62.1	60.0	59.2	58.3	54.7	56.4
10/30/15	62.9	61.1	61.0	58.8	58.2	57.4	53.9	55.6
10/31/15	62.9	61.0	61.0	58.9	58.2	57.6	54.2	55.8
11/1/15	63.3	61.7	61.7	59.7	59.0	58.2	54.5	56.0
11/2/15	62.8	61.8	61.7	59.6	58.7	57.6	53.8	55.6
11/3/15	61.8	59.5	59.8	58.0	57.2	56.7	53.4	55.1
11/4/15	60.7	57.3	58.0	56.0	55.9	55.3	52.2	54.4
11/5/15	59.6	55.7	56.3	54.6	54.6	54.4	52.0	54.2
11/6/15	58.5	54.8	55.4	54.1	54.4	54.2	51.6	54.0

Date	Hughson Sewer (RM 23.6) Temperature (F)	Waterford (RM 29.8) Temperature (F)	Hickman Bridge (RM 31.6) Temperature (F)	Roberts Ferry (RM 39.6) Temperature (F)	Riffle 21 (RM 42.9) Temperature (F)	Riffle 13B (RM 45.5) Temperature (F)	Riffle 3B (RM 49.0) Temperature (F)	Riffle A7 (RM 50.8) Temperature (F)
11/7/15	57.5	54.6	55.2	53.9	54.4	54.6	52.5	54.8
11/8/15	56.8	54.5	55.2	54.4	55.1	55.0	52.4	54.5
11/9/15	56.1	55.0	55.4	55.0	55.3	55.0	52.1	54.3
11/10/15	55.5	54.6	54.9	54.2	54.3	54.3	51.8	54.0
11/11/15	54.9	53.8	54.5	53.4	53.9	53.7	51.3	53.6
11/12/15	54.8	53.4	54.1	52.9	53.4	53.5	51.2	53.5
11/13/15	54.7	53.2	53.8	52.8	53.5	53.6	51.3	53.7
11/14/15	54.7	53.3	54.0	53.1	53.7	53.9	51.8	54.2
11/15/15	54.3	53.3	53.9	53.0	53.8	53.8	51.2	53.8
11/16/15	53.1	51.3	52.1	51.3	52.0	52.4	50.2	52.9
11/17/15	52.6	50.3	51.1	50.4	51.5	51.8	49.9	52.4
11/18/15	52.4	50.1	51.1	50.9	51.7	52.1	50.2	52.8
11/19/15	52.2	51.1	51.9	51.6	52.5	52.9	50.9	53.3
11/20/15	52.3	52.1	52.8	52.5	53.4	53.6	51.5	54.1
11/21/15	52.6	52.7	53.4	53.0	53.9	54.4	52.4	54.8
11/22/15	53.2	53.3	53.9	53.7	54.7	55.1	52.9	55.4
11/23/15	53.8	53.9	54.6	54.3	55.2	55.3	53.1	55.6
11/24/15	53.9	53.6	54.4	53.8	54.6	54.5	52.1	54.7
11/25/15	53.7	52.7	53.2	52.5	53.2	53.3	51.4	54.1
11/26/15	53.0	50.4	51.2	50.4	51.5	52.1	50.9	53.9
11/27/15	52.2	49.0	49.9	49.7	51.3	52.1	51.0	54.5
11/28/15	51.0	48.0	49.0	49.2	51.1	52.3	51.4	54.6
11/29/15	49.8	47.5	48.6	49.2	51.2	52.1	50.7	53.7
11/30/15	48.9	47.5	48.6	49.1	50.9	51.5	50.2	53.1
12/1/15	48.4	47.6	48.5	49.1	50.7	51.5	50.4	53.3
12/2/15	48.6	48.6	49.4	49.9	51.6	52.3	51.0	53.8
12/3/15	48.8	49.2	49.9	50.7	52.1	52.6	51.2	54.0
12/4/15	49.2	49.5	50.3	50.9	52.2	52.9	51.3	54.1
12/5/15	49.7	49.9	50.6	50.7	52.1	52.6	51.1	53.9
12/6/15	50.4	50.6	51.1	51.4	52.6	53.2	51.5	54.1
12/7/15	51.1	51.5	52.0	52.1	53.3	53.6	51.7	54.3
12/8/15	51.7	52.6	53.0	52.9	53.7	53.9	52.0	54.5
12/9/15	52.8	53.9	54.0	54.2	54.7	54.9	52.5	54.9
12/10/15	53.3	53.9	54.1	54.1	54.5	54.5	52.3	54.7

Date	Hughson Sewer (RM 23.6) Temperature (F)	Waterford (RM 29.8) Temperature (F)	Hickman Bridge (RM 31.6) Temperature (F)	Roberts Ferry (RM 39.6) Temperature (F)	Riffle 21 (RM 42.9) Temperature (F)	Riffle 13B (RM 45.5) Temperature (F)	Riffle 3B (RM 49.0) Temperature (F)	Riffle A7 (RM 50.8) Temperature (F)
12/11/15	53.6	53.5	54.0	53.9	54.5	54.6	52.1	54.6
12/12/15	53.1	52.3	52.8	52.1	52.7	52.9	51.2	53.9
12/13/15	53.1	51.9	52.3	51.8	52.6	53.0	50.7	53.4
12/14/15	51.7	49.4	50.1	50.1	50.7	51.3	49.7	52.8
12/15/15	50.4	47.6	48.7	48.2	49.5	50.2	49.1	52.1
12/16/15	49.3	46.5	47.5	47.6	49.1	50.0	49.0	52.0
12/17/15	48.5	46.5	47.6	47.9	49.6	50.5	49.3	52.2
12/18/15	47.8	46.4	47.6	48.2	49.8	50.7	49.5	52.5
12/19/15	48.1	48.4	49.1	50.0	51.3	51.9	50.3	52.9
12/20/15	48.1	48.8	49.5	50.5	51.4	51.8	50.3	53.1
12/21/15	48.8	50.0	50.5	51.2	52.0	52.5	50.8	53.3
12/22/15	50.1	51.8	52.1	53.1	53.5	53.7	51.8	54.0
12/23/15	50.6	52.8	53.1	53.0	53.6	53.8	51.6	54.3
12/24/15	50.8	51.0	51.3	50.9	51.7	51.9	50.2	53.0
12/25/15	50.5	48.8	49.2	49.0	50.2	50.9	49.5	52.3
12/26/15	49.7	47.1	47.9	48.0	49.3	50.0	48.7	51.7
12/27/15	48.6	46.2	47.2	47.3	48.7	49.6	48.3	51.1
12/28/15	48.0	46.6	47.5	48.2	49.4	50.2	48.7	51.4
12/29/15	46.7	45.8	46.8	47.9	49.4	50.2	49.0	51.9
12/30/15	46.2	45.8	47.0	47.5	49.1	50.0	48.8	51.7
12/31/15	46.4	46.6	47.6	47.9	49.4	50.2	48.7	51.5
1/1/16	46.2	46.3	47.3	47.5	49.0	49.8	48.4	51.3
1/2/16	46.6	46.7	47.5	48.3	49.6	50.3	48.6	51.4
1/3/16	47.1	47.4	48.2	49.1	50.2	50.9	49.4	52.0
1/4/16	47.2	48.1	48.8	49.3	50.5	51.1	49.5	52.2
1/5/16	47.9	49.1	49.6	50.8	51.7	52.0	50.1	52.5
1/6/16	48.3	49.7	50.1	50.9	51.3	51.5	49.5	52.3
1/7/16	49.1	50.1	50.5	50.8	51.3	51.5	49.7	52.2
1/8/16	49.6	50.1	50.4	50.2	50.8	51.1	49.2	51.8
1/9/16	50.2	50.3	50.9	51.0	51.6	51.9	49.9	52.1
1/10/16	50.8	51.1	51.7	51.9	52.7	52.9	50.5	52.8
1/11/16	50.9	51.4	51.9	51.9	52.4	52.4	50.2	52.7
1/12/16	50.8	50.6	51.2	50.8	51.3	51.6	49.6	52.2
1/13/16	51.6	51.4	51.9	51.6	52.1	52.5	50.2	52.3

Date	Hughson Sewer (RM 23.6) Temperature (F)	Waterford (RM 29.8) Temperature (F)	Hickman Bridge (RM 31.6) Temperature (F)	Roberts Ferry (RM 39.6) Temperature (F)	Riffle 21 (RM 42.9) Temperature (F)	Riffle 13B (RM 45.5) Temperature (F)	Riffle 3B (RM 49.0) Temperature (F)	Riffle A7 (RM 50.8) Temperature (F)
1/14/16	51.3	51.3	52.1	51.5	51.9	51.9	49.6	52.2
1/15/16	51.8	51.8	52.3	52.0	52.3	52.6	50.3	52.5
1/16/16	52.4	52.9	53.4	53.1	53.3	53.1	50.7	52.8
1/17/16	52.5	52.8	53.3	52.7	52.8	52.7	50.3	52.7
1/18/16	53.5	53.7	54.1	53.7	53.7	53.8	51.3	53.1
1/19/16	54.0	54.4	54.7	54.0	53.9	53.7	51.0	53.2
1/20/16	54.5	54.5	54.7	54.2	54.2	54.2	51.7	53.6
1/21/16	55.1	55.2	55.3	54.6	54.6	54.4	51.9	53.9
1/22/16	55.1	54.7	54.8	54.2	54.1	54.0	51.2	53.4
1/23/16	55.4	54.4	54.6	54.2	54.1	54.1	51.5	53.3
1/24/16	55.0	54.5	54.6	53.8	53.8	53.8	51.1	53.2
1/25/16	54.7	53.5	53.6	52.7	52.9	53.2	50.8	52.9
1/26/16	54.6	52.9	53.1	52.5	53.1	53.4	50.7	52.6
1/27/16	54.2	52.8	53.2	52.6	52.7	52.9	50.1	52.3
1/28/16	53.4	52.0	52.2	51.5	51.6	52.0	49.5	51.8
1/29/16	53.6	52.5	52.7	52.6	52.7	52.7	50.0	52.0
1/30/16	53.9	53.8	54.1	53.8	53.6	53.3	50.6	52.5
1/31/16	53.5	53.7	53.9	53.3	53.0	52.8	50.0	52.2
2/1/16	52.4	50.9	50.9	50.1	50.6	51.1	48.8	51.5
2/2/16	52.1	49.5	49.8	49.6	50.2	50.6	48.4	50.8
2/3/16	51.4	49.2	49.3	49.6	50.0	50.3	48.2	50.5
2/4/16	51.0	50.2	50.4	50.1	50.5	51.0	48.7	51.0
2/5/16	50.7	50.7	50.8	50.6	51.2	51.4	49.2	51.4
2/6/16	51.3	51.5	51.9	51.4	51.8	52.0	49.5	51.6
2/7/16	52.1	52.5	52.7	52.1	52.4	52.4	49.9	51.8
2/8/16	53.0	53.4	53.6	52.6	53.0	53.1	50.2	52.0
2/9/16	53.9	54.3	54.4	53.0	53.3	53.2	50.3	52.2
2/10/16	54.7	55.0	54.9	53.4	53.5	53.1	50.1	52.1
2/11/16	55.6	55.2	55.1	53.4	53.5	53.2	50.3	52.1
2/12/16	56.4	55.5	55.4	53.7	53.7	53.3	50.3	52.2
2/13/16	56.9	56.0	55.8	54.0	54.0	53.6	50.5	52.3
2/14/16	57.0	56.0	55.8	54.0	53.9	53.4	50.3	52.2
2/15/16	57.5	56.4	56.3	54.3	54.2	53.9	50.7	52.3
2/16/16	58.0	57.2	57.1	55.0	54.9	54.4	51.0	52.5

Date	Hughson Sewer (RM 23.6) Temperature (F)	Waterford (RM 29.8) Temperature (F)	Hickman Bridge (RM 31.6) Temperature (F)	Roberts Ferry (RM 39.6) Temperature (F)	Riffle 21 (RM 42.9) Temperature (F)	Riffle 13B (RM 45.5) Temperature (F)	Riffle 3B (RM 49.0) Temperature (F)	Riffle A7 (RM 50.8) Temperature (F)
2/17/16	58.1	57.4	57.3	55.5	55.0	54.1	50.5	52.4
2/18/16	57.8	56.1	56.0	54.6	53.8	53.3	50.0	51.8
2/19/16	57.8	55.7	55.4	53.6	53.1	52.6	49.7	51.4
2/20/16	57.4	55.1	54.8	53.5	52.9	52.5	49.3	51.3
2/21/16	57.1	54.3	54.1	52.9	52.6	52.3	49.5	51.3
2/22/16	57.3	55.0	54.9	53.2	53.2	52.9	49.9	51.7
2/23/16	57.3	55.6	55.5	53.8	53.8	53.5	50.3	51.9
2/24/16	57.5	56.4	56.4	54.5	54.5	54.0	50.7	52.3
2/25/16	58.1	57.3	57.2	54.9	54.8	54.2	50.7	52.2
2/26/16	58.7	57.9	57.8	55.3	55.1	54.3	50.2	51.3
2/27/16	59.3	58.8	58.7	56.2	55.5	54.5	50.7	52.2
2/28/16	59.7	58.5	58.3	55.4	54.7	54.0	50.4	52.2
2/29/16	60.1	58.0	57.7	55.0	54.4	53.9	50.6	52.1
3/1/16	60.9	59.0	58.8	56.1	55.9	55.1	51.4	52.6
3/2/16	61.1	59.6	59.6	56.7	56.2	55.2	51.3	52.7
3/3/16	61.4	60.4	60.1	57.1	56.4	55.4	51.5	52.9
3/4/16	62.1	61.0	60.6	57.6	56.8	55.7	51.6	52.8
3/5/16	62.3	60.5	60.1	57.6	56.5	55.5	51.5	52.8
3/6/16	62.1	59.6	59.4	57.1	56.4	55.5	51.9	53.0
3/7/16	61.4	58.0	57.8	56.1	55.1	54.7	50.8	52.5
3/8/16	60.6	56.2	56.0	54.4	54.1	53.9	50.7	52.2
3/9/16	60.5	57.3	57.3	55.7	55.4	54.6	51.1	52.4
3/10/16	60.1	58.2	58.1	56.1	55.3	54.6	50.9	52.4
3/11/16	59.5	57.1	56.8	55.4	54.1	53.7	49.8	51.2
3/12/16	59.3	56.2	55.9	54.4	54.2	53.6	50.7	51.5
3/13/16	58.8	56.5	56.4	55.6	55.0	54.3	50.9	52.3
3/14/16	58.6	57.0	57.0	55.7	55.9	55.1	52.1	53.0
3/15/16	58.4	58.0	58.0	56.5	56.5	55.6	52.9	54.5
3/16/16	59.4	59.1	59.1	56.9	57.3	56.4	53.0	54.1
3/17/16	60.6	60.7	60.8	58.1	58.1	56.8	53.0	53.9
3/18/16	61.8	62.4	62.4	59.0	58.6	57.1	52.6	53.2
3/19/16	62.9	63.2	63.0	59.2	58.1	56.7	52.2	53.2
3/20/16	64.1	63.5	63.2	59.2	58.2	56.8	52.6	53.5
3/21/16	64.6	63.2	62.8	59.4	58.3	56.9	52.0	53.1

Date	Hughson Sewer (RM 23.6) Temperature (F)	Waterford (RM 29.8) Temperature (F)	Hickman Bridge (RM 31.6) Temperature (F)	Roberts Ferry (RM 39.6) Temperature (F)	Riffle 21 (RM 42.9) Temperature (F)	Riffle 13B (RM 45.5) Temperature (F)	Riffle 3B (RM 49.0) Temperature (F)	Riffle A7 (RM 50.8) Temperature (F)
3/22/16	64.2	61.3	60.9	58.0	56.3	55.5	50.7	51.6
3/23/16	63.8	60.5	60.2	57.2	55.8	54.9	50.6	51.7
3/24/16	63.6	60.7	60.5	57.2	56.2	55.2	50.9	52.0
3/25/16	63.6	61.6	61.4	58.2	57.1	55.8	51.4	52.3
3/26/16	63.8	62.3	62.1	58.6	57.5	56.0	51.3	52.2
3/27/16	64.3	63.1	62.9	58.9	57.6	56.1	51.5	52.3
3/28/16	64.2	62.1	61.7	58.4	57.0	55.7	50.8	52.0
3/29/16	63.7	59.8	59.5	56.9	55.3	54.3	50.0	51.2
3/30/16	63.6	60.3	60.1	56.8	55.7	54.6	50.6	51.7
3/31/16	63.6	61.3	61.1	57.7	56.8	55.3	50.8	51.5
4/1/16	63.9	62.5	62.4	58.6	57.4	55.7	50.9	51.5
4/2/16	64.8	64.0	63.8	59.3	58.0	56.2	51.3	51.7
4/3/16	65.7	65.2	64.9	60.1	58.5	56.5	51.2	51.6
4/4/16	66.2	65.3	65.0	60.1	58.5	56.6	51.4	51.8
4/5/16	66.7	65.2	64.8	60.1	58.5	56.7	51.8	52.2
4/6/16	67.3	65.9	65.5	60.6	59.2	57.3	52.7	53.2
4/7/16	67.9	66.6	66.1	61.1	59.7	57.5	51.5	51.8
4/8/16	67.9	66.2	65.5	60.6	58.4	56.5	51.0	51.5
4/9/16	67.4	64.8	63.9	59.6	57.1	55.7	50.3	51.0
4/10/16	66.5	61.7	61.0	58.1	56.2	55.2	50.4	51.2
4/11/16	66.3	62.4	62.1	58.7	57.5	55.8	51.4	51.7
4/12/16	66.0	64.3	64.1	60.2	59.1	57.0	51.7	52.1
4/13/16	65.8	65.1	64.9	60.7	59.0	57.2	52.2	52.6
4/14/16	66.2	65.4	65.0	60.7	59.1	57.3	51.7	52.2
4/15/16	66.0	64.0	63.4	58.9	56.6	55.0	49.9	51.4

**STUDY REPORT
SALMONID REDD MAPPING
2014/2015 AND 2015/2016 MONITORING REPORT**

ATTACHMENT B

**CHINOOK SALMON AND *O. MYKISS* SPAWNING DISTRIBUTION ON
THE TUOLUMNE RIVER DURING THE 2014/2015 AND 2015/2016
MONITORING SEASONS**

This Page Intentionally Left Blank.

Table B-1. Chinook salmon and *O. mykiss* spawning distribution on the Tuolumne River during 2014/2015.

Riffle ID	RM	Riffle Area (ft ²)	# Chinook Redds	Chinook Redd Density (redd/100ft ²)	# <i>O. mykiss</i> Redds
4 FW Riffle	51.9	38,804	17	0.044	1
11 FW Riffle	51	53,581	7	0.013	0
11 FW Riffle-R ¹	51	6,287	4	0.064	0
11 FW Riffle-R2011 ¹	51	14,222	18	0.127	4
14 BC Riffle	50.6	44,651	5	0.011	0
14 BC Riffle-DFW ¹	50.6	73,207	22	0.030	4
18 BC Riffle	50.4	30,596	0	0.000	0
21 FW Riffle	50	63,348	4	0.006	0
25 BC Riffle	49.5	60,699	13	0.021	1
27 FW Riffle	49.2	15,468	4	0.026	1
30 FW Riffle	49.1	114,769	12	0.010	0
33 FW Riffle	48.5	155,935	0	0.000	0
36 BC Riffle	48.3	24,008	0	0.000	0
38 BC Riffle	48.1	13,651	0	0.000	0
41 BC Riffle	47.2	68,536	11	0.016	1
43 FW Riffle	47	29,713	3	0.010	0
46 FW Riffle	46.8	26,942	4	0.015	2
54 BC Riffle	46	55,788	5	0.009	2
57 BC Riffle	45.9	96,122	14	0.015	14
61 BC Riffle	45.7	38,773	0	0.000	0
70 BC Riffle	45.2	20,526	0	0.000	0
72 BC Riffle	45	39,428	3	0.008	2
75 BC Riffle	44.9	8,525	2	0.023	0
79 BC Riffle	44.8	10,295	3	0.029	0
81 BC Riffle	44.7	23,334	2	0.009	0
89 BC Riffle-Bobcat U ¹	43.5	22,310	9	0.042	0
91 BC Riffle- Bobcat M ¹	43.1	16,373	1	0.003	0
94 BC Riffle- Bobcat L ¹	43	11,183	1	0.001	0
96 BC Riffle	42.8	7,851	3	0.038	0
99 BC Riffle	42.4	25,364	1	0.004	1
102 BC Riffle	42.4	16,428	0	0.000	0
104 FW Riffle	42.4	15,413	0	0.000	0
107 BC Riffle	42.2	37,954	5	0.013	1
109 BC Riffle	41.9	29,689	2	0.007	0
116 BC Riffle	41.1	19,520	9	0.046	0
120 BC Riffle	40.4	19,120	1	0.005	0
124 BC Riffle	39.6	28,817	0	0.000	0
285 BC Riffle	39.3	6,786	2	0.029	-- ²
126 BC Riffle	39.1	36,186	1	0.003	0
128 FW Riffle	38.7	13,475	2	0.015	0
132 FW Riffle	38.4	9,176	0	0.000	0
135 BC Riffle	38.3	45,119	6	0.013	0
140 BC Riffle	37.9	36,089	4	0.011	0
144 BC Riffle	37.7	42,122	3	0.007	0
146 BC Riffle	37.5	24,624	2	0.008	1
148 BC Riffle	37.3	26,748	1	0.004	0
152 BC Riffle	37	35,940	0	0.000	1
156 BC Riffle	36.9	36,182	4	0.011	0
158 BC Riffle	36.7	13,904	1	0.007	0

Riffle ID	RM	Riffle Area (ft ²)	# Chinook Redds	Chinook Redd Density (redd/100ft ²)	# <i>O. mykiss</i> Redds
160 BC Riffle	36.5	14,309	1	0.007	0
162 BC Riffle	36.4	27,731	1	0.004	0
165 FW Riffle	35.7	37,627	11	0.029	0
167 BC Riffle	35.3	8,700	0	0.000	0
170 BC Riffle	35.2	35,329	1	0.003	0
172 BC Riffle	35.1	13,278	7	0.053	0
175 BC Riffle	34.8	21,135	4	0.019	0
182 BC Riffle	34.3	32,429	3	0.009	0
185 BC Riffle	34.2	54,462	1	0.002	0
187 BC Riffle	34	67,286	1	0.001	0
190 BC Riffle	33.8	14,143	5	0.035	1
192 BC Riffle	33.6	17,312	2	0.012	0
194 BC Riffle	33.4	45,803	9	0.020	0
197 FW Riffle	32.6	25,154	1	0.004	0
200 BC Riffle	32.4	23,300	1	0.004	0
203 BC Riffle	32.2	27,765	2	0.007	0
206 BC Riffle	32	28,305	2	0.007	0
209 BC Riffle	31.8	42,196	5	0.012	0
211 BC Riffle	31.7	11,667	1	0.009	0
214 FW Riffle	31.3	22,235	0	0.000	-- ²
216 BC Riffle	31.1	46,057	1	0.002	-- ²
219 BC Riffle	31	98,003	0	0.000	-- ²
221 BC Riffle	30.8	29,697	1	0.003	-- ²
227 FW Riffle	30.2	8,050	0	0.000	-- ²
229 FW Riffle	30.2	5,379	2	0.003	-- ²
235 BC Riffle	29.9	26,243	2	0.007	-- ²
237 BC Riffle	29.7	19,403	0	0.000	-- ²
240 FW Riffle	27.9	6,845	0	0.000	-- ²
242 FW Riffle	27.8	12,750	0	0.000	-- ²
244 FW Riffle	26	44,415	2	0.005	-- ²
246 FW Riffle	25.9	11,081	2	0.018	-- ²
248 FW Riffle	25.7	16,353	0	0.000	-- ²
250 FW Riffle	25.6	104,566	3	0.003	-- ²
253 FW Riffle	25.1	33,484	1	0.003	-- ²
255 FW Riffle	24.8	37,399	0	0.000	-- ²
257 FW Riffle	24.5	26,956	2	0.007	-- ²
259 BC Riffle	24.2	28,935	0	0.000	-- ²
261 FW Riffle	23.8	17,155	0	0.000	-- ²
263 FW Riffle	23.6	12,972	0	0.000	-- ²

¹ Gravel augmentation sites

² Riffles not surveyed during *O. mykiss* spawning period

Table B-2. Chinook salmon and *O. mykiss* spawning distribution on the Tuolumne River during 2015/2016.

Riffle ID	RM	Riffle Area (ft²)	# Chinook Redds	Chinook Redd Density (redd/100ft²)	# <i>O. mykiss</i> Redds
4 FW Riffle	51.9	38,781	6	0.015	8
11 FW Riffle	51	58,507	4	0.007	0
11 FW Riffle-R ¹	51	6,284	0	0.000	0
11 FW Riffle-R2011 ¹	51	14,213	4	0.028	0
14 BC Riffle	50.6	54,070	3	0.006	0
14 BC Riffle-DFW ¹	50.6	73,166	7	0.010	0
18 BC Riffle	50.4	30,579	0	0.000	0
21 FW Riffle	50	63,313	1	0.002	1
25 BC Riffle	49.5	60,665	8	0.013	0
27 FW Riffle	49.2	15,459	4	0.026	0
30 FW Riffle	49.1	114,706	2	0.002	0
33 FW Riffle	48.5	155,850	0	0.000	0
36 BC Riffle	48.3	23,995	0	0.000	0
38 BC Riffle	48.1	13,644	1	0.007	0
41 BC Riffle	47.2	68,500	2	0.003	5
43 FW Riffle	47	29,697	1	0.003	0
46 FW Riffle	46.8	26,928	2	0.007	0
54 BC Riffle	46	55,759	1	0.002	2
57 BC Riffle	45.9	96,073	1	0.001	9
61 BC Riffle	45.7	38,753	0	0.000	1
70 BC Riffle	45.2	20,516	2	0.010	0
72 BC Riffle	45	39,409	2	0.005	2
75 BC Riffle	44.9	8,521	1	0.012	0
79 BC Riffle	44.8	10,290	0	0.000	0
81 BC Riffle	44.7	23,322	2	0.009	0
89 BC Riffle-Bobcat U ¹	43.5	21,282	1	0.005	0
91 BC Riffle-Bobcat M ¹	43.1	29,090	0	0.000	0
94 BC Riffle- Bobcat L ¹	43	83,546	1	0.001	0
96 BC Riffle	42.8	7,847	1	0.013	0
99 BC Riffle	42.4	25,352	0	0.000	0
102 BC Riffle	42.4	16,420	0	0.000	0
104 FW Riffle	42.4	15,406	1	0.006	0
107 BC Riffle	42.2	37,936	0	0.000	0
109 BC Riffle	41.9	29,676	3	0.010	0
116 BC Riffle	41.1	19,511	4	0.021	2
120 BC Riffle	40.4	19,111	2	0.010	0
124 BC Riffle	39.6	28,805	0	0.000	0
285 BC Riffle	39.3	6,783	2	0.029	0
128 FW Riffle	38.7	13,469	1	0.007	0
132 FW Riffle	38.4	9,172	1	0.011	0
135 BC Riffle	38.3	45,101	2	0.004	0
140 BC Riffle	37.9	36,075	2	0.006	2
144 BC Riffle	37.7	42,106	4	0.009	0
146 BC Riffle	37.5	24,615	2	0.008	1
148 BC Riffle	37.3	26,738	0	0.000	0
152 BC Riffle	37	35,926	2	0.006	0
156 BC Riffle	36.9	36,168	0	0.000	2
158 BC Riffle	36.7	13,898	2	0.014	0
160 BC Riffle	36.5	14,304	0	0.000	0

Riffle ID	RM	Riffle Area (ft ²)	# Chinook Redds	Chinook Redd Density (redd/100ft ²)	# <i>O. mykiss</i> Redds
162 BC Riffle	36.4	27,721	0	0.000	0
165 FW Riffle	35.7	37,613	2	0.005	0
167 BC Riffle	35.3	8,697	2	0.023	0
170 BC Riffle	35.2	35,317	2	0.006	0
172 BC Riffle	35.1	13,273	1	0.008	0
175 BC Riffle	34.8	21,128	2	0.009	0
182 BC Riffle	34.3	32,418	2	0.006	0
185 BC Riffle	34.2	54,444	2	0.004	1
187 BC Riffle	34	67,263	0	0.000	0
190 BC Riffle	33.8	14,138	0	0.000	0
192 BC Riffle	33.6	17,306	0	0.000	0
194 BC Riffle	33.4	45,788	3	0.007	0
197 FW Riffle	32.6	25,146	1	0.004	0
200 BC Riffle	32.4	23,293	2	0.009	0
203 BC Riffle	32.2	27,757	0	0.000	0
206 BC Riffle	32	28,296	0	0.000	0
209 BC Riffle	31.8	42,183	2	0.005	0
211 BC Riffle	31.7	11,664	0	0.000	0
214 FW Riffle	31.3	22,229	-- ²	-- ²	-- ²
216 BC Riffle	31.1	46,043	-- ²	-- ²	-- ²
219 BC Riffle	31	97,975	-- ²	-- ²	-- ²
221 BC Riffle	30.8	29,688	-- ²	-- ²	-- ²
227 FW Riffle	30.2	8,048	-- ²	-- ²	-- ²
229 FW Riffle	30.2	5,377	-- ²	-- ²	-- ²
235 BC Riffle	29.9	26,236	-- ²	-- ²	-- ²
237 BC Riffle	29.7	19,398	-- ²	-- ²	-- ²
240 FW Riffle	27.9	6,844	-- ²	-- ²	-- ²
242 FW Riffle	27.8	12,747	-- ²	-- ²	-- ²
244 FW Riffle	26	44,405	-- ²	-- ²	-- ²
246 FW Riffle	25.9	11,079	-- ²	-- ²	-- ²
248 FW Riffle	25.7	16,349	-- ²	-- ²	-- ²
250 FW Riffle	25.6	104,543	-- ²	-- ²	-- ²
253 FW Riffle	25.1	33,477	-- ²	-- ²	-- ²
255 FW Riffle	24.8	37,391	-- ²	-- ²	-- ²
257 FW Riffle	24.5	26,950	-- ²	-- ²	-- ²
259 BC Riffle	24.2	28,929	-- ²	-- ²	-- ²
261 FW Riffle	23.8	17,151	-- ²	-- ²	-- ²
263 FW Riffle	23.6	12,969	-- ²	-- ²	-- ²

¹ Gravel augmentation sites

² Reach 4 not surveyed in 2015/2016 due to excessive water hyacinth that blocked access