July 2008 Population Size Estimate of *Oncorhynchus mykiss* in the Lower Tuolumne River

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SUMMARY

In mid-July 2008, a population size estimate of resident (*Oncorhynchus mykiss*) was conducted in the lower Tuolumne River in accordance with the April 3, 2008 Delegated Order issued by the Federal Energy Regulatory Commission (FERC) implementing portions of a study plan developed in coordination with California Dept. of Fish and Game (CDFG), National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) biologists, and submitted to FERC on July 16, 2007.

Snorkel surveys were conducted during daylight hours (6:00am–8:00pm) from 11 to 16 July 2008 using a two-phase survey design after Hankin and Mohr (2001) to sample seven different habitat strata (i.e., riffle, run head, run body, run tail, pool head, pool body, and pool tail) found downstream of La Grange Dam from river mile (RM) 51.8 to Robert's Ferry Bridge at RM 39.6. The study reach extent included in the FERC study plan corresponds to historical observations of *O. mykiss* found in past summer snorkel surveys and was validated by routine snorkel surveys conducted in late June 2008. Out of 155 sampling units delineated by habitat-typing surveys, 42 units were selected for either single pass or multi-pass snorkel surveys.

Based upon the maximum count obtained over all dive passes in each sampled unit, 135 young-of-the-year (YOY)/juvenile (< 150 mm FL) and 45 adult (> 150 mm FL) (180 total) *O. mykiss* were observed along the study reach. Most juveniles were found in riffles and the upstream end (heads) of run habitat, while adults mainly were found within pool heads and riffles. Using a bounded counts population estimator, approximately 3,096 *O. mykiss* are estimated within the survey reach (RM 51.8–39.6), with 95% confidence bounds of 1,905–3,047 and 325–914 YOY/juvenile and adult size classes, respectively.

Other species observed included Chinook salmon (*O. tshawytscha*), smallmouth bass (*Micropterus dolomieu*), largemouth bass (*M. salmoides*), Sacramento pikeminnow (*Ptychocheilus grandis*), bluegill (*Lepomis macrochirus*), Sacramento sucker (*Catostomus occidentalis*), and riffle sculpin (*Cottus gulosus*). Ninety-six juvenile (< 150 mm FL) Chinook salmon were observed along the study reach from RM 51.8 to RM 43.1, within all habitat types except pool tail and run tail.. A combination of hardhead and Sacramento pikeminnow, along with Sacramento sucker accounted for 98% of observed non-salmonid fish, while centrarchids (largemouth bass, smallmouth bass, spotted bass, bluegill, and green sunfish) and sculpin (*Cottidae sp*.) accounted for the remaining 2%. Most centrarchids occurred toward the downstream end of the study reach at water temperatures >22°C (71.6 °F), while native minnow (hardhead and pikeminnow) and sucker were found throughout the reach.

To test the hypothesis that the summertime distribution of suitable habitat by observed life stages of *O. mykiss* is related to ambient river water temperature, water temperature data taken from thermographs were compared to juvenile and adult *O. mykiss* density along the study reach. The data show that temperatures increased in the downstream direction, from 12.9 ºC (55.2 °F) to 24.6 ºC (76.3°F) (maximum weekly average temperature), and that *O. mykiss* density decreased along the same gradient. Although adult *O. mykiss* density was greatest just downstream of La Grange Dam, density decreased markedly in the downstream direction and no adults were found downstream of RM 45.8 at temperatures of 20.0 °C (68 °F). In contrast, juvenile *O. mykiss* occurred at higher density farther downstream of La Grange dam, with the most downstream observation (RM 41.1) in waters with temperatures of 24.7°C (<76.5°F).

Habitat use of juvenile *O. tshawytscha* life stages followed the same general trend as for *O. mykiss* juveniles, with decreasing densities in the downstream direction. *O. mykiss* and *O. tshawytscha* data collected within this survey were compared to routine snorkel survey data collected during mid-June (17–19 June) by TID/MID. The comparison shows similar juvenile *O. mykiss* density in riffles and runs, and a similar longitudinal trend. Along the study reach 210 *O. mykiss* juveniles and 22 adults were observed in June, while 101 juveniles and 5 adults were observed in July. Forty three juvenile Chinook were seen in June and 61 were seen in July 2008.

A second hypothesis that habitat use by *O. mykiss* juveniles and adults observed in the Tuolumne River occurred at the same density in both restored and nearby reference sites was not tested during the initial snorkel surveys conducted in July 2008. Because of delays in construction funding of planned restoration projects, the habitat unit selection for the population estimate coincided with only one restoration site at Bobcat Flat (RM 43) completed by the Friends of the Tuolumne (FOT) in 2005, where two fish, a juvenile *O. mykiss* and a juvenile *O. tshawytscha*, were observed. Routine snorkeling of a CDFG gravel augmentation site (RM 50.6) completed in 2003 found 74 juvenile and 2 adult *O. mykiss*, along with 26 juvenile *O. tshawytscha*. No other restoration sites were examined over the course of either survey, thus a valid comparison between restoration and reference sites was not attainable. Depending upon habitat unit selection in subsequent surveys, or targeted sampling at habitat units surrounding these restoration sites, this hypothesis may be examined further in winter or summer 2009 surveys.

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1 INTRODUCTION

Routine fisheries monitoring surveys for the Don Pedro Project (FERC Project No. 2299) by the Turlock Irrigation District (TID) and Modesto Irrigation District (MID) have long documented the presence of *Oncorhynchus mykiss* in the lower Tuolumne River (TID/MID 2005). Summer snorkel surveys, conducted in most years since 1988, have documented an increased *O. mykiss* presence and relative abundance that is associated with the more consistent and higher summer flows provided since 1997 (TID/MID 2008a).

On 19 March 1998, the National Marine Fisheries Service (NMFS) first listed the Central Valley steelhead as threatened under the Endangered Species Act (ESA). After several court challenges, NMFS issued a new final rule relisting the Central Valley steelhead on 5 January 2006 (71 FR 834). In a separate process resulting from terms of the 1996 FERC license amendment for the Project, NMFS staff provided input to a draft limiting factors analysis for Tuolumne River salmonids (Mesick et al. 2007) and included recommendations for developing abundance estimates, habitat use surveys, and anadromy determination of resident *O. mykiss*. These recommendations were conceptually used to develop the Districts' FERC Study Plan (TID/MID 2007), which was the subject of a 3 April 2008 FERC Order. As part of the Order, the Districts were required to conduct population estimate surveys in summer (June/July) and winter (February/March), starting in summer 2008 to determine *O. mykiss* population abundance by habitat type.

The Districts submitted a detailed *O. mykiss* population estimate study plan to FERC on 3 July 2008 to provide information on the abundance and habitat requirements within the lower Tuolumne River. In addition to data on population size, the study plan employed snorkel surveys to examine the following hypotheses:

Hypothesis 1: Summertime distribution of suitable habitat by observed life stages of *O. mykiss* is related to ambient river water temperature.

Hypothesis 2: Habitat use by *O. mykiss* juveniles and adults observed in the Tuolumne River occurs at the same density in both restored and nearby reference sites.

The *O. mykiss* snorkel surveys employed a two-phase sampling approach for the development of a reach-wide population estimate (Hankin and Mohr 2001) in the lower Tuolumne River. Survey sites were selected using a stratified random sampling approach, where the strata were major habitat types. The overall sampling "universe" from which sampling strata were delineated was within areas where *O. mykiss* have been frequently observed rearing during the summer. The survey reach (Figure 1) typically extends from approximately river mile (RM) 52–40 during most summers and the routine June 2008 snorkel survey reference counts recorded *O. mykiss* as far downstream as RM 42.9 (TID/MID 2008b).

The two-phase stratified sampling design involved snorkeling pre-selected habitat units (e.g., riffle, run, pool, etc.) multiple times in order to quantify the variance associated with density and subsequent population estimates. As in a typical Phase 1 sampling approach, primary snorkel surveys (Edmundson et al. 1968, Hankin and Reeves 1988, McCain 1992, Dolloff et al. 1996) were conducted across a subset of the all habitat units. In Phase 2, approximately 20–70% of each habitat type sampled was randomly selected for replicated surveys by repeated dive counts.

The methods presented by Stillwater Sciences (2008) discussed using a combined approach of both repeated dive counts and electrofishing. Current ESA permit restrictions for both NMFS Section 10(a)(1)(A) permit No's 1280 (TID) and 1282 (Stillwater) did not allow sufficient incidental take to conduct the second-phase surveys using electrofishing. Consequently, the first survey effort conducted in July 2008 utilized only snorkel surveys, as provided for in the 2007 study plan and identified in a 3 July 3008 letter to FERC from the Districts. Depending upon the outcome of the pending amendment request for permit No. 1282 with NMFS, subsequent surveys may be conducted using the combined dive survey and electrofishing methodology.

2 METHODS

2.1 Habitat Characterization

2.1.1 Habitat mapping

We produced habitat maps from a combination of past habitat surveys, historical and more recent aerial photographs, and recent field surveys superimposed within a geographic information system (GIS). Field maps for the July 2008 snorkel survey were created using an orthorectified aerial photo and accompanying Light Detection and Ranging (LiDAR) topographic data from 21 September 2005 recorded at river flows of 321 cfs. Preliminary sampling unit boundaries of common habitat features (pools, riffles, and runs) were estimated from the LiDAR and bathymetric data between RM 52–38 within GIS by calculating locations corresponding to major water depth transitions (**Table 2-1**)

Table 2-1. Coarse-scale habitat types used during snorkel surveys.

Habitat Type	Description[a]	Approximate Depth
Riffle	Shallow with swift flowing, turbulent water. Partially exposed substrate dominated by cobble or boulder. Gradient moderate (less than 4%).	0–4 ft
Run	Fairly smooth water surface, low gradient, and few flow obstructions. Mean column velocity generally greater than one foot per second (fts^{-1}).	4–10 ft
Pool	Slow flowing, tranquil water with mean column water velocity less than 1 fts^{-1}.	>10 ft

a. Major habitat types determined based upon observed hydraulic conditions (McCain 1992, Thomas and Bovee 1993, Cannon and Kennedy 2003)

As an initial validation of these coarse scale habitat types, we compared the habitat types mapped in July 2008 (Appendix A) with previous habitat type maps (Appendix B) developed by McBain and Trush (2004) between 1999–2001 on a base-layer map corresponding to a wetted perimeter of 622 cfs flown on 20 May 20 1991. Appendix B shows major habitat types (i.e., riffle, run, pool) encountered during the 1999–2001 surveys along with past and planned gravel introduction locations included in the *Tuolumne River Coarse Sediment Management Plan* (McBain and Trush 2004).

In general, habitat typing shown by McBain and Trush (Appendix B) indicates larger proportions of "pool" habitat types than those determined during this effort (Appendix A), which reserved the pool habitat designation for water greater than 10 ft in depth. Additionally, because *O. mykiss* tend to congregate at transitions between habitat types, Appendix A shows a further division of

pools and runs into smaller, transitional habitat sampling units (pool head, pool body, pool tail, run head, run body, and run tail) based upon location of slope channel slope break at the upstream and downstream end of the unit.

2.1.2 Habitat data collection

On 7-8 July 2008, we conducted float surveys to further refine and validate the preliminary habitat maps (Appendix A) described above at flows of approximately 100 cfs (Figure 2). In addition to refining the locations and sizes of potential habitat sampling units, we collected habitat data (**Table 2-2**) at several locations within each sampling unit. Starting at upstream end of the study reach just downstream of La Grange Dam (Figure 1), we assigned habitat units a natural sequence order (NSO), a number, beginning with NSO 001, and incremented this identifier at each habitat transition (e.g., NSO 001 pool head, NSO 002 pool body, etc). We located and marked the upstream and downstream end of each unit on field maps, recorded location with a handheld GPS unit, and tied flagging labeled with the date, unit number, and habitat type.

Table 2-2. Habitat data collected at each unit.

Parameter	Method	Metric/Descriptor	Method Reporting Limit
Natural Sequence Order (NSO – Habitat unit #)	N/A	NSO-1, NSO-2, NSO-3, …	N/A
Latitude/Longitude	Handheld GPS receiver	UTM	N/A
Habitat type	Visual estimation	See Table 2-1. Coarse-scale habitat types used during snorkel surveys	N/A
Average unit width	Horizontal distance	Meters (feet) (measured at multiple transects)	0.01 m (0.1 ft)
Average unit length	Horizontal distance	Meters (feet)	0.01 m (0.1 ft)
Maximum/minimum depth	Vertical distance	Meters (feet)	0.15 m (0.5 ft)
Bed substrate composition	Visual estimation	Bedrock, boulder, cobble, gravel, organic, sand, silt	10%
Cover type	Visual estimation	None, boulder, cobble, IWM, bedrock ledges, overhead vegetation, aquatic vegetation	10%

Note that although the base layer of the July 2008 habitat maps corresponds to a 2005 air photo at flows of 321 cfs, in order to provide a more accurate channel edge boundary for the July 2008 surveys, the channel edge of the habitat unit boundaries shown in Appendix A correspond to a wetted perimeter of 96 cfs, previously digitized from air photos taken on taken on 19 January 1991. For each habitat unit shown, habitat unit length and width were determined in GIS. Appendix C shows accompanying field habitat data (**Table 2-2**) collected in all habitat units mapped, including maximum depth and width (usually at 1/3 and 2/3 of the unit's length), bed substrate composition, and instream cover type.

2.2 Snorkel Surveys

2.2.1 Study design and survey unit selection

After habitat typing and collecting habitat data in all units, we selected a subset of six units of each habitat type for single-pass snorkel surveys (**Table 2-3**). The subsets were selected to balance the habitat sampling unit replication, total available number of units to draw from, coverage of at least 10% of the total length of a given habitat type, as well as sampling effort. The selection process involved random selection of one of the most upstream units of each habitat type, followed by a systematic uniform sampling of the remaining units in the study reach. Certain units were prohibitively large to allow divers to survey the entire length, so units longer than approximately 600 ft (200 m) were sub-sampled in about 300 ft (100 m) sections centered on the unit's mid-point and extending about 150 ft (50 m) upstream and downstream. After the first dive pass was completed, a tab was then pulled to determine if the unit was included in the second phase of sampling.

Table 2-3. Sample unit selection and survey count.

Habitat	Phase I Dives		Phase II Survey	
	Initial Units	Passes	Repeat Units	Passes
Riffle	6	1	4	3
Pool head	6	1	2	3
Pool body	6	1	2	3
Pool tail	6	1	2	3
Run head	6	1	2	3
Run body	6	1	2	3
Run tail	6	1	2	3
	Total	42	Total	48

2.2.2 Snorkel data collection

Snorkel surveys were conducted during daylight hours (6:00 a.m.–8:00 p.m.) from 11 to 16 July 2008. A two-phase survey design was used to survey the seven different riffle, run, and pool strata (**Table 2-3**). At the first phase, single-pass dive surveys were conducted by a four-person team. Sampling units were sampled from downstream to upstream in dive lanes using a zigzag pattern, passing fish and allowing them to escape downstream of the diver. If fish were observed to escape upstream, the diver took care to avoid counting these individuals twice. Divers recorded the type, length, and number of fish (**Table 2-4**). Total lengths were estimated in 50 mm size ranges, or "bins," using markings on dive slates to correct for underwater size distortion.

Table 2-4. Fish collected within each unit during snorkel surveys.

Parameter	Method	Metric/Descriptor	Method Reporting Limit
Date/Start time/End time	N/A	Day/month/year	N/A
Number of Individuals	Visual estimation	Number	1
Fish length – snorkeling	Visual estimation	Millimeter	50 mm

The second phase of sampling required the collection of fish count and size data during each of three passes subsequent passes through a selected habitat unit. These data were later used to extrapolate dive counts to total population estimates. Lastly, occurrence of other non-salmonid native and non-native fish species was recorded as presence/absence and abundance.

2.3 Water Quality and Flow

At fish sampling locations, in addition to noting the type, length, and number of fish (Section 2.2), we collected spot measurements of *in situ* water quality data (temperature, dissolved oxygen, and conductivity) using a pre-calibrated multi-probe (YSI 85, Yellow Springs Instruments, Yellow Springs, OH) (**Table 2-5**). Dissolved oxygen probes were recalibrated at each site and checked for accuracy in the laboratory against concentrations measured in aerated tap water. Changes in underwater visibility were monitored using a Secchi disk oriented both toward and away from the sun. Daily average flow data for each day were obtained from the stream gage below the La Grange powerhouse at RM 51.8 (USGS No. 11289650).

Table 2-5. Water quality data collected during snorkel surveys.

Parameter	Method	Metric/Descriptor	Method Reporting Limit
Temperature	EPA 170.1	°C	0.1 °C
Dissolved Oxygen	SM 4500-O	mg/L	0.01 mg/L
Conductivity	SM 2510A	umhos/cm	1.0 umhos/cm
Visibility	Secchi depth	meters (feet)	0.01 m (0.1 ft)

2.4 Water and Air Temperatures

From Spring 1987 to present, TID/MID has collected water temperature data from below the La Grange Dam powerhouse (RM 52.0) to the San Joaquin River confluence (RM 0.0) using recording thermographs. These are currently Hobo Pro V2 thermographs (OnSet Computer Corporation, Bourne, MA) housed in protective cases and placed near shore in areas deep enough to avoid dewatering. The thermographs measured and stored water temperature data at one-hour intervals, and these data were historically and are currently downloaded at least twice a year.

Water temperature data collection during summer 2008 also included spot measurements taken during snorkel surveys. The measurements were recorded over the course of the day as divers moved further downstream; as such, it was anticipated that these water temperatures would not be as representative as hourly thermograph recordings. The data do provide a general description of relative temperature conditions during dive surveys.

Regional air temperature data were obtained from the National Weather Service (NWS) station at Modesto Airport near RM 18. Water and air temperature data for the June through July 2008 period are presented in this report (Figure 2).

2.5 Data analysis

2.5.1 Bounded counts population estimate

Water quality and fish observation counts were summarized by habitat unit type and initial density estimates were calculated based upon the area searched within each habitat unit sampled. In addition to comparisons of fish density between habitat types, the density estimates and uncertainties were propagated across the unsampled areas for an overall population estimate.

Population estimates were made for each stratum and size class using the general methods of Hankin and Mohr (2001). For units receiving multiple dives, the bounded counts formulae are used to produce an estimate of the unit population and an estimate of the variance of this estimate. Specifically, when there are four passes, and the counts of these are sorted in increasing order as $m_1 \le m_2 \le m_3 \le m_4$, the population is estimated as

$$\tilde{y}_B = m_4 + (m_4 - m_3),$$

and the mean squared error of this is estimated as

$$\tilde{\mathrm{MSE}}(\tilde{y}_B) = (m_4 - m_3)^2.$$

The total population of multiply dived units is estimated as the sum of the bounded-counts estimates for the individual units. The total population of the survey region is estimated by expanding this, first to *all* dived units (singly or multiply dived) on the basis of mean dive counts, and then to all units (dived or undived) on the basis of area. An estimator of the variance of this is constructed from estimates of the mean-squared errors of the bounded-counts estimates for the multiply dived individual units, and the variance of the bounded-counts estimates around their common mean. The final formulae are included in Hankin and Mohr (2001). A nominal confidence interval for each stratum and size class was calculated formally as

$\hat{Y} \pm 1.96\sqrt{\hat{V}}$, where $\hat{Y}$ and $\hat{V}$ are the mean and variance estimates, *except* that the lower bound of this interval was clipped to the number of fish actually observed.

2.5.2 June 2008 TID/MID Snorkel Surveys

Data collected during the July 2008 snorkel surveys (11–16 July) were compared to routine snorkel survey data collected during mid-June (17–19 June) (TID/MID 2008b). In general, although the sampled areas and locations of these surveys differ, these data were collected only a few weeks prior to the data collected for this report, allowing for comparison of presence/absence and relative proportions of larger and smaller size classes of *O. mykiss* and *O. tshawytscha* in habitat units sampled during both surveys. Further, although TID/MID has sampled the same locations since 2001, we limit our comparison to the June 2008 data as these are the most directly comparable.

3 RESULTS

3.1 Habitat Characterization

The "Run body" habitat type was the most abundant and occupied the greatest length of channel along the study reach, followed by riffles (**Table 3-1**). Pool bodies, while less abundant than other habitat types (e.g., run head and tail), occupied the third greatest length of channel. Other habitat types, despite being abundant, accounted for only 9% of the total reach length. Habitat maps and data for the entire study reach are shown in Appendices A and C.

Table 3-1. Summary of habitat data collected in July 2008.

Habitat Type	Count	% by Count	Total length (feet)	Total length (miles)	% reach length	Area (ft^2)
Riffle	34	22	14,320	2.71	22	1,209,945
Pool head	6	4	619	0.12	1	51,140
Pool body	9	6	6,741	1.28	11	915,948
Pool tail	6	4	781	0.15	1	74,401
Run head	32	20	2,067	0.39	3	199,592
Run body	37	24	37,350	7.07	58	3,946,812
Run tail	31	20	2,393	0.45	4	264,732
Total	**155**	**100**	**64,271**	**12.2**	**100**	**6,662,570**

The longitudinal distribution of the area of each of the major habitat types is shown in Figure 3. Pool habitat, designated as slow-flowing waters at depths greater than 10 ft (**Table 2-1**), was more concentrated in the survey reach upstream of RM 48. In contrast, areas of shallower run-type habitats were less abundant upstream of RM 48 than downstream. Riffle habitats were more uniformly distributed throughout the survey reach, but accounted for less than 10% of the total area surveyed downstream of RM 44.

3.2 Water Quality and Flow

As water quality data were collected exclusively within units chosen for snorkel survey, data are presented by river mile, rather than by NSO, or summarized for the entire reach (**Table 3-2**). Daily average flow during the study period ranged from 88–110 cfs. Water quality data for habitat units selected for snorkel surveys are shown in Appendix D. The water temperature ranges shown in **Table 3-2** represent changes over the course of the sampling day, and do not include nighttime temperatures or lows that are shown at representative thermograph locations in Appendix E. In general, dissolved oxygen concentration decreased with increasing temperatures along the same gradient, while specific conductivity increased. Horizontal and vertical visibility also decreased in the downstream direction, except that vertical visibility generally extended to the channel bottom and the maximum depth of habitat units also decreased moving downstream.

Table 3-2. Range of water quality data collected at snorkel sites during fish surveys.

River Miles	Sample Date	Flow (cfs)[1]	Water Temp °C [°F]	DO (mg/L)	Horizontal visibility (ft)	Specific conductivity (uS/cm)
51.8−51.0	7/11/2008	110	11.5–14.0 [52.7–57.2]	11.4−12.7	12–27	38.2–40.0
49.7−49.1	7/12/2008	102	13.8–18.4 [56.8–65.1]	11.8−12.2	14–15	39.6–40.8
49.2−48	7/15/2008	88	15.1–18.4 [59.2–65.1]	11.1−11.9	10–14	40.0–40.8
48.0−45.1	7/13/2008	105	15.5–23.0 [59.9–73.4]	10.1−11.5	7–12	41.0–45.5
45.0−43.1	7/14/2008	102	21.0–24.6 [69.8–76.3]	10.1−10.8	6–8	45.0–50.5
43.1−39.6	7/16/2008	95	21.8–25.0 [71.2–77.0]	10.3−11.0	6–8	NA

[1] Daily average flow data are measured from the stream gauge below La Grange powerhouse at RM 51.8 (USGS No. 11289650).

Because of the strong influence of ambient air temperatures (Sullivan et al. 1990), temperatures of water released from the cold water pool of Don Pedro Reservoir increase in a downstream direction for both the spot measurements (**Table 3-2**) and in the continuous thermograph record (Appendix E).

3.3 Water and Air Temperature

The daily average water temperature for all thermographs and the daily minimum, maximum, and average air temperature (from the NWS station at the Modesto Airport) are shown in Appendix E. Water temperature data collected by thermographs followed similar trends to spot temperature data collected during snorkel surveys, which showed a general increase in the downstream direction (**Table 3-3**). We determined the range of daily averages, instantaneous maximum temperature, maximum weekly average temperature (MWAT), and the seven-day maximum temperature for the study period (11–16 July 2008), and all three metrics showed a similar trend of increasing in the downstream direction. The MWAT is the seven-day rolling average of average daily temperatures and describes ambient water temperature conditions over the previous week. It is a standard used in water quality studies and total maximum daily load (TMDL) estimations of allowable temperature. Along the study reach, the MWAT increased from 12.9°C (55.2 °F) at Riffle A7 to 24.6°C (76.3 °F) at Roberts Ferry Bridge (**Table 3-3**). The seven-day maximum temperature is the seven-day rolling average of the daily maximum temperatures and is a potentially more accurate indicator of conditions affecting survival and growth of salmonids (Sullivan et al 2000; Stillwater Sciences 2002). The seven-day maximum temperature (7dayMAX) ranged from 14.4°C (57.9 °F) at the Riffle A7 location to 26.2°C (79.2 °F) at the Roberts Ferry Bridge. The daily minimum, maximum, and average water temperatures for Riffle A7 (RM 50.7), Riffle 3B (RM 49), Riffle 13B (RM 45.5), Riffle 21 (RM 42.9), and Roberts Ferry Bridge (RM 39.6) from 1 June to 31 July 2008 are presented graphically in Appendix E.

Table 3-3. Maximum weekly average temperature, seven-day average of daily maximum temperatures, and instantaneous maximum temperatures recorded by thermographs in the survey reach of the lower Tuolumne River during July 2008.

Monitoring Location	RM	MWAT ºC [°F] (week ending)	7dayMAX ºC [°F] (week ending)	Instantaneous maximum ºC [°F] (date)
Riffle A7	50.8	12.9 [55.2] (16 July)	14.4 [57.9] (16 July)	14.9 [58.8] (15 July)
Riffle 3B	49.0	15.8 [60.4] (11 July)	18.1 [64.6] (11 July)	18.5 [65.3] (13 July)
Riffle 13B	45.5	20.2 [68.4] (11 July)	21.3 [70.3] (11 July)	22.0 [71.6] (14 July)
Riffle 21	42.9	22.8 [73.0] (11 July)	24.3 [75.7] (11 July)	24.1 [75.4] (14 July)
Roberts Ferry Bridge	39.6	24.6 [76.3] (12 July)	26.2 [79.2] (11 July)	25.8 [78.4] (14 July)

Note: Thermographs used have a reported error of ±0.2ºC.

The daily Modesto Airport air temperatures over the study period ranged from 25.0 to 28.9 ºC (77.0 to 84.0 °F) with a high temperature of 36.7 °C (98.1 °F) (Table 3-4). The warmest day of the summer occurred just before the study period on 9 July with an average daily temperature of 33.9 °C (93.0 °F) and a daily high temperature of 42.5 °C (108.5 °F) (Figure 2).

Table 3-4. Daily average, minimum, and maximum air temperature recorded at the NWS station at the Modesto Airport during the snorkeling study period.

Date	Average air temperature ºC [°F]	Minimum air temperature ºC [°F]	Maximum air temperature ºC [°F]
11 July 2008	27.8 [82.0]	20.6 [69.1]	35.0 [95.0]
12 July 2008	26.1 [79.0]	18.3 [64.9]	33.9 [93.0]
13 July 2008	28.3 [82.9]	20.0 [68.0]	36.7 [98.1]
14 July 2008	28.9 [84.0]	21.1 [70.0]	36.1 [97.0]
15 July 2008	25.0 [77.0]	17.2 [63.0]	32.2 [90.0]
16 July 2008	25.6 [78.1]	15.6 [60.1]	35.0 [95.0]

We compared hourly water temperature for several monitoring stations along the length of the study reach and daily air temperature from the Modesto Airport station (Figure 2). Interestingly, Figure 2 shows that at the upstream-most monitoring station, water and air temperature are more independent of each other than at thermographs located farther downstream. That is, water temperature becomes more influenced by air temperature in the downstream direction, with water and air temperature peaks and troughs occurring at the same times of day at the downstream monitoring site at Roberts Ferry Bridge (RM 39.6).

3.4 Snorkel Surveys

3.4.1 *O. mykiss* observations

In total, we observed 180 *O. mykiss* ranging from 0–499 mm (50 mm size bins) based upon maximum counts of all dive passes in each sampling unit (**Table 3-5** and Appendix F). Figure 4 shows the majority of these fish (138) were young-of-the-year (YOY) and juvenile (<150 mm), with fewer (45) adult (>150 mm) size classes.

The *O. mykiss* were observed in 20 different habitat units (NSOs) from RM 51.8 to RM 43.1 and in all habitat types except "run tail" (**Table 3-5** and **Table 3-6**). Habitat use and reach-wide distribution of YOY/juvenile and adult *O. mykiss* differed markedly, with first pass dive counts (Figure 5a) and fish densities (Figure 5b) highest in riffle habitats for juvenile size classes (<150mm) and higher counts and densities of adult size classes (>150 mm) in pool head habitats. Juvenile size classes were also in run head transitional habitat downstream of riffles, with lower densities in run bodies and no fish observed in pool habitats. Some adult-size classes were observed in riffle habitats and transitional pool head habitats as well as within run body habitats. Adult fish habitat use were concentrated at upstream pool head habitat units (three NSOs), a single riffle (one unit), and a single run body (Appendix F). In contrast, juvenile fish habitat use was more uniformly distributed from upstream to downstream with the highest counts within a single run head sampling unit (NSO 34 and RM 49.2) and a single riffle (NSO 74 at RM 45.7) (Appendix F).

Table 3-5. Maximum count of *O. mykiss* by NSO (data are divided into 50 mm total length size classes).

RM	Unit ID (NSO)	Habitat	Single (S) or multiple (M) pass survey	0-49 mm	50-99 mm	100-149 mm	150-199 mm	200-249 mm	250-299 mm	300-349 mm	350-399 mm	400-449 mm	450-499 mm
51.8	1	Pool Head	S								3	2	
51.6	4	Pool Head	S				1	2		1			
51.5	7	Riffle	M						2	3		4	3
51.1	9	Run Body	S								1	3	
49.7	27	Pool Head	M		4	4	3	1		3	1		
49.6	28	Pool Body	M						2	1	1		
49.6	29	Pool Tail	M			1							
49.2	33	Riffle	S		4	3				1			
49.2	34	Run Head	M		25	24			1				
49.1	35	Run Body	M		1						1	1	
48.0	53	Riffle	M		6	3							
47.0	58	Run Head	S			1					1		
46.9	59	Run Body	S		3								
45.7	74	Riffle	S	5	26	11	1						
45.0	86	Pool Head	M	1	2	2	1						
44.6	97	Riffle	S			2							
44.5	101	Riffle	M			3	1						
43.1	109	Run Body	S			1							
42.3	128	Riffle	S			2							
41.1	141	Run Head	M			1							
Total (Max. unit count of all passes)				**6**	**71**	**58**	**7**	**3**	**5**	**9**	**8**	**10**	**3**

Table 3-6. Maximum count of *O. mykiss* by habitat type (data are divided into 50 mm total length size classes).

Habitat	0-49 mm	50-99 mm	100-149 mm	150-199 mm	200-249 mm	250-299 mm	300-349 mm	350-399 mm	400-449 mm	450-499 mm	Total (Max. unit count of all passes)
Pool Body						2	1	1			4
Pool Head	1	6	6	5	3		4	4	2		31
Pool Tail			1								1
Riffle	5	36	24	2		2	4		4	3	80
Run Body		4	1					2	4		11
Run Head		25	26			1		1			53
Totals by size class	**6**	**71**	**58**	**7**	**3**	**5**	**9**	**8**	**10**	**3**	**180**

3.4.2 Summer 2008 *O. mykiss* Population Estimate

To provide a more consistent count basis for single pass dive units, the population estimate was derived using the first pass counts of all units surveyed, consistent with Hankin and Mohr (2001). **Table 3-7** shows the July 2008 *O. mykiss* population estimate for the lower Tuolumne River by length (<150 mm for YOY and juvenile; >150 mm for adults) and habitat type using the method of bounded counts (Hankin and Mohr 2001). Out of an overall population estimate of 3,096 *O. mykiss* in summer 2008, we estimated a 95% confidence interval of about 1,905–3,047 and 325–914 for YOY/juvenile and adults, respectively (**Table 3-7**). As discussed above, the data show that the greatest estimated abundance of YOY and juvenile *O. mykiss* occurred in riffles and run bodies, despite observing the greatest numbers in riffles and run heads (Figure 5a). The large differences between estimated and observed abundance in run habitat types are due to the large differences in habitat unit area with run bodies occupying 20 times more area than run heads (**Table 3-1**). A similar result was found for adult *O. mykiss* size classes, with high estimated abundance in riffles and run bodies despite greater numbers observed in pool heads during snorkel surveys (Figure 5a). The differences between estimated abundance and observed fish counts are due to differences in habitat unit area with run body habitat units occupying approximately 80 times more habitat area than pool head units (**Table 3-1**).

Table 3-7. *O. mykiss* summer 2008 bounded count population estimates by fish length and habitat type.

	***O. mykiss* < 150 mm**				***O. mykiss* ≥ 150 mm**				***Total***			
habitat	Seen[1]	est.	stdev	95% interval[2]	seen[1]	est.	stdev	95% interval[2]	seen	est	stdev	95% interval
Pool Head	12	20	10.1	12–40	17	45	13.2	19–71	29	65	16.7	33–98
Pool Body	0				3	24	18.0	3–59	3	24	18.0	3–59
Pool Tail	1	2	2.6	1–7	0				1	2	2.6	1–7
Run Head	46	166	179.0	46–517	1	6	8.8	1–23	47	172	179.2	47–523
Run Body	5	860	115.6	634–1,087	6	319	77.5	167–471	11	1,179	139.2	906–1,452
Run Tail	0				0				0			
Riffle	65	1,428	198.2	1,039–1,816	13	226	126.7	13–474	78	1,653	235.2	1,192–2,114
Total	**129**	**2,476**	**291.2**	**1,905–3,047**	**40**	**619**	**150.4**	**325–914**	**169**	**3,096**	**327.7**	**2,453–3,738**

[1] Largest numbers seen in any single dive pass for each unit, summed over units. Note that summation of the largest numbers seen within individual (50 mm) size bins yields higher estimates of total fish smaller and larger than 150 mm (Table 3-6).

[2] Nominal confidence intervals calculated as +/- 1.96 standard deviations. When this yielded lower bounds less than the numbers seen, the lower bound was truncated accordingly and the interval shaded.

3.4.3 *O. tshawytscha* observations

Divers observed Chinook salmon (*O. tshawytscha*) within the study reach. Salmon were seen in 15 different sampling units from RM 51.7 to RM 43.1 (**Table 3-8**) and all habitat types except pool tail and run tail (**Table 3-9**). Most were oversummering juveniles found within the 50–99 mm size class.

Table 3-8. Maximum counts of juvenile Chinook salmon by size class and sampling unit.

River Mile	Sampling Unit (NSO)	Habitat type	Single (S) or multiple (M) pass survey	0–49 mm	50–99 mm	100–149 mm
51.7	2	Pool Body	S			
51.5	7	Riffle	M			
49.7	27	Pool Head	M		4	3
49.6	28	Pool Body	M		10	10
49.2	34	Run Head	M		25	
49.1	35	Run Body	M		1	
48.0	53	Riffle	M		7	
46.9	59	Run Body	S		9	
45.7	74	Riffle	S	1	6	
45.3	82	Run Head	S		7	
45.0	86	Pool Head	M		3	1
44.9	87	Pool Body	M		3	
44.6	97	Riffle	S		2	
44.5	101	Riffle	M		2	1
43.1	109	Run Body	S		1	
Total (Max. unit count of all passes)				**1**	**80**	**15**

Table 3-9. Maximum counts of juvenile Chinook salmon by size class and habitat type.

Habitat	0–49 mm	50–99 mm	100–149 mm	Total (Max. unit count of all passes)
Pool Body		13	10	23
Pool Head		7	4	11
Riffle	1	17	1	19
Run Body		11		11
Run Head		32		32
Totals by size class	**1**	**80**	**15**	**96**

Divers also observed two adult Chinook salmon, including a spawned out female, 0.3 miles (0.5 km) downstream of La Grange Dam, and eight more adults between RM 51 and 51.8. The adult Chinook salmon observations were incidental and occurred while the divers moved from one dive unit to the next. Five Chinook salmon redds were also observed along the reach from RM 51 to RM 51.8. The complete *O. tshawytsch*a observation data by pass are shown in Appendix F.

3.4.4 Non-salmonid observations

Several other fish species were observed and counted during the study period (**Table 3-10**). Most fish seen within the study reach were native species in the minnow (*Cyprinidae*) and sucker (*Catostomidae*) families. A combination of hardhead and Sacramento pikeminnow, along with Sacramento sucker accounted for 98% of observed non-salmonid fish, while centrarchids (largemouth bass, smallmouth bass, spotted bass, bluegill, and green sunfish) and sculpin (*Cottidae sp*.) accounted for the remaining 2%. Most centrarchids occurred toward the downstream end of the study reach in water >22°C (71.6 °F), while native minnows and suckers were found throughout the reach. The complete non-salmonid fish observation data are in Appendix F.

Table 3-10. Maximum counts of non-salmonid species by sampling unit (NSO).

RM	Unit ID (NSO)	Habitat	BG	GS	LMB	SMB	SB	SC	HH/PM	SS
51.8	1	Pool Head								1
51.7	2	Pool Body								2
51.6	5	Pool Body							1	
51.4	8	Run Head								100
51.0	10	Run Tail							1	200
49.7	27	Pool Head								200
49.6	28	Pool Body							1	200
49.6	29	Pool Tail							30	60
49.2	33	Riffle						1		2
49.2	34	Run Head								50
49.1	35	Run Body						1		70
49.1	36	Run Tail								100
48.0	53	Riffle						1		50
47.2	55	Pool Body							200	15
47.2	56	Pool Tail								5
47.0	58	Run Head						1		4
46.9	59	Run Body				1			40	50
46.9	60	Run Tail							1	10
45.7	74	Riffle			1				100	100
45.3	82	Run Head			1	1			14	5
45.1	83	Run Body			2				17	1
45.1	84	Run Tail	14		4				40	4
45.0	86	Pool Head						1	225	50
44.9	87	Pool Body		2			3		30	12
44.9	88	Pool Tail							15	
44.6	97	Riffle			3				75	8
44.5	101	Riffle			1				44	12
43.2	108	Run Head							40	4
43.1	109	Run Body			1				150	10
43.1	110	Run Tail							35	1
43.0	112	Pool Head			4				35	3
43.0	113	Pool Body			1				20	1
43.0	114	Pool Tail							3	

RM	Unit ID (NSO)	Habitat	BG	GS	LMB	SMB	SB	SC	HH/PM	SS
42.3	128	Riffle			2				12	
41.1	141	Run Head			1				50	4
41.0	142	Run Body			2	1			40	
41.0	143	Run Tail				1			45	24
40.4	148	Riffle			1				100	100
Total (all sampled units):			14	2	24	4	3	5	1,364	1,458

Species abbreviations:

BG = bluegill
GS = green sunfish
LMB = large mouth bass
SMB = small mouth bass
SB = spotted bass
SC = sculpin
HH/PM = hardhead/pikeminnow
SS = Sacramento sucker

4 DISCUSSION

4.1 Summer 2008 *O. mykiss* Bounded Count Population Estimate

Overall, the summer population estimate of 3,096 fish indicates a relatively high proportion of juvenile *O. mykiss* (2,476) relative to adults (619), with these proportions similar to historical routine snorkel surveys by conducted by the Districts (TID/MID 2008a). It should be noted that the bounded counts method was developed for use in smaller stream systems (Hankin and Mohr 2001) and applying the methodology to a larger system such as the Tuolumne River is only feasible provided key assumptions are satisfied.

One critical assumption of the bounded counts approach is that all individuals have an equal probability of being observed. This may not be practically attainable in some cases due to the depths of some of the in-channel mining pits or low visibility conditions occurring at downstream locations. This assumption may present further challenges during future wintertime surveys depending upon turbidity levels and expected winter rainfall patterns.

A second assumption of the bounded counts method is that observation efficiency is not 100%, so the number of fish seen in any single dive pass is, in general, an underestimate of the true number of fish present. For a closed population where fish do not migrate into or out of the unit between dives, the maximum number of fish seen over multiple passes is a low-biased estimator of the true population. However, because we subsampled larger habitat units, for run habitat types in particular, the resulting density expansions may have introduced a high-biased estimate of the true population size since fish are able to migrate freely into and out of the searched area due to the lack of habitat boundaries relevant to the sampled fish (e.g., riffle transitions).

4.2 Water Temperature Relationships

4.2.1 *O. mykiss* distribution

To test Hypothesis #1 that summertime distribution of observed life stages of *O. mykiss* across suitable habitat is related to ambient river water temperature, we compared water temperature data taken from thermographs to fish density in the sampled units. The data show that temperatures increase in the downstream direction (Section 3.3, **Table 3-3**) and that the density of

adult *O. mykiss* (>150 mm) decreased along this same gradient (Figure 6). In habitat units where fish were seen, density of adult fish was greatest just downstream of La Grange Dam and decreased markedly in the downstream direction. This observation is consistent with the findings of Brown and Ford (2002), which showed that distance downstream of the dam had a strong inverse correlation with native fish density in the Tuolumne River. Pool heads occupy the least amount of channel area (**Table 3-1**) and are also more concentrated in upstream locations (Figure 3) so adult fish presence here may indicate a preference for pool habitats, or simply a preference for cooler water (<21 °C [69.8 °F]). We sampled six pool heads throughout the reach (Appendix F), and found few adult fish within these habitat types downstream of RM 48.0, suggesting that water temperature and possibly microhabitat elements such as cover type are a stronger determinant of longitudinal distribution of *O. mykiss* than macrohabitat type.

In contrast to the distribution of larger *O. mykiss* farther upstream, we observed smaller fish at higher density farther downstream of La Grange dam (Figure 6). The greatest density of YOY and juvenile *O. mykiss* occurred in a run head and a riffle, but occurred downstream of habitat units with the greatest density of adult fish (Figure 6). This may indicate that adult *O. mykiss* are better able to move upstream than YOY and juveniles to seek thermal refuge, age-specific differences in physical habitat preference by *O. mykiss*, or that juveniles observed in this particular location are using local cool water refugia. As air and water temperatures increase, smaller fish may seek deeper habitat and thermal refuge among interstitial spaces in bed substrates, such as cobble and boulder, which in the absence of substantial bed armoring or embeddedness are large enough to create spaces of sufficient size for YOY and juvenile fish, but too small for adult fish. These spaces could allow juvenile *O. mykiss* to occupy the deepest parts of channels, below any thermal layers that may develop, and may also be influenced by upwelling of cooler hyporheic water. Use of these interstitial habitats would also provide valuable cover from predatory fishes. We found that habitat types with the greatest percent of channel area covered by cobble and boulder substrate were run head and riffle (**Table 4-1**), which also supported the greatest densities of YOY and juvenile *O. mykiss*. Interaction with juvenile salmon, predation pressure, or territorial exclusion by the larger size classes of *O. mykiss* may also influence relative distributions of juveniles and adults in the habitat units surveyed.

Table 4-1. Cover and substrate type found in snorkeled habitat units with fish present.

	Pool Body	Pool Head	Pool Tail	Riffle	Run Body	Run Head
Cover Type (%) (range)						
No cover	55–55	70–85	85–85	50–90	30–80	75–95
Boulder	10–10	5–10	5–5	0–0	5–10	0–0
Wood	5–5	5–5	0–0	5–10	10–20	10–10
Ledge	0–0	5–10	0–0	5–5	5–10	5–5
Overhang	5–5	15–15	0–0	10–20	10–10	10–10
Aquatic Vegetation	25–25	5–10	0–0	5–20	10–50	5–5
Other	0–0	5–10	10–10	10–10	0–0	0–0
Substrate type (%covering channel bed) (range)						
Bedrock	15–15	40–50	0–0	5–20	10–25	0–0
Boulder	25–25	20–25	10–10	5–5	10–15	5–5
Cobble	30–30	20–70	50–50	50–80	30–60	50–70
Gravel	20–20	5–20	40–40	10–30	10–20	25–30

	Pool Body	Pool Head	Pool Tail	Riffle	Run Body	Run Head
Sand	10–10	10–20	0–0	5–20	5–15	10–25
Silt	0–0	0–0	0–0	0–0	5–15	0–0
Organic	0–0	0–0	0–0	0–0	5–5	0–0

4.2.2 *O. tshawytscha* distribution

The greatest abundance of juvenile Chinook salmon (*O. tshawytscha)* occurred in a pool body and a run head (**Table 3-8** and **Table 3-9**). Still, salmon were more consistently observed, albeit with lower abundance, in pool heads, riffles, and run bodies. Abundance followed the same general trend as *O. mykiss* juvenile abundance, decreasing in the downstream direction with initial *O. tshawytscha* observation at RM 49.7 (NSO 27). The greatest abundance of both *O. mykiss* and *O. tshawytscha* occurred in a run head habitat unit (NSO 34), which was also snorkeled in June 2008 as part of the Districts' routine snorkel surveys (Section 4.4).

4.2.3 Non-salmonid distribution

The most abundant non-salmonid fish species observed were native minnows (hardhead and Sacramento pikeminnow) and suckers (Sacramento sucker). These species were observed throughout the study reach and were seen as YOY, juvenile, and adults. Centrarchid observations were limited to reaches below RM 46.9 where calculated MWATs were above 15.8°C (60.4°F). Overall, centrarchids made up a small percentage of non-salmonid fish observed in the study reach (Section 3.4.2). We observed a greater frequency of occurrence of centrarchids and few *O. mykiss* downstream in warmer reaches, indicating differences in thermal preferences and habitat preferences between the species, and possibly the influence of predation on *O. mykiss* by centrarchid fishes. This longitudinal distribution pattern was also observed by Brown and Ford (2002) in a previous Tuolumne River fish community study, and is typical of other San Joaquin River and Sacramento River tributaries. Centrarchids generally can tolerate water temperatures up to or exceeding 32°C (89.6 °F) (Moyle 2002) while *O. mykiss* may typically prefer temperatures cooler than <18.3°C (<65°F) (NMFS 2000, U.S. EPA 2003). Although these findings are consistent with those from the June 2008 snorkel survey data and data from past years (TID/MID 2008a), we observed *O. mykiss* juveniles as far downstream as RM 41.1 at temperatures of 24.7°C (76.5°F) and adults as far downstream as RM 45.8 at temperatures of 20.0°C (68.0°F).

4.3 Habitat Use at Restored and Reference Sites

Hypothesis #2 states that the density of *O. mykiss* juveniles and adults is the same in restored sites as in nearby reference sites in the Tuolumne River. This hypothesis was formulated with the intention of testing habitat use at planned gravel augmentation sites. Other than the CDFG gravel addition projects near Old La Grange Bridge from 1999–2003, and the joint Tuolumne River Technical Advisory Committee/Friends of the Tuolumne (FOT) gravel augmentation at Bobcat Flat (RM 43) in 2005, no further recent gravel augmentation projects have been implemented. The goal of the summer 2008 study, a summer population estimate using the method of bounded counts, required a minimum number of habitat units of each habitat type and a uniform sampling across the entire reach. Selected sample units for this study (July 2008) did not coincide with

CDFG restoration sites, but did include estimates of fish abundance at the Bobcat Flat restoration site, where two fish, a juvenile *O. mykiss* and a juvenile *O. tshawytscha*, were observed (**Table 4-2**). The June 2008 snorkel survey examined the 2001 CDFG gravel augmentation site and found 74 juvenile and 2 adult *O. mykiss*, along with 26 juvenile *O. tshawytscha*. In comparison to data for the entire reach from Riffle A7 to Riffle 23C (RM 50.7 to 42.3), these data represent a considerable portion (up to 60% in the case of juvenile Chinook) of the total fish observed. Depending upon habitat unit selection in subsequent surveys, or targeted sampling, Hypothesis #2 may be examined further in winter or summer 2009.

Table 4-2. Salmonid abundance in July (first pass) and June (single pass) 2008 for units within gravel augmentation sites.

			June 2008 TID/MID Snorkel Survey				July 2008 Bounded Count Estimate Data				
Project	**Location**	**RM**	**Area (ft^2)**	**<150 mm *O. mykiss* count**	**>150 mm *O. mykiss count***	**<150 mm *O. tshawytscha* count**	**Habitat unit (NSO)**	**Area (ft^2)**	**<150 mm *O. mykiss* count**	**>150 mm *O. mykiss* count**	**<150 mm *O. tshawytscha* count**
CDFG Gravel Restoration Site (2003)	Riffle A7	50.6	6,000	42	0	16	14	45,670	Site not included in July 2008 snorkel surveys		
	Riffle A7	50.6	4,000	32	2	10	15	13,760			
CDFG Gravel Restoration Site (2001)	Riffle 1A	50.3	Site not included in routine summer snorkel surveys				18	977	Site not included in July 2008 snorkel surveys		
		50.3					19	135,674			
		50.1					20	8,333			
		50.1					21	16,750			
		50.1					22	12,379			
		50.0					23	121,948			
Bobcat Flat Restoration site (2005)	Run (R20-R21)	43.2	Site not included in routine summer snorkel surveys				108	3,020	0	0	0
		43.1					109	56,464	1	0	1
		43.1					110	1,771	0	0	0
	Riffle 21	43.0	3,750	5	6	0	111	10,077	Site not included in July 2008 snorkel surveys		
		43.0	5,400	0	0	0	112	2,392	0	0	0
		43.0		0	0	0	113	26,397	0	0	0
		43.0		0	0	0	114	7,767	0	0	0

4.4 Comparison to June 2008 TID/MID Snorkel Surveys

4.4.1 *O. mykiss* observations

July 2008 snorkel data were compared to June 2008 data (TID/MID 2008b) for the entire sampled reach and within habitat units surveyed during both sampling events (**Table 4-3** and **Table 4-4**). July 2008 data are observations from the first pass of the multiple pass bounded count estimation method to allow a direct comparison to June 2008 data, which came from single pass snorkel surveys. From RM 50.7 to 42.3 (the entire sampled reach) 210 *O. mykiss* juveniles and 22 adults were observed in June, while 101 juveniles and 5 adults were observed in July.

The between-site comparison shows similar longitudinal trends, with juvenile and adult *O. mykiss* density decreasing in the downstream direction (**Table 4-4**), the same trend observed in the July surveys (Figure 6). In the June and July surveys the greatest abundance of *O. mykiss* occurred within riffles and runs near Riffle 3B (**Table 4-4**). In June, 51 juveniles were observed at the upstream end of Riffle 3B (Site 1 and NSO 33) while 7 were observed at this location in July. In July, 35 juveniles were seen in the run habitat below Riffle 3B (Site 2 and NSOs 33 and 34), whereas 25 juveniles seen at this location in the June surveys. Adult *O. mykiss* abundance was similarly low for both time periods along Riffle 3B and for sites downstream, with just 5 fish observed in June and 3 fish observed in July. In all other units, the counts of juvenile and adult *O. mykiss* were similar between June and July 2008.

It should be noted that the June 2008 data were collected from sites established in past years and targeted based on prior years' data as likely areas of relatively high *O. mykiss* abundance. The area surveyed during the July surveys was greater (by an order of magnitude in most cases) than in June (**Table 4-4**). The June survey method, which reoccupies the same habitat units and areas on an annual basis, produces a yearly index with which to evaluate yearly trends, assuming reoccupied habitat units and areas are representative of the entire reach. The method of bounded counts estimation used in July 2008 produces a population estimate, with appropriate confidence intervals, that, due to the incorporation of multiple passes in each unit and greater area searched in each unit and along the reach, can be used to evaluate habitat- and reach-wide distribution patterns.

4.4.2 *O. tshawytscha* observations

A greater number of *O. tshawytscha* juveniles were observed at Riffle 3B in July than in June, and all (52) were observed downstream in NSOs 34 and 35 (**Table 4-4**). In comparison, only 15 *O. tshawytscha* juveniles were observed at the upstream end of Riffle 3B in June. Over all habitat units snorkeled, 43 juvenile Chinook were seen in June and 61 were seen in July. Although a stream-type life history strategy is not believed to be common for Chinook salmon in the Tuolumne River, the presence of juveniles in mid-summer indicates that conditions (e.g., water temperature, food availability) in summer 2008 were suitable for survival. This is further supported by the presence of a small number of spawned out females just downstream of La Grange Dam.

Table 4-3. Salmonid observations in July (first pass) and June (single pass) 2008 for the entire reach sampled during both studies.

		June 2008 Snorkel Survey			July 2008 Snorkel Survey			
Location	**RM**	**<150 mm *O. mykiss* count**	**>150 mm *O. mykiss* count**	**<150 mm *O. tshawytscha* count**	**Habitat Unit (NSO)**	**<150 mm *O. mykiss* count**	**>150 mm *O. mykiss* count**	**<150 mm *O. tshawytscha* count**
Riffle A7 - R23C	50.7 - 42.3	210	22	43	14 - 128	101	5	51

Table 4-4. Salmonid counts and estimated densities in July (first pass) and June (single pass) 2008 for units snorkeled during both dates.

					June 2008 Snorkel Survey						July 2008 Snorkel Surveys							
Location	**RM**	**Site**	**Habitat type**	**Area (ft^2)**	**<150 mm *O. mykiss***		**>150 mm *O. mykiss***		**<150 mm *O. tshawytscha***		**Habitat unit (NSO)**	**Habitat type**	**Area (ft^2)**	**<150 mm *O. mykiss***		**>150 mm *O. mykiss***		**<150 mm *O. tshawytscha***	
					#	**#/ft^2**	**#**	**#/ft^2**	**#**	**#/ft^2**				**#**	**#/ft^2**	**#**	**#/ft^2**	**#**	**#/ft^2**
Riffle 3B	49.1	1	Riffle	4,400	51	0.0116	2	0.0005	15	0.0034	33	Riffle	22,500	7	0.0003	1	0.0000	0	0.0000
		2	Run-Riffle	11,500	25	0.0022	0	0.0000	2	0.0002	34,35	Run Head, Body	33,713	35	0.0010	2	0.0001	52	0.0015
Riffle 5B	47.9	3	Run-Pool	12,000	1	0.0001	2	0.0002	0	0.0000	54,55	Pool Head, Body	59,569	0	0.0000	0	0.0000	0	0.0000
Riffle 7	46.9	2	Run	8,000	0	0.0000	1	0.0001	0	0.0000	59	Run Body	18,000	3	0.0002	0	0.0000	9	0.0005
Riffle 21	42.9	2	Run-Pool	5,400	0	0.0000	0	0.0000	0	0.0000	112-114	Pool Head, Body, Tail	16,442	0	0.0000	0	0.0000	0	0.0000
Riffle 23C	42.3	2	Riffle	4,500	0	0.0000	0	0.0000	0	0.0000	128	Riffle	8,714	2	0.0002	0	0.0000	0	0.0000

5 REFERENCES

Brown, L. R., and T. Ford. 2002. Effects of flow on the fish communities of a regulated California river: implications for managing native fishes. River Research and Applications 18: 331-342.

Cannon, T.C., and T. Kennedy. 2003. Snorkel survey of the lower American River 2003. Prepared by Fishery Foundation of California, San Francisco for U.S. Fish and Wildlife Service, Central Valley Project Improvement Program, Sacramento, California.

Dolloff, A., J. Kershner, and R. Thurow. 1996. Underwater observations. Pages 533–551 *in* B. R. Murphy and D. W. Willis, editor. Fisheries techniques. American Fisheries Society, Bethesda, Maryland.

Edmundson, E., F. E. Everest, and D. W. Chapman. 1968. Permanence of station in juvenile Chinook salmon and steelhead trout. Journal of the Fisheries Research Board of Canada 25: 1453–1464.

Hankin, D.G. and M. Mohr. 2001. Improved two-phase survey designs for estimation of fish abundance in small streams. Preprint from David G. Hankin, Department of Fisheries Biology, Humboldt State University, Arcata, California.

Hankin, D. G., and G. H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Sciences 45: 834–844.

McCain, M. E. 1992. Comparison of habitat use and availability for juvenile fall Chinook salmon in a tributary of the Smith River, California. FHR Currents. No. 7. USDA Forest Service, Region 5.

McBain and Trush. 2004. Habitat maps for the upper 15.8 miles of the gravel bedded reach. Appendix D *in* Coarse sediment management plan for the lower Tuolumne River. Revised final report. Prepared by McBain and Trush, Arcata, California for Tuolumne River Technical Advisory Committee, Turlock and Modesto Irrigation Districts, USFWS Anadromous Fish Restoration Program, and CALFED Bay Delta Authority.

Mesick, C., J. McClain, D. Marston, and T. Heyne. 2007. Draft limiting factor analyses & recommended studies for fall-run Chinook salmon and rainbow trout in the Tuolumne River, attachment 2 to USFWS comments on FERC study plan. http://elibrary.FERC.gov/idmws/file_list.asp?accession_num=20070314-0089 [Accessed 10 October 2008].

NMFS (National Marine Fisheries Service). 2000. Biological opinion for the operation of the federal Central Valley Project and the California State Water Project from December 1, 1999 through March 31, 2000. NMFS, Southwest Region.

Moyle, P. B. 2002. Inland fishes of California. Revised edition. University of California Press, Berkeley.

Stillwater Sciences. 2002. Stream temperature indices, thresholds, and standards used to protect coho salmon habitat: a review. Unpublished white paper. Prepared by Stillwater Sciences, Arcata, California for Campbell Timberland Management, Fort Bragg, California.

Stillwater Sciences. 2008. Population size estimates of resident *O. mykiss* in the lower Tuolumne River. Study plan. Prepared by Stillwater Sciences, Berkeley, California for Turlock Irrigation District and Modesto Irrigation District.

Sullivan, K., D. J. Martin, R. D. Cardwell, J. E. Toll, and S. Duke. 2000. An analysis of the effects of temperature on salmonids of the Pacific Northwest with implications for selecting temperature criteria. Draft report. Prepared for Sustainable Ecosystems Institute, Portland, Oregon.

Sullivan, K. J. J. Tooley, K. Doughty, J. E. Caldwell, P. Knudsen. 1990. Evaluation of prediction models and characterization of stream temperature regimes in Washington. Timber/Fish/Wildlife Report Number TFW-WQ3-90-006. Washington Department of Natural Resources, Olympia, Washington.

Thomas, J. A., and K. D. Bovee. 1993. Application and testing of a procedure to evaluate transferability of habitat suitability criteria. Regulated Rivers: Research and Management 8: 285–294.

TID/MID (Turlock Irrigation District/Modesto Irrigation District). 2005. Ten year summary report of Turlock Irrigation District and Modesto Irrigation District pursuant to Article 58 of the license for the Don Pedro Project, No. 2299. 1 Volume.

TID/MID. 2007. Tuolumne River fisheries study plan - Don Pedro Hydroelectric Project (FERC No. 2299). Prepared by T. Ford, N. Hume, S. Wilcox, and R. Yoshiyama for Turlock Irrigation District and Modesto Irrigation District. http://elibrary.FERC.gov/idmws/file_list.asp?accession_num=20070718-0082 [Accessed 10 October 2008].

TID/MID 2008a. Report 2007-7: 2007 rainbow trout data summary report. *In* 2007 report of Turlock Irrigation District and Modesto Irrigation District pursuant to Article 39 of the license for the Don Pedro Project, No. 2299.

TID/MID 2008b. Unpublished June 2008 snorkel data. http://sanjoaquinbasin.com/tuolumne-river-archives.html#tuolumne_snorkel [Accessed 10 October 2008].

U.S. EPA (United States Environmental Protection Agency). 2003. EPA Region 10 guidance for Pacific Northwest state and tribal temperature water quality standards. EPA 910-B-03-002.

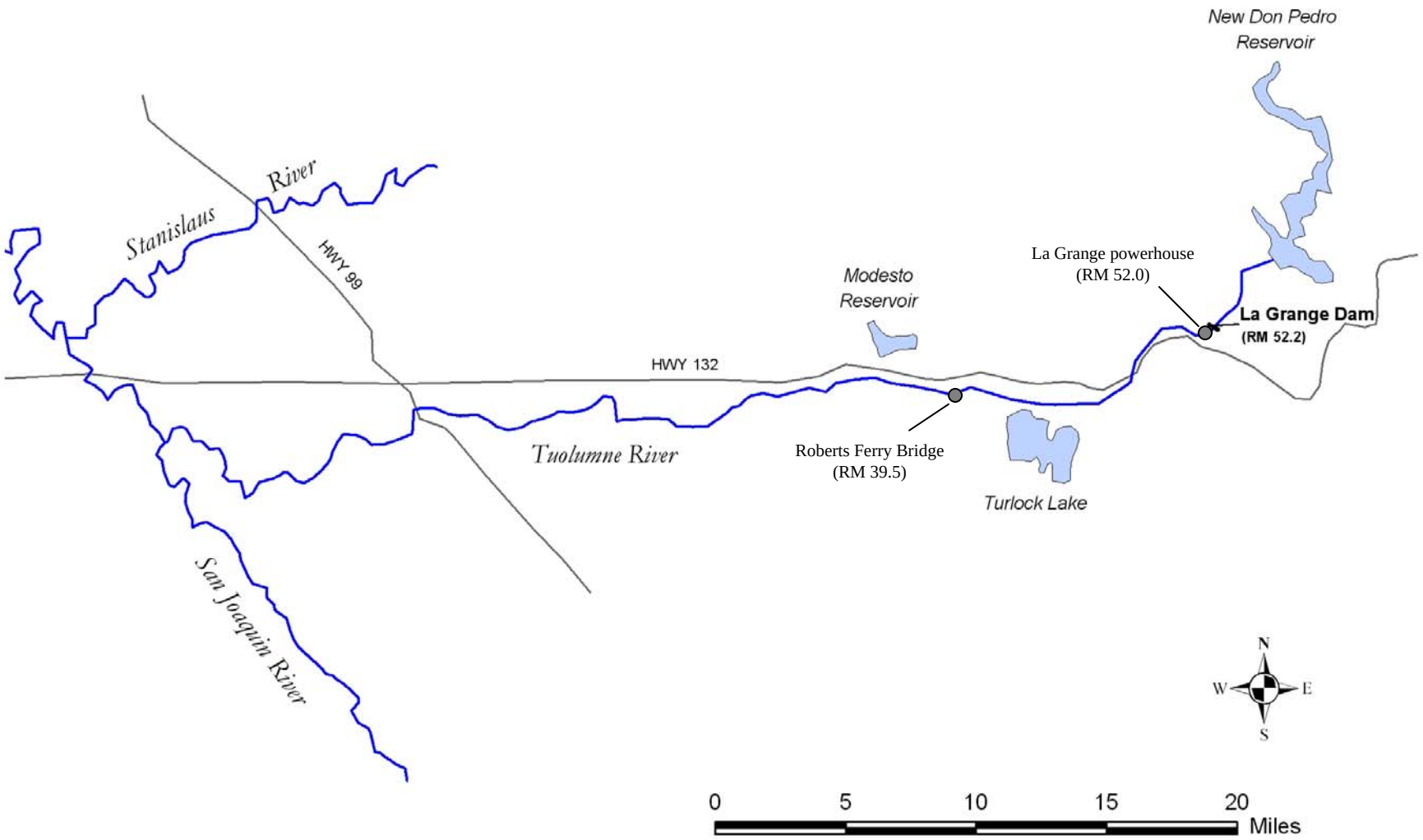


Figure 1. Survey reach for July 2008 *O. mykiss* snorkel surveys in the lower Tuolumne River.

Stillwater Sciences

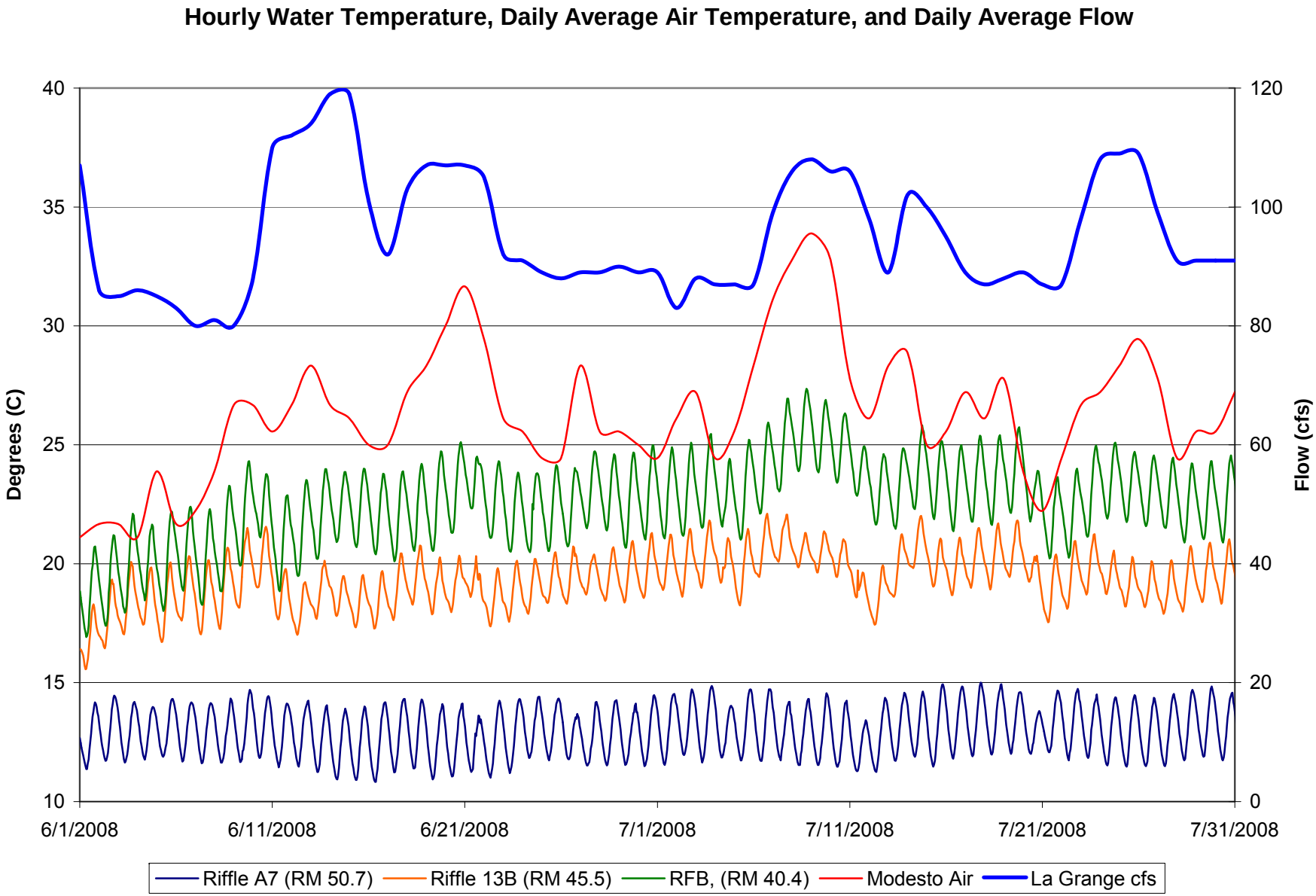


Figure 2. Hourly water and daily average air temperature and flow for the study reach from 1 June to 31 July 2008.

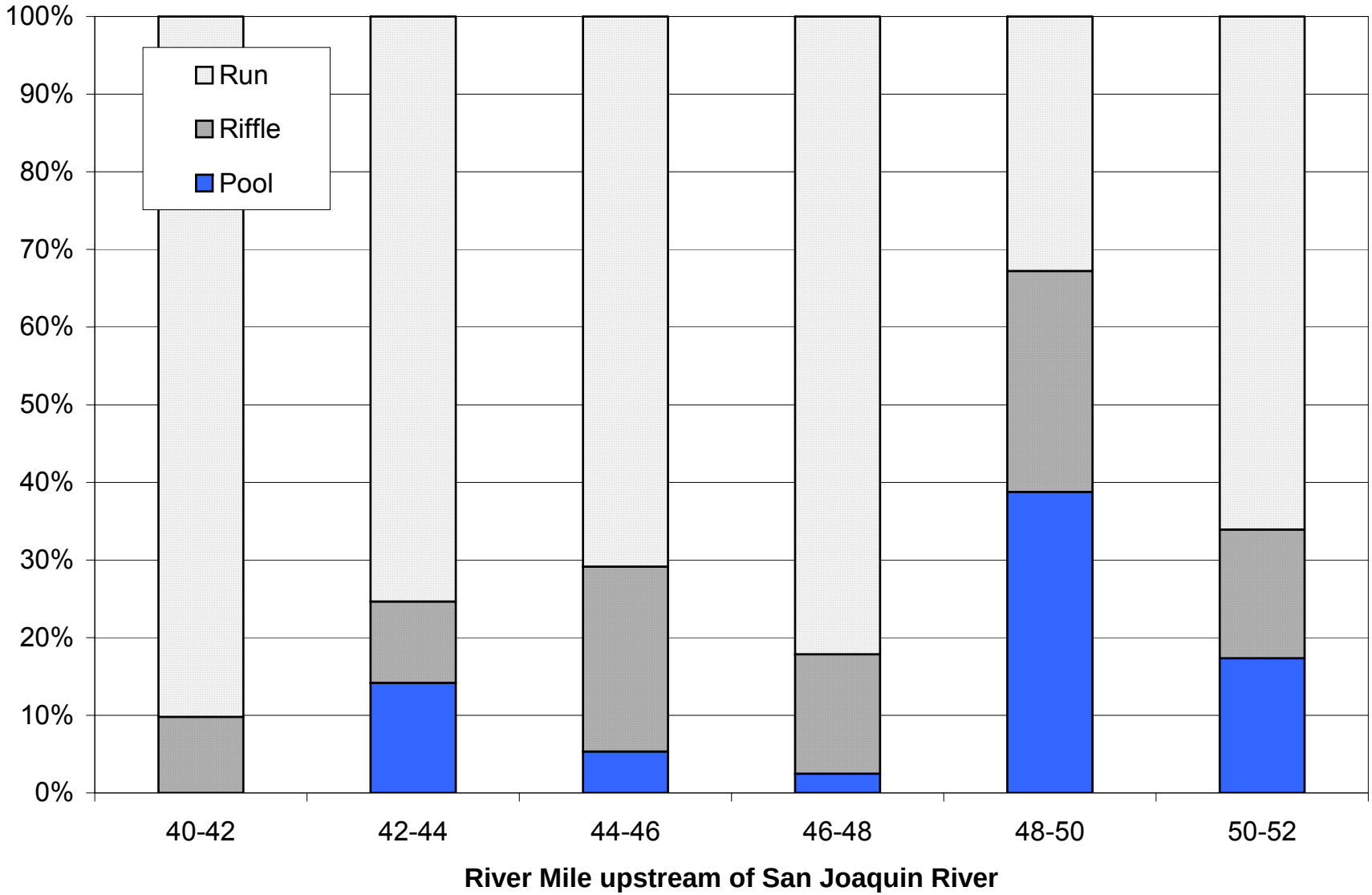


Figure 3. Longitudinal distribution of major habitat types by river mile in the lower Tuolumne River (RM 52–40).

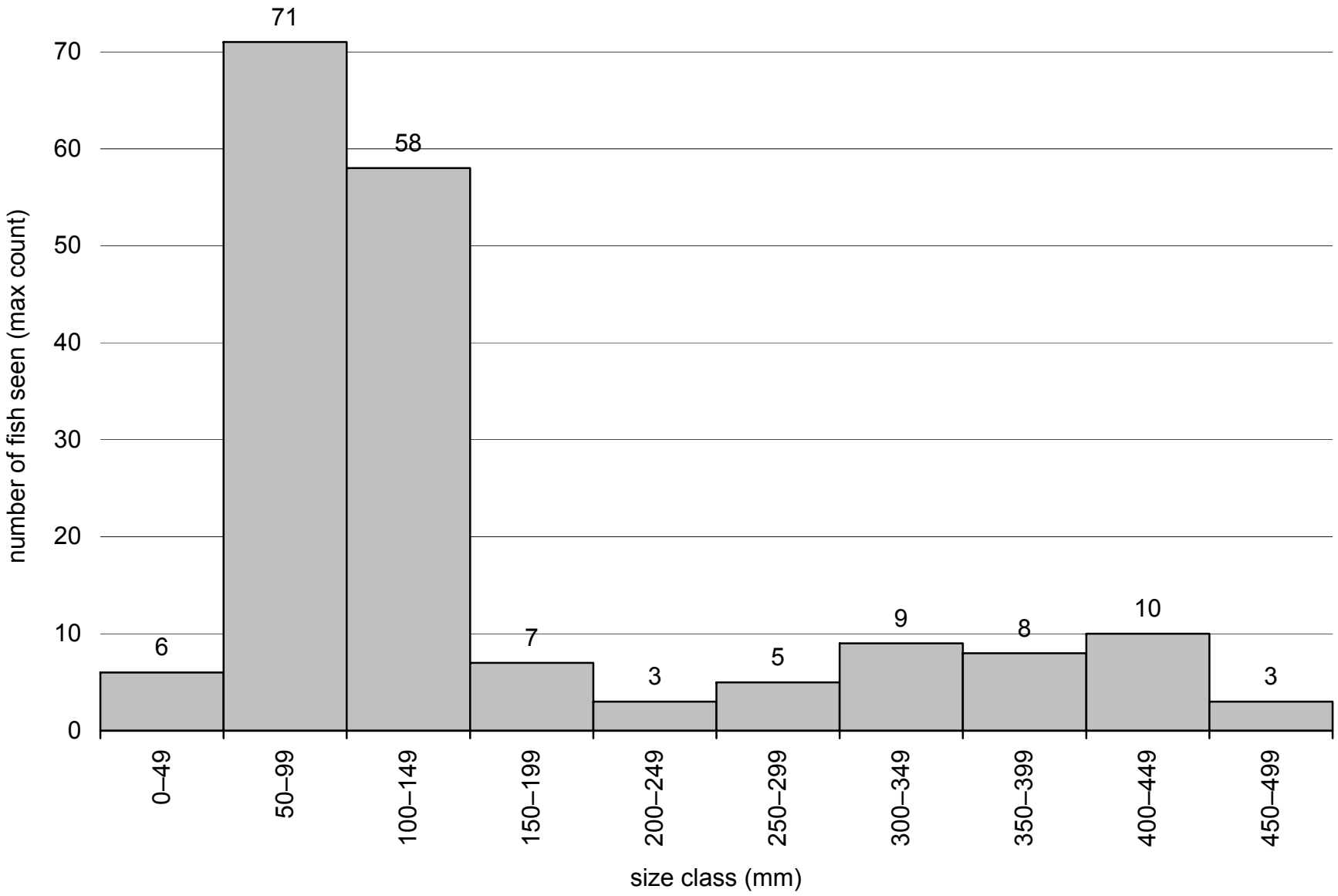


Figure 4. Size distribution of *O. mykiss* observed in Tuolumne River snorkel surveys, July 2008. For units sampled with multiple dives, the maximum count for each size class was used.

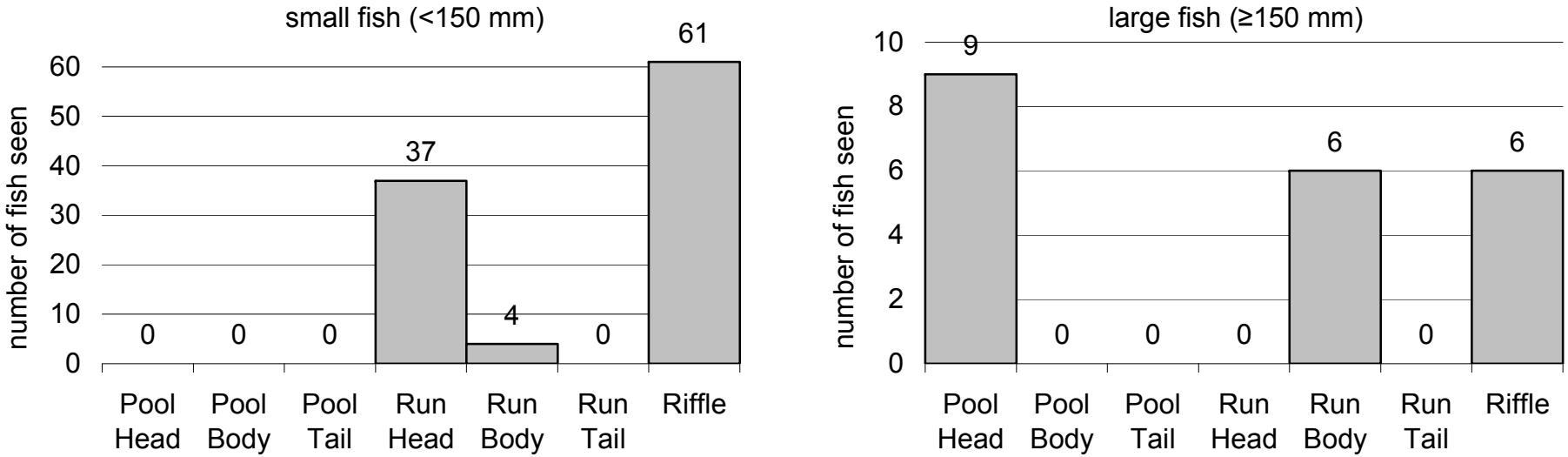


Figure 5a. Distribution of observed *O. mykiss* counts among habitat types, by size class (first pass only for units receiving multiple passes)

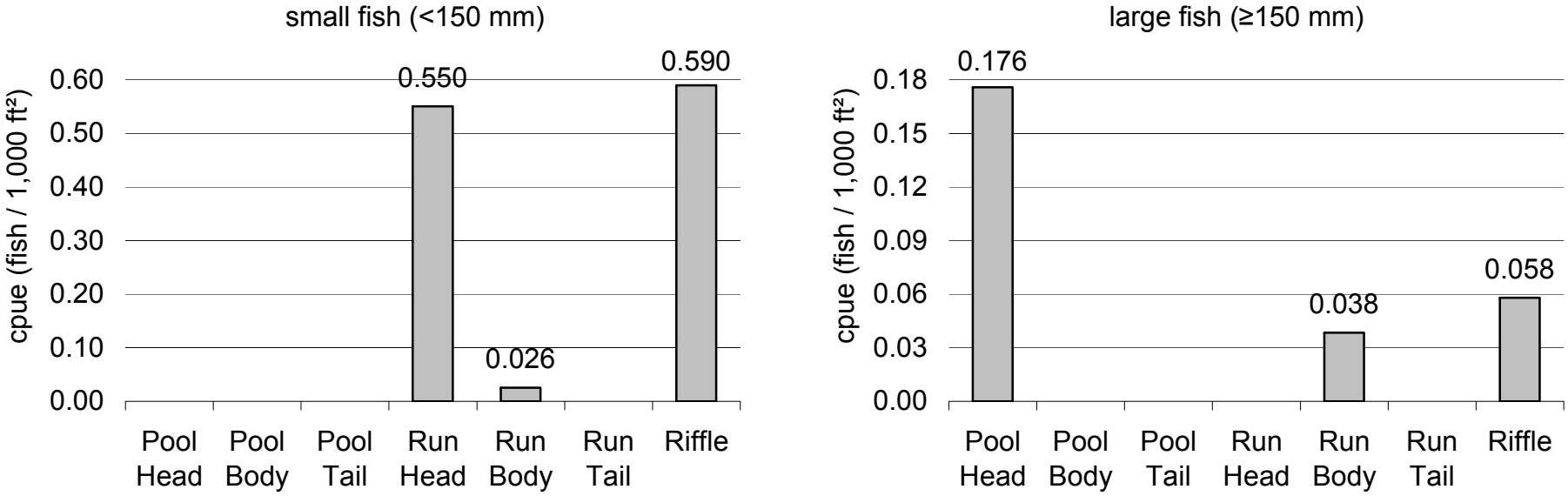


Figure 5b. Distribution of calculated *O. mykiss* sampling effort (density) among habitat types, by size class (all passes).

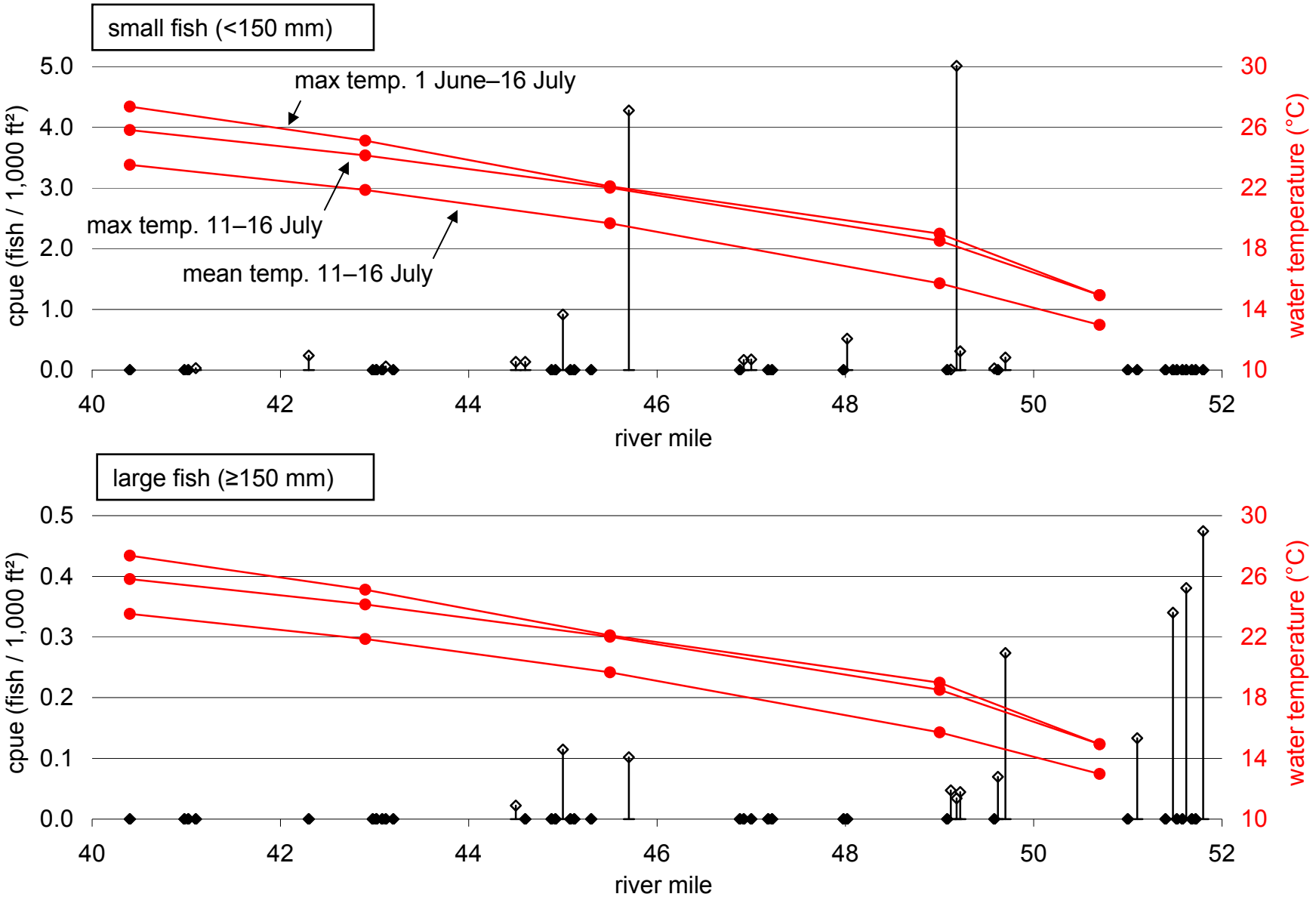


Figure 6. Longitudinal distribution of observed fish and water temperature in the lower Tuolumne River, July 2008. Solid diamonds are observed zeros, open diamonds are observed non-zero values.

Appendices

Appendix A: 2008 Habitat Maps


Run Body
NSO 009
NSO 008
Run Head
NSO 007
Riffle
NSO 006
Pool Tail
NSO 005
Pool Body
NSO 004
Pool Head
Pool Tail
NSO 003
NSO 002 Pool Body
NSO 001
Pool Head
Riffle
RM 52
Pool Tail
Pool Body
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 01
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet

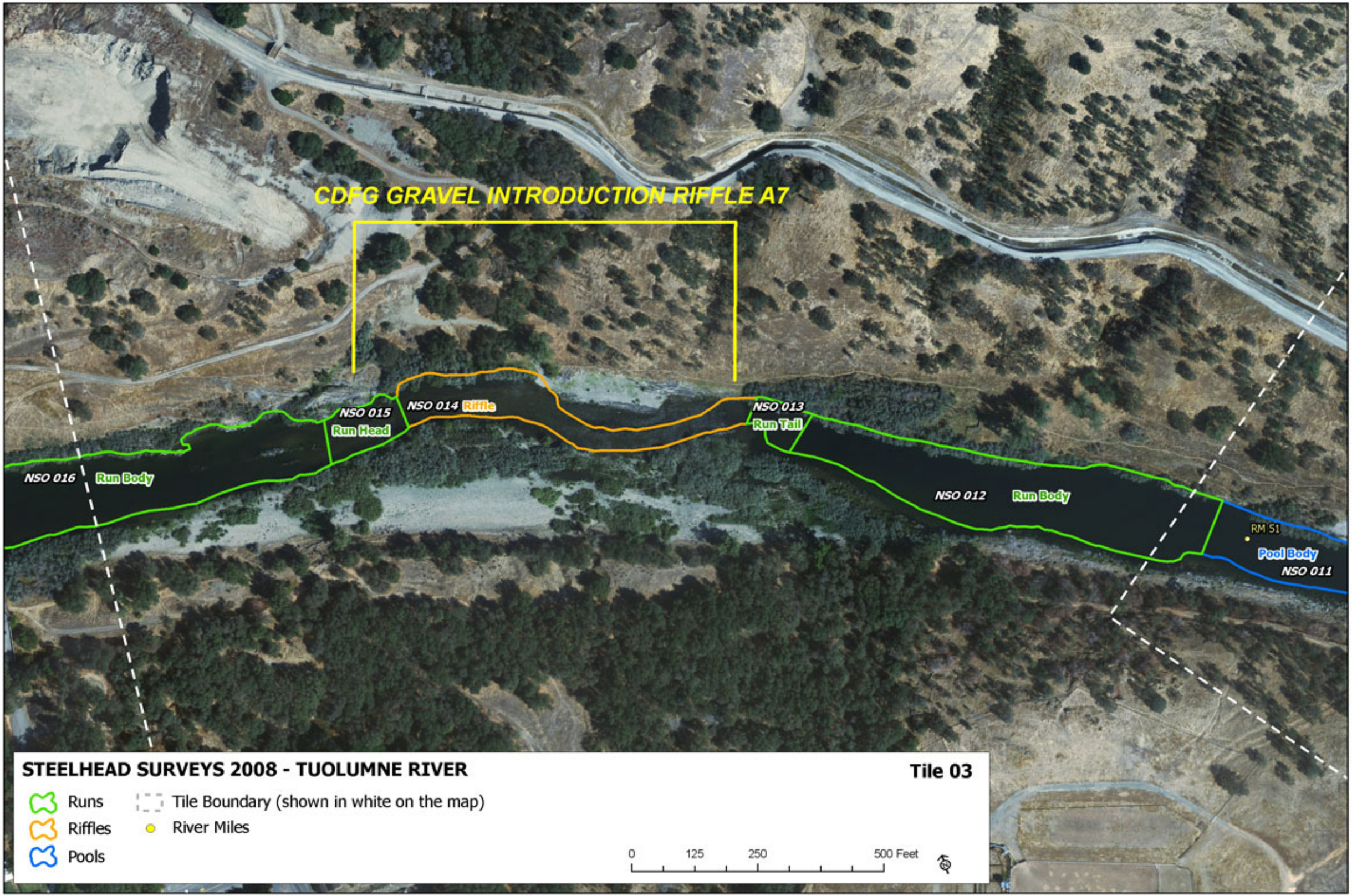
Run Body
NSO 012
RM 51
NSO 011
Pool Body
NSO 010
Run Tail
NSO 009
Run Body
NSO 008
Run Head
NSO 007
Riffle

STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER

Tile 02

Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles

0 125 250 500 Feet


CDFG GRAVEL INTRODUCTION RIFFLE A7
NSO 015
Run Head
NSO 014 Riffle
NSO 013
Run Tail
NSO 016
Run Body
NSO 012
Run Body
RM 51
Pool Body
NSO 011
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 03
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet

CDFG GRAVEL INTRODUCTION RIFFLE 1A/1B

NSO 021
Run Tail
NSO 020
Run Body
NSO 019
Run Head
NSO 018
Riffle
NSO 017
Run Tail
Run Body
NSO 016
NSO 023
Riffle
Run Head
NSO 022
NSO 024
Run Body
RM 50

STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER

Tile 04

Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles

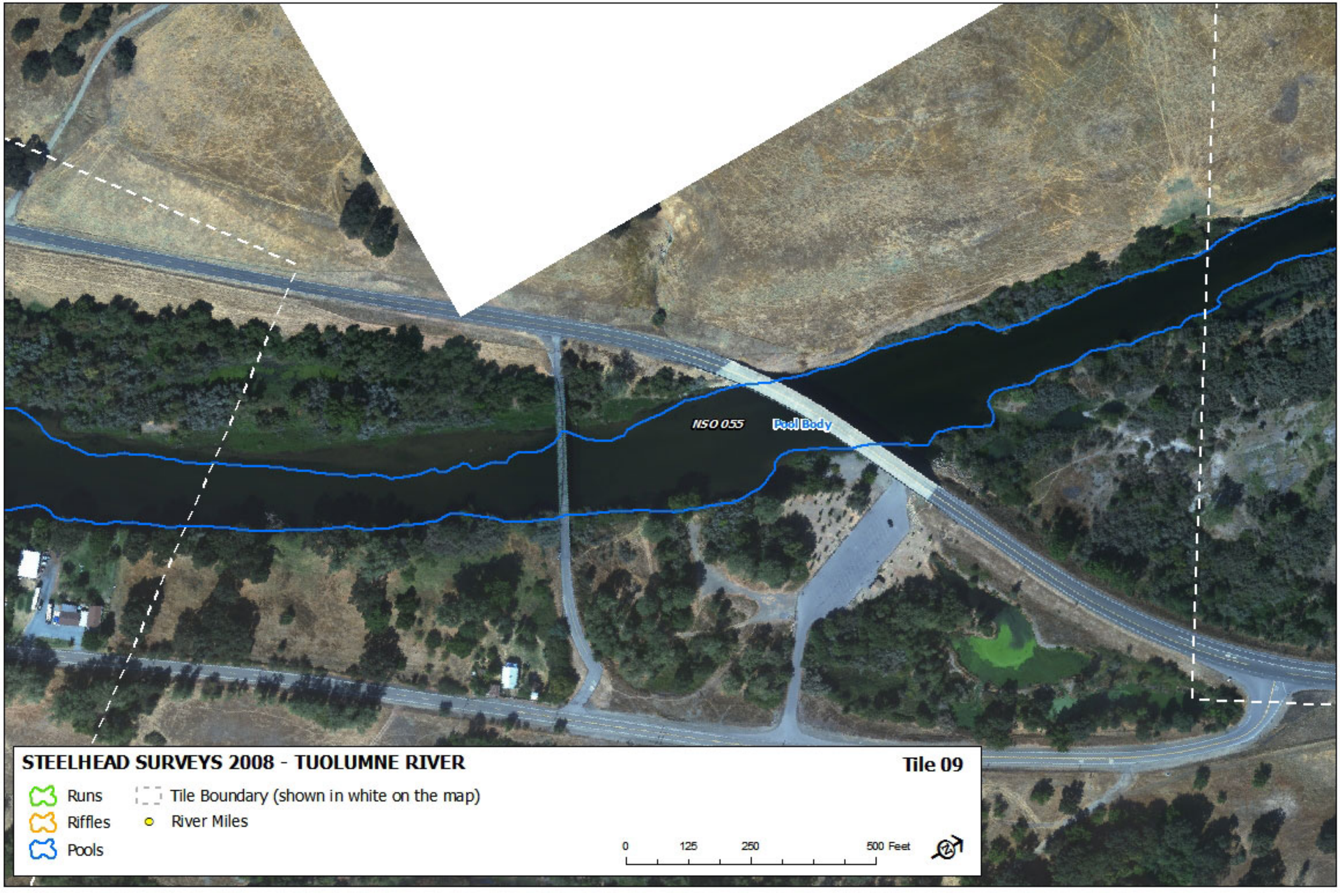
0 125 250 500 Feet

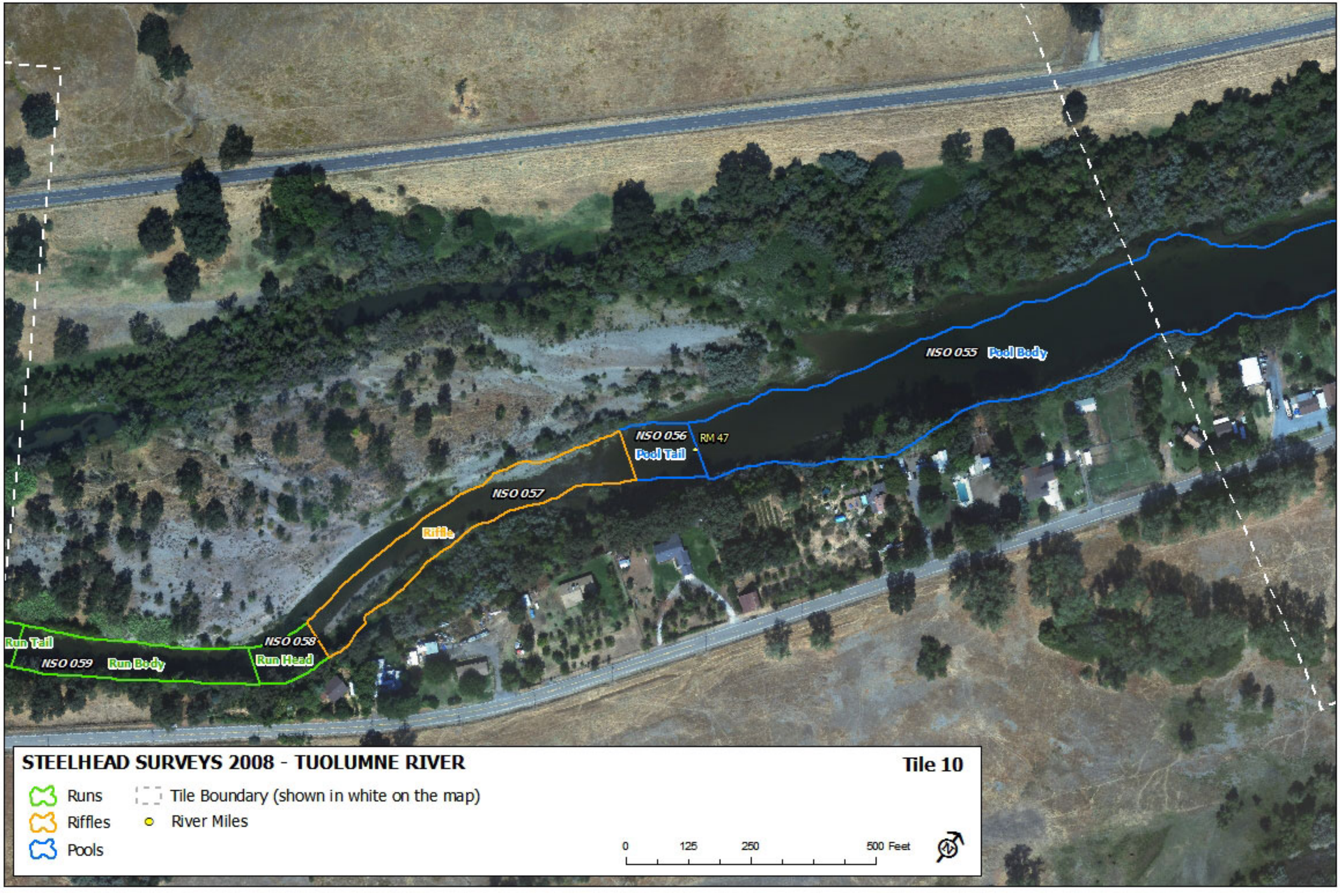

NSO 028
Pool Body
NSO 027
Pool Head
Pool Tail
Run Head
NSO 029
NSO 030
NSO 026
Riffle
Run Tail
NSO 025
NSO 031
Run Body
NSO 024
Run Body
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 05
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet
N


NSO 032
Run Tail
NSO 031
Run Body
NSO 033
Riffle
Riffle
NSO 041
Run Tail
NSO 039
NSO 040
Run Body
NSO 037
Run Head
Run Tail
NSO 035
RM 49
Run Body
NSO 034
Run Head
Riffle
NSO 038
NSO 036
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 06
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet


NSO 042
Run Head
NSO 043
Run Body
NSO 041
Riffle
NSO 044
Run Tail
Run Head
NSO 045
Riffle
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 07
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet


NSO 055
Pool Body
Pool Head
NSO 054
Riffle NSO 053
NSO 052
Run Tail
NSO 051
Run Body
NSO 050
Run Head
NSO 049
Riffle
RM 48
NSO 048
Run Tail
NSO 047
Run Body
NSO 046
Run Head
NSO 045 Riffle
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 08
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet


NSO 055
Pool Body
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 09
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet


NSO 055
Pool Body
NSO 056
Pool Tail
RM 47
NSO 057
Riffle
NSO 058
Run Head
Run Tail
NSO 059
Run Body
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 10
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet

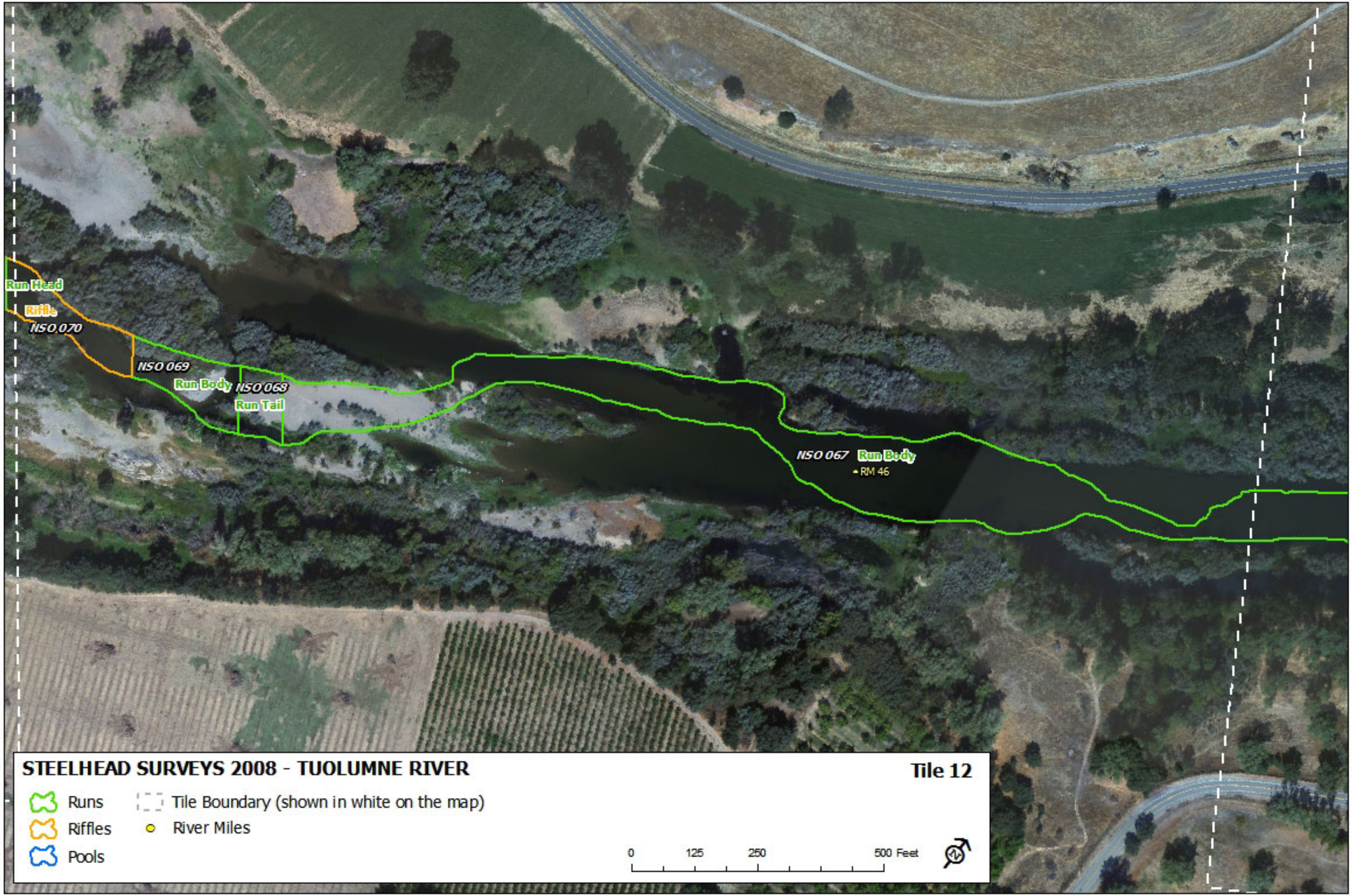
NSO 067
Run Body
NSO 066
Run Head
NSO 065
Riffle
Run Tail
NSO 064
NSO 063
Run Body
NSO 062
Run Head
NSO 061
Riffle
Run Tail

STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER

Tile 11

Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles

0 125 250 500 Feet


Run Head
Riffle
NSO 070
NSO 069
Run Body
NSO 068
Run Tail
NSO 067
Run Body
RM 46
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 12
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet

NSO 083
Run Body

Run Head
NSO 082

NSO 081
Pool Body

NSO 080
Run Body

NSO 079
Run Head

NSO 078
Riffle

Run Tail

NSO 077
Run Body

NSO 076

NSO 075
Run Head

NSO 074
Riffle

NSO 073
Run Tail

NSO 072
Run Body

STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER

Tile 13

Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles

0 125 250 500 Feet

NSO 089
Riffle
NSO 088
Pool Tail
NSO 087
Pool Body
NSO 086
Pool Head
Riffle
NSO 085
NSO 084
Run Tail
RM 45
NSO 083
Run Body
Run Head
NSO 082
Pool Body
NSO 081
NSO 080
Run Body

STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER

Tile 14

Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles

0 125 250 500 Feet

N

NSO 101
Riffle
NSO 100
Run Tail
NSO 099
Run Body
NSO 098
Run Head
NSO 097
Riffle
Run Tail
NSO 096
Run Body
NSO 095
NSO 094
Run Head
NSO 093
Riffle
Run Tail
NSO 091
Run Body
NSO 090
Run Head
NSO 089
Riffle
Run Head
NSO 103
Run Body

STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER

Tile 15

Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles

0 125 250 500 Feet

N


NSO 104
Pool Body
Run Body
NSO 103
RM 44
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 16
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet
N


NSO 106
Run Tail
Riffle
NSO 107
NSO 105
Run Body
Pool Body
NSO 104
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 17
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet


FOT BOBCAT FLAT RESTORATION SITE
NSO 120
Run Body
Riffle
NSO 118
Run Head
Run Tail
NSO 119
NSO 117
Run Body
NSO 116
NSO 115
Pool Tail
NSO 114
Run Head
NSO 113
Pool Body
NSO 112
Pool Head
NSO 111
Riffle
NSO 110
Run Tail
RM 43
NSO 109
Run Body
NSO 108
Run Head
NSO 107
Riffle
NSO 106
Run Tail
NSO 105
Run Body
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 18
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet


NSO 125
Run Body
NSO 126
Riffle
NSO 124 Run Body
NSO 123
Run Head
Riffle
NSO 122
Run Body
NSO 120
Run Tail
NSO 121
Run Head
Riffle
NSO 128
Run Body
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 19
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet
N

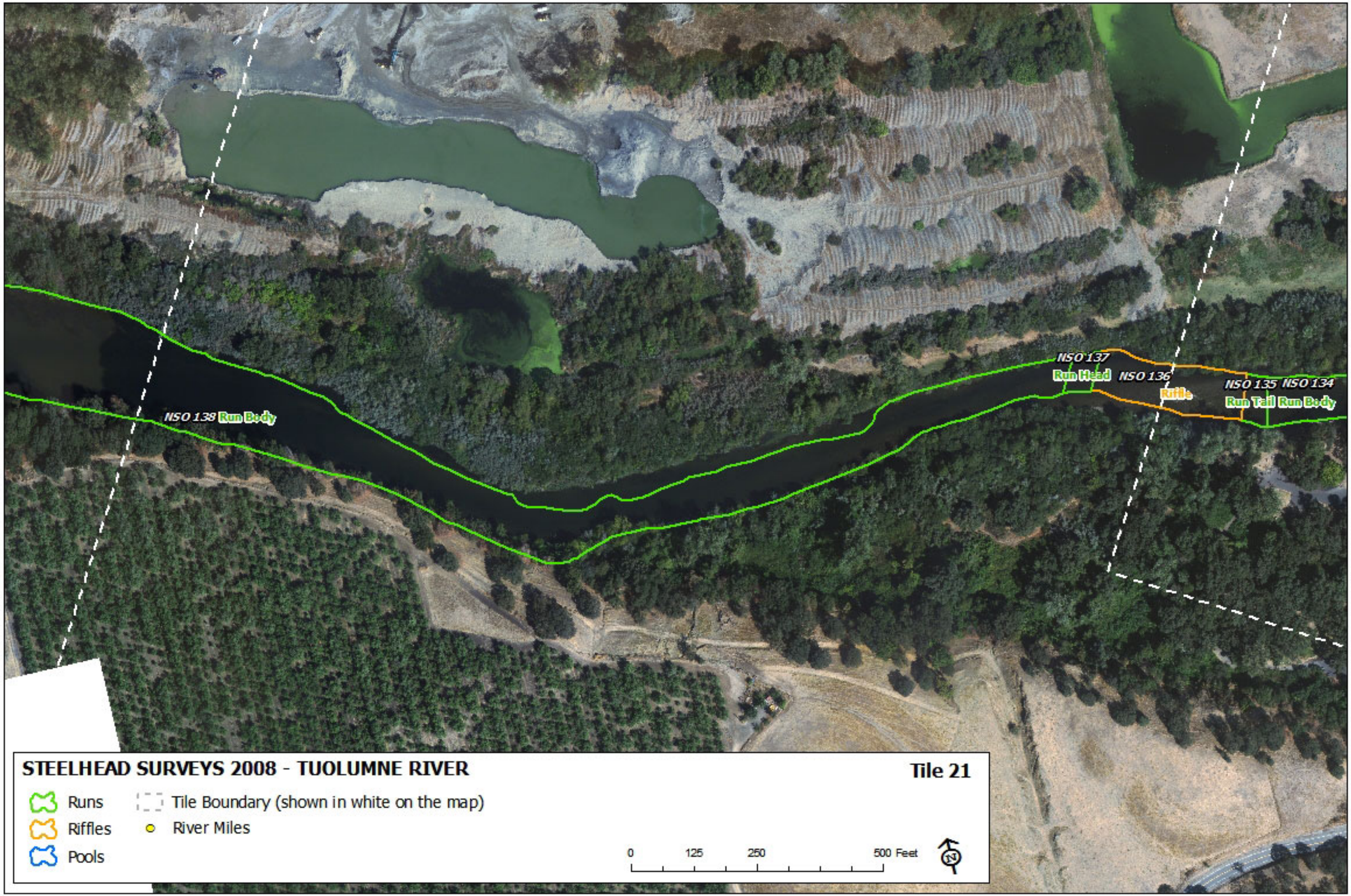
NSO 128
NSO 129 Riffle
Run Head
Riffle
NSO 131
NSO 132
Run Tail
NSO 130 Run Body
NSO 133
Run Head
NSO 134
Run Body
NSO 135
Run Tail

STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER

Tile 20

Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles

0 125 250 500 Feet


NSO 138 Run Body
NSO 137
Run Head
NSO 136
Riffle
NSO 135
NSO 134
Run Tail Run Body
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 21
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet
N


NSO 146
Run Body
NSO 145
Run Head
NSO 144
Riffle
NSO 143
Run Tail
NSO 142
RM 41
Run Body
NSO 141
Run Head
NSO 140
Riffle
NSO 139
Run Tail
NSO 138
Run Body
NSO 139
Run Tail
NSO 140
Riffle
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 22
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet

Riffle
Run Tail
NSO 150
Run Body
NSO 149
Run Head
NSO 148
Riffle
NSO 147
Run Tail
Run Body
NSO 146

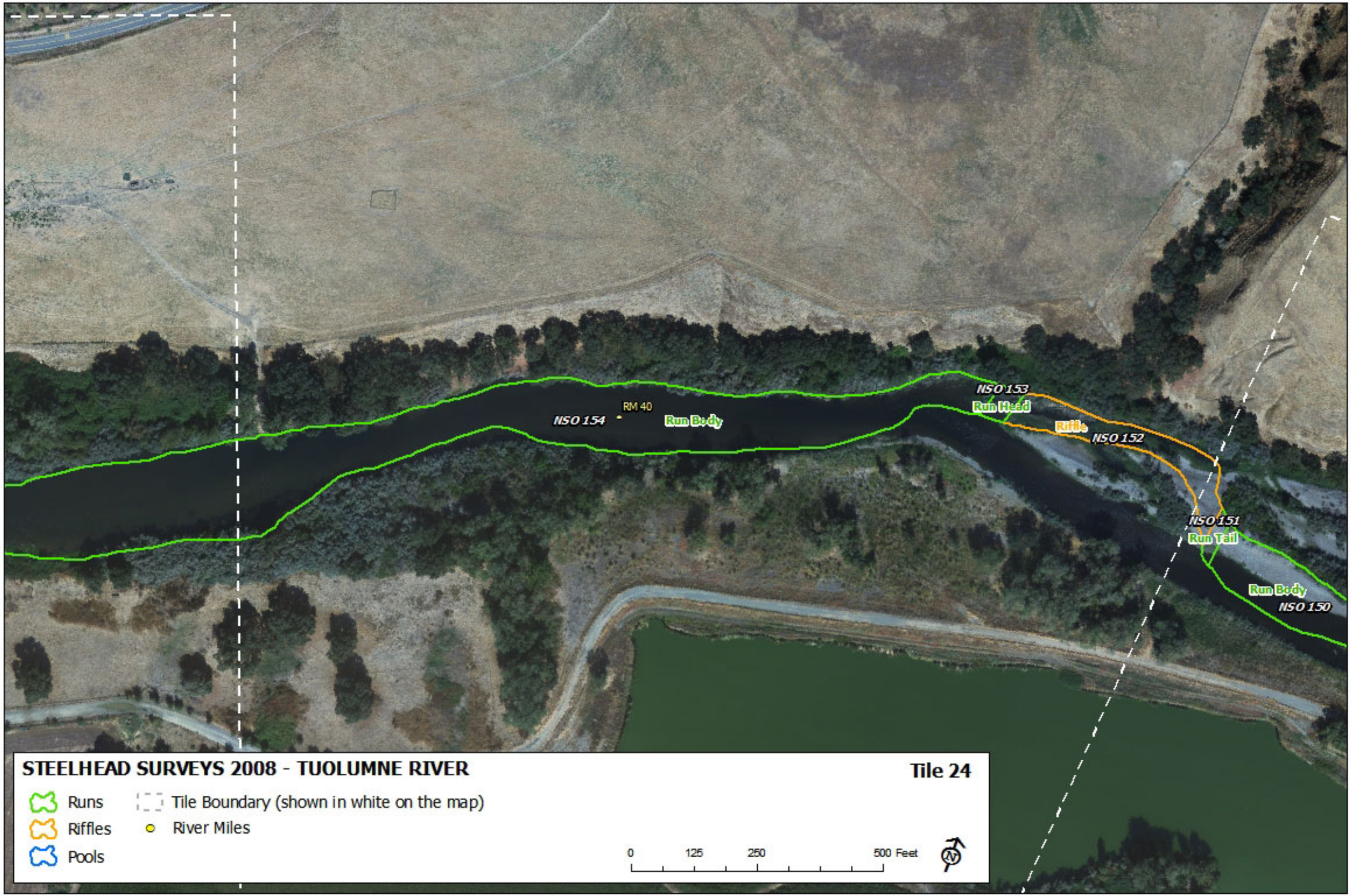
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER

Tile 23

Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles

0 125 250 500 Feet

N


NSO 154
RM 40
Run Body
NSO 153
Run Head
Riffle
NSO 152
NSO 151
Run Tail
Run Body
NSO 150
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 24
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet

RM 39
Run Body
Run Head
Riffle
Run Tail
Run Body
Run Head
Riffle
Run Tail
Run Tail
Run Body
NSO 155
Run Body
NSO 154

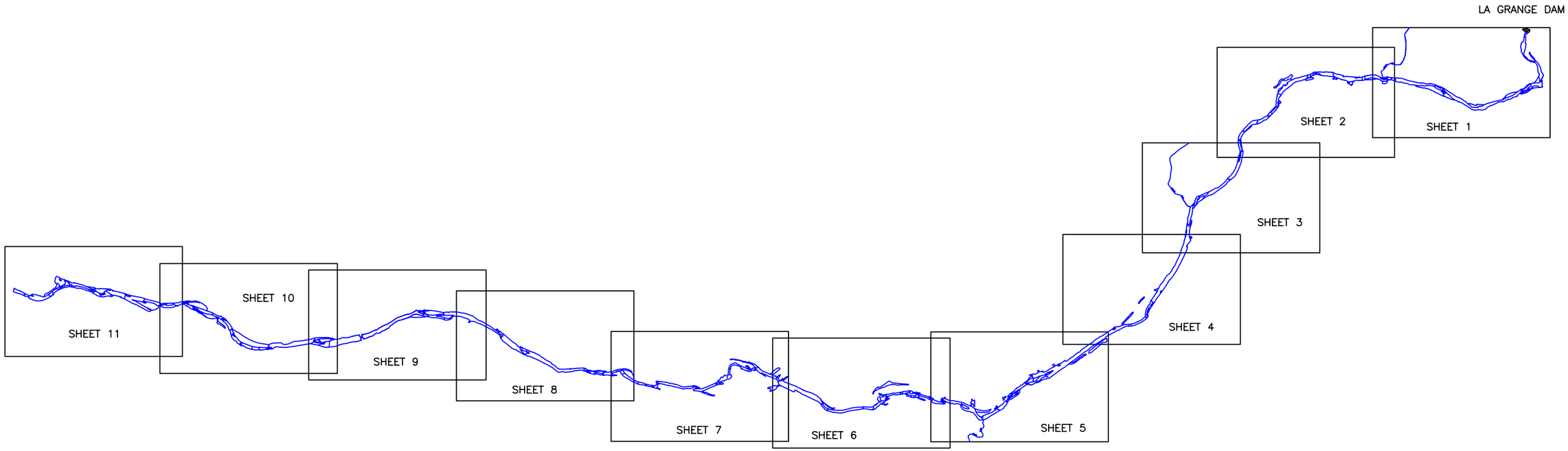
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER

Tile25

Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles

0 125 250 500 Feet

Appendix B: 2004 Habitat Maps



NORTH

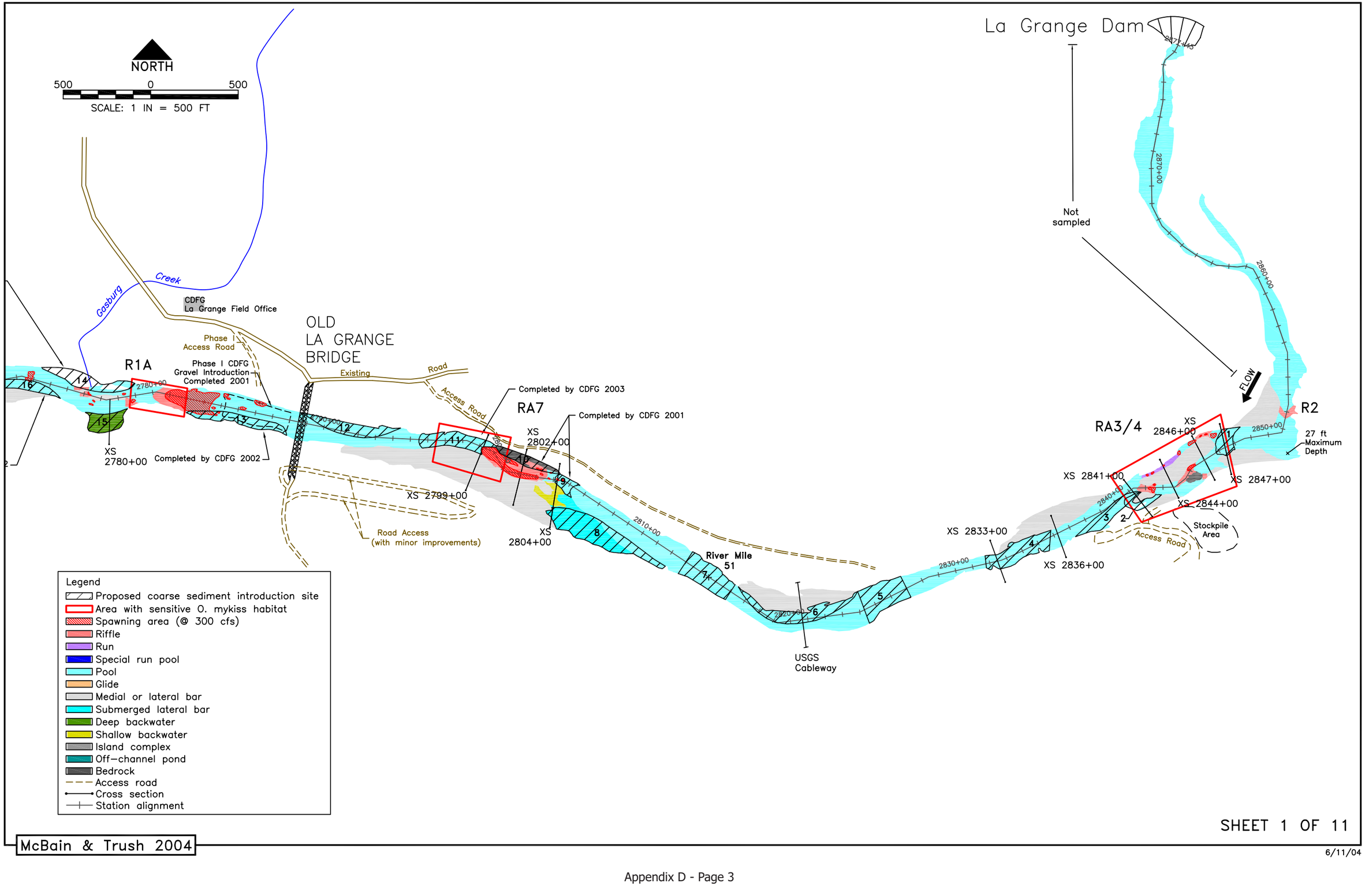
4500 2250 0 4500

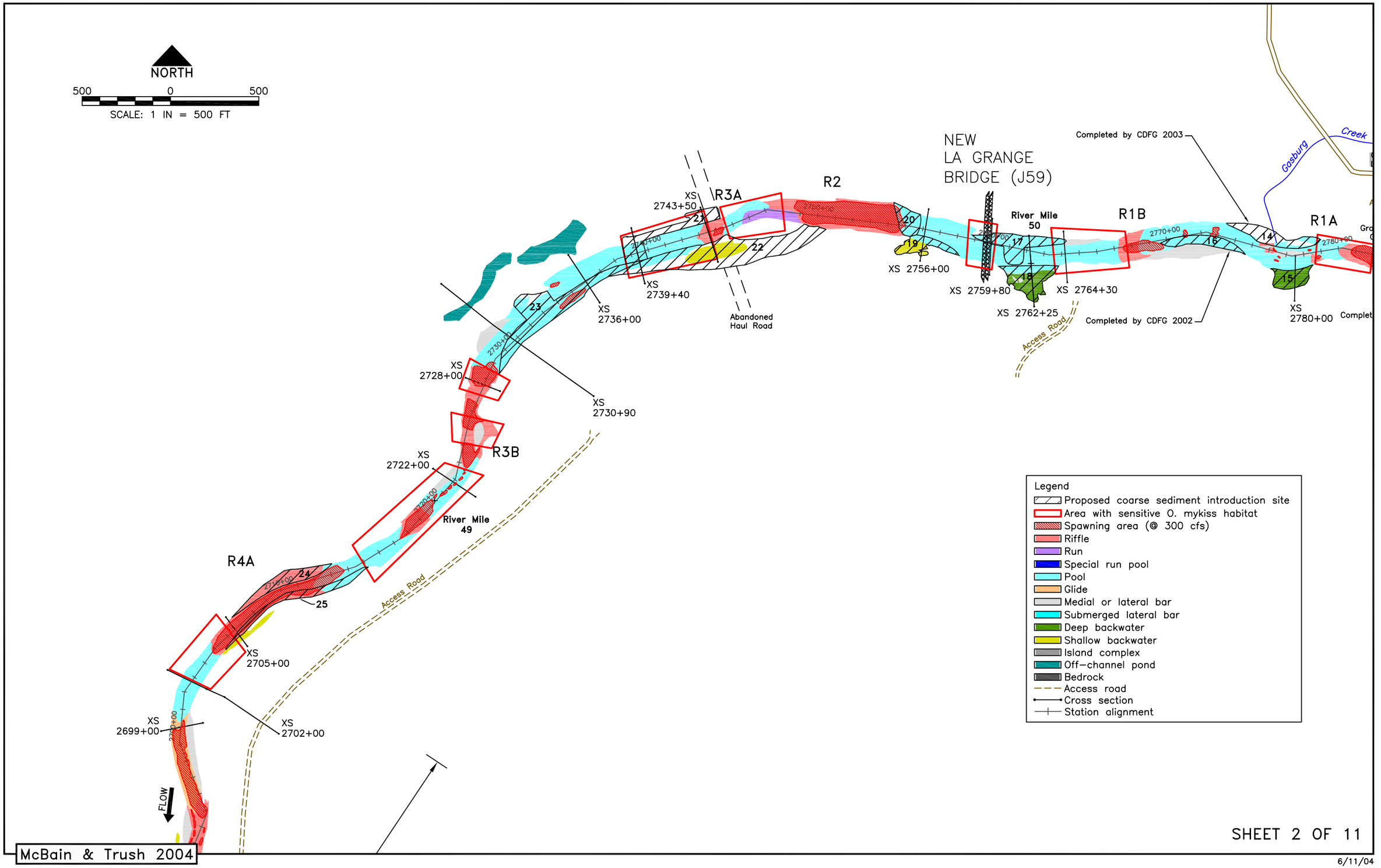
SCALE: 1 IN = 4500 FT

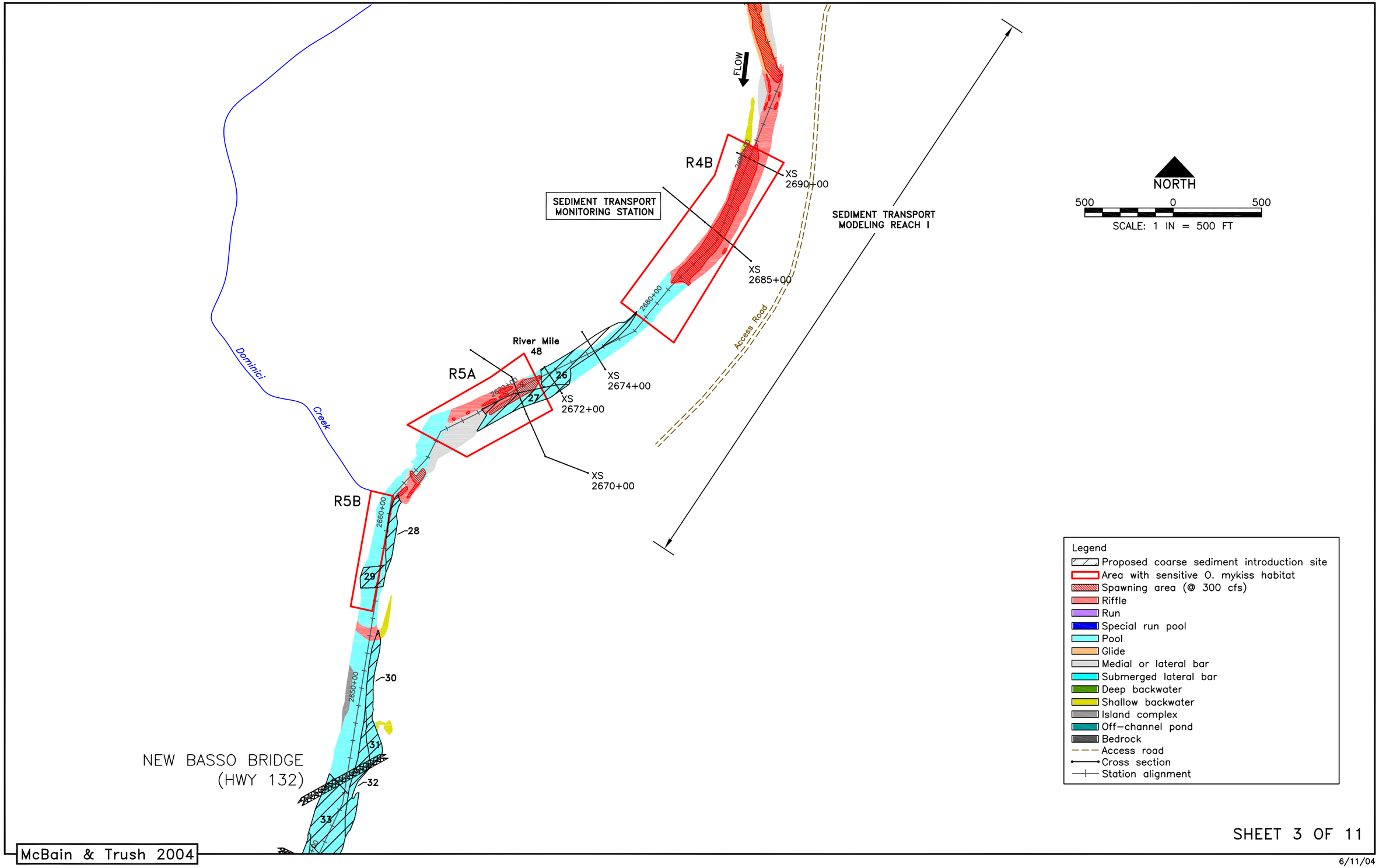
TUOLUMNE RIVER HABITAT MAP SHEET INDEX

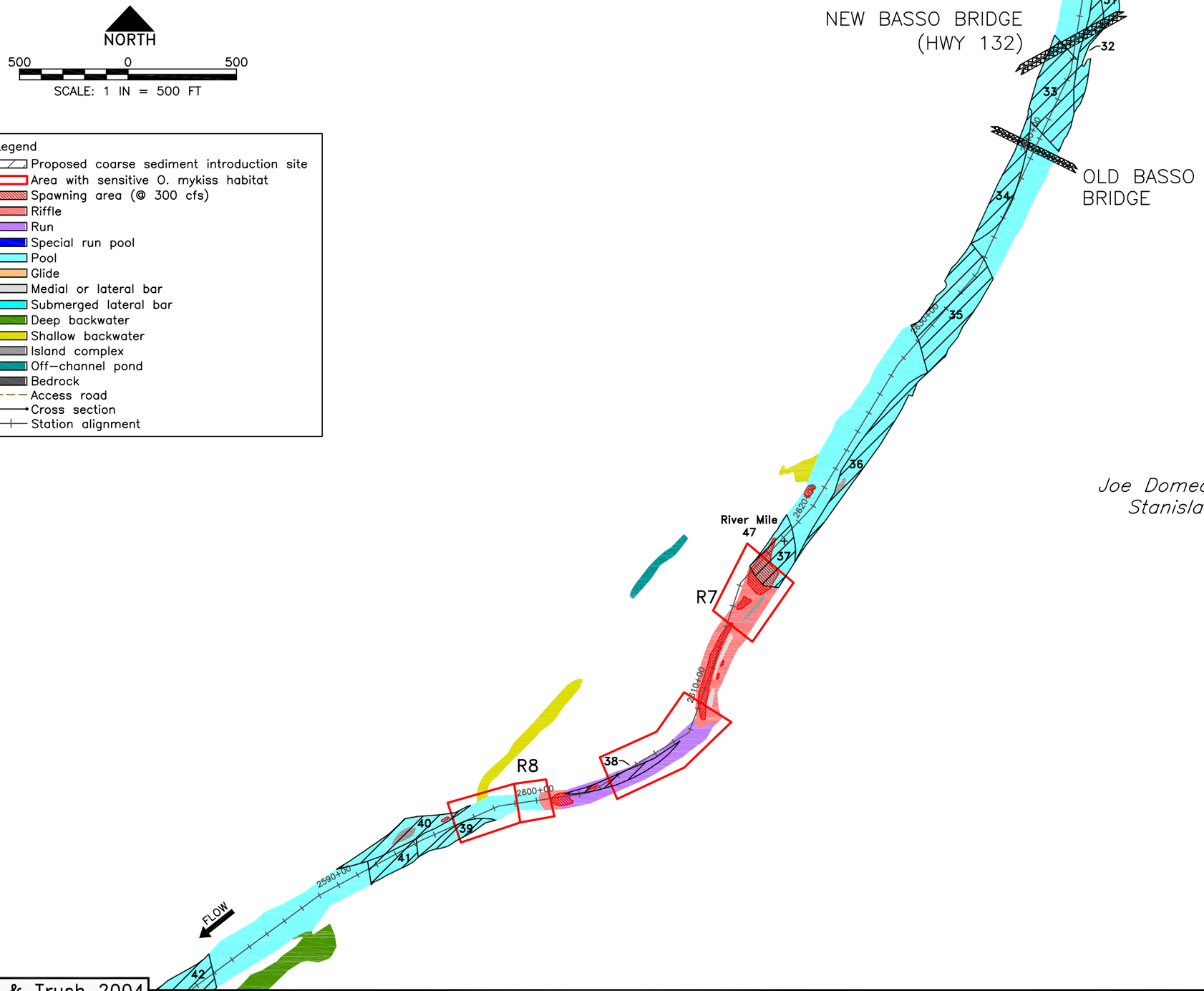
McBain & Trush 2004

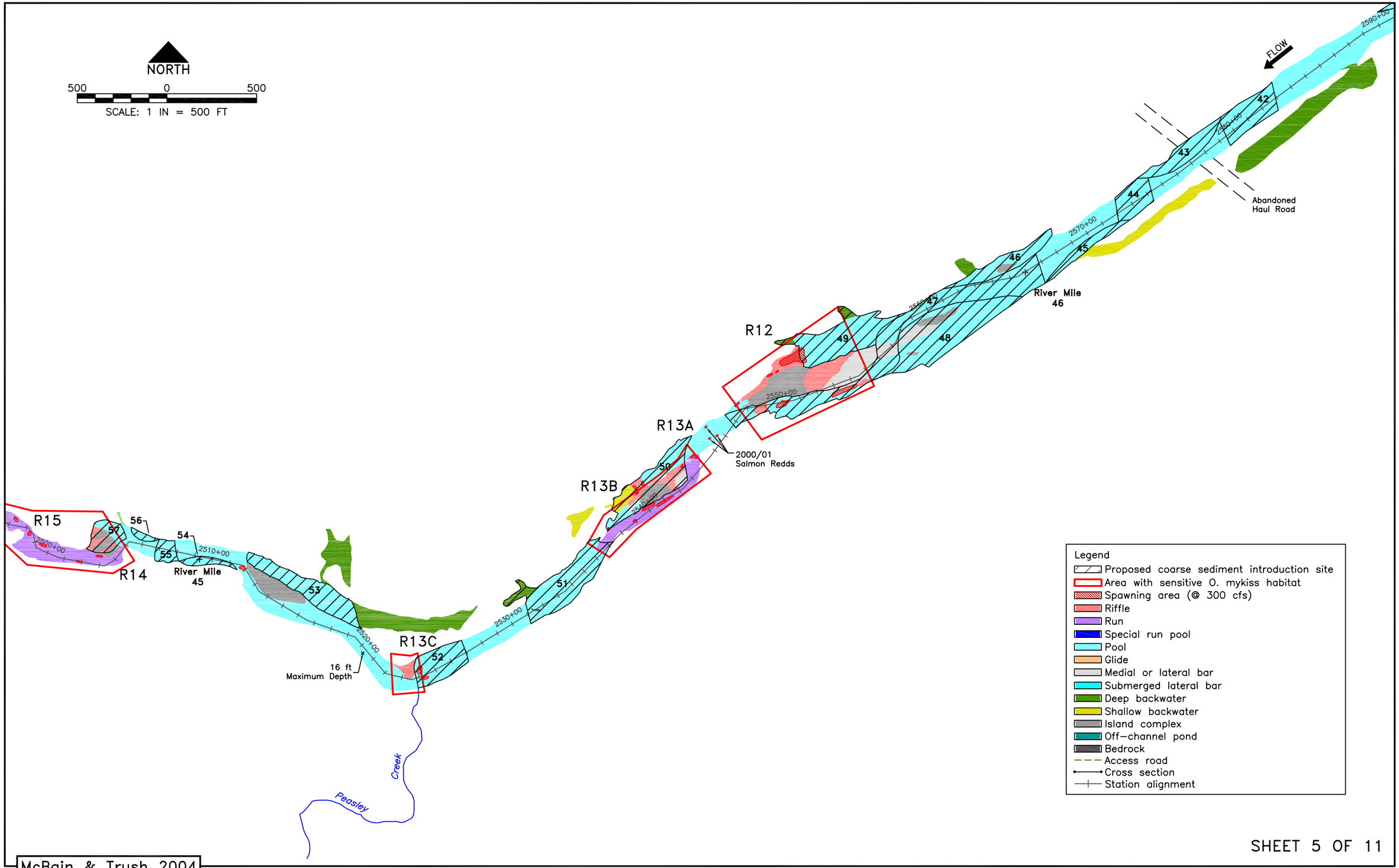
6/11/04

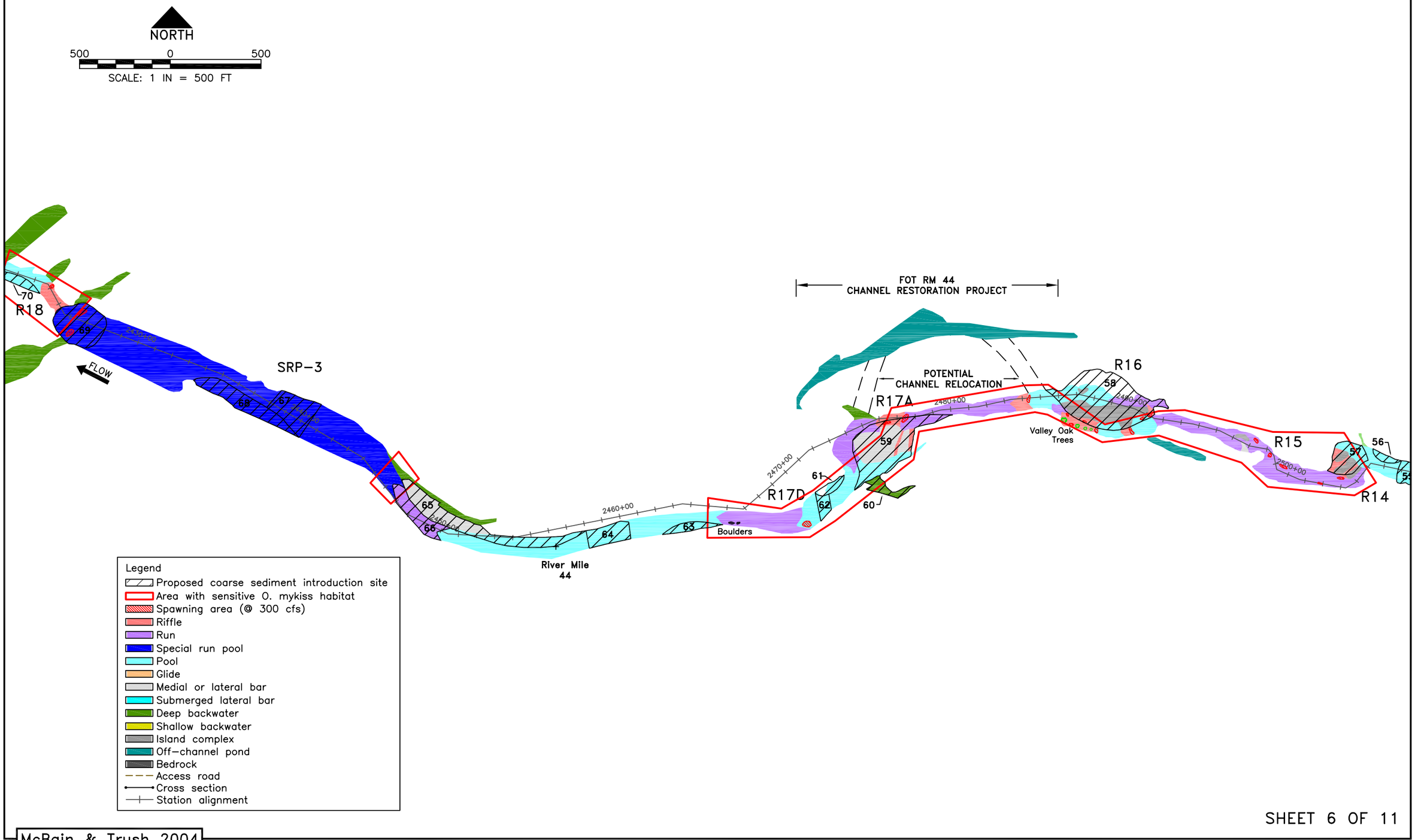

NORTH
500 0 500
SCALE: 1 IN = 500 FT
La Grange Dam
Not sampled
FLOW
Gasburg Creek
CDFG La Grange Field Office
Phase I Access Road
OLD LA GRANGE BRIDGE
Existing Road
Access Road
R1A
Phase I CDFG Gravel Introduction Completed 2001
2780+00
XS 2780+00
Completed by CDFG 2002
2790+00
RA7
Completed by CDFG 2003
Completed by CDFG 2001
XS 2802+00
XS 2799+00
XS 2804+00
2810+00
Road Access (with minor improvements)
River Mile 51
2820+00
USGS Cableway
2830+00
XS 2833+00
XS 2836+00
RA3/4
XS 2846+00
2850+00
R2
27 ft Maximum Depth
XS 2841+00
XS 2847+00
XS 2844+00
2840+00
Stockpile Area
Access Road
2860+00
2870+00
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off-channel pond
Bedrock
Access road
Cross section
Station alignment
McBain & Trush 2004
SHEET 1 OF 11
6/11/04


NORTH
500 0 500
SCALE: 1 IN = 500 FT
NEW
LA GRANGE
BRIDGE (J59)
Completed by CDFG 2003
Completed by CDFG 2002
Gasburg Creek
River Mile
50
River Mile
49
R1A
R1B
R2
R3A
R3B
R4A
XS 2743+50
XS 2739+40
XS 2736+00
XS 2730+90
XS 2728+00
XS 2722+00
XS 2705+00
XS 2702+00
XS 2699+00
XS 2756+00
XS 2759+80
XS 2762+25
XS 2764+30
XS 2780+00
Abandoned Haul Road
Access Road
Access Road
FLOW
McBain & Trush 2004
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off-channel pond
Bedrock
Access road
Cross section
Station alignment
SHEET 2 OF 11
6/11/04


FLOW
R4B
XS 2690+00
SEDIMENT TRANSPORT MONITORING STATION
XS 2685+00
2680+00
SEDIMENT TRANSPORT MODELING REACH 1
Access Road
River Mile 48
R5A
26
XS 2674+00
27
XS 2672+00
XS 2670+00
Dominici Creek
R5B
2660+00
28
29
30
2650+00
31
32
33
NEW BASSO BRIDGE (HWY 132)
NORTH
500 0 500
SCALE: 1 IN = 500 FT
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off-channel pond
Bedrock
Access road
Cross section
Station alignment
McBain & Trush 2004
SHEET 3 OF 11
6/11/04


NORTH
500 0 500
SCALE: 1 IN = 500 FT
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off-channel pond
Bedrock
Access road
Cross section
Station alignment
NEW BASSO BRIDGE
(HWY 132)
OLD BASSO
BRIDGE
River Mile
47
R7
R8
FLOW
31
32
33
34
35
36
37
38
39
40
41
42
2620+00
2610+00
2600+00
2590+00
Joe Domecq Wilderness
Stanislaus County
McBain & Trush 2004
SHEET 4 OF 11
6/11/04

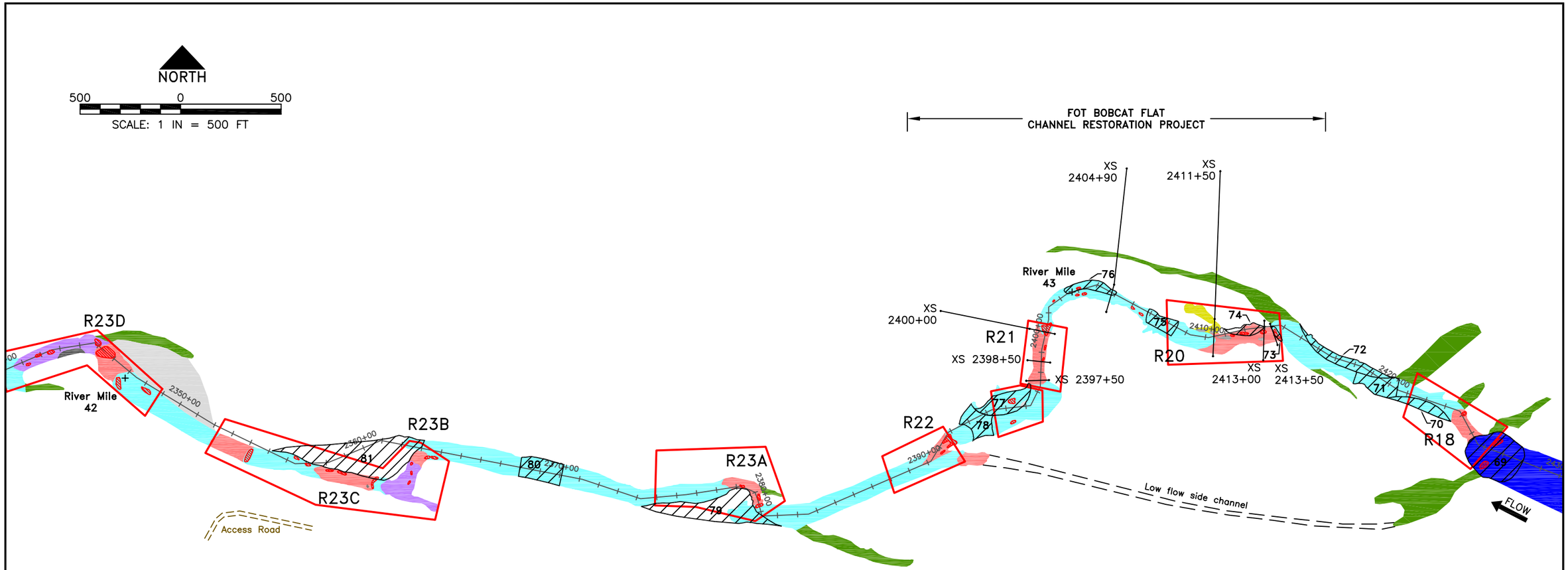

NORTH
500 0 500
SCALE: 1 IN = 500 FT
FLOW
2590+00
42
43
44
45
46
47
48
49
2570+00
2550+00
Abandoned Haul Road
River Mile 46
R12
R13A
R13B
R13C
2000/01 Salmon Redds
50
51
52
53
54
55
56
57
R14
R15
River Mile 45
2510+00
2530+00
2520+00
16 ft Maximum Depth
Peasley Creek
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off-channel pond
Bedrock
Access road
Cross section
Station alignment
McBain & Trush 2004
SHEET 5 OF 11
6/11/04



SHEET 6 OF 11

McBain & Trush 2004

6/11/04



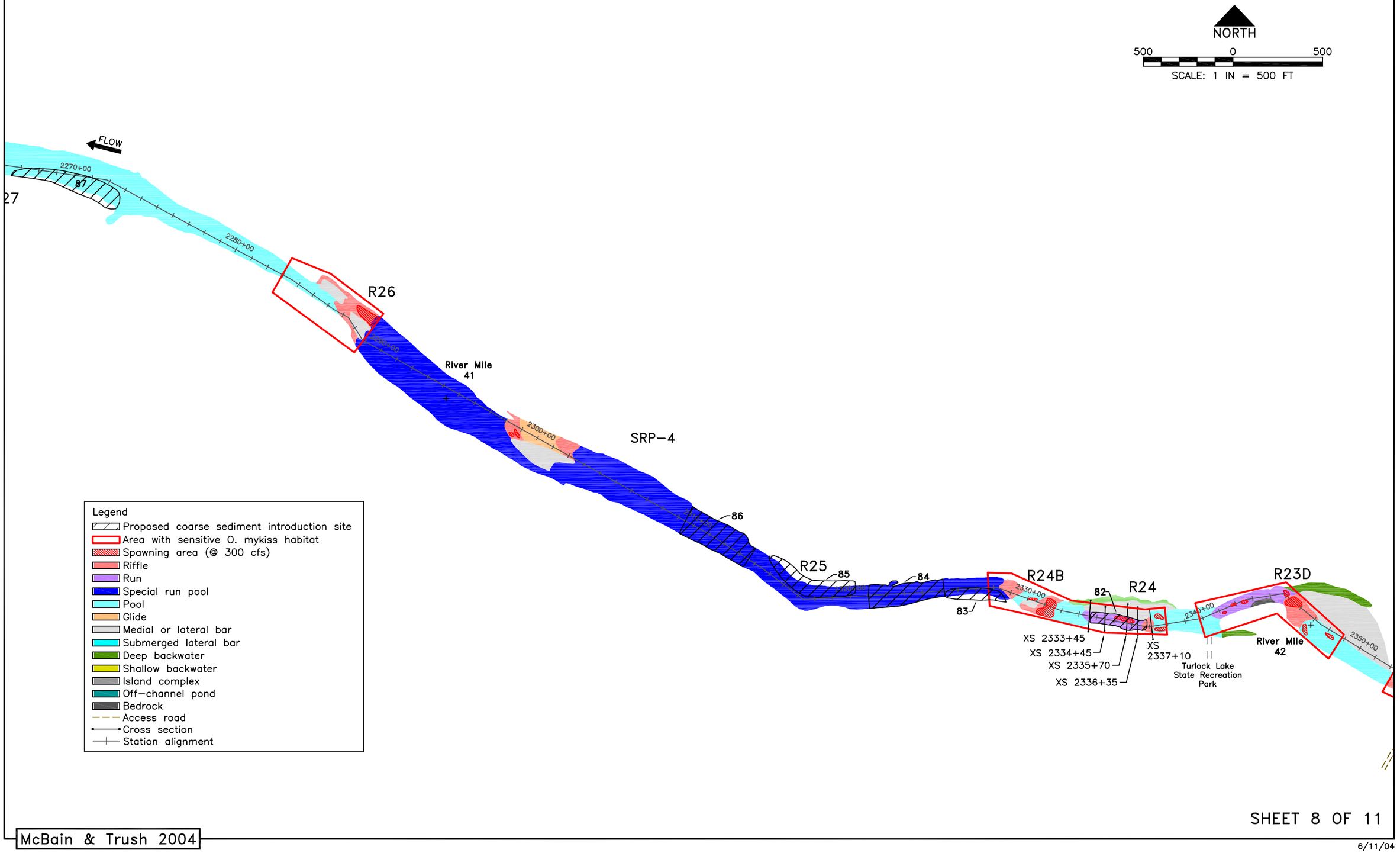
Legend

- Proposed coarse sediment introduction site
- Area with sensitive O. mykiss habitat
- Spawning area (@ 300 cfs)
- Riffle
- Run
- Special run pool
- Pool
- Glide
- Medial or lateral bar
- Submerged lateral bar
- Deep backwater
- Shallow backwater
- Island complex
- Off-channel pond
- Bedrock
- Access road
- Cross section
- Station alignment

SHEET 7 OF 11

McBain & Trush 2004

6/11/04


NORTH
500 0 500
SCALE: 1 IN = 500 FT
FLOW
2270+00
81
27
2280+00
R26
River Mile
41
SRP-4
2300+00
86
R25
85
84
83
R24B
2330+00
82
R24
XS 2333+45
XS 2334+45
XS 2335+70
XS 2336+35
XS
2337+10
2340+00
Turlock Lake
State Recreation
Park
R23D
River Mile
42
2350+00
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off-channel pond
Bedrock
Access road
Cross section
Station alignment
SHEET 8 OF 11
McBain & Trush 2004
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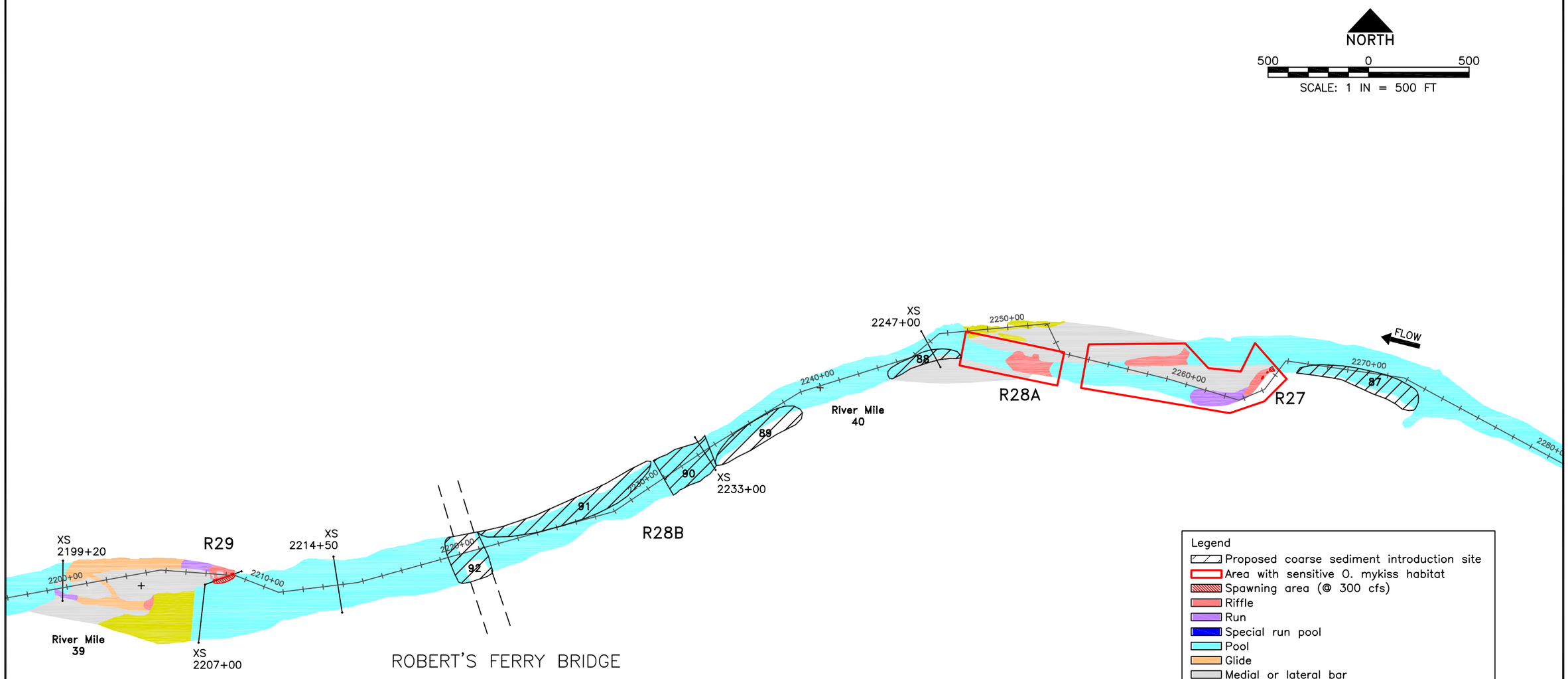
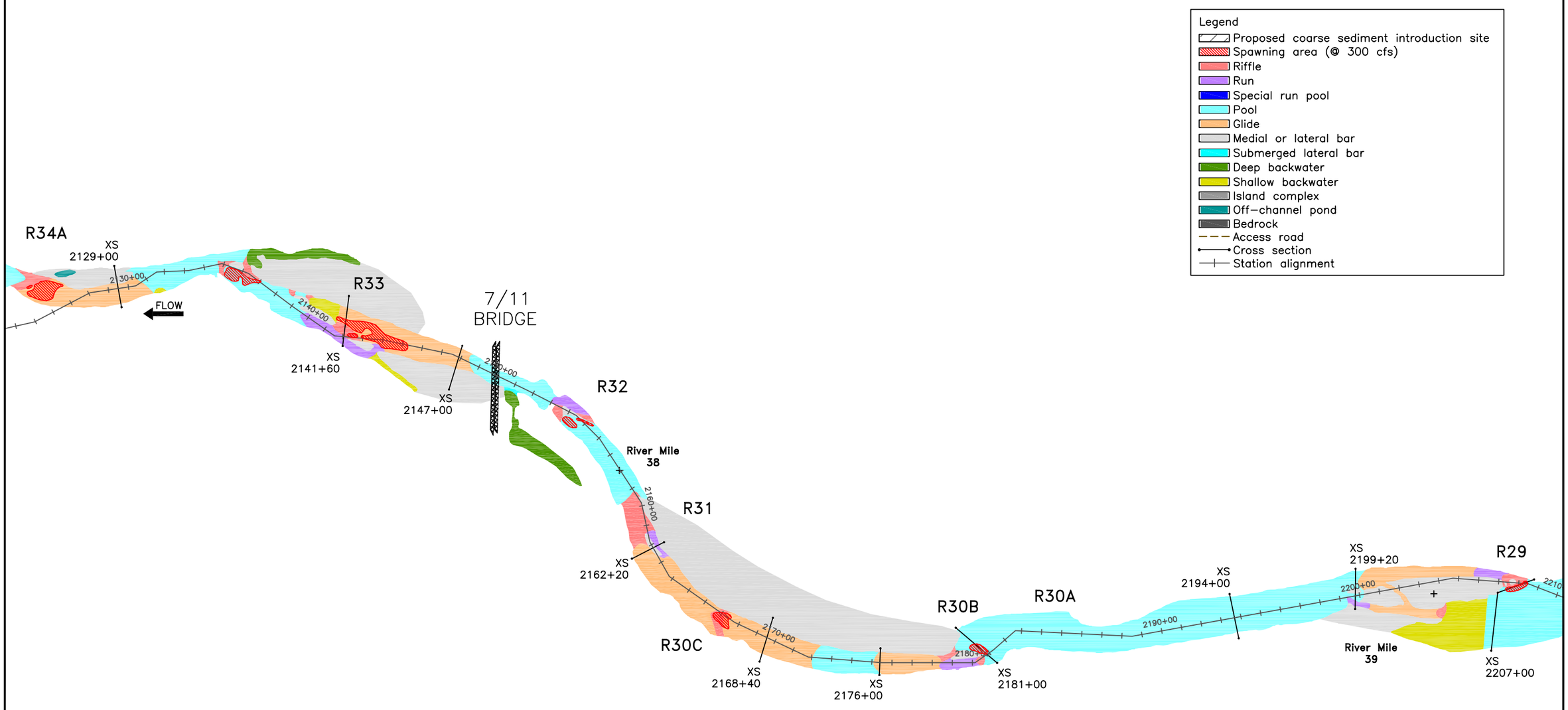


SHEET 9 OF 11

McBain & Trush 2004

6/11/04



SHEET 10 OF 11

McBain & Trush 2004

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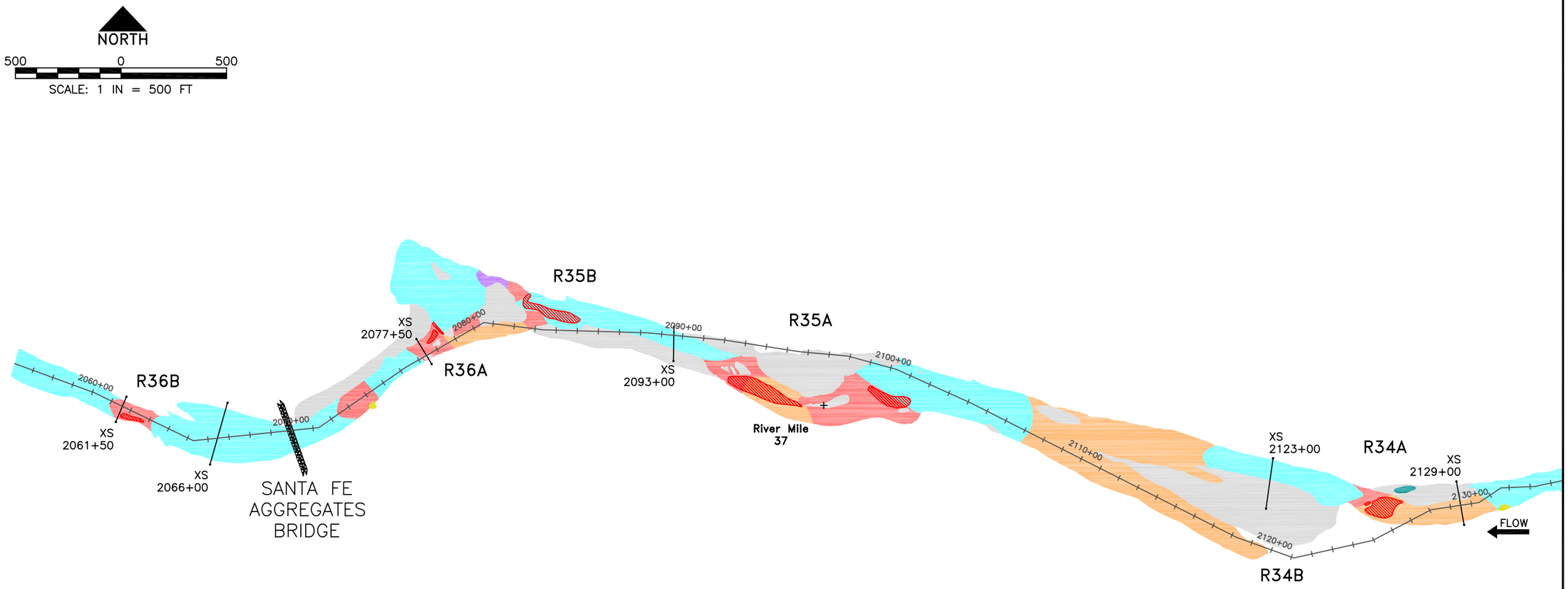

Legend
- Proposed coarse sediment introduction site
- Spawning area (@ 300 cfs)
- Riffle
- Run
- Special run pool
- Pool
- Glide
- Medial or lateral bar
- Submerged lateral bar
- Deep backwater
- Shallow backwater
- Island complex
- Off-channel pond
- Bedrock
- Access road
- Cross section
- Station alignment

McBain & Trush 2004

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6/11/04

Appendix C: Habitat Data

Table C-1. Physical habitat types and dimensions of surveyed areas in the lower Tuolumne River (RM 52–40).

Habitat Unit (NSO)	RM	BCE Site	Length (ft)	Average Width (ft)	Area (Sq. ft)	Average Depth (ft)	Maximum Depth (ft)	July 2008 Habitat Type	McBain & Trush (2004) Habitat Type
1	51.8	Yes	140	75	10,537	5.0	8.0	Pool Head	Pool
2	51.8	Yes	450	143	64,161	18.0	28.0	Pool Body	Pool
3	51.7	Yes	157	61	9,600	1.5	3.0	Pool Tail	Riffle
4	51.7	Yes	85	124	10,506	3.0	5.0	Pool Head	Pool
5	51.6	Yes	393	129	50,702	18.0	25.0	Pool Body	Pool
6	51.6	Yes	250	89	22,309	4.0	6.0	Pool Tail	Pool
7	51.5	Yes	292	68	19,851	3.0	6.0	Riffle	Riffle
8	51.5	Yes	117	82	9,562	5.0	6.0	Run Head	Pool
9	51.4	Yes	2,047	97	199,103	6.0	8.0	Run Body	Pool
10	51.1	Yes	182	86	15,733	3.5	4.5	Run Tail	Pool
11	51.0		457	99	45,397	10.0	16.0	Pool Body	Pool
12	50.9		843	128	107,699	4.0	7.0	Run Body	Pool
13	50.8		93	86	7,988	1.5	3.0	Run Tail	Pool
14	50.8		708	65	45,670	1.5		Riffle	Riffle
15	50.6		161	85	13,760	6.0	7.0	Run Head	Pool
16	50.6		704	132	92,609	5.0	8.0	Run Body	Pool
17	50.5		59	146	8,600	2.5	3.0	Run Tail	Pool
18	50.4		941	130	121,948	1.5	2.0	Riffle	Riffle
19	50.3		9	109	977	4.0	8.0	Run Head	Pool
20	50.3		898	151	135,674	3.0	4.0	Run Body	Pool
21	50.1		70	119	8,333	1.5	2.0	Run Tail	Pool
22	50.1		132	127	16,750	1.0	1.5	Riffle	Riffle
23	50.1		93	133	12,379	4.0	6.0	Run Head	Pool
24	50.0		1,007	199	200,462	4.0	8.0	Run Body	Pool
25	49.9		274	154	42,115	2.0	4.0	Run Tail	Pool
26	49.8		527	139	72,991	1.5	2.0	Riffle	Riffle
27	49.7	Yes	127	86	10,955	4.0	6.0	Pool Head	Run
28	49.7	Yes	161	89	14,345	6.0	9.0	Pool Body	Pool

29	49.6	Yes	112	85	9,490	1.5	2.5	Pool Tail	Riffle
30	49.6		50	110	5,520	3.0	5.0	Run Head	Riffle
31	49.6		1,440	115	166,115	2.5	3.5	Run Body	Pool
32	49.3		132	137	18,071	2.0	2.5	Run Tail	Riffle
33	49.3	Yes	552	126	69,509	1.5	2.5	Riffle	Riffle
34	49.2	Yes	112	65	7,283	2.0	3.0	Run Head	Riffle
35	49.2	Yes	321	82	26,475	3.0	5.0	Run Body	Pool
36	49.1	Yes	44	103	4,532	1.5	2.0	Run Tail	Riffle
37	49.1	Yes	78	97	7,594	1.5	2.0	Riffle	Riffle
38	49.1	Yes	43	83	3,559	2.0	3.5	Run Head	Pool
39	49.1	Yes	240	81	19,424	2.5	4.0	Run Body	Pool
40	49.1		23	95	2,180	2.5	3.0	Run Tail	Riffle
41	49.0		1,080	114	122,953	1.5	3.0	Riffle	Riffle
42	48.8		36	97	3,505	1.5	2.0	Run Head	Riffle
43	48.8		749	93	69,528	2.5	4.0	Run Body	Pool
44	48.7		39	110	4,304	2.0	3.0	Run Tail	Riffle
45	48.7		1,275	117	149,495	1.5	2.0	Riffle	Riffle
46	48.4		92	102	9,378	1.5	2.0	Run Head	Pool
47	48.4		915	111	101,397	3.5	5.0	Run Body	Pool
48	48.3		153	127	19,368	1.5	2.0	Run Tail	Pool
49	48.2		346	75	25,887	1.5	2.0	Riffle	Riffle
50	48.2		40	60	2,392	2.0	2.0	Run Head	Riffle
51	48.2		380	53	20,027	5.0	8.0	Run Body	Pool
52	48.1		114	56	6,430	3.0	3.5	Run Tail	Pool
53	48.1		234	54	12,554	1.5	2.0	Riffle	Riffle
54	48.0		164	89	14,569	5.0	7.0	Pool Head	Pool
55	48.0		4,036	143	579,150	7.0	15.0	Pool Body	Pool
56	47.2	Yes	136	115	15,575	1.5	2.5	Pool Tail	Pool
57	47.2	Yes	740	80	58,852	1.5	2.0	Riffle	Riffle
58	47.1	Yes	136	85	11,535	2.0	3.0	Run Head	Riffle
59	47.0	Yes	472	76	36,067	4.0	6.0	Run Body	Run
60	46.9	Yes	137	86	11,760	1.5	2.5	Run Tail	Run

61	46.9		318	81	25,666	1.0	2.0	Riffle	Riffle
62	46.9	Yes	64	85	5,428	1.5	2.0	Run Head	Pool
63	46.8	Yes	188	90	16,848	2.0	3.0	Run Body	Pool
64	46.8	Yes	126	131	16,480	1.0	2.5	Run Tail	Pool
65	46.8		100	123	12,268	0.8	1.5	Riffle	Pool
66	46.8		153	96	14,675	1.5	2.0	Run Head	Pool
67	46.7		3,829	97	370,148	4.0	6.0	Run Body	Pool
68	46.0		89	133	11,835	1.5	2.0	Run Tail	Riffle
69	46.0		234	95	22,286	4.0	7.0	Run Body	Pool
70	45.9		277	76	21,181	1.5	2.0	Riffle	Pool
71	45.9		61	93	5,701	2.0		Run Head	Riffle
72	45.9		243	94	22,751	2.5	3.5	Run Body	Pool
73	45.8		125	64	7,976	1.5	2.0	Run Tail	Riffle
74	45.8		243	40	9,820	0.8	1.8	Riffle	Pool
75	45.8		90	35	3,141	1.5	2.0	Run Head	Run
76	45.8		88	50	4,433	1.5	4.0	Run Body	Run
77	45.7		32	99	3,153	1.5	2.0	Run Tail	Run
78	45.7	Yes	675	109	73,797	1.5	2.0	Riffle	Pool
79	45.6		85	178	15,127	1.5	2.0	Run Head	Pool
80	45.6		1,040	120	124,357	3.5	5.0	Run Body	Pool
81	45.4		301	101	30,519	7.0	11.0	Pool Body	Pool
82	45.3		126	220	27,658	2.0	3.0	Run Head	Pool
83	45.3		1,182	97	114,144	4.0	6.0	Run Body	Pool
84	45.1		94	113	10,640	1.5	5.0	Run Tail	Pool
85	45.1		394	52	20,673	1.5	2.0	Riffle	Run
86	45.0	Yes	53	41	2,181	2.0	3.0	Pool Head	Run
87	45.0	Yes	101	71	7,213	5.0	8.0	Pool Body	Run
88	45.0	Yes	80	121	9,661	3.0	4.0	Pool Tail	Run
89	44.9		734	59	43,114	1.5	2.5	Riffle	Run
90	44.8	Yes	22	107	2,350	0.8	1.5	Run Head	Run
91	44.8	Yes	318	62	19,745	1.5	2.5	Run Body	Pool
92	44.7	Yes	15	25	368	1.0	1.5	Run Tail	Riffle

93	44.7		100	30	3,032	1.5	2.0	Riffle	Riffle
94	44.7		47	26	1,217	1.0	1.5	Run Head	Riffle
95	44.7		248	67	16,708	4.0	8.0	Run Body	Pool
96	44.7		34	87	2,950	1.5	2.0	Run Tail	Riffle
97	44.7		417	52	21,741	1.5	2.5	Riffle	Run
98	44.6		20	49	984	2.0	2.5	Run Head	Run
99	44.6		203	53	10,740	3.0	4.0	Run Body	Run
100	44.5		20	59	1,182	1.0	1.5	Run Tail	Riffle
101	44.5	Yes	472	59	27,744	1.5	2.0	Riffle	Run
102	44.4		10	68	681	2.0	2.5	Run Head	Run
103	44.4		3,209	82	261,993	3.0	3.0	Run Body	Pool
104	43.8		683	144	98,065	6.0	15.0	Pool Body	Run
105	43.7	Yes	2,173	146	316,376	4.0	6.0	Run Body	SRP3
106	43.3		50	110	5,487	1.5	2.0	Run Tail	Riffle
107	43.3		326	81	26,534	1.5	2.0	Riffle	Riffle
108	43.2		41	74	3,020	1.0	2.0	Run Head	Pool
109	43.2		906	62	56,464	2.5	6.0	Run Body	Pool
110	43.0		36	49	1,771	2.0	2.5	Run Tail	Pool
111	43.0		238	42	10,077	0.8	1.2	Riffle	Riffle
112	43.0	Yes	50	48	2,392	1.5	2.5	Pool Head	Riffle
113	43.0	Yes	159	166	26,397	5.0	7.0	Pool Body	Pool
114	43.0	Yes	46	169	7,767	1.5	5.0	Pool Tail	Pool
115	42.9		33	154	5,097	2.0	3.0	Run Head	Pool
116	42.9	Yes	309	124	38,258	4.0	10.0	Run Body	Pool
117	42.9	Yes	18	84	1,518	1.0	1.5	Run Tail	Riffle
118	42.9	Yes	77	57	4,403	1.0	2.0	Riffle	Riffle
119	42.9		31	45	1,395	2.0	2.5	Run Head	Riffle
120	42.9		978	87	84,726	1.0	8.0	Run Body	Pool
121	42.7		12	78	932	1.5	2.5	Run Tail	Riffle
122	42.7		89	48	4,288	1.0	3.0	Riffle	Riffle
123	42.6		18	55	991	2.5	3.0	Run Head	Riffle
124	42.6		1,571	77	120,609	2.0	5.0	Run Body	Pool

125	42.3		69	96	6,600	1.5	2.0	Run Body	Pool
126	42.3		227	55	12,478	1.0	3.0	Riffle	Riffle
127	42.3		84	23	1,953	1.5	4.0	Run Body	Run
128	42.3		265	32	8,417	1.5	2.3	Riffle	Riffle
129	42.2		25	28	699	1.5	3.0	Run Head	Riffle
130	42.2		1,066	62	65,871	2.0	4.0	Run Body	Pool
131	42.0		53	60	3,196	1.0	1.5	Run Tail	Riffle
132	42.0	Yes	521	64	33,202	1.0	1.5	Riffle	Run
133	41.9		41	46	1,877	2.0	2.5	Run Head	Run
134	41.9		940	82	77,063	2.0	4.0	Run Body	Run
135	41.7		47	96	4,525	0.8	1.5	Run Tail	Run
136	41.7		300	90	27,080	0.8	1.5	Riffle	Riffle
137	41.7		59	70	4,133	1.5	2.0	Run Head	Riffle
138	41.6		2,512	123	308,848	3.0	6.0	Run Body	SRP4
139	41.2		125	151	18,858	1.0	1.3	Run Tail	Riffle
140	41.1		312	107	33,422	1.0	1.5	Riffle	Riffle
141	41.1		102	163	16,604	1.5	2.0	Run Head	Riffle
142	41.1		666	185	122,933	2.0	4.5	Run Body	SRP4
143	40.9		83	182	15,121	0.8	1.3	Run Tail	Riffle
144	40.9		189	32	6,116	0.8	1.5	Riffle	Riffle
145	40.9	Yes	62	39	2,425	1.5	2.0	Run Head	Pool
146	40.9	Yes	2,207	101	223,893	5.0	9.0	Run Body	Pool
147	40.5	Yes	54	53	2,861	1.5	2.0	Run Tail	Riffle
148	40.5		638	53	33,978	1.5	2.5	Riffle	Run
149	40.3		37	83	3,076	1.5	2.0	Run Head	Pool
150	40.3		502	94	47,268	2.5	4.0	Run Body	Pool
151	40.2		34	81	2,767	1.0	1.5	Run Tail	Riffle
152	40.2	Yes	503	53	26,860	0.8	1.5	Riffle	Pool
153	40.1		51	68	3,462	1.5	2.0	Run Head	Pool
154	40.1		2,569	123	317,216	3.0	7.0	Run Body	Pool
155	39.6		26	142	3,699	1.5		Run Tail	Pool

Table C-2. Percent cover and type for habitat units within the study area.

River Mile	Habitat Unit (NSO)	Habitat Type	Sample Date	No Cover (%)	Boulder (%)	Wood (%)	Ledge (%)	Overhang (%)	Aq Veg (%)	Other (%)
51.8	1	Pool Head	7/11/2008	70	10		10			10
51.7	2	Pool Body	7/11/2008	50	20	10		5	15	
51.7	3	Pool Tail	7/11/2008	90			5		5	
51.6	4	Pool Head	7/11/2008	85			5		10	
51.6	5	Pool Body	7/11/2008	35			10	5	50	
51.5	6	Pool Tail	7/11/2008	60	10		10		20	
51.5	7	Riffle	7/11/2008	65		5			25	5
51.4	8	Run Head	7/11/2008	75		5	5	5	10	
51.1	9	Run Body	7/11/2008	30	10		10		50	
51.0	10	Run Tail	7/11/2008	60			10		30	
50.9	11	Pool Body	7/8/2008	50					50	
50.8	12	Run Body	7/8/2008	45	5				50	
50.8	13	Run Tail	7/8/2008	90				10		
50.6	14	Riffle	7/8/2008	80	10		10			
50.6	15	Run Head	7/8/2008	90	10					
50.5	16	Run Body	7/8/2008	95				5		
50.4	17	Run Tail	7/8/2008	90				5		5
50.3	18	Riffle	7/8/2008	90	5				5	
50.3	19	Run Head	7/8/2008	90					10	
50.1	20	Run Body	7/8/2008	95				5		
50.1	21	Run Tail	7/8/2008	90	5			5		
50.1	22	Riffle	7/8/2008	95					5	
50.0	23	Run Head	7/8/2008	95				5		
49.9	24	Run Body	7/8/2008	95				5		
49.8	25	Run Tail	7/8/2008	95				5		
49.7	26	Riffle	7/8/2008	90	5			5		
49.7	27	Pool Head	7/12/2008	80	5				10	5
49.6	28	Pool Body	7/12/2008	55	10	5		5	25	
49.6	29	Pool Tail	7/12/2008	85	5					10

River Mile	Habitat Unit (NSO)	Habitat Type	Sample Date	No Cover (%)	Boulder (%)	Wood (%)	Ledge (%)	Overhang (%)	Aq Veg (%)	Other (%)
49.6	30	Run Head	7/8/2008	100						
49.3	31	Run Body	7/8/2008	95		5				
49.3	32	Run Tail	7/8/2008	95				5		
49.2	33	Riffle	7/12/2008	85				10	5	
49.2	34	Run Head	7/15/2008	75		5	5	10	5	
49.1	35	Run Body	7/15/2008	70	5		5	10	10	
49.1	36	Run Tail	7/15/2008	90	5			5		
49.1	37	Riffle	7/8/2008	95				5		
49.1	38	Run Head	7/8/2008	90		5		5		
49.1	39	Run Body	7/8/2008	90	5			5		
49.0	40	Run Tail	7/8/2008	95				5		
48.8	41	Riffle	7/8/2008	95				5		
48.8	42	Run Head	7/8/2008	75				5	20	
48.7	43	Run Body	7/8/2008	90				10		
48.7	44	Run Tail	7/8/2008	95				5		
48.4	45	Riffle	7/8/2008	90				10		
48.4	46	Run Head	7/8/2008	90				10		
48.3	47	Run Body	7/8/2008	90				10		
48.2	48	Run Tail	7/8/2008	90				10		
48.2	49	Riffle	7/8/2008	90				10		
48.2	50	Run Head	7/8/2008	90		5		5		
48.1	51	Run Body	7/8/2008	95	5					
48.1	52	Run Tail	7/8/2008	95	5					
48.0	53	Riffle	7/15/2008	75		5		10		10
48.0	54	Pool Head	7/13/2008	75	10	5		5	5	
47.2	55	Pool Body	7/13/2008	80		10	5	5		
47.2	56	Pool Tail	7/13/2008	95					5	
47.1	57	Riffle	7/8/2008	100						
47.0	58	Run Head	7/13/2008	90		10				

River Mile	Habitat Unit (NSO)	Habitat Type	Sample Date	No Cover (%)	Boulder (%)	Wood (%)	Ledge (%)	Overhang (%)	Aq Veg (%)	Other (%)
46.9	59	Run Body	7/13/2008	70		20			10	
46.9	60	Run Tail	7/13/2008	100						
46.9	61	Riffle	7/8/2008	95				5		
46.9	62	Run Head	7/8/2008	90				10		
46.8	63	Run Body	7/8/2008	95				5		
46.8	64	Run Tail	7/8/2008	95				5		
46.8	65	Riffle	7/8/2008	95				5		
46.8	66	Run Head	7/8/2008	100						
46.0	67	Run Body	7/8/2008	95				5		
46.0	68	Run Tail	7/8/2008	95				5		
45.9	69	Run Body	7/8/2008	100						
45.9	70	Riffle	7/8/2008	90				10		
45.9	71	Run Head	7/8/2008	95				5		
45.8	72	Run Body	7/8/2008	95				5		
45.8	73	Run Tail	7/8/2008	100						
45.7	74	Riffle	7/13/2008	60		10		10	10	10
45.7	75	Run Head	7/9/2008	90				10		
45.7	76	Run Body	7/9/2008	90				10		
45.7	77	Run Tail	7/9/2008	100						
45.6	78	Riffle	7/9/2008	95				5		
45.6	79	Run Head	7/9/2008	85				5	10	
45.4	80	Run Body	7/9/2008	80	15			5		
45.3	81	Pool Body	7/9/2008	40		5		5	50	
45.3	82	Run Head	7/13/2008	10		10			80	
45.1	83	Run Body	7/13/2008	60		10			30	
45.1	84	Run Tail	7/13/2008	50		5		5	40	
45.0	85	Riffle	7/9/2008	70		5		25		
45.0	86	Pool Head	7/14/2008	70		5		15	5	5
44.9	87	Pool Body	7/14/2008	87		5		5	3	

River Mile	Habitat Unit (NSO)	Habitat Type	Sample Date	No Cover (%)	Boulder (%)	Wood (%)	Ledge (%)	Overhang (%)	Aq Veg (%)	Other (%)
44.9	88	Pool Tail	7/14/2008	85		5		5	5	
44.8	89	Riffle	7/9/2008	90				10		
44.8	90	Run Head	7/9/2008	90		5		5		
44.8	91	Run Body	7/9/2008	100						
44.8	92	Run Tail	7/9/2008	85				15		
44.7	93	Riffle	7/9/2008	80				20		
44.7	94	Run Head	7/9/2008	90				10		
44.7	95	Run Body	7/9/2008	100						
44.7	96	Run Tail	7/9/2008	95				5		
44.6	97	Riffle	7/14/2008	50		5	5	20	20	
44.6	98	Run Head	7/9/2008	95				5		
44.6	99	Run Body	7/9/2008	95				5		
44.5	100	Run Tail	7/9/2008	95				5		
44.5	101	Riffle	7/14/2008	90					10	
44.5	102	Run Head	7/9/2008	100						
43.9	103	Run Body	7/9/2008	90				10		
43.7	104	Pool Body	7/9/2008	65				5	30	
43.3	105	Run Body	7/9/2008	65				5	30	
43.3	106	Run Tail	7/9/2008	90				5	5	
43.2	107	Riffle	7/9/2008	85		5		10		
43.2	108	Run Head	7/14/2008	85				5	10	
43.1	109	Run Body	7/14/2008	80		10		10		
43.1	110	Run Tail	7/16/2008	80		5	5	10		
43.0	111	Riffle	7/9/2008	95				5		
43.0	112	Pool Head	7/16/2008	70		15		10	5	
43.0	113	Pool Body	7/16/2008	90		5			5	
43.0	114	Pool Tail	7/16/2008	80		20				
43.0	115	Run Head	7/9/2008	70		20		10		
42.9	116	Run Body	7/9/2008	100						

River Mile	Habitat Unit (NSO)	Habitat Type	Sample Date	No Cover (%)	Boulder (%)	Wood (%)	Ledge (%)	Overhang (%)	Aq Veg (%)	Other (%)
42.9	117	Run Tail	7/9/2008	95				5		
42.9	118	Riffle	7/9/2008	95				5		
42.9	119	Run Head	7/9/2008	95				5		
42.7	120	Run Body	7/9/2008	95				5		
42.7	121	Run Tail	7/9/2008	95				5		
42.7	122	Riffle	7/9/2008	90				5	5	
42.7	123	Run Head	7/9/2008	95				5		
42.4	124	Run Body	7/9/2008	95				5		
42.4	125	Run Body	7/9/2008	95				5		
42.3	126	Riffle	7/9/2008	80				20		
42.3	127	Run Body	7/9/2008	100						
42.3	128	Riffle	7/16/2008	80	5	5		5	5	
42.2	129	Run Head	7/9/2008	90				10		
42.1	130	Run Body	7/9/2008	90				10		
42.0	131	Run Tail	7/9/2008	95				5		
41.9	132	Riffle	7/9/2008	95				5		
41.9	133	Run Head	7/9/2008	95				5		
41.8	134	Run Body	7/9/2008	95				5		
41.8	135	Run Tail	7/9/2008	95				5		
41.7	136	Riffle	7/9/2008	95				5		
41.7	137	Run Head	7/9/2008	90				10		
41.2	138	Run Body	7/9/2008	100						
41.2	139	Run Tail	7/9/2008	95				5		
41.1	140	Riffle	7/9/2008	95				5		
41.1	141	Run Head	7/16/2008	95					5	
41.0	142	Run Body	7/16/2008	85					15	
41.0	143	Run Tail	7/16/2008	80				5	15	
40.9	144	Riffle	7/9/2008	95				5		
40.9	145	Run Head	7/9/2008	100						

River Mile	Habitat Unit (NSO)	Habitat Type	Sample Date	No Cover (%)	Boulder (%)	Wood (%)	Ledge (%)	Overhang (%)	Aq Veg (%)	Other (%)
40.5	146	Run Body	7/9/2008	65				10	25	
40.5	147	Run Tail	7/9/2008	85				15		
40.4	148	Riffle	7/16/2008	55		5		35	5	
40.4	149	Run Head	7/9/2008	75				5	20	
40.3	150	Run Body	7/9/2008	100						
40.3	151	Run Tail	7/9/2008	100						
40.2	152	Riffle	7/9/2008	95				5		
40.2	153	Run Head	7/9/2008	100						
39.7	154	Run Body	7/9/2008	95				5		
39.7	155	Run Tail	7/9/2008	95				5		

Table C-3. Substrate types for habitat units within the study area.

River Mile	NSO #	Habitat Type	Sample Date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Organic (%)
51.8	1	Pool Head	7/11/2008	40	20	20	20			
51.7	2	Pool Body	7/11/2008	45	5	20		30		
51.7	3	Pool Tail	7/11/2008	20	10	30	30	10		
51.6	4	Pool Head	7/11/2008	50		30	10	10		
51.6	5	Pool Body	7/11/2008	35	5	30	10	10	10	
51.5	6	Pool Tail	7/11/2008	50		40	10			
51.5	7	Riffle	7/11/2008	20		50	10	20		
51.4	8	Run Head	7/11/2008	20	10	50		20		
51.1	9	Run Body	7/11/2008	20	10	60	10			
51.0	10	Run Tail	7/11/2008	10	10	50	25	5		
50.9	11	Pool Body	7/8/2008	20	10	50		20		
50.8	12	Run Body	7/8/2008	20	10	50		20		
50.8	13	Run Tail	7/8/2008			60	30	10		
50.6	14	Riffle	7/8/2008			60	30	10		
50.6	15	Run Head	7/8/2008		10	50	40			
50.5	16	Run Body	7/8/2008	10	10	60	20			
50.4	17	Run Tail	7/8/2008		20	60	20			
50.3	18	Riffle	7/8/2008		20	60	20			
50.3	19	Run Head	7/8/2008		20	60	20			
50.1	20	Run Body	7/8/2008		20	60	20			
50.1	21	Run Tail	7/8/2008		20	60	20			
50.1	22	Riffle	7/8/2008		20	60	20			
50	23	Run Head	7/8/2008		20	60	20			
49.9	24	Run Body	7/8/2008		60	20	20			
49.8	25	Run Tail	7/8/2008		40	40	20			
49.7	26	Riffle	7/8/2008		20	60	20			
49.7	27	Pool Head	7/12/2008		25	70	5			
49.6	28	Pool Body	7/12/2008	15	25	30	20	10		
49.6	29	Pool Tail	7/12/2008		10	50	40			

River Mile	NSO #	Habitat Type	Sample Date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Organic (%)
49.6	30	Run Head	7/8/2008		20	60	20			
49.3	31	Run Body	7/8/2008		20	60	20			
49.3	32	Run Tail	7/8/2008		10	70	20			
49.2	33	Riffle	7/12/2008			80	20			
49.2	34	Run Head	7/15/2008		5	70	25			
49.1	35	Run Body	7/15/2008	25	10	50	10	5		
49.1	36	Run Tail	7/15/2008	5	5	60	25	5		
49.1	37	Riffle	7/8/2008		10	70	20			
49.1	38	Run Head	7/8/2008		10	70	20			
49.1	39	Run Body	7/8/2008		10	70	20			
49	40	Run Tail	7/8/2008		10	70	20			
48.8	41	Riffle	7/8/2008		10	70	20			
48.8	42	Run Head	7/8/2008		10	70	20			
48.7	43	Run Body	7/8/2008		40	40	20			
48.7	44	Run Tail	7/8/2008		40	40	20			
48.4	45	Riffle	7/8/2008		20	60	20			
48.4	46	Run Head	7/8/2008		10	40	50			
48.3	47	Run Body	7/8/2008		10	50	40			
48.2	48	Run Tail	7/8/2008		10	70	20			
48.2	49	Riffle	7/8/2008		10	70	20			
48.2	50	Run Head	7/8/2008		10	70	20			
48.1	51	Run Body	7/8/2008	20	10	50	20			
48.1	52	Run Tail	7/8/2008	20	10	50	20			
48.0	53	Riffle	7/15/2008			70	20	10		
48.0	54	Pool Head	7/13/2008		10	60	10	20		
47.2	55	Pool Body	7/13/2008			80	10		10	
47.2	56	Pool Tail	7/13/2008			75	15	5	5	
47.1	57	Riffle	7/8/2008		10	70	20			
47.0	58	Run Head	7/13/2008			60	30	10		
46.9	59	Run Body	7/13/2008	10	15	30	15	15	15	

River Mile	NSO #	Habitat Type	Sample Date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Organic (%)
46.9	60	Run Tail	7/13/2008							
46.9	61	Riffle	7/8/2008		10	70	20			
46.9	62	Run Head	7/8/2008		10	70	20			
46.8	63	Run Body	7/8/2008		10	70	20			
46.8	64	Run Tail	7/8/2008		10	60	30			
46.8	65	Riffle	7/8/2008		10	60	30			
46.8	66	Run Head	7/8/2008		10	50	30	10		
46	67	Run Body	7/8/2008		20	50	20	10		
46	68	Run Tail	7/8/2008		10	70	20			
45.9	69	Run Body	7/8/2008		10	70	20			
45.9	70	Riffle	7/8/2008			20	70	10		
45.9	71	Run Head	7/8/2008			30	40	30		
45.8	72	Run Body	7/8/2008			40	40	20		
45.8	73	Run Tail	7/8/2008			40	50	10		
45.7	74	Riffle	7/13/2008			80	15	5		
45.7	75	Run Head	7/9/2008		10	60	20	10		
45.7	76	Run Body	7/9/2008		10	60	20	10		
45.7	77	Run Tail	7/9/2008		10	60	20	10		
45.6	78	Riffle	7/9/2008			70	20	10		
45.6	79	Run Head	7/9/2008		10	10	30	50		
45.4	80	Run Body	7/9/2008	20	20	30		30		
45.3	81	Pool Body	7/9/2008	30	20	20		30		
45.3	82	Run Head	7/13/2008				25	75		
45.1	83	Run Body	7/13/2008			40	40	20		
45.1	84	Run Tail	7/13/2008			40	10	50		
45	85	Riffle	7/9/2008		10	60	30			
45.0	86	Pool Head	7/14/2008			70	10	20		
44.9	87	Pool Body	7/14/2008			40	20	40		
44.9	88	Pool Tail	7/14/2008			50	25	20	5	
44.8	89	Riffle	7/9/2008		20	60	20			

River Mile	NSO #	Habitat Type	Sample Date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Organic (%)
44.8	90	Run Head	7/9/2008			40	50	10		
44.8	91	Run Body	7/9/2008		10	60	30			
44.8	92	Run Tail	7/9/2008		10	60	30			
44.7	93	Riffle	7/9/2008			60	30	10		
44.7	94	Run Head	7/9/2008			60	30	10		
44.7	95	Run Body	7/9/2008							
44.7	96	Run Tail	7/9/2008			40	10	50		
44.6	97	Riffle	7/14/2008		5	50	25	20		
44.6	98	Run Head	7/9/2008		10	50	40			
44.6	99	Run Body	7/9/2008		10	40	40	10		
44.5	100	Run Tail	7/9/2008		10	40	40	10		
44.5	101	Riffle	7/14/2008	5	5	50	20	20		
44.5	102	Run Head	7/9/2008		10	50	30	10		
43.9	103	Run Body	7/9/2008	40	10	30	10	10		
43.7	104	Pool Body	7/9/2008	20	10	20		50		
43.3	105	Run Body	7/9/2008	20	10	20		50		
43.3	106	Run Tail	7/9/2008		10	60	20	10		
43.2	107	Riffle	7/9/2008		10	60	30			
43.2	108	Run Head	7/14/2008			40	40	15	5	
43.1	109	Run Body	7/14/2008		10	50	20	10	5	5
43.1	110	Run Tail	7/16/2008			50	25	25		
43	111	Riffle	7/9/2008		10	60	30			
43.0	112	Pool Head	7/16/2008		5	60	15	15	5	
43.0	113	Pool Body	7/16/2008			50	10	40		
43.0	114	Pool Tail	7/16/2008			50	30	20		
43	115	Run Head	7/9/2008		10	50	30	10		
42.9	116	Run Body	7/9/2008		10	60	30			
42.9	117	Run Tail	7/9/2008		10	60	30			
42.9	118	Riffle	7/9/2008		10	60	30			
42.9	119	Run Head	7/9/2008		20	50	30			

River Mile	NSO #	Habitat Type	Sample Date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Organic (%)
42.7	120	Run Body	7/9/2008		20	50	30			
42.7	121	Run Tail	7/9/2008		10	60	30			
42.7	122	Riffle	7/9/2008		10	50	40			
42.7	123	Run Head	7/9/2008		10	50	40			
42.4	124	Run Body	7/9/2008		10	50	40			
42.4	125	Run Body	7/9/2008		10	50	40			
42.3	126	Riffle	7/9/2008		10	50	40			
42.3	127	Run Body	7/9/2008	50		40	10			
42.3	128	Riffle	7/16/2008		5	50	30	15		
42.2	129	Run Head	7/9/2008	15	10	50	20	5		
42.1	130	Run Body	7/9/2008		10	60	30			
42	131	Run Tail	7/9/2008		10	50	40			
41.9	132	Riffle	7/9/2008		15	50	35			
41.9	133	Run Head	7/9/2008	15	15	45	25			
41.8	134	Run Body	7/9/2008	15	15	40	20	10		
41.8	135	Run Tail	7/9/2008		10	60	30			
41.7	136	Riffle	7/9/2008		10	60	30			
41.7	137	Run Head	7/9/2008	15	10	50	25			
41.2	138	Run Body	7/9/2008	15	10	50	25			
41.2	139	Run Tail	7/9/2008		10	60	20	10		
41.1	140	Riffle	7/9/2008		10	50	30	10		
41.1	141	Run Head	7/16/2008			50	25	25		
41.0	142	Run Body	7/16/2008			30	10	50	10	
41.0	143	Run Tail	7/16/2008			40	30	30		
40.9	144	Riffle	7/9/2008		10	60	20	10		
40.9	145	Run Head	7/9/2008		10	50	40			
40.5	146	Run Body	7/9/2008		50	20		30		
40.5	147	Run Tail	7/9/2008		10	60	30			
40.4	148	Riffle	7/16/2008			50	20	30		
40.4	149	Run Head	7/9/2008		10	50	30	10		

River Mile	NSO #	Habitat Type	Sample Date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Organic (%)
40.3	150	Run Body	7/9/2008							
40.3	151	Run Tail	7/9/2008		20	50	30			
40.2	152	Riffle	7/9/2008		20	50	30			
40.2	153	Run Head	7/9/2008		20	50	30			
39.7	154	Run Body	7/9/2008	20	10	50	10	10		
39.7	155	Run Tail	7/9/2008		10	50	40			

Appendix D: Water Quality Data

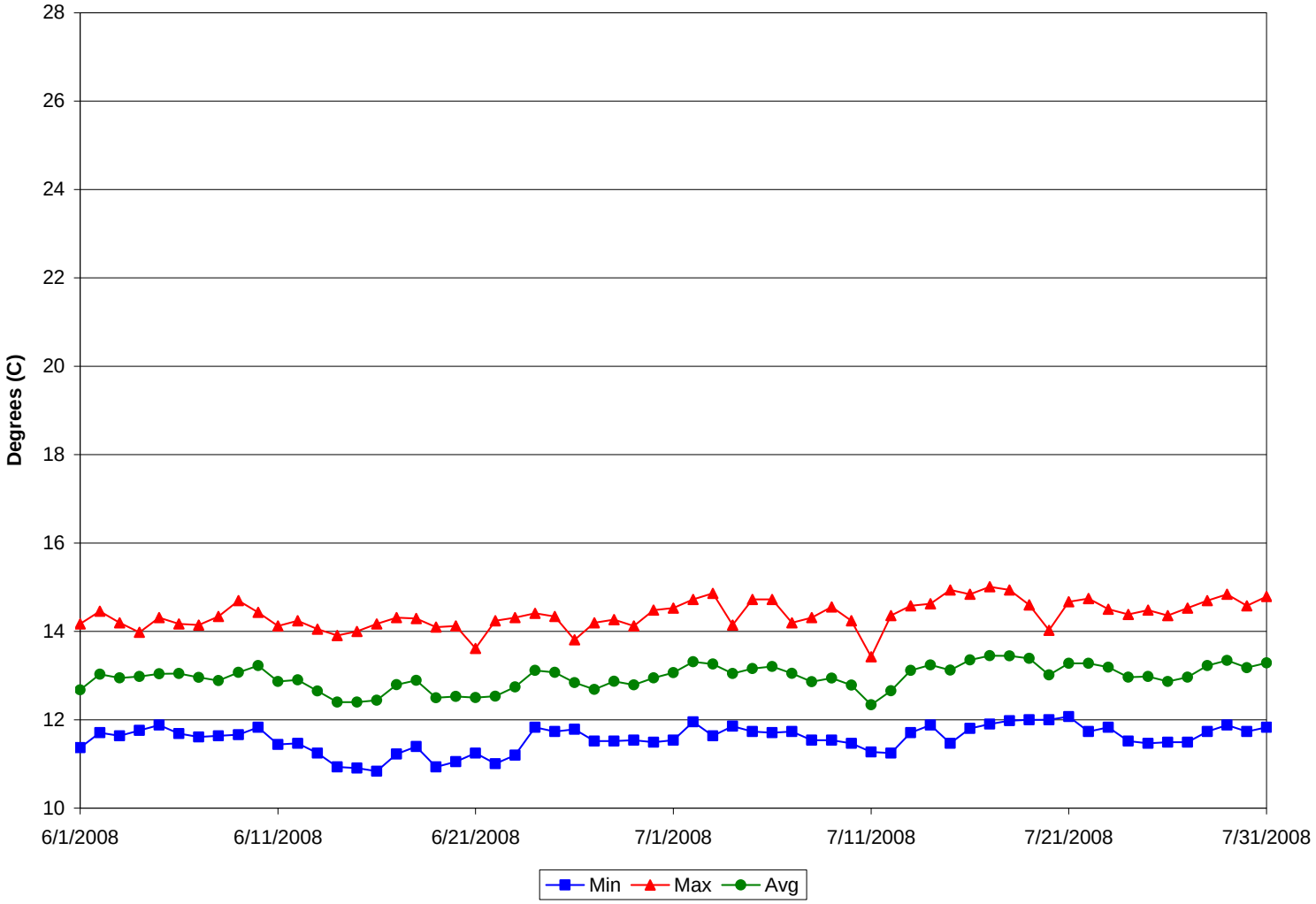
Table D-1. Water quality data for the habitat units selected for snorkel sampling.

River Mile	NSO #	Habitat Type	Sample Date	Start Time	Water Temp (C)	DO (ppm)	Sp. Cond. (mS)	Visability Horizontal (ft)	Visability Vertical (ft)	Avg Depth (ft)	Max Depth (ft)
51.8	1	Pool Head	7/11/2008	09:25 AM	11.5	11.6	39.6			4	8
51.7	2	Pool Body	7/11/2008	09:48 AM	12.0	11.4	39.9	27		16	254
51.7	3	Pool Tail	7/11/2008	10:38 AM	11.6	11.9	39.7			1.5	5
51.6	4	Pool Head	7/11/2008	10:52 AM	12.3	12.7	38.8			2	8
51.6	5	Pool Body	7/11/2008	11:06 AM	11.3	11.2	40.9		32.5	18	32.5
51.5	6	Pool Tail	7/11/2008	12:20 PM	12.0	11.4	40.5			3	8
51.5	7	Riffle	7/11/2008	12:48 PM	12.7	11.5	38.2	15		3	7
51.4	8	Run Head	7/11/2008	02:35 PM	13.7		39.9	12	6	4	6
51.1	9	Run Body	7/11/2008	03:13 PM	13.8	11.8	40.0	18			
51.0	10	Run Tail	7/11/2008	03:48 PM	14.0	12.5	40.2	18	8	6	8
49.7	27	Pool Head	7/12/2008	09:17 AM	13.8	12.1	40.8	15	10	3	10
49.6	28	Pool Body	7/12/2008	10:15 AM	14.5	11.8	40.3	15	15	6	15
49.6	29	Pool Tail	7/12/2008	12:35 PM	15.8	12.0	39.6			1	2
49.2	33	Riffle	7/12/2008	01:49 PM	17.2	12.2	40.5		1.5	0.6	1.5
49.2	34	Run Head	7/15/2008	11:30 AM	16.5	11.1	40.3	14	3.5	2	3.5
49.1	35	Run Body	7/15/2008	12:55 PM	17.1	11.4	40.8	10	6	2.5	6
49.1	36	Run Tail	7/15/2008	02:00 PM	17.6	11.9	40.2	12	2.5	1	2.5
48.0	53	Riffle	7/15/2008	09:00 AM	15.1	11.6	40.0	14	1.5	0.5	1.5
48.0	54	Pool Head	7/13/2008	09:17 AM	16.3	11.5	41.0	12	7	3	7
47.2	56	Pool Tail	7/13/2008	10:40 AM	17.6	10.1	42.0	12	2	4	7.5
47.2	55	Pool Body	7/13/2008	09:50 AM	17.5	10.2	42.5	12	7.5	0.7	2
47.0	58	Run Head	7/13/2008	10:58 AM	19.4	10.5	42.5	12	3	1.5	3
46.9	59	Run Body	7/13/2008	11:23 AM	18.1	10.2	43.1	12	4	2	4
46.9	60	Run Tail	7/13/2008	11:57 AM		10.2				1	4
45.7	74	Riffle	7/13/2008	01:32 PM	20.0	10.8	43.6	12	1.5	0.5	1.5
45.3	82	Run Head	7/13/2008	02:25 PM	21.9	10.9	45.5	9	12	4	
45.1	83	Run Body	7/13/2008	02:57 PM	22.9	10.6	45.4	6	10	2	5
45.1	84	Run Tail	7/13/2008	03:25 PM	23.0	10.3	45.4	7	4	3	4
45.0	86	Pool Head	7/14/2008	10:00 AM	21.0	10.8	45.0	7	5	2	7

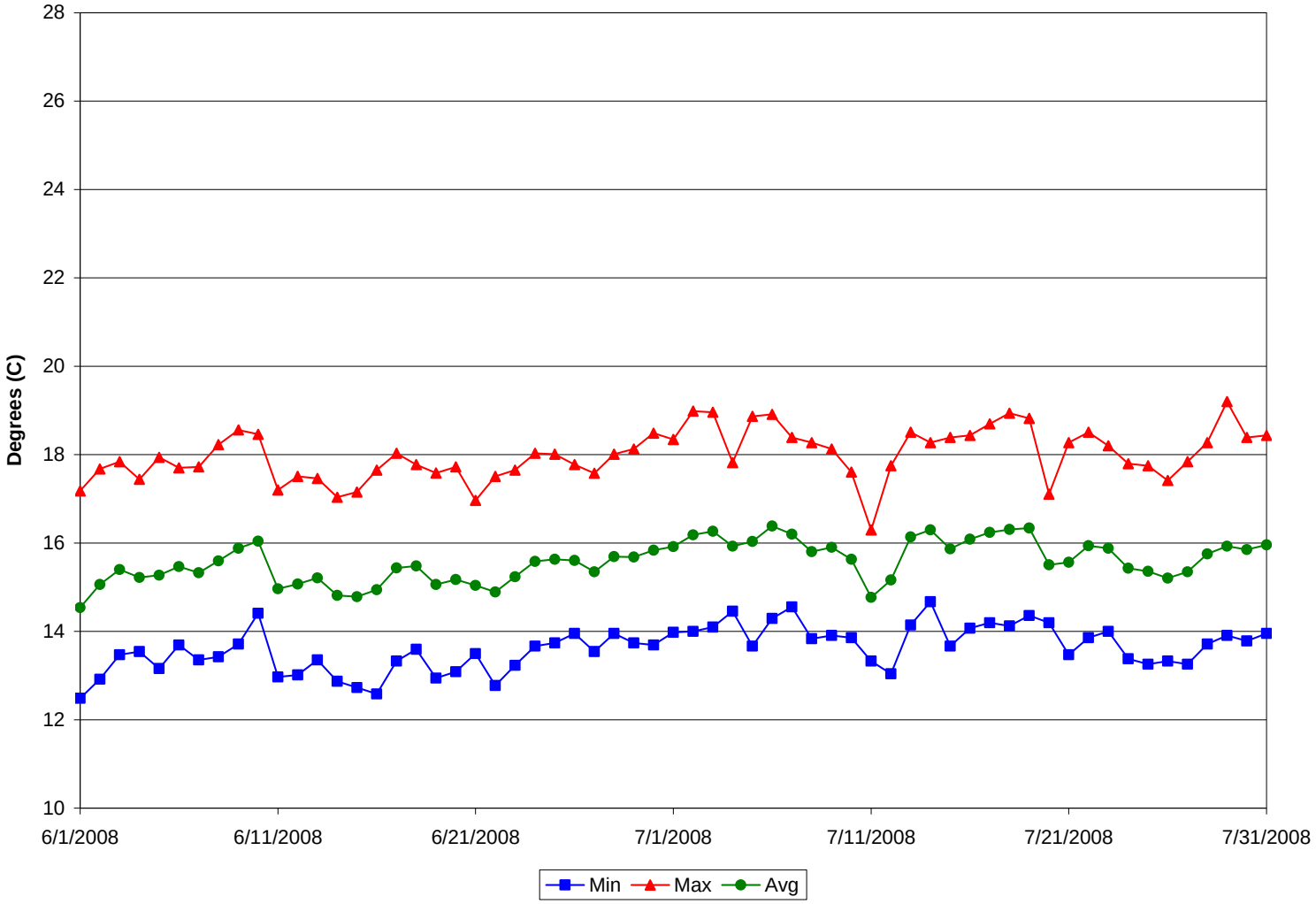
River Mile	NSO #	Habitat Type	Sample Date	Start Time	Water Temp (C)	DO (ppm)	Sp. Cond. (mS)	Visability Horizontal (ft)	Visability Vertical (ft)	Avg Depth (ft)	Max Depth (ft)
44.9	87	Pool Body	7/14/2008	12:15 PM	22.5	10.4	45.0	8	6	4	8
44.9	88	Pool Tail	7/14/2008	11:10 AM	21.9	10.4	45.0		4	2.5	4
44.6	97	Riffle	7/14/2008	01:45 PM	24.0	10.5	46.0	6	3	2	3
44.5	101	Riffle	7/14/2008	03:30 PM	24.1	10.5	46.8	8	2	1.25	2
43.2	108	Run Head	7/14/2008	05:35 PM	24.6	10.5	50.5	7	5	2.5	5
43.1	109	Run Body	7/14/2008	06:05 PM	24.4	10.1	48.8	8	6	4	6
43.1	110	Run Tail	7/16/2008	01:15 PM	21.8	10.7		6	4.5	3	4.5
43.0	112	Pool Head	7/16/2008	01:40 PM	22.2	10.6		6	4.5	3	4.5
43.0	113	Pool Body	7/16/2008	01:55 PM	22.2	10.5		6	6	6	9
43.0	114	Pool Tail	7/16/2008	02:15 PM	22.2	10.6		6	2	1.5	2
42.3	128	Riffle	7/16/2008	02:45 PM	23.3	10.9		6	2	1	2
41.1	141	Run Head	7/16/2008	04:00 PM	24.7	10.7		8	2.4	1.8	2.4
41.0	142	Run Body	7/16/2008	04:45 PM	25.1	11.0		8	2.2	1.8	2.2
41.0	143	Run Tail	7/16/2008		25.0	10.6			2	1.25	2
40.4	148	Riffle	7/16/2008	06:15 PM	25.0	10.3		6	2	1.5	4

Appendix E: Water Temperature Data

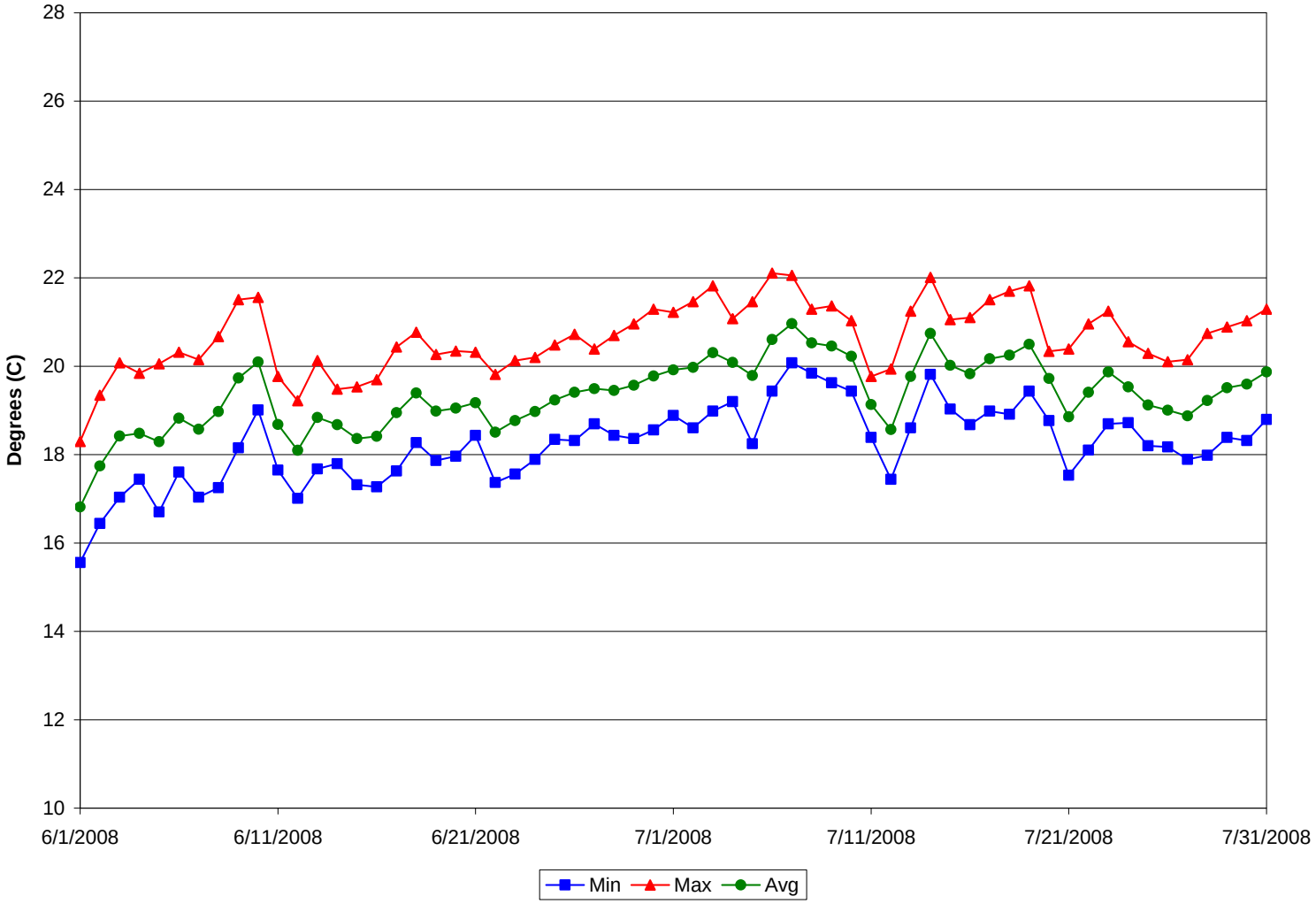
Riffle A7 (RM 50.8) Daily minimum, maximum, and average water temperature



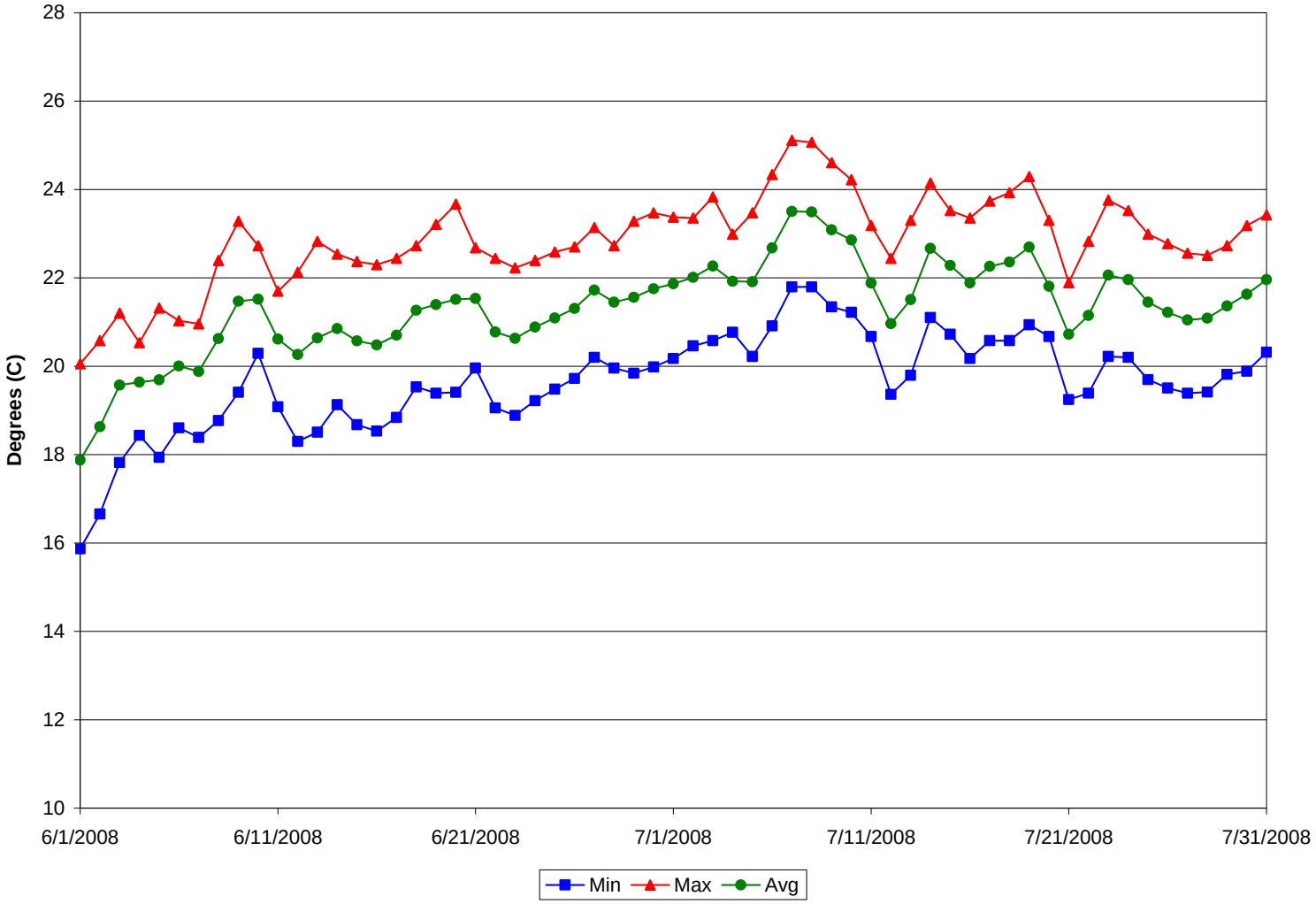
Riffle 3B (RM 49.0) Daily minimum, maximum, and average water temperature



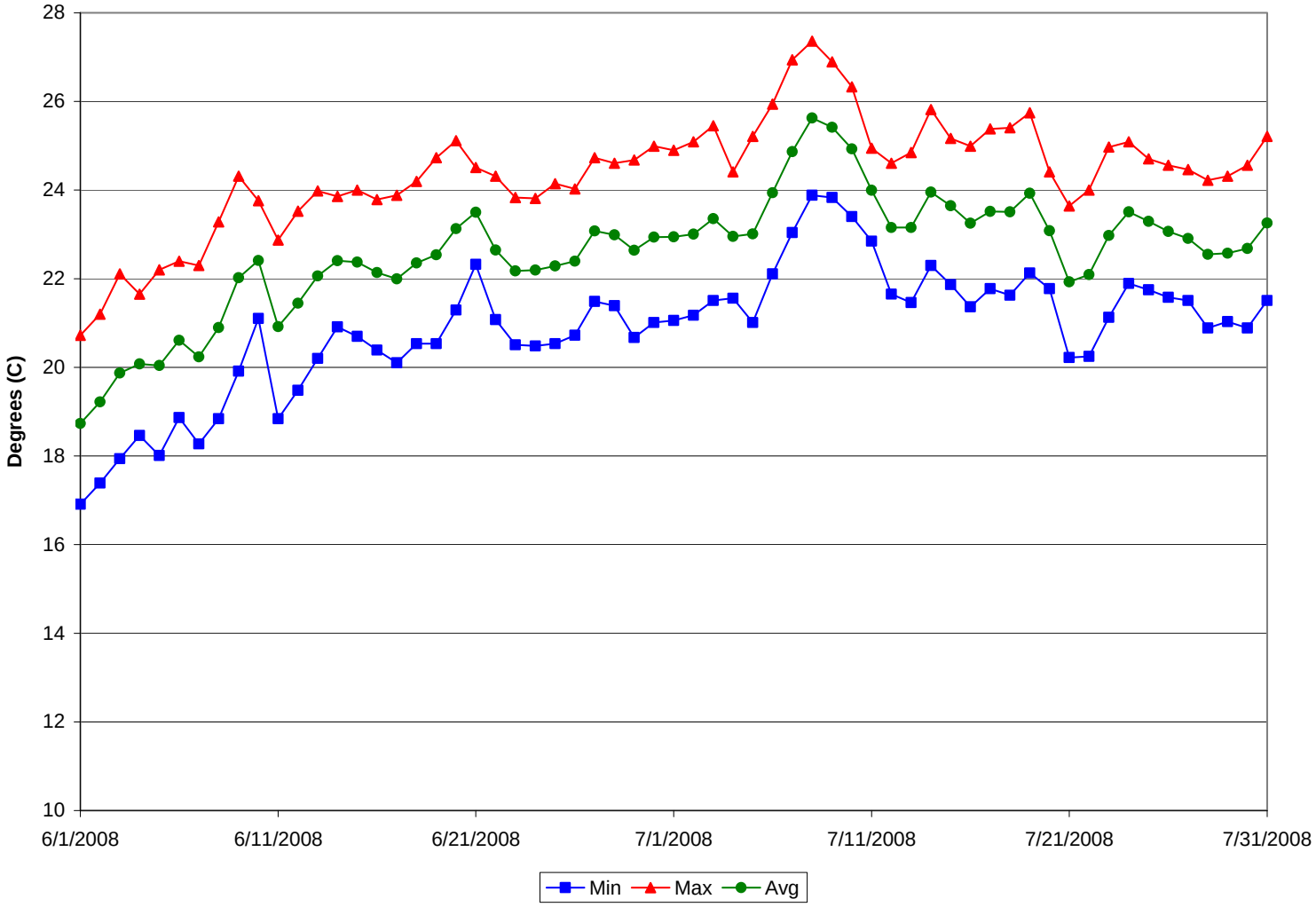
Riffle 13B (RM 45.5) Daily minimum, maximum, and average water temperature



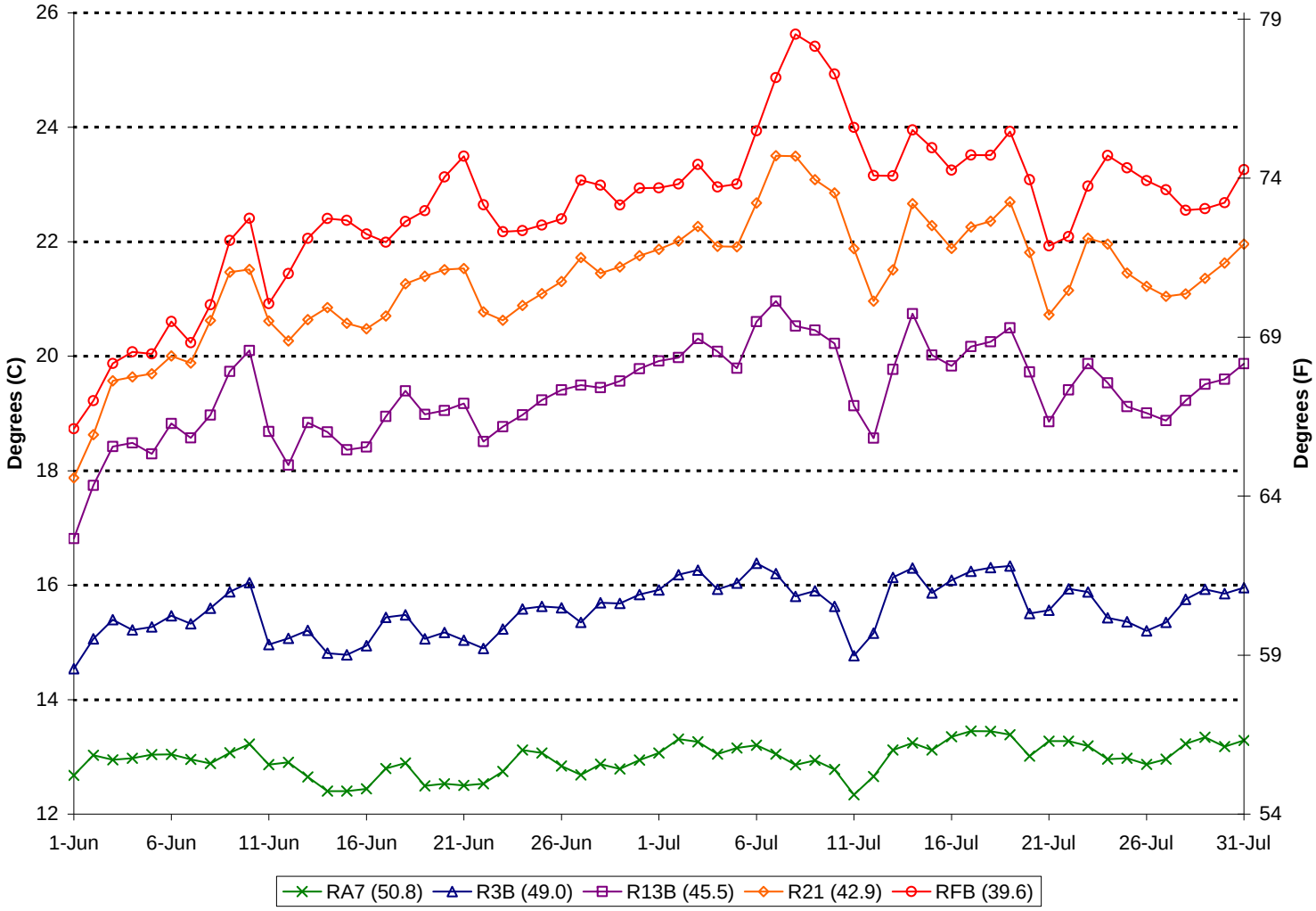
Riffle 21 (RM 42.9) Daily minimum, maximum, and average water temperature



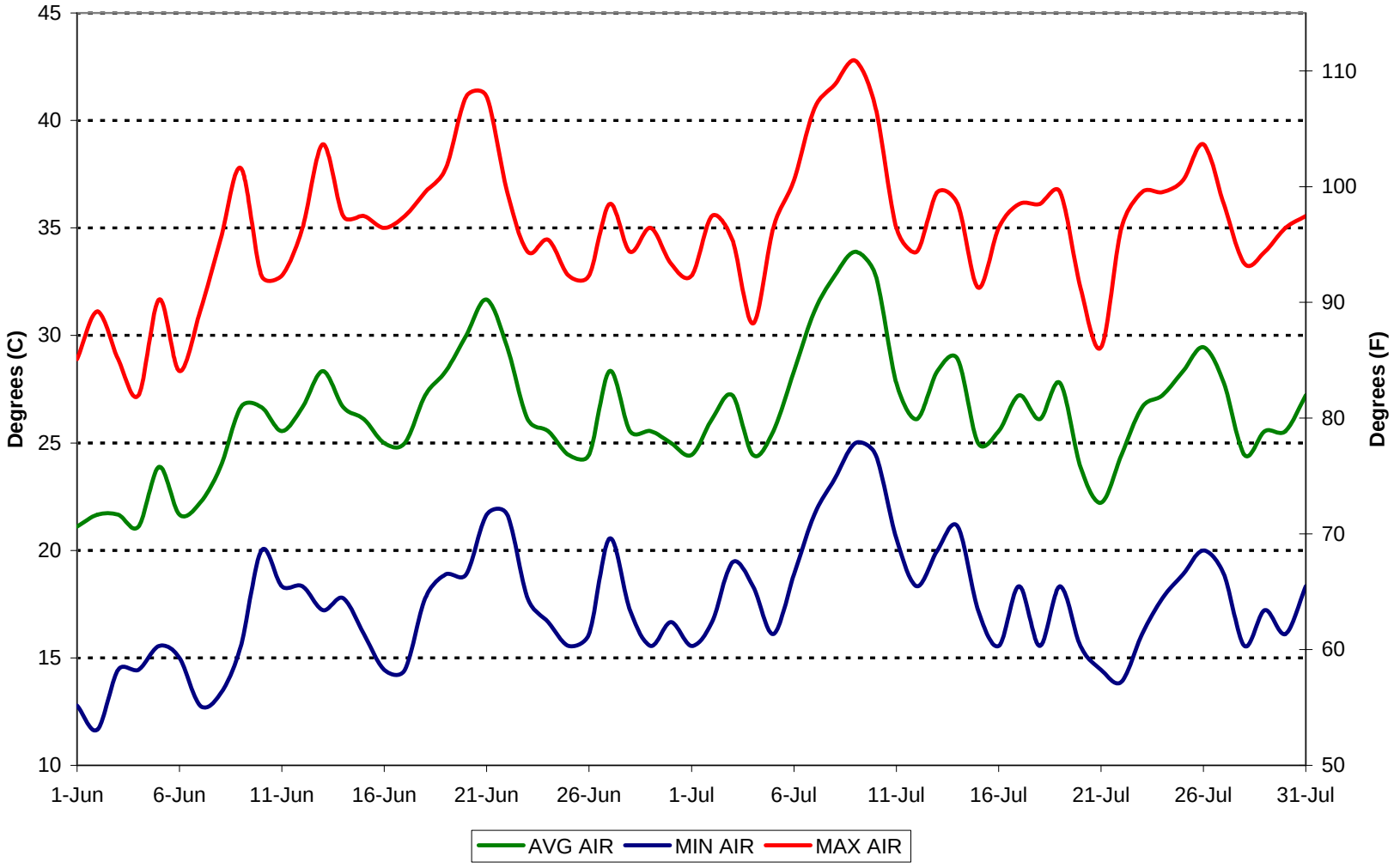
Roberts Ferry Bridge (RM 39.6) Daily minimum, maximum, and average water temperature



Average daily water temperature from thermographs, June-July, 2008



Daily Average, Mininum, and Maximum Air Temperature, Modesto Airport June-July, 2008



Appendix F: Fish Observation Data

Table F-1. *O. mykiss* observation data for the study area.

RM	NSO	Habitat	Single (S) or multiple (M) pass survey	Pass	Species	Count	size range (mm)
51.8	1	Pool Head	S	1	Mykiss	3	350–399
51.8	1	Pool Head	S	1	Mykiss	2	400–449
51.7	2	Pool Body	S	1	Mykiss	0	NONE
51.7	3	Pool Tail	S	1	Mykiss	0	NONE
51.6	4	Pool Head	S	1	Mykiss	1	150–199
51.6	4	Pool Head	S	1	Mykiss	2	200–249
51.6	4	Pool Head	S	1	Mykiss	1	300–349
51.6	5	Pool Body	S	1	Mykiss	0	NONE
51.5	6	Pool Tail	S	1	Mykiss	0	NONE
51.5	7	Riffle	M	1	Mykiss	1	250–299
51.5	7	Riffle	M	1	Mykiss	1	400–449
51.5	7	Riffle	M	1	Mykiss	1	400–449
51.5	7	Riffle	M	1	Mykiss	1	450–499
51.5	7	Riffle	M	2	Mykiss	2	250–299
51.5	7	Riffle	M	2	Mykiss	3	300–349
51.5	7	Riffle	M	2	Mykiss	1	400–449
51.5	7	Riffle	M	2	Mykiss	1	400–449
51.5	7	Riffle	M	3	Mykiss	1	250–299
51.5	7	Riffle	M	3	Mykiss	2	300–349
51.5	7	Riffle	M	3	Mykiss	1	400–449
51.5	7	Riffle	M	3	Mykiss	1	400–449
51.5	7	Riffle	M	3	Mykiss	1	450–499
51.5	7	Riffle	M	4	Mykiss	1	250–299
51.5	7	Riffle	M	4	Mykiss	2	300–349
51.5	7	Riffle	M	4	Mykiss	1	400–449
51.5	7	Riffle	M	4	Mykiss	1	400–449
51.5	7	Riffle	M	4	Mykiss	2	400–449
51.5	7	Riffle	M	4	Mykiss	1	450–499
51.5	7	Riffle	M	4	Mykiss	1	450–499
51.5	7	Riffle	M	4	Mykiss	1	450–499
51.4	8	Run Head	S	1	Mykiss	0	NONE
51.1	9	Run Body	S	1	Mykiss	1	350–399
51.1	9	Run Body	S	1	Mykiss	2	400–449
51.1	9	Run Body	S	1	Mykiss	1	400–449
51.0	10	Run Tail	S	1	Mykiss	0	NONE
49.7	27	Pool Head	M	1	Mykiss	0	NONE
49.7	27	Pool Head	M	2	Mykiss	3	300–349
49.7	27	Pool Head	M	2	Mykiss	1	350–399
49.7	27	Pool Head	M	3	Mykiss	1	100–149
49.7	27	Pool Head	M	3	Mykiss	3	150–199
49.7	27	Pool Head	M	3	Mykiss	3	300–349
49.7	27	Pool Head	M	3	Mykiss	1	350–399
49.7	27	Pool Head	M	4	Mykiss	4	100–149

RM	NSO	Habitat	Single (S) or multiple (M) pass survey	Pass	Species	Count	size range (mm)
49.7	27	Pool Head	M	4	Mykiss	1	200–249
49.7	27	Pool Head	M	4	Mykiss	4	50–99
49.6	28	Pool Body	M	1	Mykiss	0	NONE
49.6	28	Pool Body	M	2	Mykiss	2	250–299
49.6	28	Pool Body	M	2	Mykiss	1	350–399
49.6	28	Pool Body	M	3	Mykiss	1	300–349
49.6	28	Pool Body	M	4	Mykiss	0	NONE
49.6	29	Pool Tail	M	1	Mykiss	0	NONE
49.6	29	Pool Tail	M	2	Mykiss	0	NONE
49.6	29	Pool Tail	M	3	Mykiss	1	100–149
49.6	29	Pool Tail	M	4	Mykiss	0	NONE
49.2	33	Riffle	S	1	Mykiss	1	100–149
49.2	33	Riffle	S	1	Mykiss	2	100–149
49.2	33	Riffle	S	1	Mykiss	1	300–349
49.2	33	Riffle	S	1	Mykiss	4	50–99
49.2	34	Run Head	M	1	Mykiss	10	100–149
49.2	34	Run Head	M	1	Mykiss	25	50–99
49.2	34	Run Head	M	2	Mykiss	10	100–149
49.2	34	Run Head	M	2	Mykiss	1	250–299
49.2	34	Run Head	M	2	Mykiss	25	50–99
49.2	34	Run Head	M	3	Mykiss	10	100–149
49.2	34	Run Head	M	3	Mykiss	1	100–149
49.2	34	Run Head	M	3	Mykiss	1	100–149
49.2	34	Run Head	M	3	Mykiss	1	100–149
49.2	34	Run Head	M	3	Mykiss	20	50–99
49.2	34	Run Head	M	4	Mykiss	14	100–149
49.2	34	Run Head	M	4	Mykiss	10	100–149
49.2	34	Run Head	M	4	Mykiss	19	50–99
49.1	35	Run Body	M	1	Mykiss	1	350–399
49.1	35	Run Body	M	1	Mykiss	1	400–449
49.1	35	Run Body	M	2	Mykiss	1	400–449
49.1	35	Run Body	M	3	Mykiss	1	400–449
49.1	35	Run Body	M	4	Mykiss	1	400–449
49.1	35	Run Body	M	4	Mykiss	1	50–99
49.1	36	Run Tail	M	1	Mykiss	0	NONE
49.1	36	Run Tail	M	2	Mykiss	0	NONE
49.1	36	Run Tail	M	3	Mykiss	0	NONE
49.1	36	Run Tail	M	4	Mykiss	0	NONE
48.0	53	Riffle	M	1	Mykiss	1	100–149
48.0	53	Riffle	M	1	Mykiss	1	100–149
48.0	53	Riffle	M	1	Mykiss	1	100–149
48.0	53	Riffle	M	1	Mykiss	1	50–99
48.0	53	Riffle	M	1	Mykiss	1	50–99
48.0	53	Riffle	M	2	Mykiss	1	100–149

RM	NSO	Habitat	Single (S) or multiple (M) pass survey	Pass	Species	Count	size range (mm)
48.0	53	Riffle	M	2	Mykiss	4	50–99
48.0	53	Riffle	M	3	Mykiss	1	100–149
48.0	53	Riffle	M	3	Mykiss	1	100–149
48.0	53	Riffle	M	3	Mykiss	4	50–99
48.0	53	Riffle	M	3	Mykiss	1	50–99
48.0	53	Riffle	M	4	Mykiss	1	100–149
48.0	53	Riffle	M	4	Mykiss	1	100–149
48.0	53	Riffle	M	4	Mykiss	1	100–149
48.0	53	Riffle	M	4	Mykiss	1	50–99
48.0	53	Riffle	M	4	Mykiss	4	50–99
48.0	53	Riffle	M	4	Mykiss	1	50–99
48.0	54	Pool Head	S	1	Mykiss	0	NONE
47.2	55	Pool Body	S	1	Mykiss	0	NONE
47.2	56	Pool Tail	S	1	Mykiss	0	NONE
47.0	58	Run Head	S	1	Mykiss	1	100–149
47.0	58	Run Head	S	1	Mykiss	1	350–399
46.9	59	Run Body	S	1	Mykiss	3	50–99
46.9	60	Run Tail	S	1	Mykiss	0	NONE
45.7	74	Riffle	S	1	Mykiss	5	0–49
45.7	74	Riffle	S	1	Mykiss	2	100–149
45.7	74	Riffle	S	1	Mykiss	5	100–149
45.7	74	Riffle	S	1	Mykiss	4	100–149
45.7	74	Riffle	S	1	Mykiss	1	150–199
45.7	74	Riffle	S	1	Mykiss	1	50–99
45.7	74	Riffle	S	1	Mykiss	7	50–99
45.7	74	Riffle	S	1	Mykiss	5	50–99
45.7	74	Riffle	S	1	Mykiss	13	50–99
45.3	82	Run Head	S	1	Mykiss	0	NONE
45.1	83	Run Body	S	1	Mykiss	0	NONE
45.1	84	Run Tail	S	1	Mykiss	0	NONE
45.0	86	Pool Head	M	1	Mykiss	0	NONE
45.0	86	Pool Head	M	2	Mykiss	1	0–49
45.0	86	Pool Head	M	2	Mykiss	1	150–199
45.0	86	Pool Head	M	2	Mykiss	2	50–99
45.0	86	Pool Head	M	3	Mykiss	1	100–149
45.0	86	Pool Head	M	3	Mykiss	1	100–149
45.0	86	Pool Head	M	3	Mykiss	2	50–99
45.0	86	Pool Head	M	4	Mykiss	1	100–149
44.9	87	Pool Body	M	1	Mykiss	0	NONE
44.9	87	Pool Body	M	2	Mykiss	0	NONE
44.9	87	Pool Body	M	3	Mykiss	0	NONE
44.9	87	Pool Body	M	4	Mykiss	0	NONE
44.9	88	Pool Tail	M	1	Mykiss	0	NONE
44.9	88	Pool Tail	M	2	Mykiss	0	NONE

RM	NSO	Habitat	Single (S) or multiple (M) pass survey	Pass	Species	Count	size range (mm)
44.9	88	Pool Tail	M	3	Mykiss	0	NONE
44.9	88	Pool Tail	M	4	Mykiss	0	NONE
44.6	97	Riffle	S	1	Mykiss	1	100–149
44.6	97	Riffle	S	1	Mykiss	1	100–149
44.5	101	Riffle	M	1	Mykiss	1	100–149
44.5	101	Riffle	M	1	Mykiss	1	100–149
44.5	101	Riffle	M	1	Mykiss	1	100–149
44.5	101	Riffle	M	2	Mykiss	1	100–149
44.5	101	Riffle	M	2	Mykiss	1	150–199
44.5	101	Riffle	M	3	Mykiss	1	100–149
44.5	101	Riffle	M	4	Mykiss	1	100–149
43.2	108	Run Head	S	1	Mykiss	0	NONE
43.1	109	Run Body	S	1	Mykiss	1	100–149
43.1	110	Run Tail	S	1	Mykiss	0	NONE
43.0	112	Pool Head	S	1	Mykiss	0	NONE
43.0	113	Pool Body	S	1	Mykiss	0	NONE
43.0	114	Pool Tail	S	1	Mykiss	0	NONE
42.3	128	Riffle	S	1	Mykiss	1	100–149
42.3	128	Riffle	S	1	Mykiss	1	100–149
41.1	141	Run Head	M	1	Mykiss	0	NONE
41.1	141	Run Head	M	2	Mykiss	1	100–149
41.1	141	Run Head	M	3	Mykiss	0	NONE
41.1	141	Run Head	M	4	Mykiss	0	NONE
41.0	142	Run Body	M	1	Mykiss	0	NONE
41.0	142	Run Body	M	2	Mykiss	0	NONE
41.0	142	Run Body	M	3	Mykiss	0	NONE
41.0	142	Run Body	M	4	Mykiss	0	NONE
41.0	143	Run Tail	M	1	Mykiss	0	NONE
41.0	143	Run Tail	M	2	Mykiss	0	NONE
41.0	143	Run Tail	M	3	Mykiss	0	NONE
41.0	143	Run Tail	M	4	Mykiss	0	NONE
40.4	148	Riffle	M	1	Mykiss	0	NONE
40.4	148	Riffle	M	2	Mykiss	0	NONE
40.4	148	Riffle	M	3	Mykiss	0	NONE
40.4	148	Riffle	M	4	Mykiss	0	NONE

Table F-2. *O. tshawyschta* observation data for the study area.

NSO	Habitat	Single (S) or multiple (M) pass survey	Pass	Species	Count	Size range (mm)
1	Pool Head	S	1	Chinook	0	NONE
2	Pool Body	S	1	Chinook	1	600–649
3	Pool Tail	S	1	Chinook	0	NONE
4	Pool Head	S	1	Chinook	0	NONE
5	Pool Body	S	1	Chinook	0	NONE
6	Pool Tail	S	1	Chinook	0	NONE
7	Riffle	M	1	Chinook	1	650–699
7	Riffle	M	2	Chinook	0	NONE
7	Riffle	M	3	Chinook	1	650–699
7	Riffle	M	4	Chinook	1	650–699
8	Run Head	S	1	Chinook	0	NONE
9	Run Body	S	1	Chinook	0	NONE
10	Run Tail	S	1	Chinook	0	NONE
27	Pool Head	M	1	Chinook	0	NONE
27	Pool Head	M	2	Chinook	0	NONE
27	Pool Head	M	3	Chinook	0	NONE
27	Pool Head	M	4	Chinook	3	100–149
27	Pool Head	M	4	Chinook	4	50–99
28	Pool Body	M	1	Chinook	0	NONE
28	Pool Body	M	2	Chinook	0	NONE
28	Pool Body	M	3	Chinook	10	100–149
28	Pool Body	M	3	Chinook	10	50–99
28	Pool Body	M	4	Chinook	10	100–149
28	Pool Body	M	4	Chinook	10	50–99
29	Pool Tail	M	1	Chinook	0	NONE
29	Pool Tail	M	2	Chinook	0	NONE
29	Pool Tail	M	3	Chinook	0	NONE
29	Pool Tail	M	4	Chinook	0	NONE
33	Riffle	S	1	Chinook	0	NONE
34	Run Head	M	1	Chinook	25	50–99
34	Run Head	M	2	Chinook	25	50–99
34	Run Head	M	3	Chinook	13	50–99
34	Run Head	M	4	Chinook	16	50–99
35	Run Body	M	1	Chinook	0	NONE
35	Run Body	M	2	Chinook	1	50–99
35	Run Body	M	3	Chinook	0	NONE
35	Run Body	M	4	Chinook	0	NONE
36	Run Tail	M	1	Chinook	0	NONE
36	Run Tail	M	2	Chinook	0	NONE
36	Run Tail	M	3	Chinook	0	NONE
36	Run Tail	M	4	Chinook	0	NONE
53	Riffle	M	1	Chinook	0	NONE

NSO	Habitat	Single (S) or multiple (M) pass survey	Pass	Species	Count	Size range (mm)
53	Riffle	M	2	Chinook	4	50–99
53	Riffle	M	3	Chinook	4	50–99
53	Riffle	M	3	Chinook	1	50–99
53	Riffle	M	3	Chinook	2	50–99
53	Riffle	M	4	Chinook	1	50–99
53	Riffle	M	4	Chinook	5	50–99
54	Pool Head	S	1	Chinook	0	NONE
55	Pool Body	S	1	Chinook	0	NONE
56	Pool Tail	S	1	Chinook	0	NONE
58	Run Head	S	1	Chinook	0	NONE
59	Run Body	S	1	Chinook	9	50–99
60	Run Tail	S	1	Chinook	0	NONE
74	Riffle	S	1	Chinook	1	0–49
74	Riffle	S	1	Chinook	3	50–99
74	Riffle	S	1	Chinook	3	50–99
82	Run Head	S	1	Chinook	7	50–99
83	Run Body	S	1	Chinook	0	NONE
84	Run Tail	S	1	Chinook	0	NONE
86	Pool Head	M	1	Chinook	0	NONE
86	Pool Head	M	2	Chinook	3	50–99
86	Pool Head	M	3	Chinook	1	100–149
86	Pool Head	M	3	Chinook	2	50–99
86	Pool Head	M	4	Chinook	1	50–99
87	Pool Body	M	1	Chinook	0	NONE
87	Pool Body	M	2	Chinook	0	NONE
87	Pool Body	M	3	Chinook	2	50–99
87	Pool Body	M	4	Chinook	3	50–99
88	Pool Tail	M	1	Chinook	0	NONE
88	Pool Tail	M	2	Chinook	0	NONE
88	Pool Tail	M	3	Chinook	0	NONE
88	Pool Tail	M	4	Chinook	0	NONE
97	Riffle	S	1	Chinook	2	50–99
101	Riffle	M	1	Chinook	0	NONE
101	Riffle	M	2	Chinook	0	NONE
101	Riffle	M	3	Chinook	1	100–149
101	Riffle	M	3	Chinook	1	50–99
101	Riffle	M	3	Chinook	1	50–99
101	Riffle	M	4	Chinook	1	100–149
101	Riffle	M	4	Chinook	1	50–99
101	Riffle	M	4	Chinook	1	50–99
108	Run Head	S	1	Chinook	0	NONE
109	Run Body	S	1	Chinook	1	50–99
110	Run Tail	S	1	Chinook	0	NONE
112	Pool Head	S	1	Chinook	0	NONE

NSO	Habitat	Single (S) or multiple (M) pass survey	Pass	Species	Count	Size range (mm)
113	Pool Body	S	1	Chinook	0	NONE
114	Pool Tail	S	1	Chinook	0	NONE
128	Riffle	S	1	Chinook	0	NONE
141	Run Head	M	1	Chinook	0	NONE
141	Run Head	M	2	Chinook	0	NONE
141	Run Head	M	3	Chinook	0	NONE
141	Run Head	M	4	Chinook	0	NONE
142	Run Body	M	1	Chinook	0	NONE
142	Run Body	M	2	Chinook	0	NONE
142	Run Body	M	3	Chinook	0	NONE
142	Run Body	M	4	Chinook	0	NONE
143	Run Tail	M	1	Chinook	0	NONE
143	Run Tail	M	2	Chinook	0	NONE
143	Run Tail	M	3	Chinook	0	NONE
143	Run Tail	M	4	Chinook	0	NONE
148	Riffle	M	1	Chinook	0	NONE
148	Riffle	M	2	Chinook	0	NONE
148	Riffle	M	3	Chinook	0	NONE
148	Riffle	M	4	Chinook	0	NONE

Table F-3 Non-salmonid observation data for the study area.

NSO	Habitat	Single (S) or multiple (M) pass survey	Pass	Species	Count	Size range (mm)
1	Pool Head	S	1	Sacramento sucker	1	450
2	Pool Body	S	1	Sacramento sucker	2	300–350
5	Pool Body	S	1	Hardhead/Pikeminnow	1	500
8	Run Head	S	1	Sacramento sucker	100	0–50
10	Run Tail	S	1	Hardhead/Pikeminnow	1	500
10	Run Tail	S	1	Sacramento sucker	200	0–50
27	Pool Head	M	1	Sacramento sucker	200	0–50
27	Pool Head	M	2	Sacramento sucker	200	0–50
27	Pool Head	M	3	Sacramento sucker	200	0–50
27	Pool Head	M	4	Sacramento sucker	200	0–50
28	Pool Body	M	1	Sacramento sucker	200	0–50
28	Pool Body	M	1	Sacramento sucker	2	250–350
28	Pool Body	M	3	Hardhead/Pikeminnow	1	450
28	Pool Body	M	3	Sacramento sucker	2	300
28	Pool Body	M	3	Sacramento sucker	3	400–450
28	Pool Body	M	4	Hardhead/Pikeminnow	1	450
28	Pool Body	M	4	Sacramento sucker	3	400–450
28	Pool Body	M	4	Sacramento sucker	8	100–150
29	Pool Tail	M	1	Hardhead/Pikeminnow	30	50–100
29	Pool Tail	M	1	Sacramento sucker	10	50–100
29	Pool Tail	M	1	Sacramento sucker	50	0–50
29	Pool Tail	M	2	Sacramento sucker	60	0–50
29	Pool Tail	M	3	Sacramento sucker	50	0–50
29	Pool Tail	M	4	Sacramento sucker	50	0–50
33	Riffle	S	1	Sculpin sp.	1	75
33	Riffle	S	1	Sacramento sucker	2	100–150
34	Run Head	M	1	Sacramento sucker	20	50–100
34	Run Head	M	2	Sacramento sucker	3	50–100
34	Run Head	M	2	Sacramento sucker	50	0–50
34	Run Head	M	3	Sacramento sucker	5	0–100
34	Run Head	M	3	Sacramento sucker	40	0–100
34	Run Head	M	4	Sacramento sucker	50	50–100
35	Run Body	M	1	Sacramento sucker	70	0–50
35	Run Body	M	3	Sculpin sp.	1	70
35	Run Body	M	3	Sacramento sucker	70	0–50
35	Run Body	M	4	Sacramento sucker	1	n/a
35	Run Body	M	4	Sacramento sucker	50	0–50
36	Run Tail	M	1	Sacramento sucker	100	0–50
36	Run Tail	M	2	Sacramento sucker	100	0–50
36	Run Tail	M	3	Sacramento sucker	100	0–50
36	Run Tail	M	4	Sacramento sucker	100	0–50
53	Riffle	M	1	Sacramento sucker	1	475

53	Riffle	M	1	Sacramento sucker	50	0–50
53	Riffle	M	2	Sacramento sucker	25	0–50
53	Riffle	M	3	Sculpin sp.	1	80
53	Riffle	M	3	Sacramento sucker	2	400–500
53	Riffle	M	4	Sacramento sucker	1	470
53	Riffle	M	4	Sacramento sucker	1	450
53	Riffle	M	4	Sacramento sucker	50	50–150
55	Pool Body	S	1	Hardhead/Pikeminnow	12	250–300
55	Pool Body	S	1	Hardhead/Pikeminnow	30	150–200
55	Pool Body	S	1	Hardhead/Pikeminnow	200	100–150
55	Pool Body	S	1	Sacramento sucker	15	100–150
56	Pool Tail	S	1	Sacramento sucker	5	50–100
58	Run Head	S	1	Sculpin sp.	1	75
58	Run Head	S	1	Sacramento sucker	4	50–100
59	Run Body	S	1	Hardhead/Pikeminnow	40	50–100
59	Run Body	S	1	Hardhead/Pikeminnow	1	400
59	Run Body	S	1	Smallmouth bass	1	300
59	Run Body	S	1	Sacramento sucker	50	50–100
59	Run Body	S	1	Sacramento sucker	50	100–150
59	Run Body	S	1	Sacramento sucker	1	350
60	Run Tail	S	1	Hardhead/Pikeminnow	1	100
60	Run Tail	S	1	Sacramento sucker	8	50–100
60	Run Tail	S	1	Sacramento sucker	10	100–150
74	Riffle	S	1	Largemouth bass	1	125
74	Riffle	S	1	Hardhead/Pikeminnow	100	100–150
74	Riffle	S	1	Hardhead/Pikeminnow	100	50–100
74	Riffle	S	1	Hardhead/Pikeminnow	11	50–100
74	Riffle	S	1	Hardhead/Pikeminnow	20	50–100
74	Riffle	S	1	Hardhead/Pikeminnow	12	100–150
74	Riffle	S	1	Hardhead/Pikeminnow	34	100–150
74	Riffle	S	1	Sacramento sucker	100	50–100
74	Riffle	S	1	Sacramento sucker	100	100–150
74	Riffle	S	1	Sacramento sucker	10	0–50
74	Riffle	S	1	Sacramento sucker	14	50–100
74	Riffle	S	1	Sacramento sucker	3	100–150
74	Riffle	S	1	Sacramento sucker	1	75
82	Run Head	S	1	Largemouth bass	1	200
82	Run Head	S	1	Hardhead/Pikeminnow	14	50–100
82	Run Head	S	1	Hardhead/Pikeminnow	3	100–150
82	Run Head	S	1	Hardhead/Pikeminnow	5	50–200
82	Run Head	S	1	Hardhead/Pikeminnow	1	400
82	Run Head	S	1	Smallmouth bass	1	250
82	Run Head	S	1	Sacramento sucker	5	100–150
82	Run Head	S	1	Sacramento sucker	1	175
83	Run Body	S	1	Largemouth bass	2	100–150
83	Run Body	S	1	Largemouth bass	2	100–150
83	Run Body	S	1	Largemouth bass	1	340
83	Run Body	S	1	Hardhead/Pikeminnow	1	200

83	Run Body	S	1	Hardhead/Pikeminnow	8	50–100
83	Run Body	S	1	Hardhead/Pikeminnow	17	100–150
83	Run Body	S	1	Sacramento sucker	1	200
84	Run Tail	S	1	Bluegill	14	100–150
84	Run Tail	S	1	Largemouth bass	1	150
84	Run Tail	S	1	Largemouth bass	4	100–150
84	Run Tail	S	1	Largemouth bass	1	180
84	Run Tail	S	1	Largemouth bass	1	220
84	Run Tail	S	1	Hardhead/Pikeminnow	40	50–100
84	Run Tail	S	1	Hardhead/Pikeminnow	2	150–300
84	Run Tail	S	1	Hardhead/Pikeminnow	2	150–200
84	Run Tail	S	1	Hardhead/Pikeminnow	7	50–100
84	Run Tail	S	1	Hardhead/Pikeminnow	12	100–150
84	Run Tail	S	1	Hardhead/Pikeminnow	3	50–100
84	Run Tail	S	1	Sacramento sucker	4	100–150
86	Pool Head	M	1	Hardhead/Pikeminnow	30	50–100
86	Pool Head	M	1	Hardhead/Pikeminnow	4	50–100
86	Pool Head	M	1	Hardhead/Pikeminnow	1	175
86	Pool Head	M	1	Hardhead/Pikeminnow	1	250
86	Pool Head	M	1	Hardhead/Pikeminnow	1	200
86	Pool Head	M	1	Hardhead/Pikeminnow	4	140–180
86	Pool Head	M	1	Hardhead/Pikeminnow	100	100–150
86	Pool Head	M	1	Hardhead/Pikeminnow	2	100–150
86	Pool Head	M	1	Hardhead/Pikeminnow	1	125
86	Pool Head	M	1	Hardhead/Pikeminnow	18	50–100
86	Pool Head	M	1	Sacramento sucker	1	75
86	Pool Head	M	1	Sacramento sucker	30	50–100
86	Pool Head	M	2	Hardhead/Pikeminnow	1	225
86	Pool Head	M	2	Hardhead/Pikeminnow	3	100–150
86	Pool Head	M	2	Hardhead/Pikeminnow	25	50–100
86	Pool Head	M	2	Hardhead/Pikeminnow	6	140–180
86	Pool Head	M	2	Sacramento sucker	1	75
86	Pool Head	M	3	Hardhead/Pikeminnow	4	140–180
86	Pool Head	M	3	Hardhead/Pikeminnow	25	50–150
86	Pool Head	M	3	Hardhead/Pikeminnow	10	50–200
86	Pool Head	M	3	Hardhead/Pikeminnow	75	100–250
86	Pool Head	M	3	Sculpin sp.	1	75
86	Pool Head	M	3	Sacramento sucker	50	100–250
86	Pool Head	M	4	Hardhead/Pikeminnow	15	50–200
86	Pool Head	M	4	Hardhead/Pikeminnow	4	140–180
86	Pool Head	M	4	Hardhead/Pikeminnow	36	50–150
86	Pool Head	M	4	Hardhead/Pikeminnow	75	150–250
86	Pool Head	M	4	Sacramento sucker	50	150–250
86	Pool Head	M	4	Sacramento sucker	1	120
87	Pool Body	M	1	Hardhead/Pikeminnow	1	450
87	Pool Body	M	1	Hardhead/Pikeminnow	24	50–150
87	Pool Body	M	1	Hardhead/Pikeminnow	6	50–150
87	Pool Body	M	1	Hardhead/Pikeminnow	3	200–300

87	Pool Body	M	1	Hardhead/Pikeminnow	2	400–450
87	Pool Body	M	1	Spotted bass	1	225
87	Pool Body	M	1	Sacramento sucker	10	50–100
87	Pool Body	M	2	Green sunfish	2	100–150
87	Pool Body	M	2	Hardhead/Pikeminnow	6	100–200
87	Pool Body	M	2	Hardhead/Pikeminnow	1	400
87	Pool Body	M	2	Hardhead/Pikeminnow	2	400–450
87	Pool Body	M	2	Hardhead/Pikeminnow	25	150–200
87	Pool Body	M	2	Hardhead/Pikeminnow	1	300
87	Pool Body	M	2	Sacramento sucker	12	50–150
87	Pool Body	M	3	Hardhead/Pikeminnow	18	100–450
87	Pool Body	M	3	Hardhead/Pikeminnow	2	100–300
87	Pool Body	M	3	Hardhead/Pikeminnow	30	50–200
87	Pool Body	M	3	Hardhead/Pikeminnow	5	100–300
87	Pool Body	M	3	Spotted bass	3	100–200
87	Pool Body	M	3	Sacramento sucker	12	50–150
87	Pool Body	M	4	Hardhead/Pikeminnow	1	400
87	Pool Body	M	4	Hardhead/Pikeminnow	25	50–99
87	Pool Body	M	4	Hardhead/Pikeminnow	6	50–400
87	Pool Body	M	4	Sacramento sucker	5	50–150
88	Pool Tail	M	1	Hardhead/Pikeminnow	10	100–150
88	Pool Tail	M	1	Hardhead/Pikeminnow	10	50–150
88	Pool Tail	M	1	Hardhead/Pikeminnow	9	50–150
88	Pool Tail	M	1	Hardhead/Pikeminnow	3	100–150
88	Pool Tail	M	2	Hardhead/Pikeminnow	6	50–150
88	Pool Tail	M	2	Hardhead/Pikeminnow	5	100–200
88	Pool Tail	M	2	Hardhead/Pikeminnow	10	100–250
88	Pool Tail	M	2	Hardhead/Pikeminnow	10	100–150
88	Pool Tail	M	3	Hardhead/Pikeminnow	6	150–200
88	Pool Tail	M	3	Hardhead/Pikeminnow	15	50–150
88	Pool Tail	M	3	Hardhead/Pikeminnow	6	100–150
88	Pool Tail	M	3	Hardhead/Pikeminnow	4	100–150
88	Pool Tail	M	4	Hardhead/Pikeminnow	3	50–150
88	Pool Tail	M	4	Hardhead/Pikeminnow	3	100–200
88	Pool Tail	M	4	Hardhead/Pikeminnow	9	50–200
97	Riffle	S	1	Largemouth bass	3	100–150
97	Riffle	S	1	Largemouth bass	1	140
97	Riffle	S	1	Hardhead/Pikeminnow	24	150–200
97	Riffle	S	1	Hardhead/Pikeminnow	40	50–250
97	Riffle	S	1	Hardhead/Pikeminnow	75	50–15
97	Riffle	S	1	Hardhead/Pikeminnow	4	150–200
97	Riffle	S	1	Hardhead/Pikeminnow	4	450–500
97	Riffle	S	1	Sacramento sucker	8	150–200
97	Riffle	S	1	Sacramento sucker	1	60
101	Riffle	M	1	Hardhead/Pikeminnow	20	50–200
101	Riffle	M	1	Hardhead/Pikeminnow	28	50–150
101	Riffle	M	1	Hardhead/Pikeminnow	24	100–200
101	Riffle	M	1	Hardhead/Pikeminnow	4	50–100

101	Riffle	M	1	Sacramento sucker	1	100
101	Riffle	M	1	Sacramento sucker	6	50–150
101	Riffle	M	1	Sacramento sucker	6	100–200
101	Riffle	M	1	Sacramento sucker	8	50–200
101	Riffle	M	2	Largemouth bass	1	50
101	Riffle	M	2	Hardhead/Pikeminnow	15	100–200
101	Riffle	M	2	Hardhead/Pikeminnow	4	150–200
101	Riffle	M	2	Hardhead/Pikeminnow	16	50–200
101	Riffle	M	2	Hardhead/Pikeminnow	40	50–100
101	Riffle	M	2	Sacramento sucker	3	100–200
101	Riffle	M	2	Sacramento sucker	12	50–200
101	Riffle	M	2	Sacramento sucker	8	50–100
101	Riffle	M	3	Hardhead/Pikeminnow	6	50–150
101	Riffle	M	3	Hardhead/Pikeminnow	44	50–150
101	Riffle	M	3	Hardhead/Pikeminnow	7	100–200
101	Riffle	M	3	Hardhead/Pikeminnow	12	n/a
101	Riffle	M	3	Sacramento sucker	2	100–200
101	Riffle	M	3	Sacramento sucker	10	50–150
101	Riffle	M	3	Sacramento sucker	3	n/a
101	Riffle	M	4	Hardhead/Pikeminnow	44	50–100
101	Riffle	M	4	Hardhead/Pikeminnow	20	50–200
101	Riffle	M	4	Hardhead/Pikeminnow	12	50–150
101	Riffle	M	4	Hardhead/Pikeminnow	7	100–200
101	Riffle	M	4	Sacramento sucker	2	50–150
101	Riffle	M	4	Sacramento sucker	11	50–100
108	Run Head	S	1	Hardhead/Pikeminnow	6	100–300
108	Run Head	S	1	Hardhead/Pikeminnow	25	50–150
108	Run Head	S	1	Hardhead/Pikeminnow	40	50–200
108	Run Head	S	1	Sacramento sucker	4	400–600
109	Run Body	S	1	Largemouth bass	1	200
109	Run Body	S	1	Hardhead/Pikeminnow	20	100–200
109	Run Body	S	1	Hardhead/Pikeminnow	50	100–200
109	Run Body	S	1	Hardhead/Pikeminnow	2	350–400
109	Run Body	S	1	Hardhead/Pikeminnow	150	100–200
109	Run Body	S	1	Hardhead/Pikeminnow	14	50–300
109	Run Body	S	1	Sacramento sucker	2	350–400
109	Run Body	S	1	Sacramento sucker	10	100–200
110	Run Tail	S	1	Hardhead/Pikeminnow	35	50–250
110	Run Tail	S	1	Sacramento sucker	1	200
112	Pool Head	S	1	Largemouth bass	4	150–200
112	Pool Head	S	1	Hardhead/Pikeminnow	35	50–200
112	Pool Head	S	1	Sacramento sucker	3	100–200
113	Pool Body	S	1	Largemouth bass	1	135
113	Pool Body	S	1	Hardhead/Pikeminnow	4	100–250
113	Pool Body	S	1	Hardhead/Pikeminnow	20	150–200
113	Pool Body	S	1	Sacramento sucker	1	350
114	Pool Tail	S	1	Hardhead/Pikeminnow	3	100–150
128	Riffle	S	1	Largemouth bass	2	100–150

128	Riffle	S	1	Hardhead/Pikeminnow	12	50–150
141	Run Head	M	1	Largemouth bass	1	225
141	Run Head	M	1	Hardhead/Pikeminnow	25	100–200
141	Run Head	M	2	Hardhead/Pikeminnow	50	50–200
141	Run Head	M	3	Hardhead/Pikeminnow	45	50–200
141	Run Head	M	3	Sacramento sucker	4	100–200
141	Run Head	M	4	Hardhead/Pikeminnow	50	5–200
142	Run Body	M	1	Largemouth bass	2	150–200
142	Run Body	M	1	Hardhead/Pikeminnow	30	100–200
142	Run Body	M	1	Smallmouth bass	1	150
142	Run Body	M	2	Largemouth bass	1	200
142	Run Body	M	2	Hardhead/Pikeminnow	40	50–200
142	Run Body	M	3	Largemouth bass	1	200
142	Run Body	M	3	Hardhead/Pikeminnow	25	50–150
142	Run Body	M	4	Hardhead/Pikeminnow	30	50–150
142	Run Body	M	4	Smallmouth bass	1	150
143	Run Tail	M	1	Hardhead/Pikeminnow	35	50–200
143	Run Tail	M	1	Sacramento sucker	12	100–200
143	Run Tail	M	2	Hardhead/Pikeminnow	40	50–200
143	Run Tail	M	2	Smallmouth bass	1	100
143	Run Tail	M	2	Sacramento sucker	8	100–200
143	Run Tail	M	3	Hardhead/Pikeminnow	45	50–200
143	Run Tail	M	3	Sacramento sucker	24	100–200
143	Run Tail	M	4	Hardhead/Pikeminnow	33	50–100
143	Run Tail	M	4	Sacramento sucker	20	100–200
148	Riffle	M	1	Largemouth bass	1	100
148	Riffle	M	1	Hardhead/Pikeminnow	100	100–300
148	Riffle	M	1	Sacramento sucker	100	100–300
148	Riffle	M	2	Hardhead/Pikeminnow	100	100–400
148	Riffle	M	2	Sacramento sucker	100	100–400
148	Riffle	M	3	Largemouth bass	1	150
148	Riffle	M	3	Hardhead/Pikeminnow	100	100–400
148	Riffle	M	3	Sacramento sucker	100	100–300
148	Riffle	M	4	Hardhead/Pikeminnow	100	100–300
148	Riffle	M	4	Sacramento sucker	100	100–300