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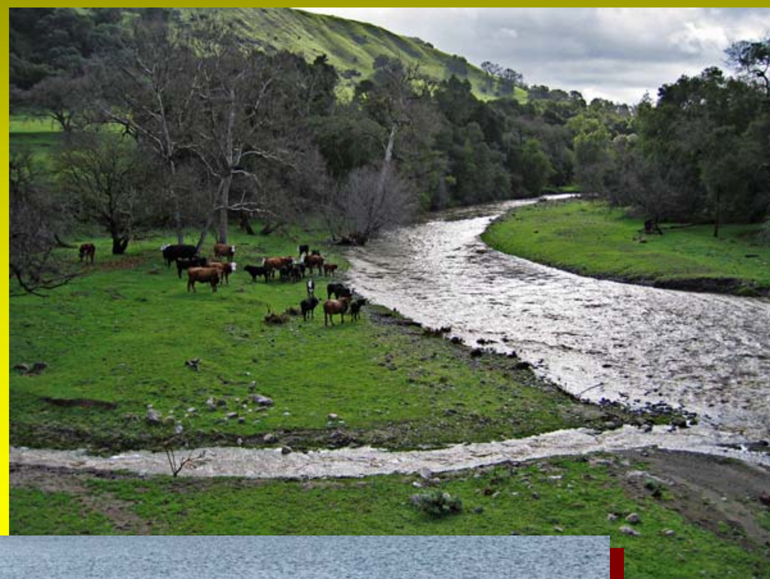
Alameda Creek
Aquatic Resource Monitoring Report
2003



Alameda Creek
Aquatic Resource Monitoring Report
2003

Prepared by:

San Francisco Public Utilities Commission
Water Quality Bureau
Sunol, CA

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Executive Summary

In partial response to a September 25, 1990 letter of complaint from California Trout to the State Water Resources Control Board, the San Francisco Public Utilities Commission (SFPUC) entered into a Memorandum of Understanding (MOU) with the California Department of Fish and Game. In the 1997 MOU, the SFPUC agreed to comply with recommended flow requirements in upper Alameda Creek, when natural flows downstream of the confluence of Alameda and Calaveras creeks are less than the defined minimums, by releasing water from Calaveras Reservoir. The minimum flow rates established in the MOU are designed to improve habitat conditions for native rainbow trout in an upstream section of upper Alameda Creek, while maintaining suitable conditions for native, warm water species in a lower section of upper Alameda Creek. The SFPUC will recapture for domestic use, at a facility just downstream of the lower section of upper Alameda Creek, a volume of water equal to what is released.

The SFPUC has not begun the program of Calaveras Reservoir water releases envisioned in the MOU due to delays in constructing a water recapture facility and water storage restrictions placed on Calaveras Dam by the Department of Water Resources' Division of Safety of Dams (DSOD) in 2001. The DSOD operating restriction at Calaveras now imposes a maximum water storage volume of 37,756 acre-feet. Calaveras Dam must be repaired or replaced if the SFPUC is to regain, at minimum, its original water storage capability of 96,850 acre-feet. It is not known at the present time whether the current reduced storage volume provides enough water of suitable quality to begin the water release program envisioned in the MOU prior to repairing or replacing Calaveras Dam.

The National Oceanographic and Atmospheric Administration's 1997 listing of Central California Coast steelhead as threatened was also not considered in the drafting of the MOU, although under its terms the proposed recapture facility (possibly a low rubber dam in the vicinity of the Sunol Valley Water Treatment Plant) must ensure passage for migratory fishes. Currently, ocean-run steelhead cannot access the watershed due to migration barriers owned and operated by other public entities in the Fremont area (Gunther, et al, 2000). The SFPUC, as an active participant in the Alameda Creek Fisheries Restoration Workgroup, intends to address the issues of water releases from Calaveras Reservoir and adequate flows for future steelhead runs as part of the permitting negotiations for several projects in the Alameda Creek Watershed (such as the replacement of Calaveras Dam and the construction of the water recapture facility). These negotiations will occur on a schedule consistent with the proposed modifications of downstream barriers that may permit fish passage to the upper watershed as early as 2009.

The MOU requires the SFPUC to conduct a monitoring program to evaluate several years of pre-water release conditions and the first five years of post-water release conditions. Monitoring elements include stream flows, Calaveras Reservoir limnology, Alameda Creek and Calaveras Creek water quality, and fish population analyses. This document presents the findings of the sixth year of pre-water release monitoring (January, 2003 through December, 2003). The SFPUC, in support of

regional steelhead trout restoration efforts, has also supplemented the monitoring required by the MOU with additional monitoring in the Alameda Creek Watershed. This document includes the findings of the second year of the additional monitoring.

Peak flows in Alameda and Calaveras creeks and Arroyo Hondo occurred between late fall and early spring, when seasonal storms resulted in dramatic fluctuations in the amount of water moving through stream channels. The greatest maximum daily mean flow in 2003 was recorded in Arroyo Hondo. Although maximum daily mean flows in Alameda Creek proper decreased from above the Alameda Creek Diversion Dam downstream through Sunol Regional Park, they increased as they flowed from the Park to the Sunol Water Treatment Plant. Average annual daily mean flows were also greatest in the Arroyo Hondo. Both maximum and average annual flows in Calaveras Creek downstream of Calaveras Dam were drastically lower that those measured at all other sites within the Alameda Creek watershed.

Water storage volumes in Calaveras Reservoir ranged from a low of 29,780 acre-feet to a high of 43,421 acre-feet. Volumes dropped below the 30,000 acre-feet minimum storage criteria defined in the MOU only briefly in December.

Water quality conditions in Calaveras Reservoir were typical of a relatively deep temperate lake, with stratification occurring during the summer months. Dissolved oxygen concentrations remained above 5 mg/L throughout the water column until the stratification process was well under way. Oxygen concentrations began to drop below the thermocline by the end of March, falling to less than 1 mg/L in the deepest waters in June. The pH ranged from a low of 6.6 in early June to a high of 8.5 in late September. The highest turbidities in Calaveras Reservoir were measured in January, ranging from about 28 to 31 NTUs throughout the water column, and are probably the result of the interaction between the reservoir's reduced water levels and storm runoff. Reservoir ammonia concentrations remained relatively low throughout the year, never exceeding 1 mg/L.

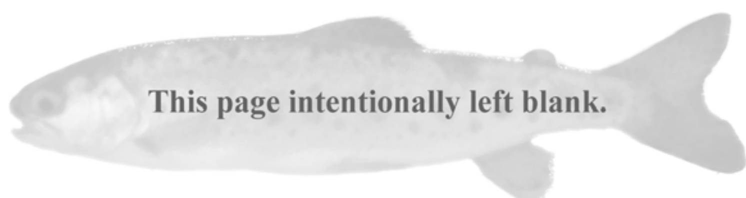
Stream water temperatures were highly variable, both temporally and spatially. Water temperatures in Alameda Creek in the lower study reach were generally higher than temperatures in the upper study reach throughout the year. The highest water temperatures at all stations in both reaches peaked in late July and early August. Following that peak the temperatures in both study reaches gradually decreased over the remainder of the year, with the lowest temperatures measured from early to mid-November. The most upstream station in Calaveras Creek had the least amount of mean daily water temperature variability. Within Alameda Creek, the station downstream of the Diversion Dam and the station below Sunol Regional Park had the lowest variability's, while the station below the confluence of Alameda and Calaveras creeks and the station at Camp Ohlone had the highest variability's.

Turbidity and pH in Alameda and Calaveras creeks, measured during electrofishing surveys, were all within the tolerance limits of rainbow trout and native, warm water fishes. Dissolved oxygen concentrations at the bottoms of a single pool in Calaveras Creek and one pool in Indian Creek were low enough to stress fishes.

The trout spawning survey was conducted in Alameda Creek only in the cold water, upper study reach. Although four rainbow trout juveniles were observed in Alameda Creek upstream of its confluence with Calaveras Creek, no adult rainbow trout, redds or trout fry were seen in the reach that will be influenced by future reservoir water releases.

Rainbow trout were not observed in Alameda Creek downstream of its confluence with Calaveras Creek, and in Calaveras Creek just upstream of Alameda Creek, during snorkel surveys, but they were encountered in Alameda Creek near Camp Ohlone and in Arroyo Hondo. There were also six other species of fishes observed in 13 pools. California roach were the most abundant species, while roach, Sacramento sucker and Sacramento pikeminnow were the most widely distributed. Largemouth bass and sunfish were observed in a single pool in Calaveras Creek, and prickly sculpin were noted from one pool in Arroyo Hondo.

Twenty-nine habitat units (riffles, runs, glides and shallow pools) from thirteen stations were sampled using electrofishing gear. A total of seven species of fishes were collected, including, in descending abundances, California roach, Sacramento pikeminnow, Sacramento sucker, rainbow trout, prickly sculpin, Pacific lamprey ammocetes and largemouth bass. In Alameda Creek, rainbow trout were not collected downstream of its confluence with Calaveras Creek, while they were found in all stations sampled upstream of the confluence. Rainbow trout were not collected in Calaveras Creek, but were found in La Costa Creek, Indian Creek and Arroyo Hondo. Other distribution patterns were also evident, although not as clear-cut as what was observed for trout. While California roach were found just about everywhere, with the exception of La Costa and Indian creeks, lamprey ammocetes, sucker and pikeminnow tended to be restricted to Alameda Creek downstream of the Little Yosemite area. Largemouth bass were only found in the first Alameda Creek site downstream of Calaveras Creek.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1.0 Introduction

Storage of water at Calaveras Dam on Calaveras Creek, a tributary to Alameda Creek, first occurred in 1916 (Hagar, et al., 1993) by Spring Valley Water Company (SVWC). The dam was reconstructed between 1918 and 1925, following a slide on the upstream face of the dam. In 1925 the SVWC began construction of the Upper Alameda Creek Diversion Dam and Tunnel, which were part of the original program for Calaveras Dam, securing the storage of runoff from the upper Alameda Creek Watershed in Calaveras Reservoir. The SFPUC began acquiring water directly from Alameda Creek, above its confluence with Calaveras Creek, with the completion of the Diversion Dam and Tunnel (Figure 1-1) in 1931 (EDAW, 1998). Calaveras Dam was built to store up to 96,000 acre-feet of water from 100 square miles of local watershed to meet a variety of water supply needs (EDAW, 1998). The majority of water stored in Calaveras Reservoir is derived from the Arroyo Hondo drainage, along with flows from upper Alameda Creek and minimal contributions from Calaveras Creek.

Figure 1-1. *Alameda Creek Diversion Tunnel outlet.*

Calaveras Dam, and the associated SVWC water delivery system, were purchased by the City of San Francisco (City) in 1930 (EDAW, 1998) to consolidate ownership of the regional water system with the Hetch Hetchy system that the City had been constructing since 1908. At the same time, the City created the San Francisco Public Utilities Commission (SFPUC) to manage the complex system obtained through the SVWC acquisition.

Prior to 1934, the SFPUC released water from Calaveras Reservoir to be recaptured at the Sunol Infiltration Gallery (Bookman-Edmonston, 1995). Since 1934, however, water management by the SFPUC in the Alameda Creek watershed has led to diminished streamflows in Alameda Creek below its confluence with Calaveras Creek. Most of the flows in Alameda Creek today, during normal rainfall years, come from leakage through Calaveras Dam, ground water seepage through geologic formations and runoff from the lower, drier part of the watershed (Bookman-Edmonston, 1995).

California Trout (Cal Trout), in a letter to the State Water Resources Control Board (SWRCB) dated September 25, 1990, claimed that “the SFPUC lacked sufficient water rights to store water in Calaveras Reservoir in Alameda and Santa Clara Counties,” that “the SFPUC’s failure to release water from Calaveras Reservoir violated section 5937 of the California Fish and Game Code,” and that “the SFPUC diverted water in an unreasonable manner into Calaveras Reservoir, pursuant to Article X, section 2 of the California Constitution” (CDFG, 1997).

In 1991, the SFPUC submitted acceptable evidence of its pre-1914 appropriative water rights for Calaveras Dam to the SWRCB (CDFG, 1997). To settle the operational points of the Cal Trout complaint, the SFPUC funded the Alameda Creek Water Resources Study (Bookman-Edmonston, 1995) to determine whether or not it would be feasible to release a portion of water from Calaveras Reservoir to improve fishery conditions, while recapturing the water further downstream for consumptive use (CDFG, 1997).

A major finding of the Alameda Creek Water Resources Study (Bookman-Edmonston, 1995) was that native, warm water fishes dominate Alameda Creek downstream of Calaveras Creek, with only small populations of native, cold water fishes. The study concluded that summer stream temperatures and early spring spawning flows were the primary factors limiting the establishment of healthy rainbow trout populations in this reach of Alameda Creek. The study also determined that it was feasible to recapture the water released from Calaveras Reservoir by building facilities upstream of the Sunol Valley quarries.

Attempting to establish native cold-water fisheries, from Calaveras Dam to the proposed location of the water recapture facilities, could be detrimental to populations of native, warm water fishes (Bookman-Edmonston, 1995). To avoid harming established fish populations, the Alameda Creek Water Resources Study proposed a flow management plan that provides habitat in the upper portion of the reach for cold-water species, and habitat in the lower portion of the reach for warm water species.

The SFPUC entered into a Memorandum of Understanding (MOU) with the California Department of Fish and Game (CDFG) in July 1997 (CDFG, 1997). In the MOU, the SFPUC and the CDFG agreed to a program of water releases from Calaveras Reservoir, and water recapture downstream of the Sunol Valley Water Treatment Plant. The success of the project will be judged on the degree of improvement of habitat conditions for both cold water and warm water fishes.

The MOU requires that the SFPUC conduct an extensive monitoring program, under both pre-water release and post-water release conditions. Monitoring elements to be implemented include stream flows, Calaveras Reservoir conditions, Alameda Creek and Calaveras Creek water quality conditions, and fish population analyses. Results from the monitoring program will be used to demonstrate compliance with the terms of the MOU and to determine whether revisions to operations or fisheries management are needed to meet the goals of the project.

This report presents the findings of the 2003 pre-water release-monitoring program. It has been supplemented with additional monitoring to provide a more comprehensive watershed approach to the restoration of Alameda Creek.

2.0 Setting

Alameda Creek flows from its headwaters on the northwestern slopes of the Diablo Range in Santa Clara County, for about 39 miles, to South San Francisco Bay. Headwater elevations are close to 4,000-feet, with stream gradients downstream through the upper reaches varying from between one to five percent. Stream gradients throughout the lower reaches seldom exceed one-half of one percent, with the last ten miles of Alameda Creek dropping to near sea level.

Upper Alameda, Calaveras, La Costa and Indian creeks and Arroyo Hondo lie within the Sunol Drainage Unit of the 175 square mile Southern Alameda Creek Watershed (Figure 2-1). Calaveras Reservoir sits in the southwestern portion of the watershed, in both Alameda and Santa Clara counties, while San Antonio Reservoir is to the north in Alameda County. The cities of Fremont and Milpitas are to the west of the drainage, Pleasanton is to the north, and Livermore lies to the northeast.

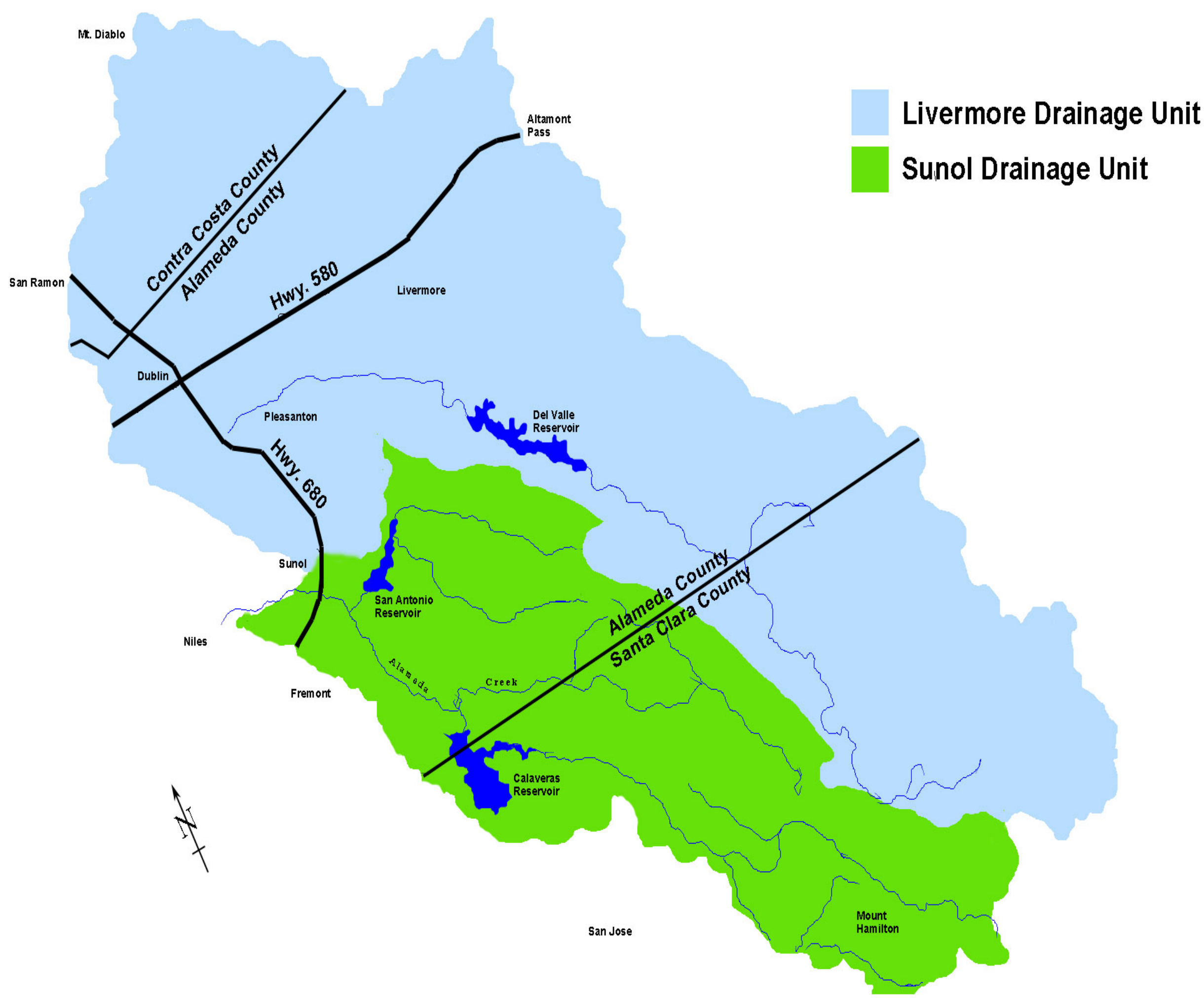


Figure 2-1. *Alameda Creek watershed.*

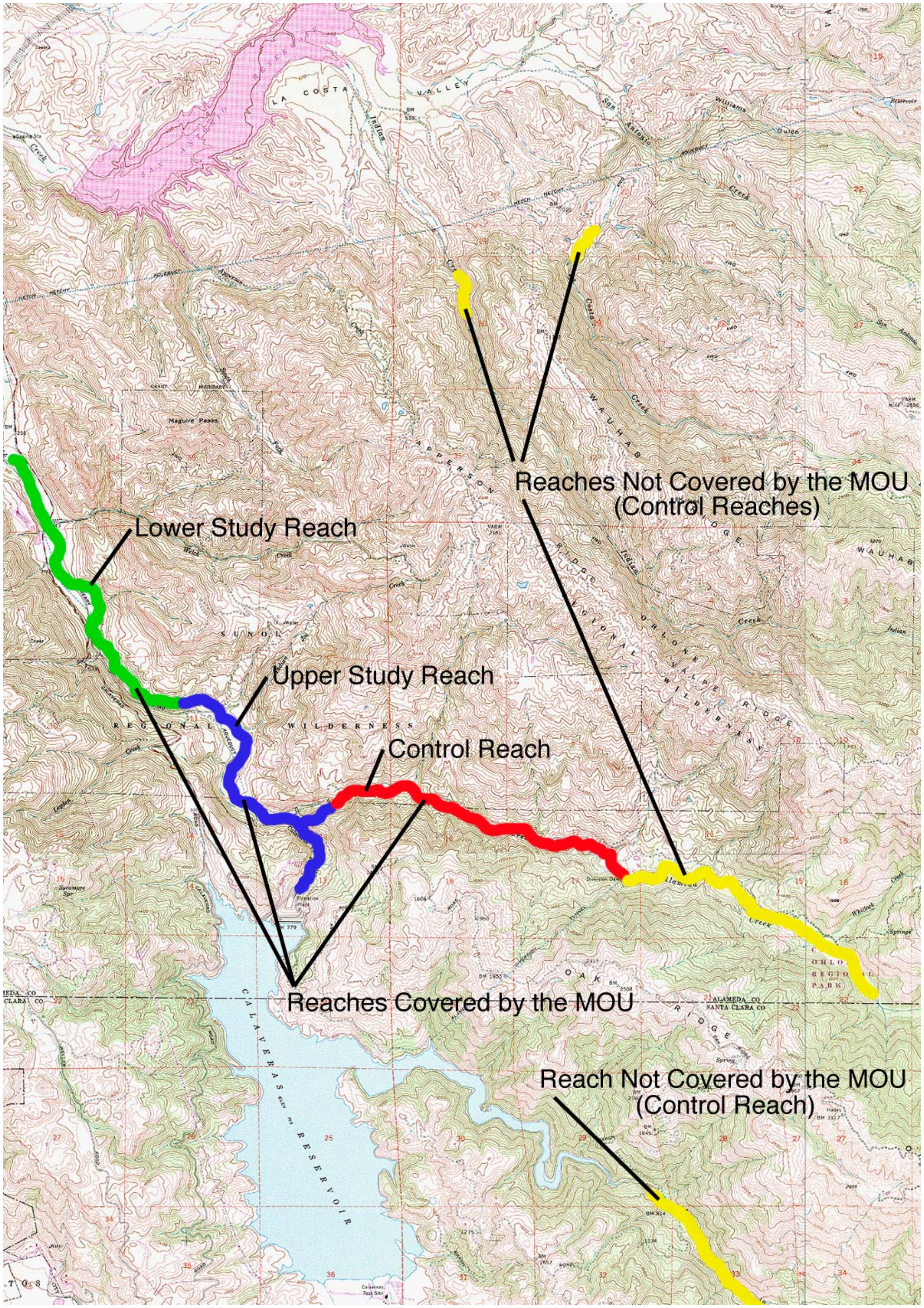
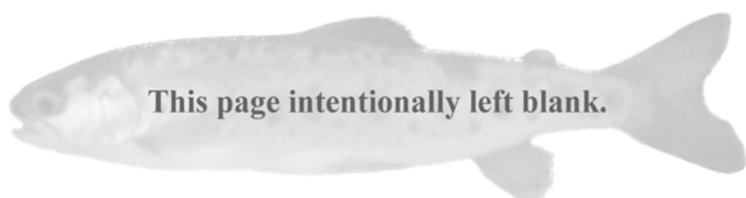


Figure 2-2. *Alameda and Calaveras creek reaches covered by the MOU between the SFPUC and CDFG, plus additional reaches added to the monitoring program to take more of a wide-ranging watershed approach to restoration.*

The Memorandum of Understanding between the San Francisco Public Utilities Commission and the California Department of Fish and Game (CDFG, 1997) includes upper Alameda Creek between the Alameda Creek Diversion Dam and the site of the proposed water recapture facility near the Sunol Valley Water Treatment Plant, and Calaveras Creek between Calaveras Dam and the confluence of Calaveras and Alameda creeks (Figure 2-2). The monitoring project was expanded in 2002, however, to cover waters in Alameda Creek upstream of the Diversion Dam and waters in a portion of La Costa Creek upstream of San Antonio Reservoir. The program was expanded further this year, adding waters in a portion of Indian Creek upstream of San Antonio Reservoir and Arroyo Hondo upstream of Calaveras Reservoir.

To enhance conditions for native, cold water species, while at the same time maintaining adequate conditions for native, warm water species, the portion of upper Alameda Creek covered by the MOU was divided into three distinct study reaches (Figure 2-2). The upper, or cold water reaches extend from Calaveras Dam to the confluence of Calaveras and Alameda creeks in Calaveras Creek, and from the base of Little Yosemite in the Sunol Regional Park downstream to the boundary between the Regional Park and the SFPUC property in Alameda Creek. The lower, or warm water reach extends from the property boundary downstream to the proposed water recapture facility in Alameda Creek, near the Sunol Valley Water Treatment Plant. The remaining reach covered by the MOU, from the base of Little Yosemite upstream to the Alameda Creek Diversion Dam, will not be influenced by water releases from Calaveras Reservoir, and is considered a control reach where cold water fishes are known to be present under existing conditions.

The reaches in Alameda Creek upstream of the Alameda Creek Diversion Dam and in La Costa Creek upstream of San Antonio Reservoir, sampled for the first time in 2002, and in Indian Creek upstream of San Antonio Reservoir and Arroyo Hondo upstream of Calaveras Reservoir, sampled for the first time this year (Figure 2-2), are not covered by the MOU. Each of these additional reaches, which are known to contain rainbow trout, will not be influenced by water releases from Calaveras Reservoir and are considered supplementary control sites. The conditions at these control sites (including both water quality and fish densities), which are assumed to be favorable to the survival of rainbow trout, will be compared to the conditions found in the reaches of Alameda Creek influenced by water releases to assess the success of the restoration project.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3.0 Streamflows

Background

Instream flows, and the effect they have on water temperatures, have been identified as a potentially limiting factor for the establishment of viable rainbow trout populations in upper Alameda Creek (CDFG, 1997).

Once initial monitoring studies are completed, the SFPUC has agreed to release water from Calaveras Reservoir to supplement unregulated runoff and accretions from Alameda Creek and Calaveras Creek below Calaveras Dam, meeting minimum flow requirements defined in the 1997 MOU (Appendix A), provided that a downstream water-recapture facility is available to minimize losses to subsurface percolation in Sunol Valley. Target flows have been designed to provide water with temperatures that are cold enough for rainbow trout in a defined upper study reach, yet with sufficient warming to satisfy the temperature requirements of native, warm water fishes in a defined lower reach. All intentionally released water from Calaveras Reservoir will be recaptured by the SFPUC from a point in Alameda Creek downstream of the Sunol Valley Water Treatment Plant.

Procedure

An initial component of the project is to assess the existing flow rates in upper Alameda Creek so that there are data available to compare to the minimum flow requirements in the 1997 MOU. Data from five USGS streamflow gauges are included in this report (Table 3-1, and Figure 3-1). All five stations were included in last year's report. Provisional daily mean streamflow values, in cubic-feet per second (cfs), were downloaded from the United States Geological Survey (USGS) website for streamflow data; http://nwis.waterdata.usgs.gov/usa/nwis/discharge.

Table 3-1. *Alameda Creek Watershed USGS streamflow gauges.*

Station	Gauge Location	Location Description
USGS 11172945	37° 29.85' N 121° 46.35' W	Alameda Creek above the Alameda Creek Diversion Dam.
USGS 11173200	37° 27.70' N 121° 46.10' W	Arroyo Hondo above the Marsh Road bridge.
USGS 11173500	37° 29.86' N 121° 49.00' W	Calaveras Creek below Calaveras Dam.
USGS 11173510	37° 30.22' N 121° 49.42' W	Alameda Creek below the confluence of Alameda and Calaveras creeks.
USGS 11173575	37° 32.43' N 121° 51.32' W	Alameda Creek below the confluence of Alameda and Welch creeks.

Figure 3-1. *United States Geological Survey streamflow gauging stations in the upper Alameda Creek Watershed.*

USGS 11172945 Streamflows

Located in Alameda Creek upstream of the SFPUC operated Alameda Creek Diversion Dam, this streamflow gauge collected data for the entire year. Measurements averaged 10.3 cfs, with multiple days in September, October and November showing no recordable flow. A maximum flow of 208 cfs was recorded on May 3, 2003 (Figure 3-2).

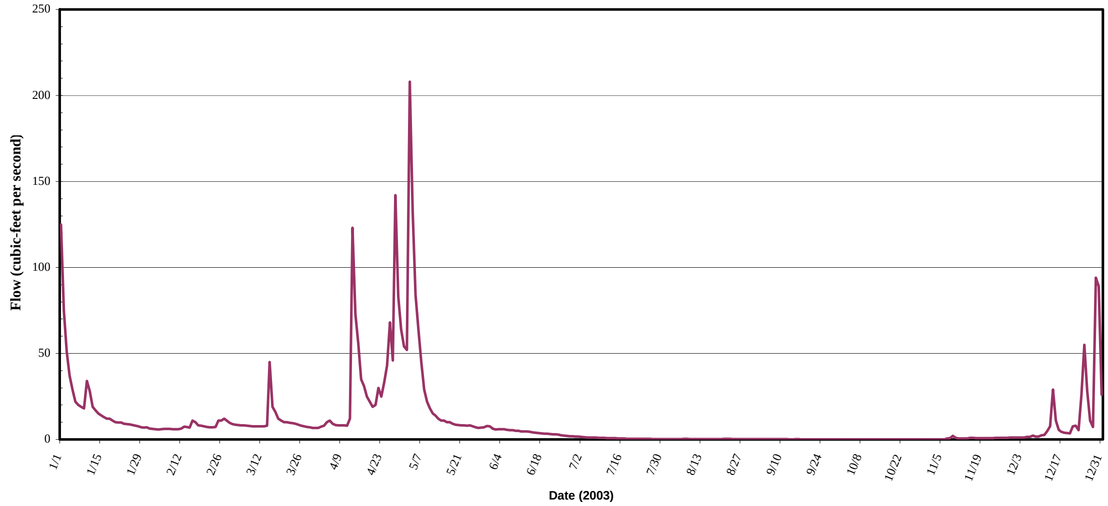


Figure 3-2. *Daily mean streamflows recorded at USGS station 11172945, located in upper Alameda Creek above the Alameda Creek Diversion Dam, for 2003.*

USGS 11173200 Streamflows

Located in Arroyo Hondo just upstream of the Marsh Road bridge, this streamflow gauge collected data for the entire year. Measurements averaged 20.4 cfs, with minimum and maximum flows of 0.64 cfs on October 29, 2003 and 304 cfs on December 30, 2003, respectively (Figure. 3-3).

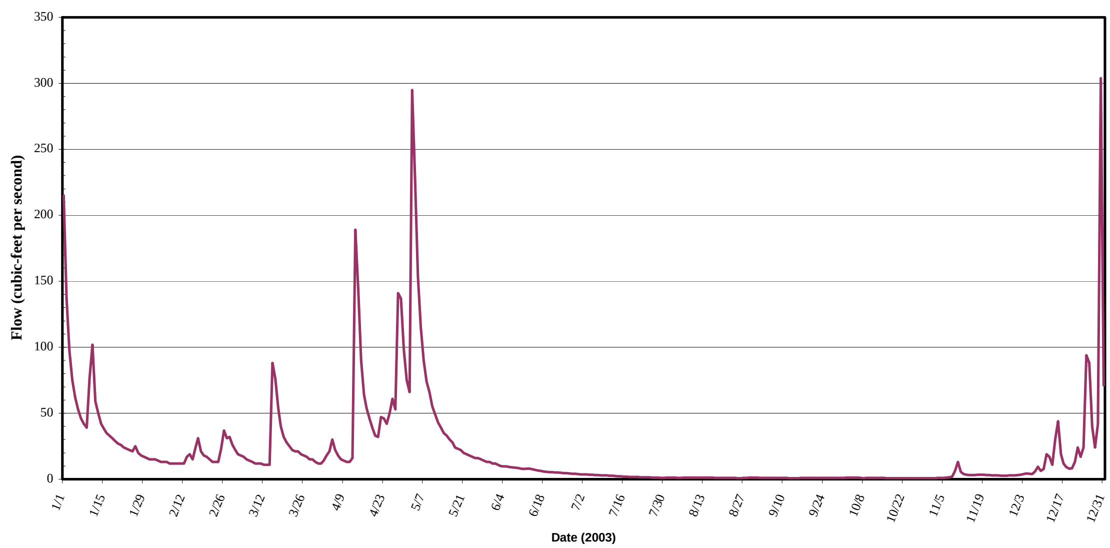


Figure 3-3. *Daily mean streamflows recorded at USGS station 11173200, located in Arroyo Hondo above the Marsh Road bridge, for 2003.*

USGS 11173500 Streamflows

Located in Calaveras Creek at the second weir downstream of Calaveras Dam, this streamflow gauge collected data throughout the year. Measurements averaged 0.09 cfs, with multiple days throughout the monitoring period showing no recordable flow. A maximum flow of 0.91 cfs was recorded on April 13, 2003 (Figure. 3-4).

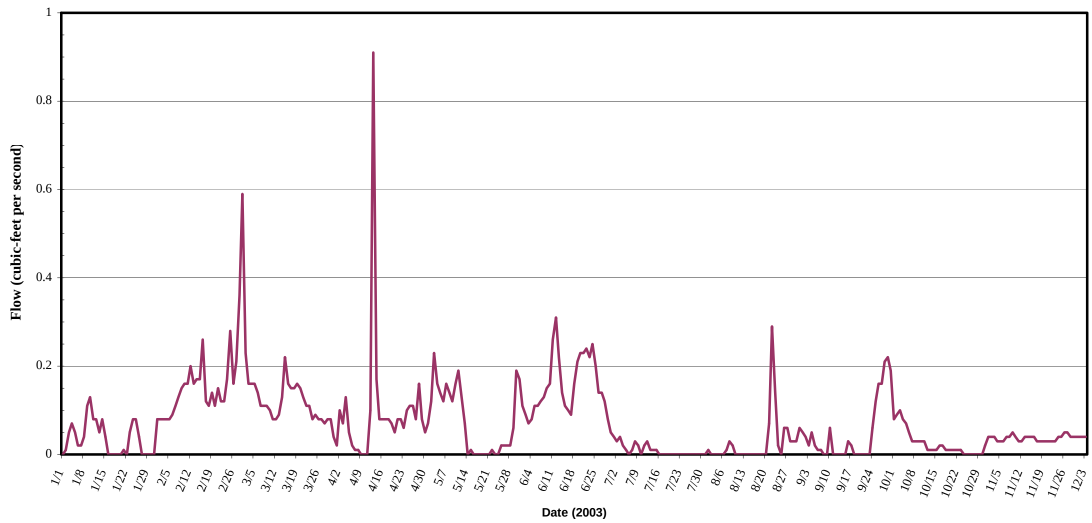


Figure 3-4. *Daily mean streamflows recorded at USGS station 11173500, located in Calaveras Creek below Calaveras Dam, for 2003.*

USGS 11173510 Streamflows

Data from this Sunol Regional Park station, located in Alameda Creek downstream of its confluence with Calaveras Creek, were included in all previous Alameda Creek Aquatic Resource reports generated by the SFPUC. Flows averaged 6.2 cfs, with a minimum flow of 0.08 cfs for five days in late October and a maximum of 131 cfs on January 1, 2003 (Figure 3-5).

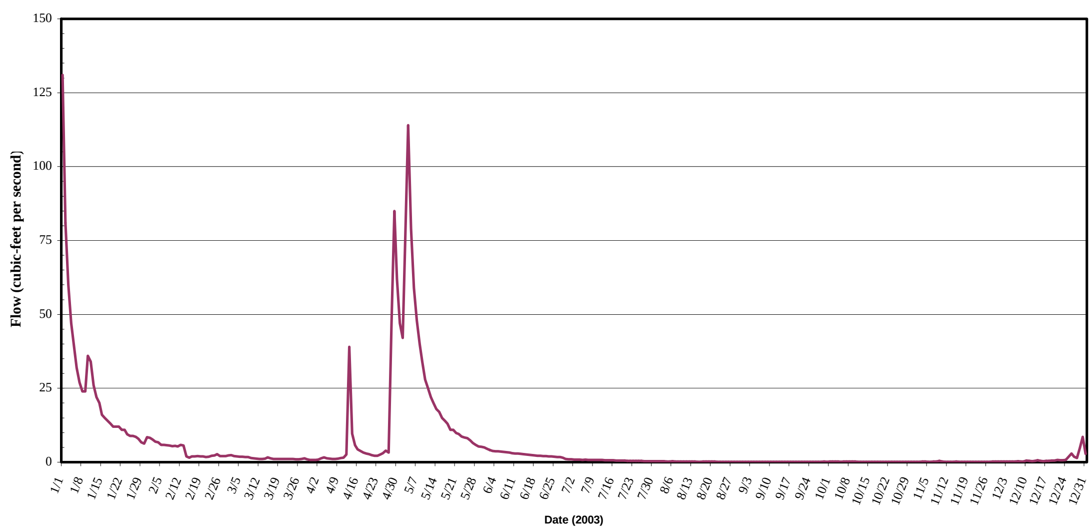


Figure 3-5. *Daily mean streamflows recorded at USGS station 11173510, located in upper Alameda Creek in Sunol Regional Park, for 2003.*

USGS 11173575 Streamflows

Located in Alameda Creek downstream of its confluence with Welch Creek, near the Sunol Valley Water Treatment Plant, this streamflow gauge collected data throughout the entire year. Measurements averaged 7.3 cfs, with a minimum flow of 0.04 cfs on September 2, 2003 and a maximum flow of 178 cfs recorded on May 3, 2003 (Figure. 3-6).

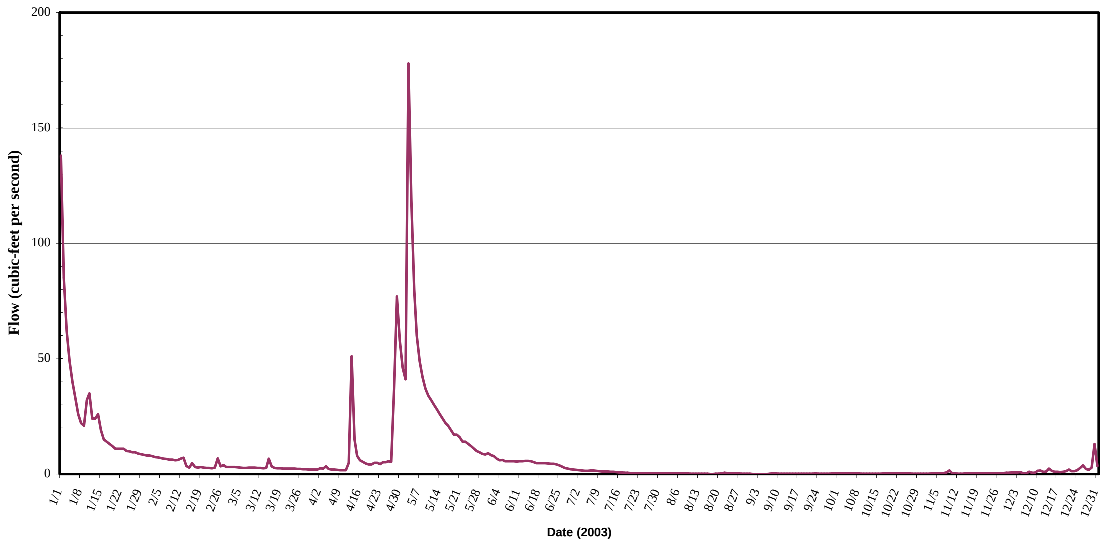
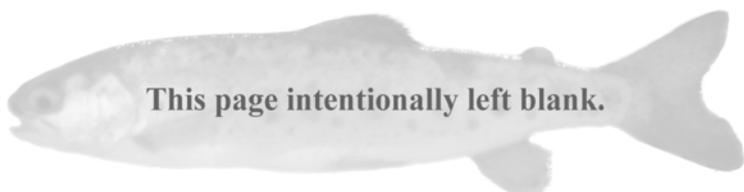


Figure 3-6. *Daily mean streamflows recorded at USGS station 11173575, located in Alameda Creek downstream of Welch Creek, for 2003.*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4.0 Calaveras Reservoir Conditions

Background

An important factor in reestablishing rainbow trout and maintaining healthy native fish assemblages in Alameda Creek is the quality of water that will be released from Calaveras Reservoir. Sufficiently cold, well-oxygenated water is required by rainbow trout and the biota they depend upon. Other parameters important to trout and native fishes downstream of the release point include pH, turbidity, ammonia and hydrogen sulfide concentrations. Due to varying water quality that sometimes occurs in a stratified reservoir, the quality of water released can be significantly different than that of the receiving stream.

To satisfy the temperature requirements for rainbow trout, Calaveras Reservoir must remain stratified during the warm summer months so that a sufficient supply of cold water is preserved in the hypolimnion. Historical data show that this requirement can be met by maintaining a minimum storage volume of 30,000 acre-feet from July through October. In 2001, however, the Department of Water Resources' Division of Safety of Dams (DSOD) placed a maximum storage restriction of 37,756 acre-feet on Calaveras Reservoir. The restriction will make it difficult to maintain the necessary minimum storage volume while meeting the water quality objectives defined in the Water Quality Control Plan (Basin Plan) for the San Francisco Bay Basin (SFBRWQC, 2005). Tables 4-1 and 4-2 summarize key components of the Basin Plan.

Table 4-1. *Surface water recommendations for the Alameda Creek Watershed.*

Parameter	Concentration
Dissolved Oxygen (cold water habitat)	7.0 mg/L
Dissolved Oxygen (warm water habitat)	5.0 mg/L
pH	6.5 to 8.5 -log[H+]
Sulfide	less than ambient
Unionized Ammonia	< 0.4 mg/L (NH_3-N)
Copper	< 13 *u*g/L
Total Dissolved Solids (TDS)	< 250 mg/L
Chlorides	< 60 mg/L

Table 4-2. *Existing beneficial uses for listed waters.*

Location	Agriculture	Cold Water	Fresh Water	Ground Water	Fish Migration	Municipal	Recreation	Spawning	Warm Water	Wild
Alameda Creek	X	X		X	X		X	X	X	X
Calaveras Reservoir		X	X			X	X	X	X	X

Procedure

Watershed keepers from the SFPUC take Calaveras Reservoir elevation readings daily at 8:00 a.m., from a staff gauge just south of the dam (Figure 4-1). Readings are maintained by reservoir managers and reported to state resource agencies. In this report, data are presented in acre-feet. SFPUC biologists monitor Calaveras Reservoir water quality conditions approximately twice a month (Appendix B). Measurements are taken at ten-foot intervals from the deepest area of the reservoir, near the dam (Figure 4-1). Hydrolab® multi-parameter instruments are used to record *in-situ* water column conditions including temperature, pH, conductivity, dissolved oxygen and oxidation-reduction potential. Discrete grab samples are collected at twenty-foot intervals with a Kemmerer bottle. These samples are analyzed for turbidity, alkalinity, hardness, color, ammonia, nitrate, phosphorus, chloride, iron and manganese. Hydrogen sulfide concentrations are measured in the field when odors indicate its presence. Plankton and chlorophyll-*a* samples are collected for analysis in the lab. When the reservoir is treated with copper sulfate (to control noxious algae blooms), samples are also collected for copper analysis.

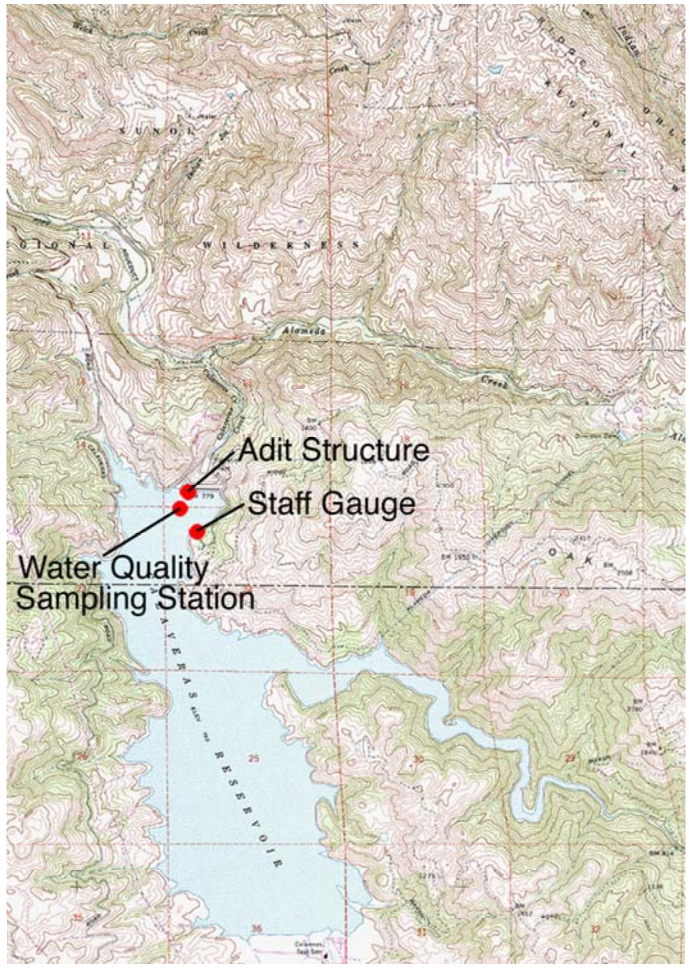


Figure 4-1. *Reservoir sampling locations.*

Water Storage

In 2003, Calaveras was operated to comply with the DSOD restrictions. Additionally, the reservoir was operated to maintain the recommended 30,000 acre-feet of minimum storage (Figure 4-2).

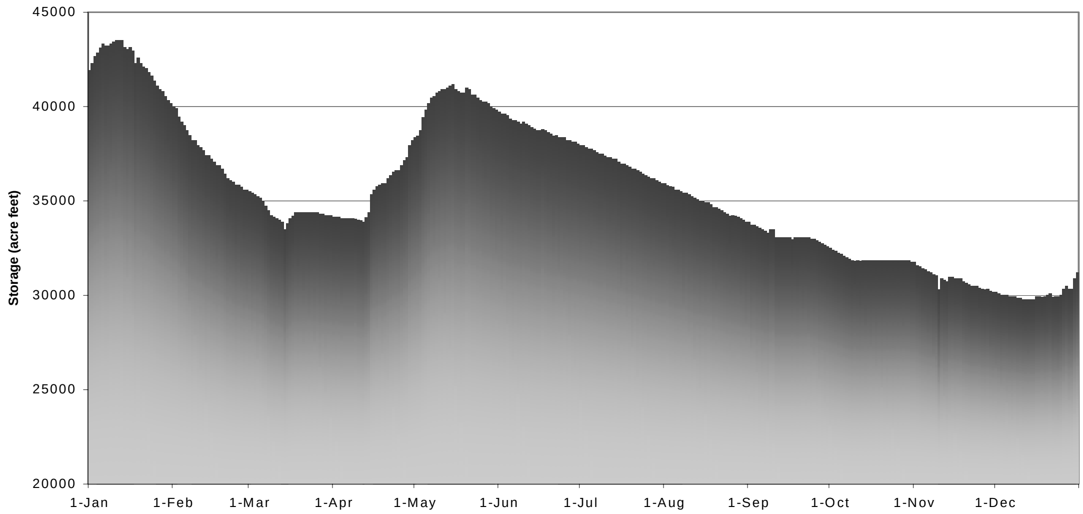


Figure 4-2. *Calaveras Reservoir daily water storage volumes for 2003.*

Notable increases in storage resulted from higher inflows from the Arroyo Hondo during seasonal storms that occurred in January, April, May and December (Figure 3-3). Maximum storage was 43,421 acre-feet on January 10 and minimum storage was 29,780 acre-feet from December 11-15.

Water Quality

Calaveras Reservoir water temperatures were typically isothermal from January through February and again in December (Figure 4-3). From March through

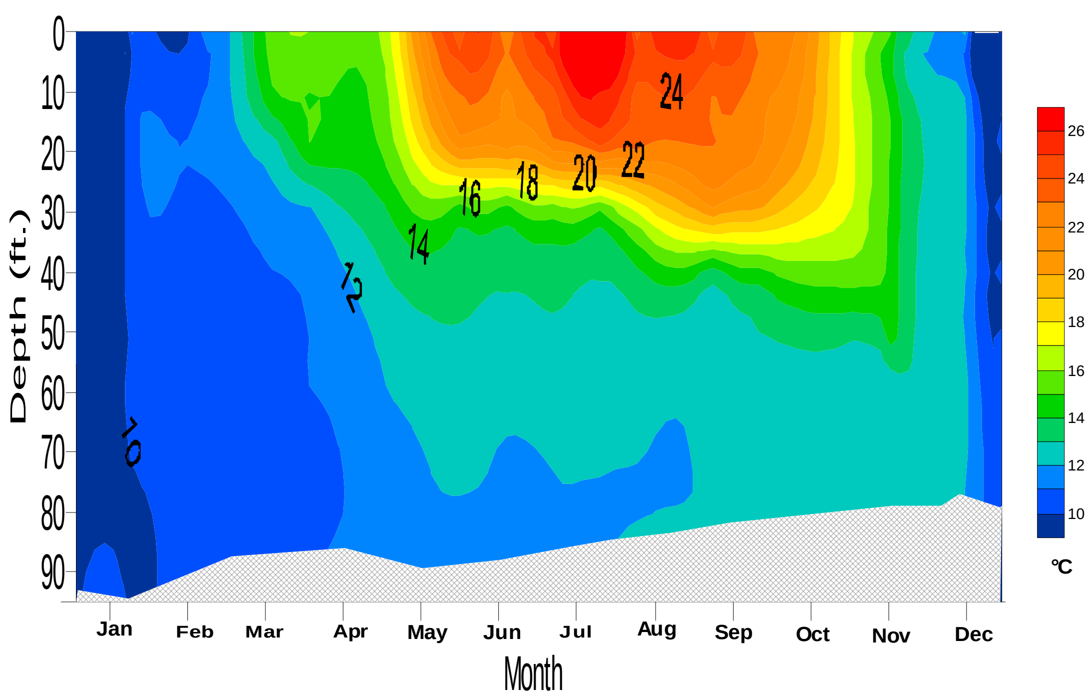


Figure 4-3. *Calaveras Reservoir water temperature profile for 2003.*

November the reservoir stratified with the most intense period between June and October. During this period, the thermocline was between 20- and 40-feet with water temperatures reaching 24°C to 26°C in the epilimnion, and 10°C to 14°C in the hypolimnion.

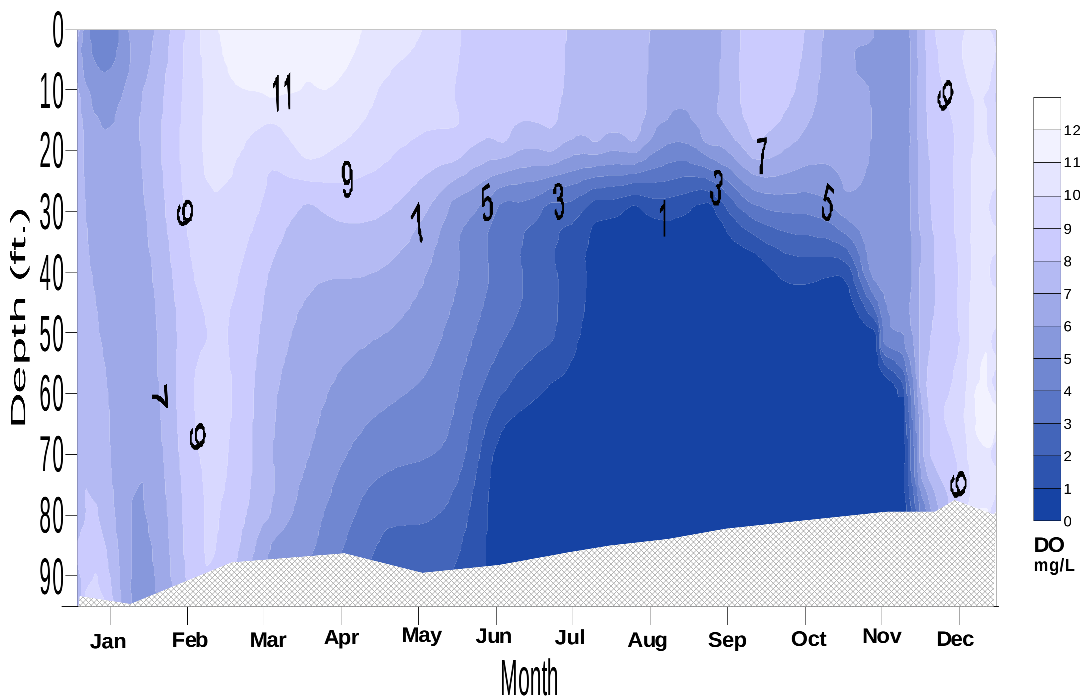


Figure 4-4. *Calaveras Reservoir dissolved oxygen profile for 2003.*

Dissolved oxygen concentrations were near saturation during the periods when the reservoir was isothermal (Figure 4-4). Between May and November, dissolved oxygen concentrations in the hypolimnion were less than 3 mg/L. From July through October, most of the water below the thermocline was anoxic with dissolved oxygen concentrations dropping to less than 1 mg/L. With the DSOD restrictions in place, these conditions are likely to recur annually due to the reduced volume of oxygenated water available at the onset of stratification.

Calaveras Reservoir pH values ranged from 6.64 to 8.32 (Figure 4-5). Both the high and low values are approximately 0.4 units more acidic than they were in 2002. After the reservoir completed its annual turnover in the fall, however, the pH trend was similar to 2002, with higher pH water near the surface mixing with the lower pH epilimnetic water causing it to increase until a near isograde condition stabilized at a pH of about 8.0.

Turbidity in Calaveras Reservoir in 2003 remained below 5 NTU throughout most of the year (Figure 4-6). This is attributable to the decreased amount of alluvium left at the Arroyo Hondo confluence after last year's storms. The moderate rain events in 2003 also contributed to the low turbidities. The highest

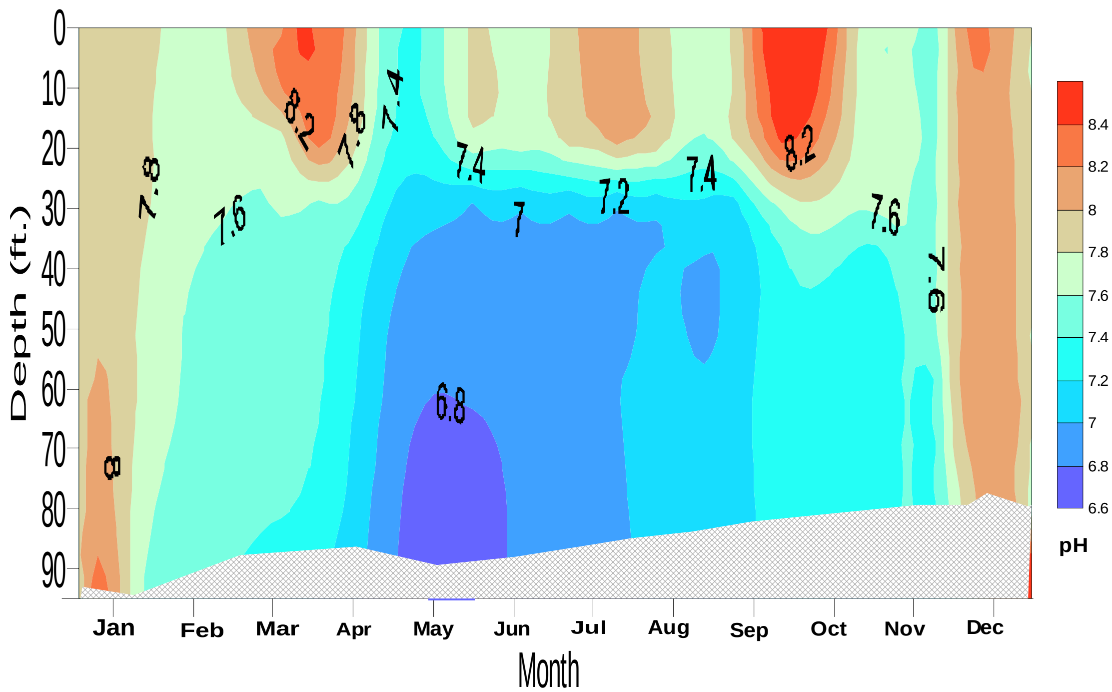


Figure 4-5. *Calaveras Reservoir pH profile for 2003.*

recorded turbidity (30.6 NTU) occurred in January following a rain event. After the rainy season ended, turbidity followed a typical settling pattern with the uppermost waters clearing more rapidly than bottom waters as suspended particles settled out. This pattern continued through May until anoxia related turbidity started to increase from the bottom upward.

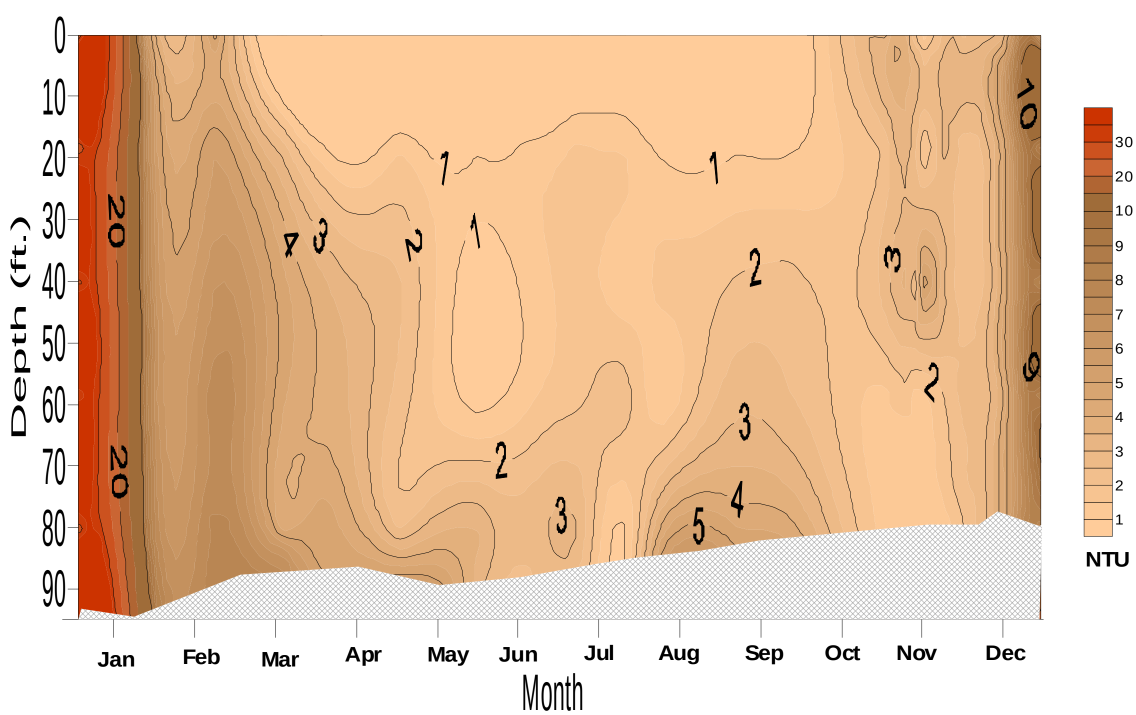


Figure 4-6. *Calaveras Reservoir turbidity profile for 2003.*

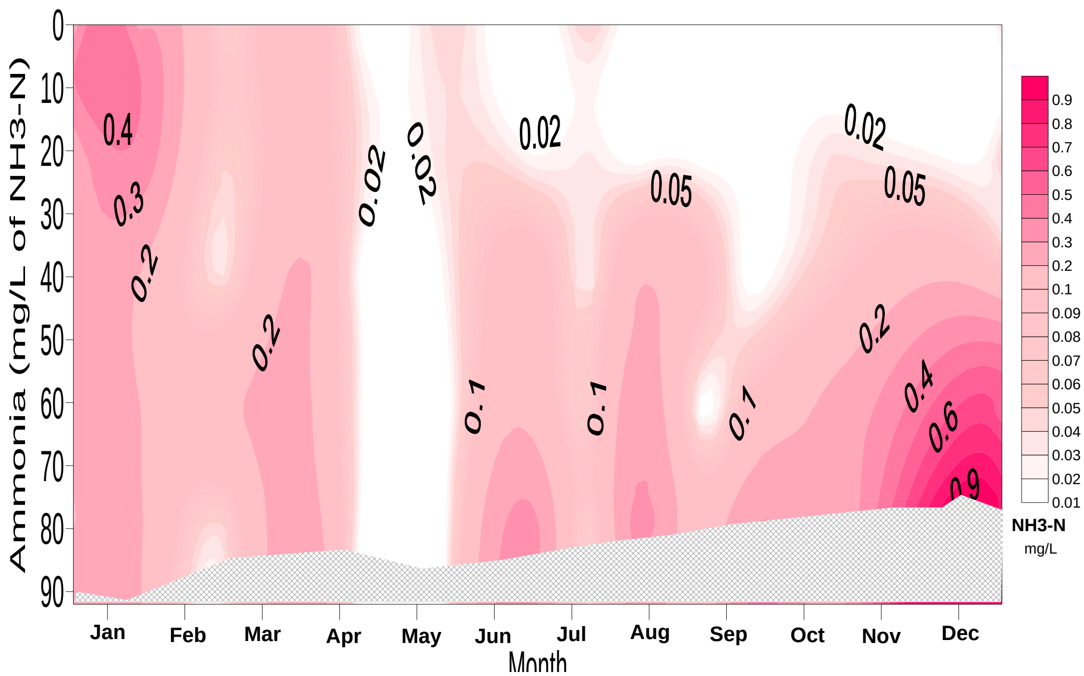


Figure 4-7. *Calaveras Reservoir ammonia concentration profile for 2003.*

Ammonia concentration in 2003 followed a typical pattern (Figure 4-7). In January, concentrations were moderate due to ammonia made available from the fall overturn, and possibly from external sources. The levels decreased from April through June, in part due to biological uptake. The concentrations above the thermocline stayed low for the remainder of the year. Below the thermocline, ammonia concentrations rose with the onset of the anoxic period.

In 2003, plankton became problematic (from a water treatment perspective) when *Anabaena*, a taste and odor causing algae, began to bloom in late October. Counts reached 13 million colony forming units (cfu) per ml/m^3 . The reservoir was treated with 2,100 pounds of copper sulfate on November 10. By November 17, *Anabaena* concentrations were down to 1.4 million cfu per ml/m^3. The copper concentrations for pre- and post-treatment monitoring are presented in Table 4-3.

Hydrogen sulfide odor was detected once on November 12, although the field test kit did not detect measurable concentrations.

Table 4-3. *Copper concentrations before and after treatment on November 10, 2003.*

	Calaveras Reservoir Copper Concentration (ug/L or ppb)			
Depth	**Nov. 10, 2003**	**Nov. 12. 2003**	**Nov. 17, 2003**	**Nov. 25, 2003**
Surface	2.9	23.1	38.4	3.6
20 feet	1.6	20.8	29.0	4.1
40 feet	3.7	18.3	19.5	4.1
60 feet	4.4	29.5	43.9	2.5
Bottom	5.4	15.0	33.9	1.1

5.0 Stream Water Quality

Background

Elevated water temperatures during the warmer months of the year have been identified as a major factor limiting the establishment of viable rainbow trout populations in Alameda Creek below the confluence of Alameda and Calaveras creeks. Reduced stream flow, channel widening and the loss of riparian vegetation in several areas contribute to thermally unsuitable conditions.

Downstream of its confluence with Calaveras Creek, however, Alameda Creek's water temperature regimes are optimal for several species of native, warm water fishes. The most common include California roach, Sacramento pikeminnow and Sacramento sucker, all of which thrive in this stretch of the stream.

The Alameda Creek minimum flow requirement schedule developed for the rainbow trout restoration MOU is designed to provide suitable cold water habitat and refugia for trout throughout the year in the upper study reach, while maintaining sufficiently warm water in the lower study reach to support native, warm water species. Areas monitored that are not covered in the MOU are done so for comparison purposes.

Turbidity, pH and dissolved oxygen concentrations are not expected to be limiting to rainbow trout or other native species residing in the upper Alameda Creek Watershed.

Procedure

Water temperature loggers (Onset, Optic StowAway Temperature Recorders (Figure 1-1)) were deployed in one of two ways: 1) Foam bumpers were attached to a recorder and it was placed in a piece of 2-inch by 6-inch galvanized pipe. Two-inch by 1/2-inch galvanized bell-reducers, with a single link of 3/8-inch galvanized chain welded on, were screwed to each end of the pipe to allow the logger to be exposed to creek water while in the housing. Units were secured by padlocking a length of 3/8-inch galvanized chain to one end of the housing, wrapping the chain around a boulder, tree or some other object too large to be easily moved, then attaching the free end of the chain back to the housing. 2) Foam bumpers were attached to a recorder and it was placed in a piece of 10-inch by 2-inch perforated PVC pipe. A PVC end cap was glued to one end, and a threaded end cap was screwed into the other. A length of steel cable was threaded through a hole in the threaded end cap and the body of the housing, and crimped secure with an aluminum ferrule such that the only way to retrieve the sensor from the housing would be to cut the cable. The other end of the cable was then wrapped around a secure structure and crimped in place with an aluminum ferrule.

Sixteen water temperature loggers, set to record at 30-minute intervals, were installed at sixteen locations in Alameda, Calaveras, La Costa and Indian creeks and Arroyo Hondo on various days between June 11 and July 14, 2003 (Table 5-1, Figure 5-2). The water temperature sensors were removed from the creeks on various dates between November 17 and 24, 2003, except for Alameda Creek Site

T-15 that was retrieved on September 4, 2003 because that portion of the creek had dried up (Table 5-1). No useable data were collected from that sensor.

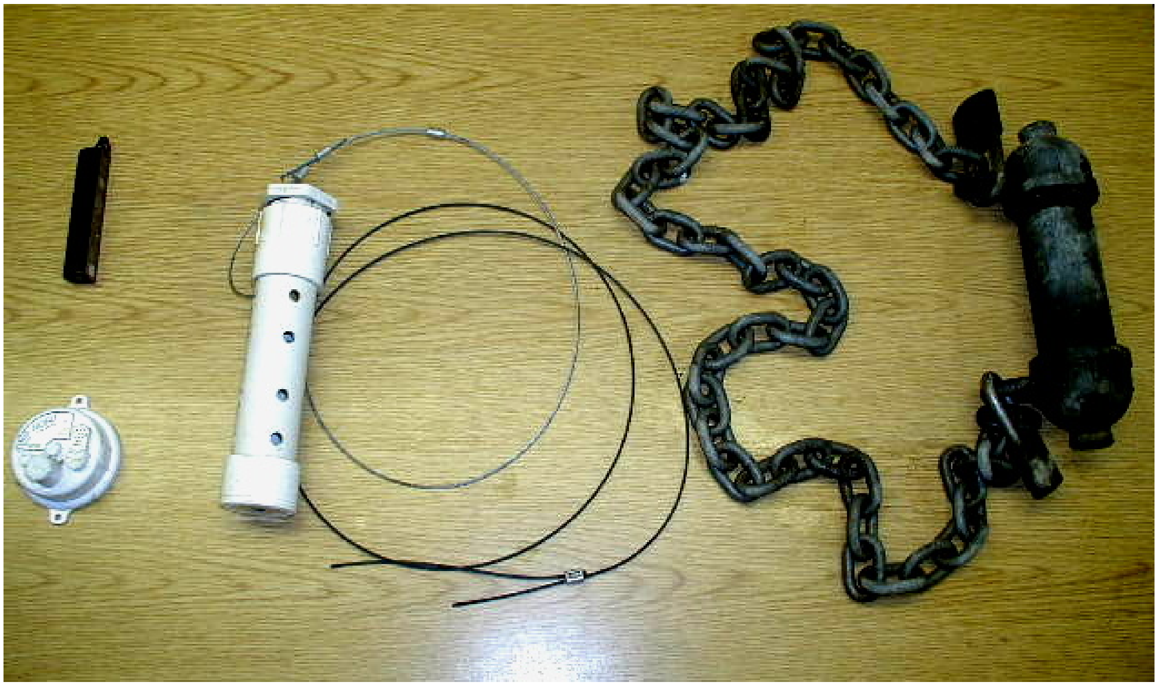


Figure 5-1. *Water and air temperature probes and protective housings.*

Four air temperature/relative humidity loggers (Onset, Hobo Pro Series Recorders (Figure 5-1)), set to record at 30-minute intervals, were installed at sites near four of the five creeks in the study area on various dates between June 11 and July 3, 2003 (Table 5-1, Figure 5-2). Loggers were mounted to secure, shaded structures (posts, trees, etc.) near the creeks. All temperature/relative humidity loggers were removed on November 21, 2003.

Instantaneous water temperature, turbidity, pH and dissolved oxygen concentrations were measured in each of the electrofishing habitat units (Figure 8-1) during the 2003 autumn and winter surveys. All water quality parameters were measured prior to electrofishing activities. Temperature, pH and dissolved oxygen were recorded with a Hydrolab Surveyor and DataSonde water quality multiprobe unit. Turbidity was measured with a Hach 2100P turbidimeter.

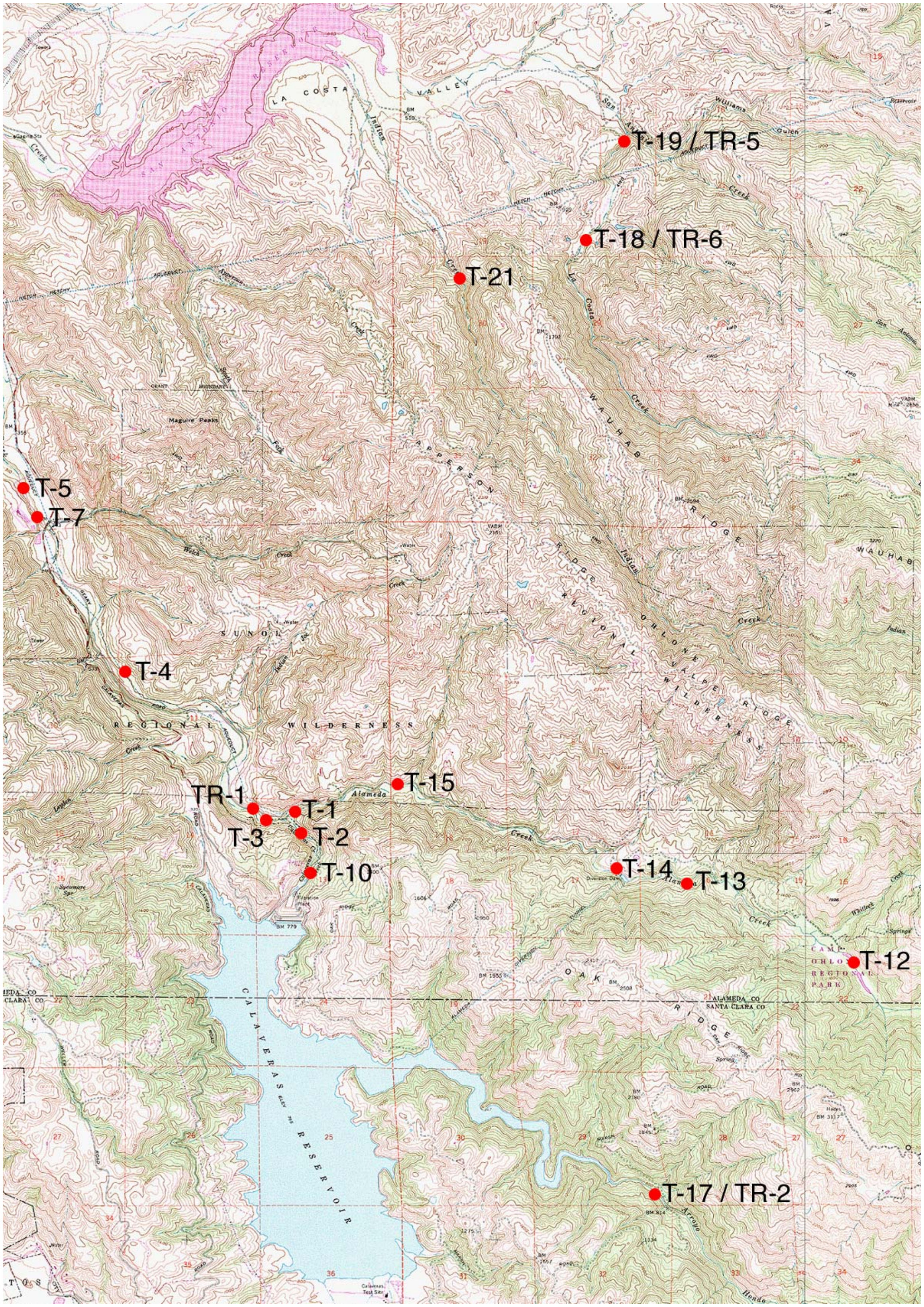


Figure 5-2. *Temperature sensor locations in Alameda, Calaveras, La Costa and Indian creeks and Arroyo Hondo.*

Table 5-1. *Remote recording device deployment descriptions for 2003.*

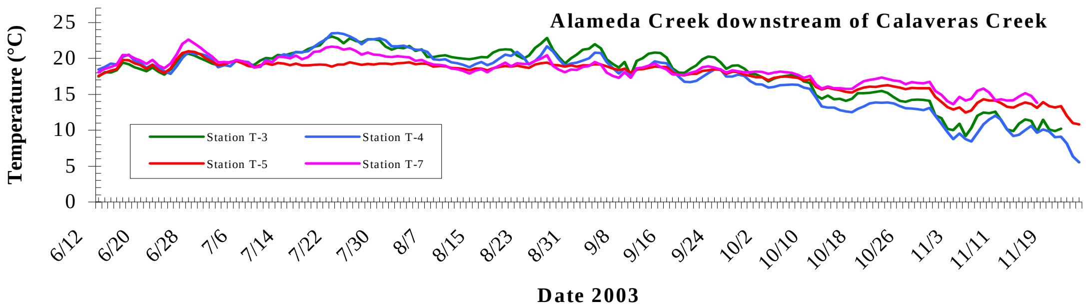
Station	Logger	Parameters	Deployed	Retrieved	Location	Site Description
T-1	1	Water Temp.	6/11/03	11/21/03	In Alameda Creek, about 650-feet upstream of the Alameda Creek / Calaveras Creek confluence. 37° 30.26’ N 121° 49.18’ W	Under a large boulder on the left side of the stream, in the shade, with flowing water.
T-2	1	Water Temp.	6/11/03	11/21/03	In Calaveras Creek, about 500-feet upstream of the Alameda Creek / Calaveras Creek confluence. 37° 30.16’ N 121° 49.16’ W	Under a large boulder just to the left of mid-stream, in the shade, with flowing water.
T-3	1	Water Temp.	6/11/03	11/21/03	In Alameda Creek, about 500-feet downstream of the Alameda Creek / Calaveras Creek confluence. 37° 30.19’ N 121° 49.42’ W	Under a large boulder in the middle of the stream, in the shade, with flowing water.
T-4	1	Water Temp.	6/11/03	11/24/03	In Alameda Creek, about 1,200-feet downstream of the Sunol Regional Park / SFPUC boundary. 37° 31.11’ N 121° 50.60’ W	Hanging from a large tree on the left stream bank, in the shade, with flowing water.
T-5	1	Water Temp.	6/11/03	11/24/03	In Alameda Creek, about 250-feet upstream of the Sunol Valley Water Treatment Plant bridge. 37° 32.40’ N 121° 51.41’ W	Hanging from a root-ball on the right stream bank, in the shade, with flowing water.
T-7	1	Water Temp.	6/11/03	11/17/03	In Alameda Creek, downstream of Welsh Creek. 37° 32.16’ N 121° 51.28’ W	Attached to a root-ball on the left stream bank, at the bottom of a pool, in the shade, with little flow.
T-10	1	Water Temp.	6/16/03	11/24/03	In Calaveras Creek, downstream of the dam, behind the downstream most concrete weir. 37° 29.87’ N 121° 49.05’ W	Attached to a rock, in the middle of the channel, just to the left of the opening in the concrete wier.
T-12	1	Water Temp.	6/11/03	11/21/03	In Alameda Creek near Camp Ohlone. 37°29.28’ N 121°44.67’ W	Attached to root-ball in dam pool near cabin.
T-13	1	Water Temp.	6/13/03	11/21/03	In Alameda Creek upstream from Diversion Dam. 37°29.77’ N 121°45.62’ W	Attached to boulder in mid-channel.
T-14	1	Water Temp.	6/11/03	11/21/03	In Alameda Creek downstream of Diversion Dam. 37° 29.97’ N 121° 46.67’ N	Attached to root-ball in small pool.
T-15	1	Water Temp.	6/11/03	9/4/03	In Alameda Creek at “W Tree”. 37°30.41’ N 121°48.21’ W	Attached to root-ball in lateral scour pool.

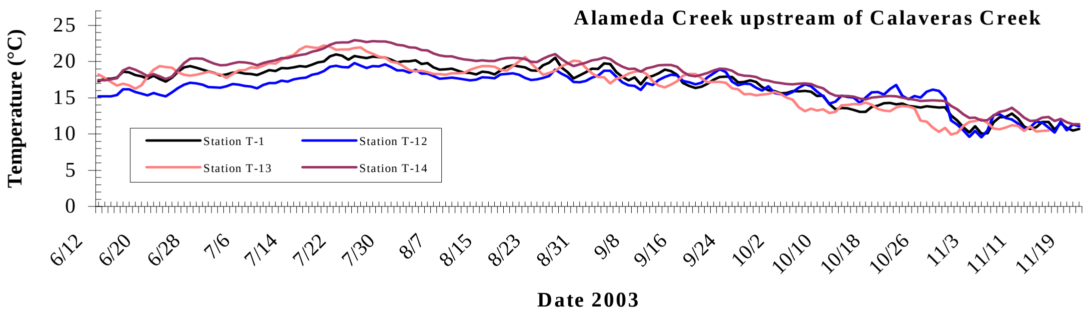
Table 5-1 continued.

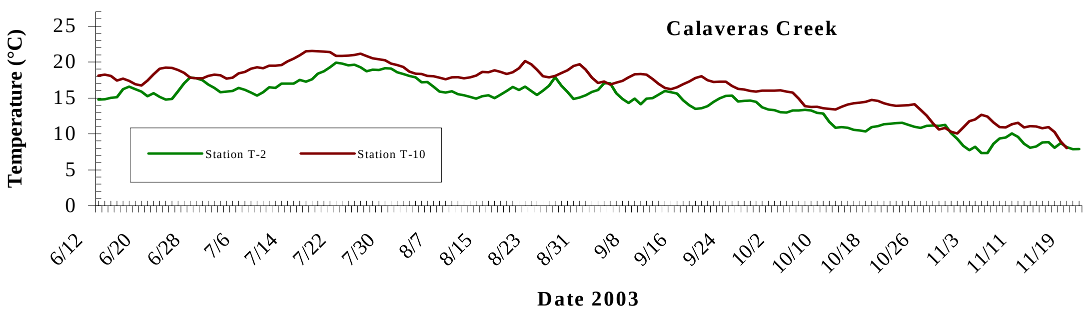
Station	Logger	Parameters	Deployed	Retrieved	Location	Site Description
T-16	1	Water Temp.	7/14/03	11/17/03	Arroyo Honda about ½ mile upstream from slide. 37°27.02' N 121°44.21' W	Attached to boulder in mid-channel.
T-17	1	Water Temp.	7/1/03	11/21/03	Arroyo Hondo about 150' downstream of USGS station (Marsh Rd. bridge) 37°27.79 N 121°46.33' W	Attached to root-ball near trapping site.
T-18	1	Water Temp.	6/13/03	11/21/03	La Costa Creek 100' below private property line. 37°33.89' N 121°46.88' W	Attached to root-ball in small pool.
T-19	1	Water Temp.	6/13/03	11/21/03	La Costa Creek 400' upstream from confluence with San Antonio Creek. 37°34.57' N 121°46.51' W	Attached to small boulder at bottom of bedrock scour pool.
T-21	1	Water Temp.	6/13/03	11/21/03	Indian Creek upstream of where it crosses over Coast Tunnel. 37°33.67' N 121°47.85' W	Attached to small boulder at bottom of bedrock scour pool.
TR-1	1	Air Temp. & Rel. Humidity	6/11/03	11/21/03	Adjacent to Alameda Creek, in the Sunol Regional Park, at USGS streamflow station 11173510. 37° 30.23' N 121° 49.51' W	Attached to a staff gauge, on the right side of the stream, in the shade.
TR-2	1	Air Temp. & Rel. Humidity	7/1/03	11/21/03	Arroyo Hondo about 150' downstream of USGS station (Marsh Rd. bridge) 37°27.79 N 121°46.33' W	Attached to laurel tree left bank of creek near trapping site.
TR-5	1	Air Temp. & Rel. Humidity	6/16/03	11/21/03	La Costa Creek 100' below private property line. 37°33.89' N 121°46.88' W	Attached to willow tree on left bank.
TR-6	1	Air Temp. & Rel. Humidity	7/3/03	11/21/03	Indian Creek upstream of where it crosses over Coast Tunnel. 37°33.67' N 121°47.84' W	Attached to laurel tree right bank of creek near temperature sensor.

Water Temperature

For the study period, graphs of water temperature data for most of the fifteen sites showed the same general shape, fluctuations and trend of having the warmest temperatures in late July and early August, tapering off to the coolest temperatures in November, at the end of the study period. Two exceptions were stations T-7 and T-17, which exhibited their warmest temperatures in early July. Station T-17 had significantly higher temperatures throughout most of July in comparison to the other fourteen stations monitored (Figure 5-3).







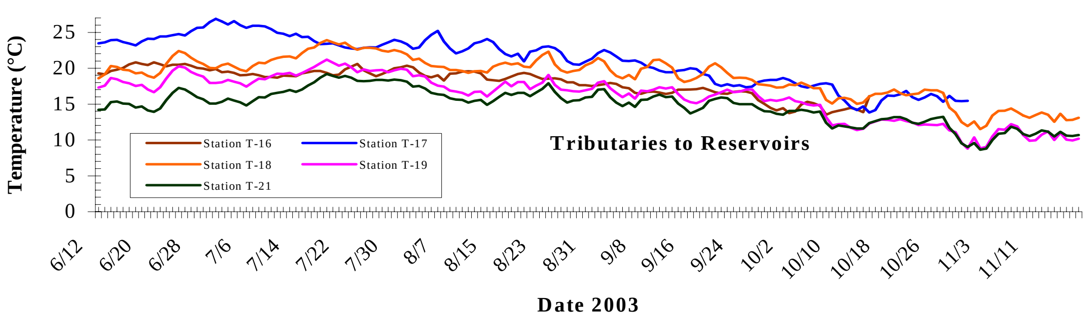


Figure 5-3. *Daily mean water temperatures at the monitoring stations in Alameda, Calaveras, La Costa and Indian creeks and Arroyo Hondo.*

Station T-4 had the lowest daily minimum mean water temperature at 5.5°C (Table 5-2, Figure 5-7) in November, while Station T-21 had the lowest maximum daily mean water temperature at 19.2°C (Table 5-2, Figure 5-18). Station T-17, located in Arroyo Hondo, had the highest minimum, maximum and average daily mean water temperatures at 13.8°C, 26.8°C and 21.2°C, respectively (Table 5-2, Figure 5-15). Station T-2, located in Calaveras Creek upstream of its confluence with Alameda Creek, had the lowest average daily mean water temperature at 14.4°C (Table 5-2, Figure 5-5), with Station T-21, located in Indian Creek, only slightly higher at 14.8°C (Table 5-2, Figure 5-18).

Station T-10, located in Calaveras Creek below the Calaveras Dam, had the lowest minimum, maximum and average daily water temperature fluctuations at 0.3°C, 1.8°C and 0.8°C, respectively (Table 5-2, Figure 5-10), sharing the minimum fluctuation with stations T-4 and T-14 (Table 5-2, Figures 5-7 and 5-13). Station T-3, located in Sunol Regional Park, had the highest minimum, maximum and average daily water temperature fluctuations at 2.0°C, 10.2°C and 7.0° C, respectively (Table 5-2, Figure 5-6).

Table 5-2. *Daily water temperature (°C) statistics for 2003.*

	Daily Mean Water Temperature			**Average Daily Water Temperature Fluctuation**		
Station	**Minimum**	**Maximum**	**Average**	**Minimum**	**Maximum**	**Average**
T-1	10.0	21.0	16.9	0.8	6.0	3.4
T-2	7.3	19.9	14.4	0.4	4.2	2.0
T-3	9.2	23.0	18.0	2.0	10.2	7.0
T-4	5.5	23.5	17.2	0.3	6.8	1.6
T-5	10.8	21.0	17.6	0.5	6.8	2.5
T-7	13.6	22.6	18.4	0.6	8.47	3.0
T-10	8.0	21.5	16.7	0.3	1.8	0.8
T-12	9.5	19.8	16.3	1.0	7.7	5.0
T-13	9.9	22.2	16.9	0.8	3.5	2.5
T-14	11.4	23.0	18.2	0.3	4.4	1.7
T-16	13.5	20.8	18.1	0.4	3.8	2.6
T-17	13.8	26.8	21.2	1.0	6.0	3.6
T-18	11.5	23.9	18.8	0.7	4.6	2.9
T-19	8.8	21.2	16.0	0.5	7.3	2.6
T-21	8.6	19.2	14.8	0.5	3.6	1.8

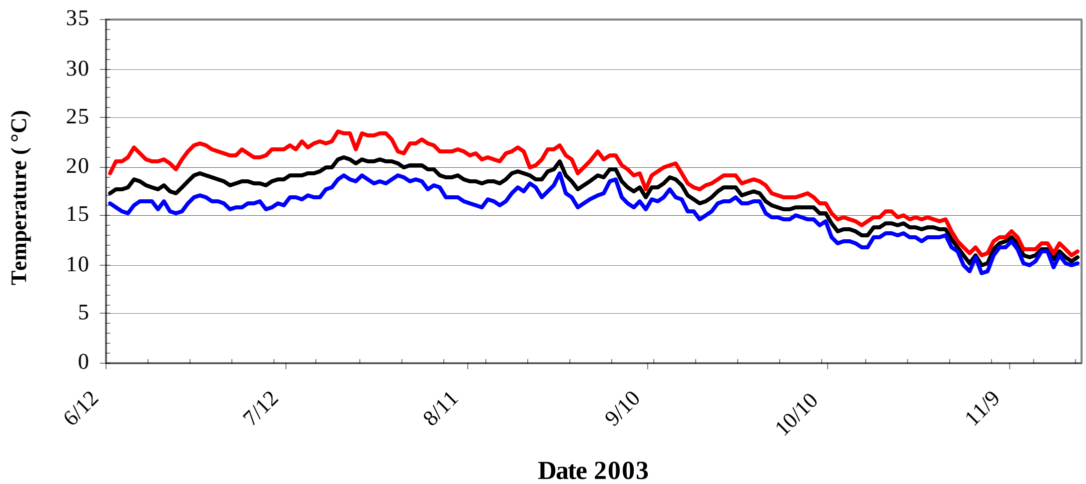


Figure 5-4. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-1 in Alameda Creek.*

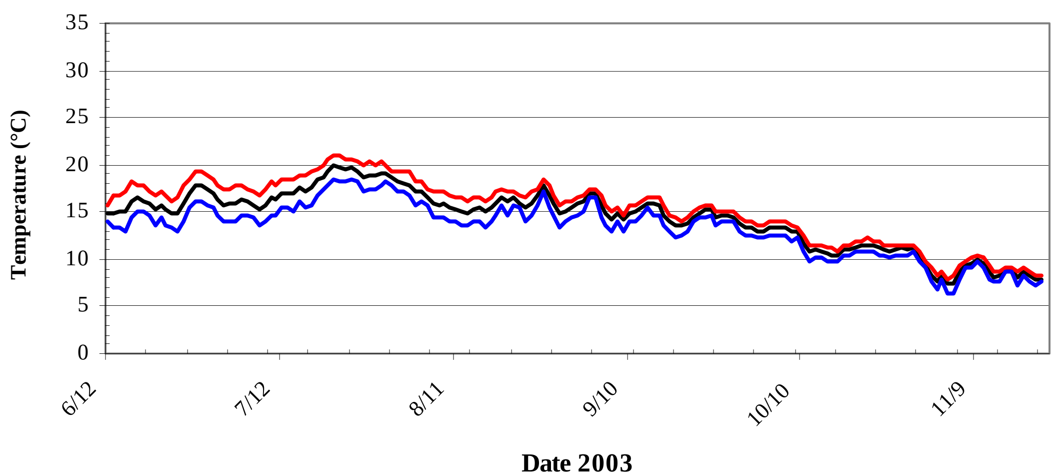


Figure 5-5. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-2 in Calaveras Creek.*

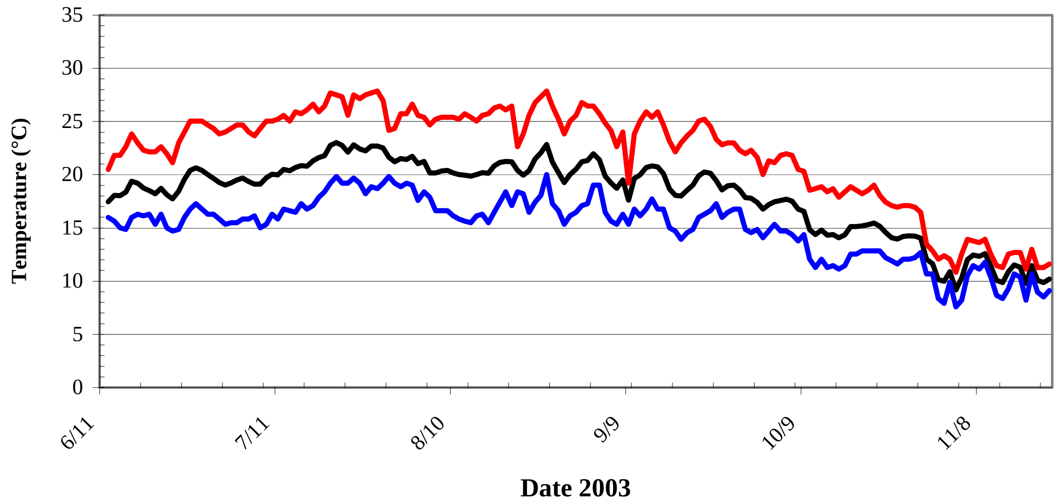


Figure 5-6. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-3 in Alameda Creek.*

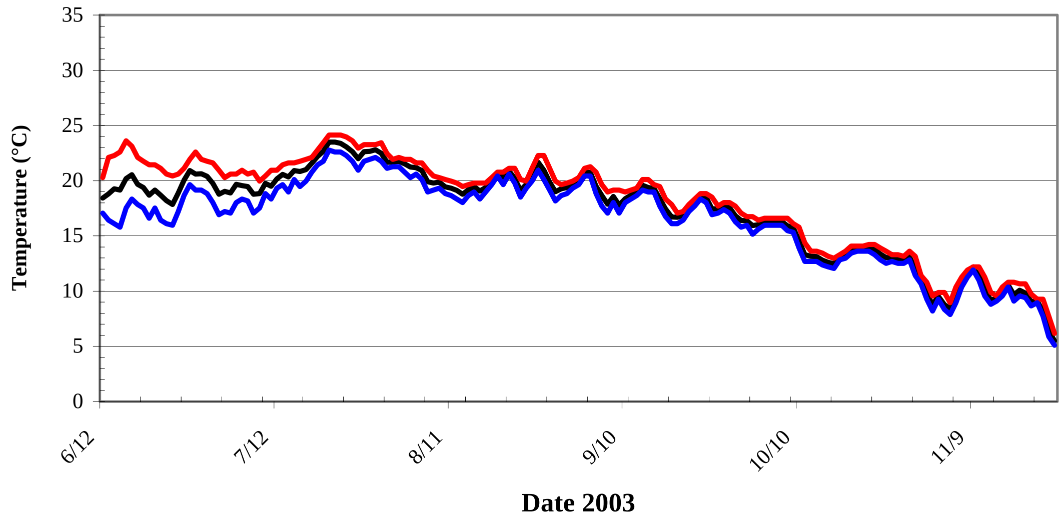


Figure 5-7. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-4 in Alameda Creek.*

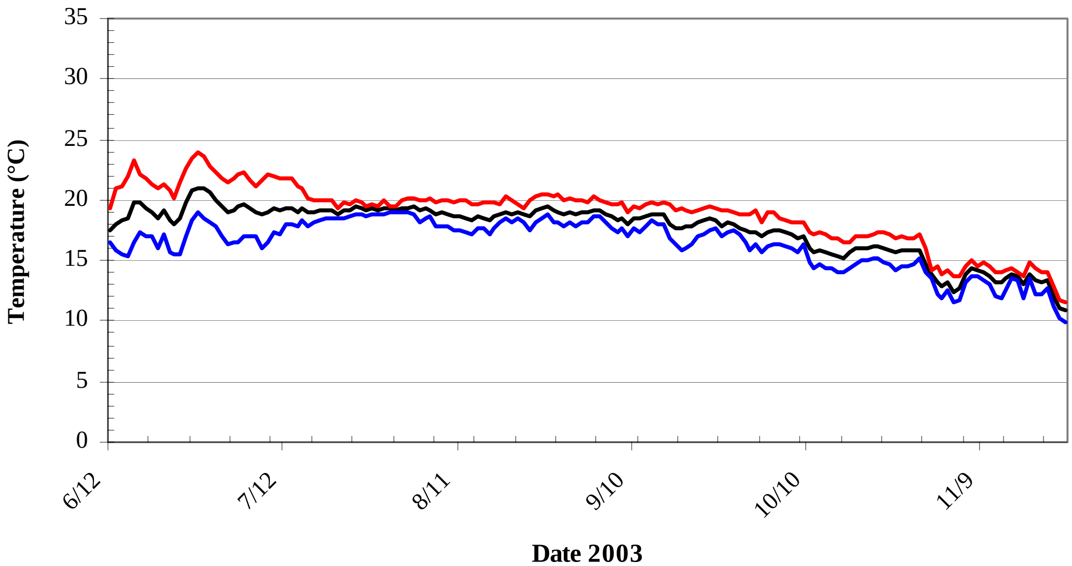


Figure 5-8. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-5 in Alameda Creek.*

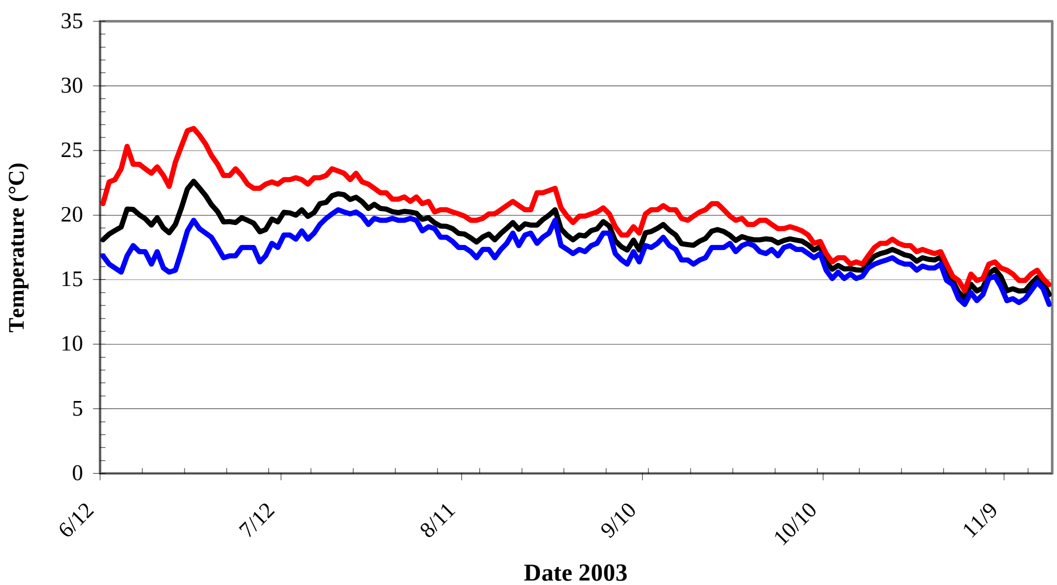


Figure 5-9. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-7 in Alameda Creek.*

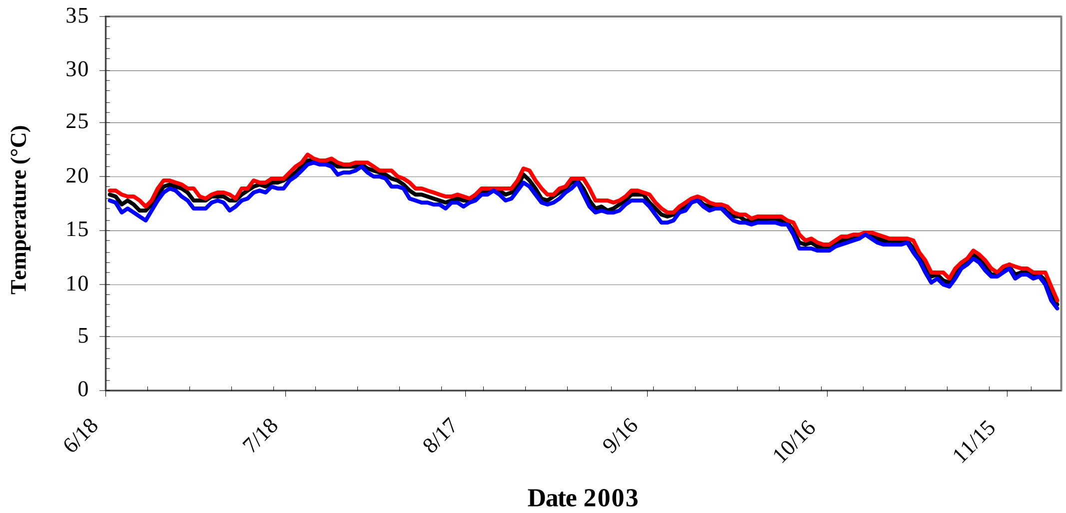


Figure 5-10. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-10 in Calaveras Creek.*

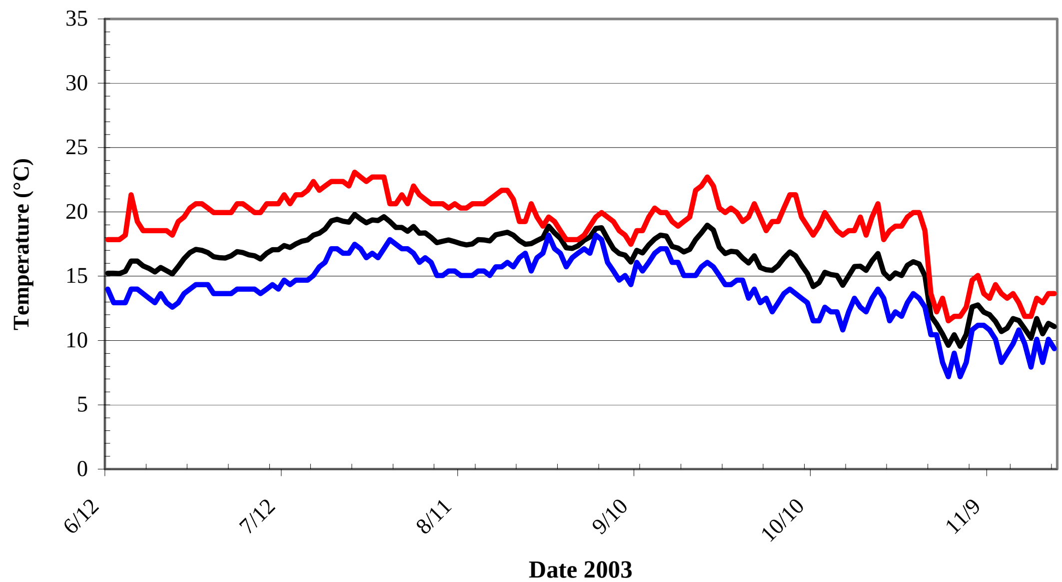


Figure 5-11. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-12 in Alameda Creek.*

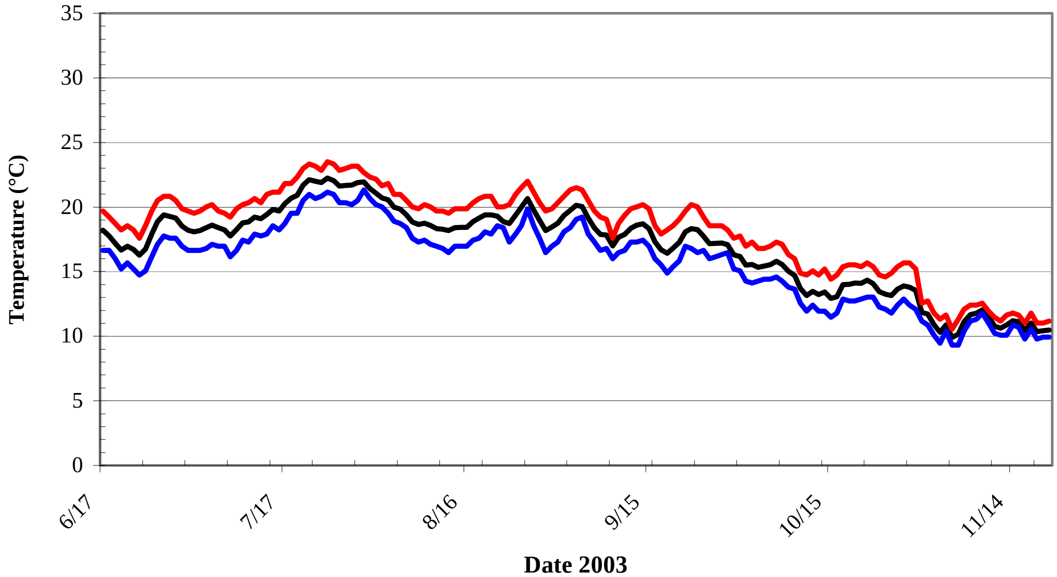


Figure 5-12. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-13 in Alameda Creek.*

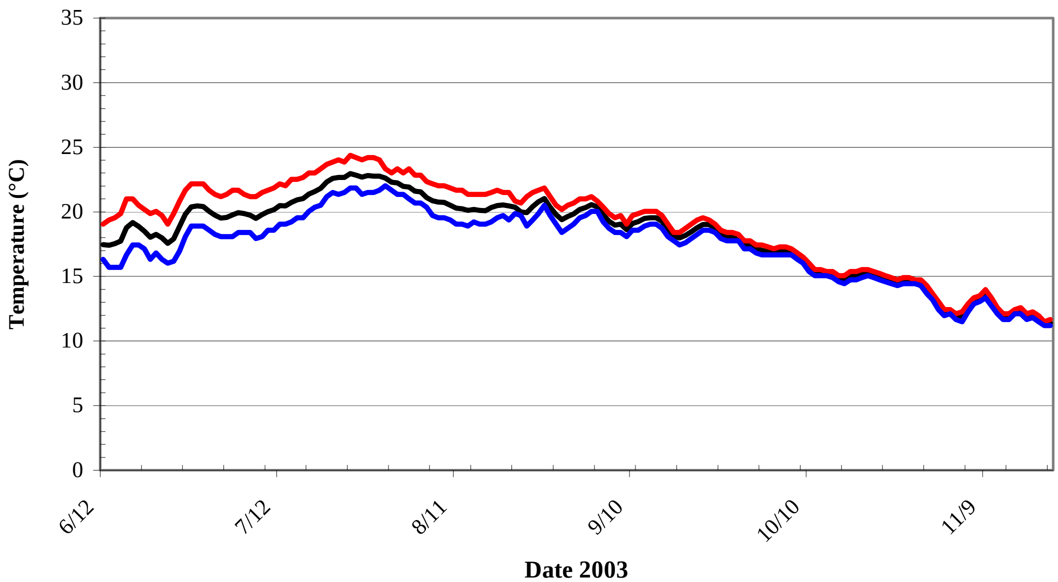


Figure 5-13. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-14 in Alameda Creek.*

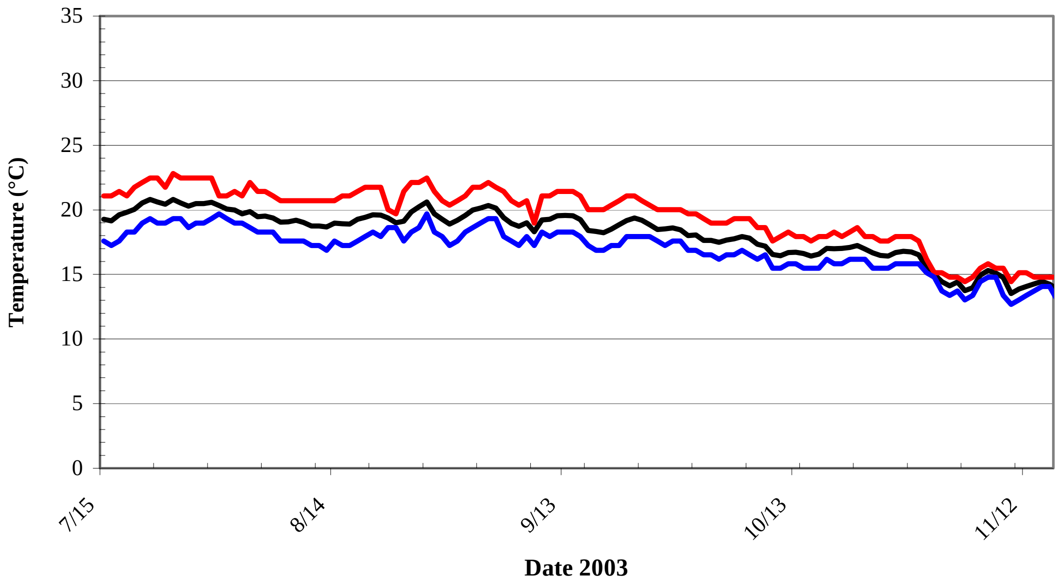


Figure 5-14. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-16 in Arroyo Hondo.*

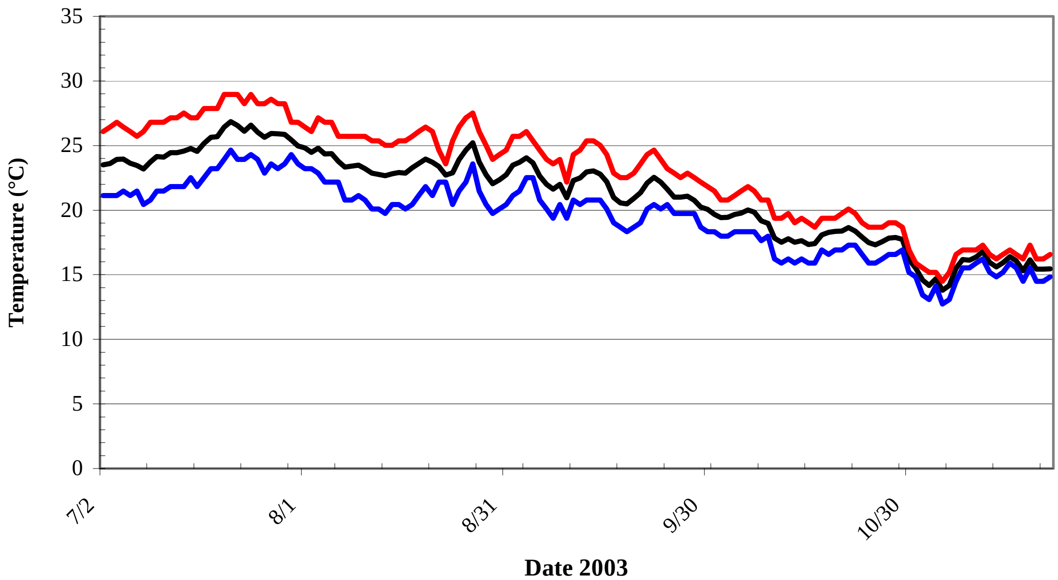


Figure 5-15. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-17 in Arroyo Hondo.*

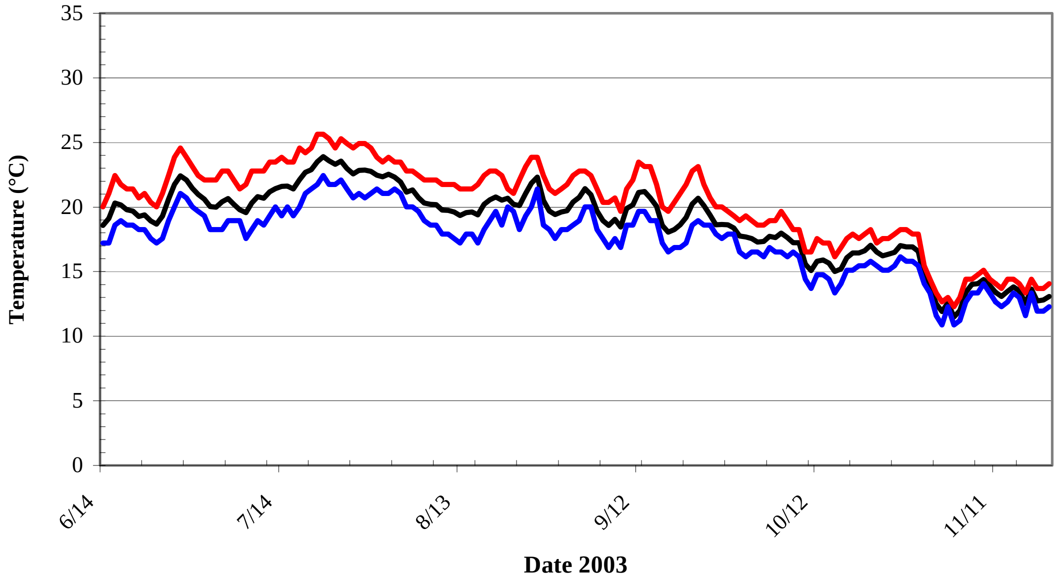


Figure 5-16 *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-18 in La Costa Creek.*

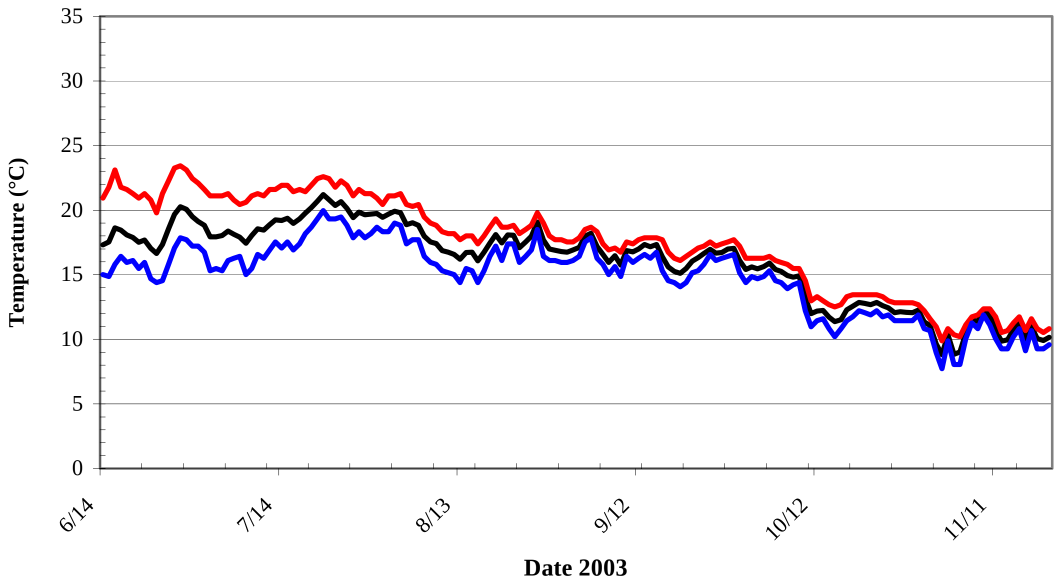


Figure 5-17 *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-19 in La Costa Creek.*

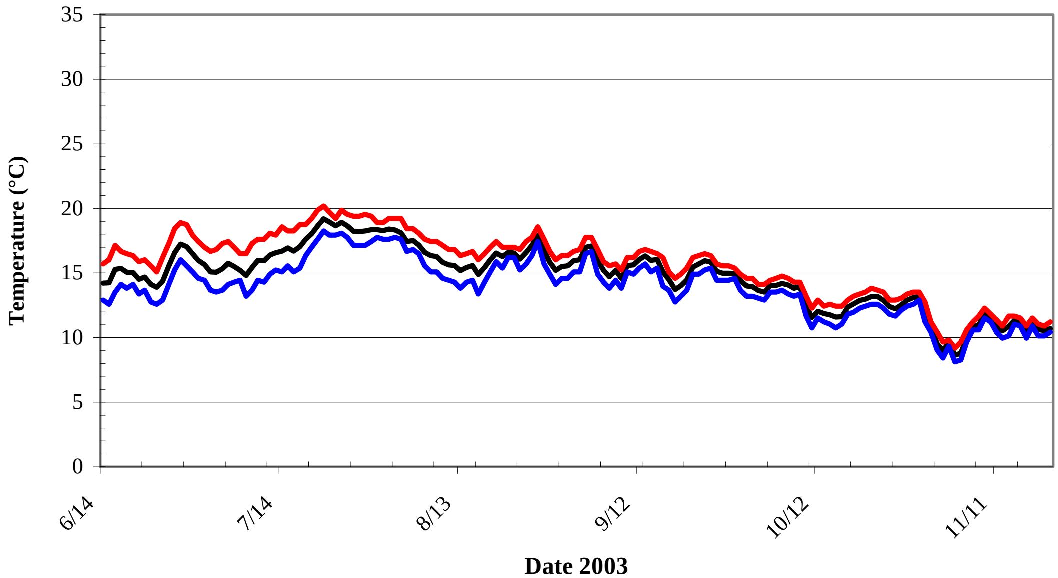


Figure 5-18. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-21 in Indian Creek.*

Air Temperature and Relative Humidity

Four air temperature and relative humidity sensors were deployed at sites near four of the creeks covered in this study: Alameda, La Costa and Indian creeks and Arroyo Hondo. Only one of the sites (TR-1) was included in the 2002 survey, with sites TR-2, TR-5 and TR-6 new for 2003.

Station TR-1, located along Alameda Creek near its confluence with Calaveras Creek in Sunol Regional Park, had the highest maximum and average daily mean air temperatures at 27.4°C and 18.3°C respectively. Station TR-1 also had the highest minimum, maximum and average daily air temperature fluctuations at 5.4°C, 23.8° C and 16.1°C, respectively (Table 5-3, Figure 5-19). The lowest maximum and average daily mean relative humidity values, at 93.7% and 59.8%, were found at Station TR-1, respectively, as was the highest minimum daily relative humidity fluctuation of 21.3% (Table 5-4, Figure 5-19).

Station TR-2, located near Arroyo Hondo downstream of the Marsh Road Bridge, had the lowest maximum and average daily mean air temperatures at 19.2°C and 14.8°C, respectively, and significantly lower minimum, maximum and average daily air temperature fluctuations in comparison to the other three sites (Table 5-3, Figure 5-21). Conversely, Station TR-2 had the highest average daily relative humidity fluctuation at 49.6% (Table 5-4, Figure 5-22).

Station TR-5, located near La Costa Creek, had the lowest daily mean air temperature at 5.9°C (Table 5-3, Figure 5-23). Station TR-6, located near Indian Creek, along with station TR-5, had several days throughout the study period with no observable daily fluctuation in relative humidity (Table 5-4 and Figures 5-24 and 5-26). Sensors at stations TR-2, TR-5 and TR-6 recorded several relative humidity values greater than 100%, which appear to be associated with early November rain events (Table 5-4, Figures 5-22, 5-24 and 5-26).

Table 5-3. *Daily air temperature (°C) statistics for 2003.*

	Daily Mean Air Temperature			Average Daily Air Temperature Fluctuation		
Station	**Minimum**	**Maximum**	**Average**	**Minimum**	**Maximum**	**Average**
TR-1	6.7	27.4	18.3	5.4	23.8	16.1
TR-2	8.6	19.2	14.8	0.5	3.6	1.8
TR-5	5.9	25.1	17.0	4.4	20.5	13.1
TR-6	6.2	23.6	16.7	3.2	22.0	10.6

Table 5-4. *Daily relative humidity (%) statistics for 2003.*

	Daily Mean Relative Humidity			Average Daily Relative Humidity Fluctuation		
Station	**Minimum**	**Maximum**	**Average**	**Minimum**	**Maximum**	**Average**
TR-1	31.8	93.7	59.8	21.3	75.1	48.7
TR-2	26.8	102.1*	60.0	12.2	81.2	49.6
TR-5	26.3	103.9*	66.6	0.0	81.4	47.1
TR-6	28.3	104.0*	66.2	0.0	75.9	38.0

**Several RH readings above 100% appear to be associated with concurrent rain events.*

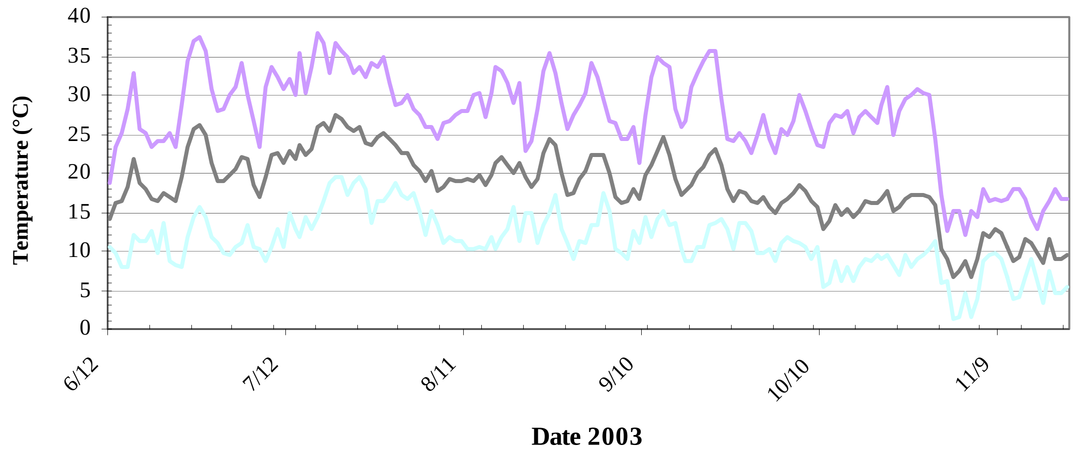


Figure 5-19. *Daily mean (gray), maximum (lavender) and minimum (turquoise) air temperatures at Station TR-1 near Alameda Creek.*

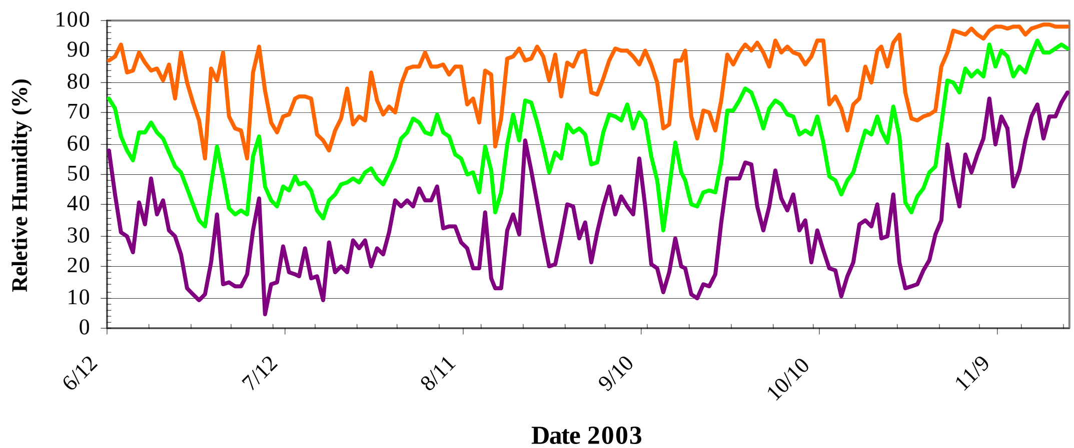


Figure 5-20. *Daily mean (green), maximum (orange) and minimum (purple) relative humidities at Station TR-1 near Alameda Creek.*

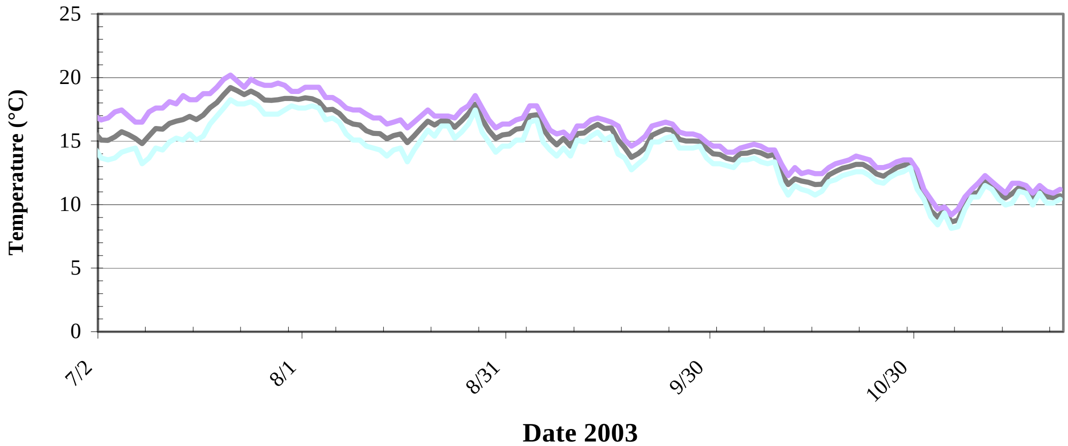


Figure 5-21. *Daily mean (gray), maximum (lavender) and minimum (turquoise) air temperatures at Station TR-2 near Arroyo Hondo.*

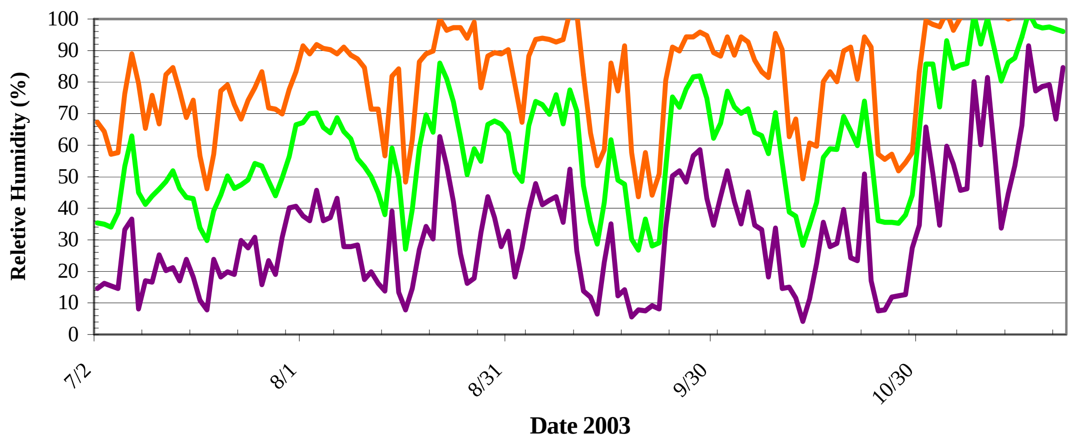


Figure 5-22. *Daily mean (green), maximum (orange) and minimum (purple) relative humidities at Station TR-2 near Arroyo Hondo.*

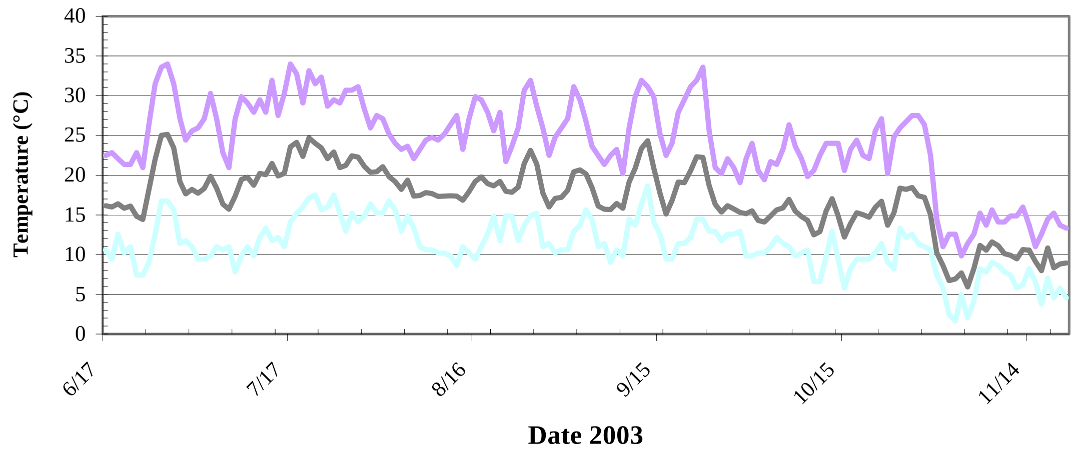


Figure 5-23. *Daily mean (gray), maximum (lavender) and minimum (turquoise) air temperatures at Station TR-5 near La Costa Creek.*

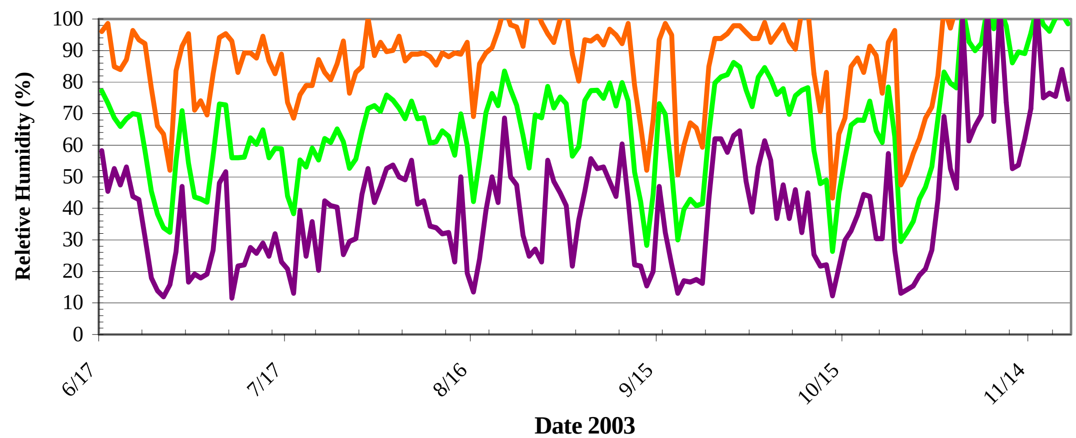


Figure 5-24. *Daily mean (green), maximum (orange) and minimum (purple) relative humidities at Station TR-5 near La Costa Creek.*

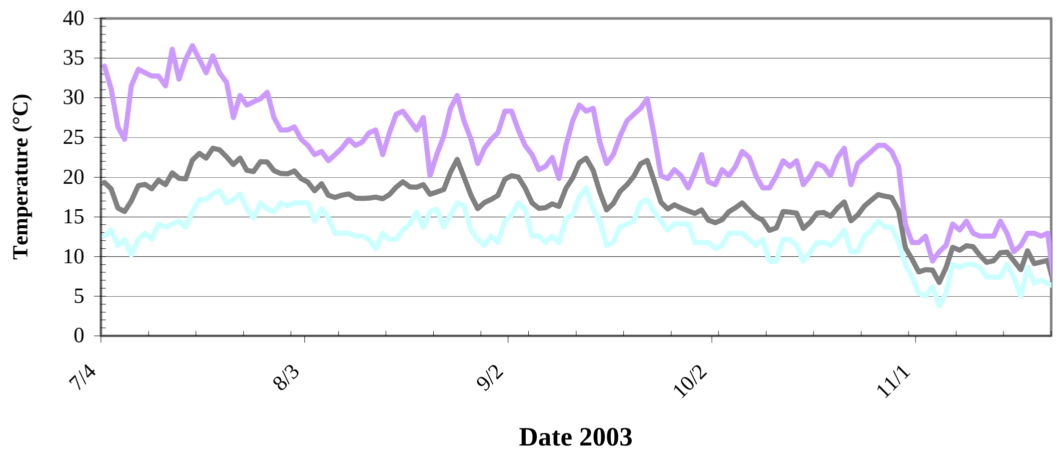


Figure 5-25. *Daily mean (gray), maximum (lavender) and minimum (turquoise) air temperatures at Station TR-6 near Indian Creek.*

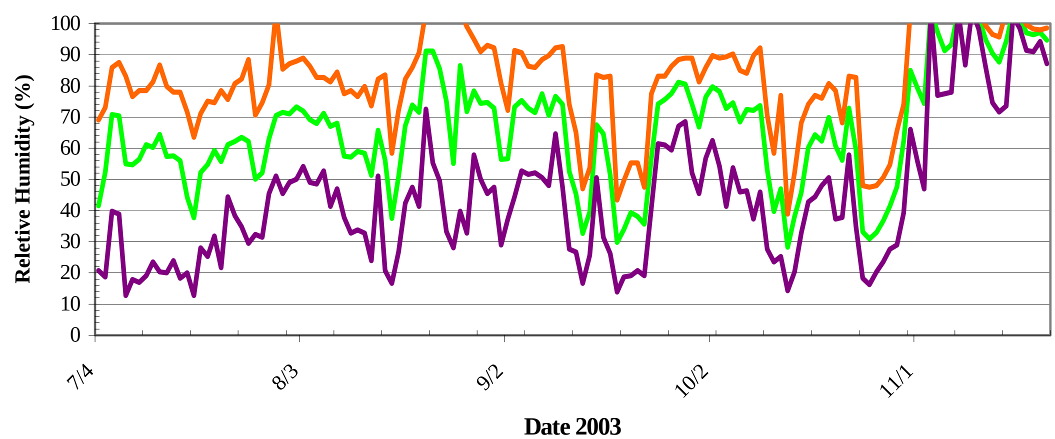


Figure 5-26. *Daily mean (green), maximum (orange) and minimum (purple) relative humidities at Station TR-6 near Indian Creek.*

Electrofishing Water Quality Measurements

During the autumn 2003 electrofishing survey, basic water quality monitoring was conducted in various habitats within Alameda, Calaveras, La Costa and Indian creeks and Arroyo Hondo from a total of twenty-nine habitat units (Figure 8-1).

Survey pH readings ranged from 7.28 to 8.18, with the lowest observed values coming from a relatively stagnant pool in Calaveras Creek (Station 8-2) and a run in Alameda Creek (Station 7-3). Conductivity readings were highest in two pools in Calaveras Creek (stations 8-1 and 8-2), at 1100 and 1380 microS/cm, respectively, and lowest at Station 13-2 in Alameda Creek at 377 microS/cm. Dissolved oxygen concentrations were below 5 mg/L at only two stations (Station 8-2 at 2.8 mg/L and

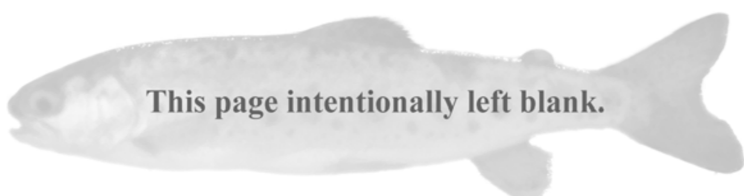
Station 15-1 at 4.0 mg/L. Turbidity readings were less than 1.0 NTU at all locations, with the exception of sites 6, 10 and 13 (Table 5-5). Although it is unclear whether or not there is a direct relationship, it is interesting to note that these three sites are in, or directly downstream of, cattle crossings. Each site (two in Alameda Creek and one in Arroyo Hondo) was visibly impacted by cattle (destabilized banks, the presence of manure in and around the creek bed, etc.).

The average dissolved oxygen measurements for all sites in Alameda Creek was 7.2 mg/L, and the average conductivity reading was 501 microS/cm. Generally speaking, water quality was best at the Arroyo Hondo sites and worst at the Calaveras Creek sites.

Table 5-5. *Alameda Creek water quality measurements for the 2003 autumn and winter electrofishing surveys. See Section 8 for details about site locations and habitat descriptions.*

	Water Quality Measurement															
	Site Number - Habitat Number															
Water Quality Parameter	1-1	3-1	3-2	4-1	4-2	4-3	5-1	6-1	6-2	6-3	6-4	7-1	7-2	7-3	8-1	8-2
Time Measured	845	828	834	850	859	904	824	831	833	836	839	853	858	902	1202	1213
Temperature (°C)	14.5	14.8	14.9	14.8	15	14.9	15.9	15.3	15.5	15.9	15.6	17.2	17.5	17.7	16.9	17.6
Turbidity (NTU)	0.37	0.42	0.38	0.9	0.4	0.4	0.67	0.55	0.92	1.35	2.81	0.35	0.61	0.36	0.32	0.86
pH	8.07	7.89	7.97	8.16	8.18	8.17	7.65	7.92	7.9	7.81	7.81	7.35	7.32	7.28	7.64	7.28
Dissolved Oxygen (mg/L)	8.2	8	8.8	8.8	8.8	9.2	6	6.3	6.2	5.9	5.5	6.3	6.4	6.2	6.5	2.8
Conductivity (microS/cm)	449	609	552	665	662	665	538	511	510	509	515	445	N/A	453	1100	1380

	Water Quality Measurement													
	Site Number - Habitat Number													
Water Quality Parameter	10-2	10-3	11-1	11-2	12-1	12-2	13-1	13-2	14-1	14-2	15-1	15-2	15-3	Mean
Time Measured	1310	1317	1326	1330	835	841	922	1205	841	836	1225	1244	1337	---
Temperature (°C)	16.7	16.5	16.8	16.5	15	15.3	12.3	14.6	13.9	14.1	14.1	14.1	13.8	15.4
Turbidity (NTU)	1.29	1.05	0.35	0.31	0.25	0.31	0.74	1.89	0.73	0.54	0.49	0.42	0.67	0.71
pH	7.77	7.83	7.33	7.35	7.95	7.76	7.93	7.68	7.63	7.59	7.52	7.72	7.79	7.73
Dissolved Oxygen (mg/L)	7.5	8	5.4	5.8	8.4	8	8.6	9.3	7.2	6.7	4	5.7	6.6	6.9
Conductivity (microS/cm)	392	434	557	558	476	477	397	377	542	543	831	834	832	581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6.0 Spawning Survey

Background

Water releases and improved water quality in the cold water reach of the study area are intended to provide conditions suitable for rainbow trout spawning and rearing. Trout spawning activities in upper Alameda Creek are expected to increase with an improvement in habitat conditions. This component of the monitoring study is designed to identify the existing rainbow trout spawning activity that occurs in upper Alameda Creek.

Procedure

A single spawning survey was conducted on March 11, 2003. The survey started in Alameda Creek at 1040, at the glide just behind the interpretive center (green barn) in Sunol Regional Park. The spawning survey ended in Alameda Creek at 1535, above “Little Yosemite” in a section where the creek is in close proximity to the road near a large culvert structure (Figure 6-1).

The survey consisted of two SFPUC biologists walking side-by-side, in an upstream direction, looking for signs of spawning trout that included paired adults, redds and fry. Each biologist was required to wear a visored hat and a pair of polarized sunglasses to optimize their ability to view fish and redds in the water.

11 March 2003

This year’s survey was conducted later in the spawning season than desired, due primarily to sustained high flows in Alameda Creek as a result of an unusually wet rainy season, and time constraints placed upon SFPUC personnel working on the Calaveras and San Antonio fish-trapping project. Therefore, observations focused on looking for fry as opposed to actively spawning adults and redds.

Water temperatures varied little during the survey, ranging from a low of 12.5 °C at a pool within Little Yosemite to a high of 15.5 °C at the USGS gauge. No adult rainbow trout, trout redds or fry were observed during the survey. Four juvenile rainbow trout were, however, observed in three different locations; one approximately five- or six-inch fish was spotted in a pool just upstream of the confluence of Calaveras and Alameda creeks. Two rainbows, both about six inches, were observed in a shallow pool within Little Yosemite and another, approximately eight-inch trout, was observed in a pool near the top of Little Yosemite. It should be noted that the relatively high flow conditions at the time of the survey, paired with the geomorphological characteristics of Little Yosemite (many large boulders), made observing fishes difficult at best, and it is reasonable to assume that additional rainbow trout were present at that location.

Figure 6-1. *March 11, 2003, Alameda Creek spawning survey route (red line).*

7.0 Snorkel Survey

Background

There are deep pools along Alameda and Calaveras creeks and Arroyo Hondo that may be important to sustaining populations of rainbow trout and native, warm water fishes (Figure 7-1). These pools can provide cool-water refugia, especially during summer and early fall when temperatures are at their highest. This component of the study is designed to evaluate the extent to which pools in these three streams currently provide suitable habitat to fishes. A series of selected pools will be monitored to determine whether or not water releases enhance pool conditions for rainbow trout in the upper study reach, and how releases affect warm water species using pools in the lower study reach. Snorkel surveys are a cost-effective means of sampling deeper pools where electrofishing does not work well (pools ≧ four-feet deep).

Figure 7-1. *Snorkelers in a deep pool in upper Alameda Creek.*

Procedure

Thirteen pools were snorkeled on August 26 and 27, and September 4, 2003 in Alameda and Calaveras creeks and Arroyo Hondo (Figure 7-2, Table 7-1). Upon arrival at each pool, the team of biologists visually inspected the area from the bank and discussed how the survey would be conducted. Issues determined at each site included the number of snorkelers, starting positions, the count direction and path, and the end-point of the survey.

The number of snorkelers required for each survey was dependent on the width and depth of the pool, such that complete coverage of the pool was ensured. Spacing between snorkelers was always small enough so that fish counts were accurate, yet large enough so that the ability to swim or count fish was not impeded (Figure 7-3).

Each snorkel survey began at the downstream end of the pool being examined (Figure 7-3). In most cases, the water depth at the survey starting point was so shallow that snorkelers were essentially crawling on their bellies with only their face-mask in the water. The snorkelers moved slowly upstream as a group, identifying species by size class, and counting fish only as they were encountered

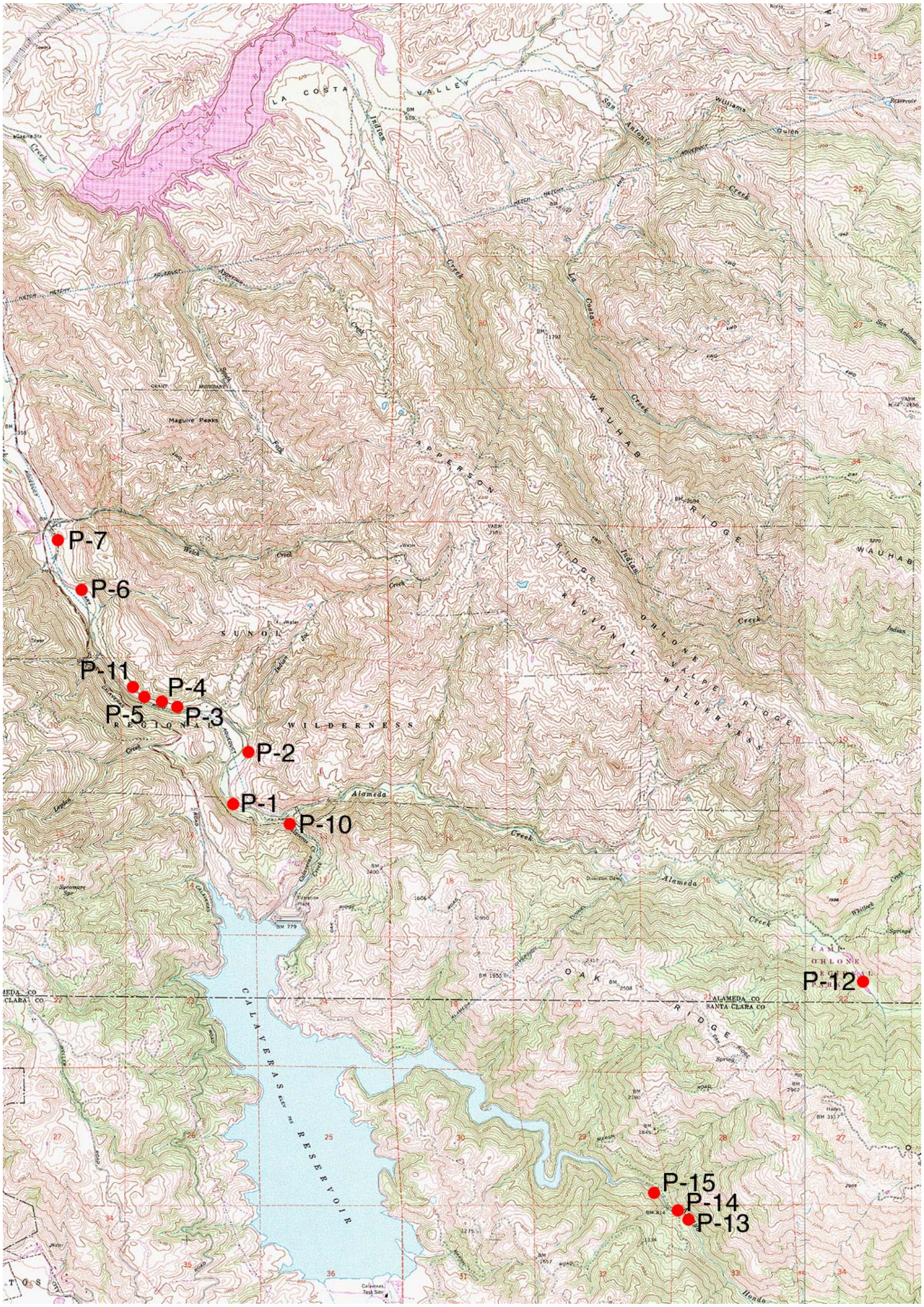


Figure 7-2. *Snorkel survey sites in Alameda and Calaveras creeks and Arroyo Hondo.*

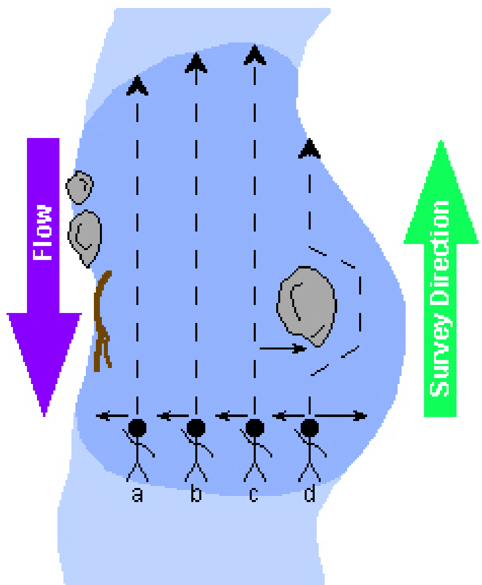


Figure 7-3. *Typical snorkel survey strategy. Snorkelers count fish in the direction the arrows indicate, from their arm to the bank or to the snorkeler next to them.*

passing between biologists or between a biologist and the bank (Figure 7-3). One snorkeler was selected to count fish to their left and right. Each snorkeler did their best to swim with one arm hanging downward to help demarcate the boundary of the counting areas. The group proceeded at the pace of the slowest member (usually the biologist encountering the most fish).

Some of the pools included large boulders or trees in the water, making it impossible for the snorkelers to swim a straight line. In these situations, the biologists determined which snorkelers would deviate from a straight line prior to the start of the survey. That snorkeler also had to be aware to count fish to the right and left whenever they became separated by an obstruction (Figure 7-3).

Surveys ended at the upstream end of each pool. In some cases, the width of the upstream end was significantly narrower than the rest of the pool, making it necessary for one or more snorkelers to drop out while the remaining biologist(s) finished the survey.

Species Composition

A total of seven species were observed in thirteen pools during the 2003 snorkel survey (Figure 7-4). An additional four pools were added to the 2003 survey; one on Alameda Creek further up into the watershed, just south of Camp Ohlone and the other three on Arroyo Hondo, which is a tributary to Calaveras Reservoir. California roach was the most abundant species, accounting for 94.2 percent of all fishes observed, followed by Sacramento sucker (2.9 percent of total) and Sacramento pikeminnow (2.1 percent of total). California roach were present in all of the pools surveyed while Sacramento sucker were found in twelve of the thirteen pools. Sacramento pikeminnow were present in eight of the thirteen pools. Largemouth bass and sunfish accounted for 0.6 percent of all fishes observed, and were each limited to a single pool. Rainbow trout accounted for 0.2 percent of the total, and were observed in three pools, two of which were in Arroyo Hondo.

Pool P-1 was approximately two-feet deep at its deepest point, on the left side (looking downstream) approximately one third through the pool. Forty percent of the surface was shaded. California roach (63 percent adults) accounted for 90 percent of the 301 fishes observed, although this pool had lower numbers of roach when compared with other pools overall (Figure 7-4, Appendix C). The remaining fishes in this pool were juvenile and adult Sacramento pikeminnow and adult Sacramento sucker. This pool experienced notable aggradations since the previous year's survey.

Table 7-1. *Snorkel survey station descriptions for 2003.*

Station	Pool Name	Pool Location	Date	Start Time	Surface Temp.	Bottom Temp.
P-1	Swimming Pool	In Alameda Creek, ~ 1,200-feet upstream of the wooden truss bridge in Sunol Regional Park.	8/26/03	10:50	21.5 °C	21.4 °C
P-2	Rat Pool	In Alameda Creek, ~ 900-feet downstream of the wooden truss bridge in Sunol Regional Park.	8/26/03	09:50	21.0 °C	20.5 °C
P-3	Fence Pool	In Alameda Creek, just downstream of the Sunol Regional Park / SFPUC boundary fence.	8/26/03	15:30	26.2 °C	24.1 °C
P-4	Lunch Pool	In Alameda Creek, ~ 3,000-feet downstream of the Sunol Regional Park / SFPUC boundary fence.	8/26/03	15:05	23.9 °C	20.5 °C
P-5	Sycamore Pool	In Alameda Creek, ~ 4,000-feet downstream of the Sunol Regional Park / SFPUC boundary fence.	8/26/03	14:25	25.2 °C	22.6 °C
P-6	S-Bend Pool	In Alameda Creek, ~ 3,000-feet upstream of the Calaveras Road bridge.	8/27/03	15:00	23.1 °C	20.5 °C
P-7	Bathing Pool	In Alameda Creek, ~120-feet upstream of the Calaveras Road bridge.	8/27/03	14:23	23.8 °C	22.5 °C
P-10	Bass Pool	In Calaveras Creek, ~50-feet upstream of the Alameda Creek / Calaveras Creek Confluence.	8/26/03	11:30	23.2 °C	20.3 °C
P-11	Shade Pool	In Alameda Creek, ~4,500-feet downstream of the Sunol Regional Park / SFPUC boundary fence.	8/26/03	13:40	24.9 °C	22.5 °C
P-12	Sycamore Camp Pool	In Alameda Creek, ~1,000-feet upstream of the Camp Ohlone southern boundary.	9/4/03	13:30	18.9 °C	18.3 °C
P-13	Butterfly Pool	In Arroyo Hondo, ~800-feet upstream of the USGS gauging station.	8/27/03	11:45	20.8 °C	18.5 °C
P-14	USGS Gauge Pool	In Arroyo Hondo, just upstream of the USGS gauging station.	8/27/03	11:00	19.6 °C	19.0 °C
P-15	Raccoon Pool	In Arroyo Hondo, ~800-feet downstream of the USGS gauging station.	8/27/03	10:00	18.8 °C	18.8 °C

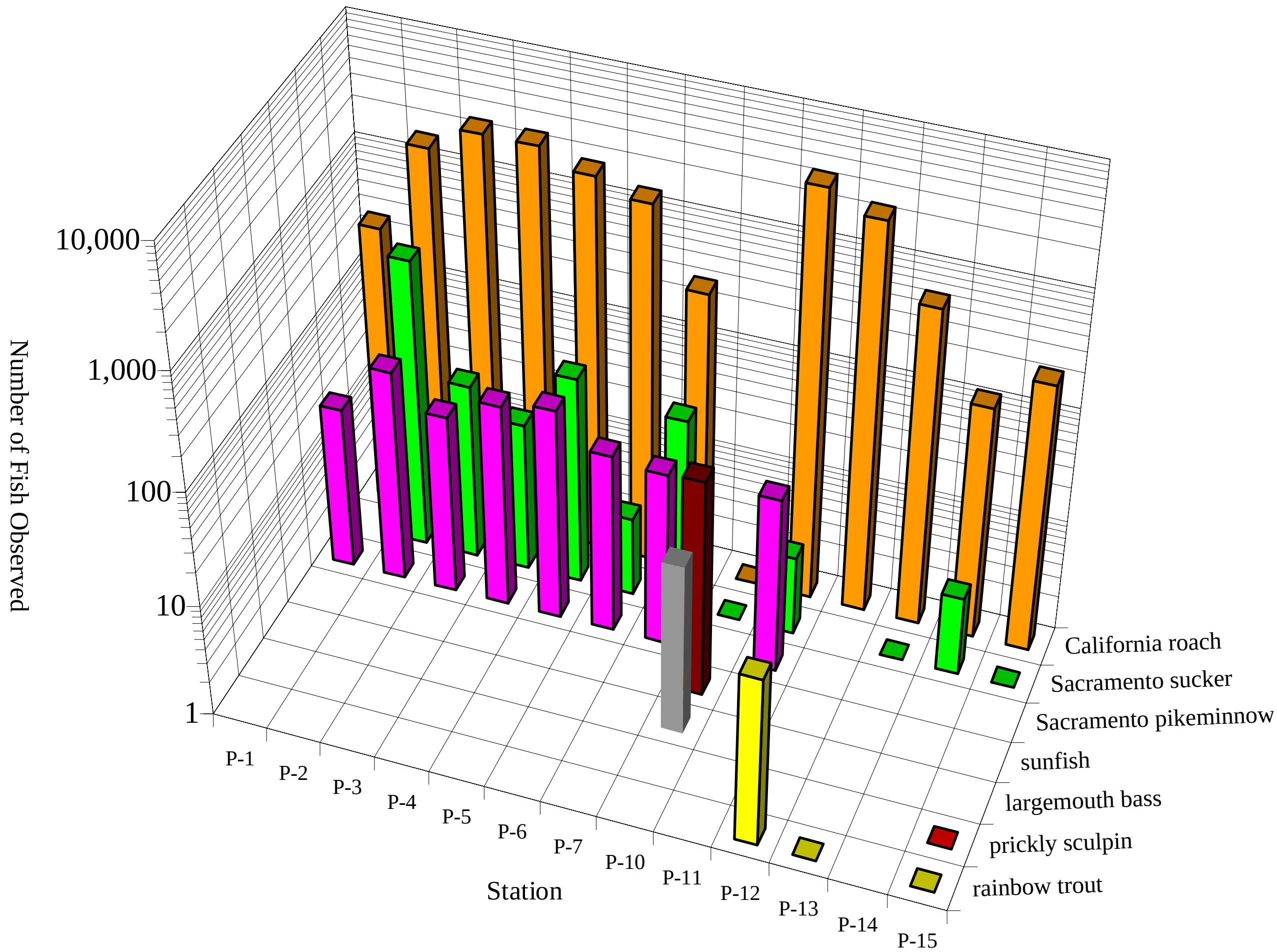


Figure 7-4. *Number of fishes observed by pool during snorkel surveys for 2003.*

Pool P-2 was deepest on the right side midway downstream, with a relatively large gravel bar at the downstream end. Riparian vegetation shaded approximately 95 percent of this pool. California roach (26 percent adults) accounted for 79 percent of the 2,009 fishes counted in Pool P-2. Sacramento pikeminnow (16 percent adults) and Sacramento sucker (three percent adults) made up the remainder of the fishes observed. This pool contained the greatest number of both Sacramento suckers and Sacramento pikeminnow.

Although Pool P-3 was almost entirely in the sun, a relatively large number of boulders provided cover for fishes. The deepest section, at just over three-feet, was midway downstream between the right bank and a large boulder. This pool had the second highest count of California roach (15 percent adults), which accounted for 97 percent of the fishes observed in the pool. Sacramento pikeminnow and Sacramento sucker combined for the remaining three percent. There were six adult pikeminnow and a single adult sucker.

Pool P-4 was deepest near the steep left bank, about one third of the way down the pool. Approximately 90 percent of the surface was shaded. A significant gravel bar divided the main channel flow and a shallow riffle at the head of the pool. This pool had the third highest count of California roach (22 percent adults), which accounted for 97 percent of the 2,629 fishes observed. Sacramento pikeminnow and Sacramento sucker made up the remaining three percent of the fishes observed.

Pool P-5 was deepest one-third the way downstream near the steep left bank, which also had the majority of riparian cover that shaded about 90 percent of the surface. California roach accounted for 93 percent of the 1,970 fishes observed, while Sacramento pikeminnow and Sacramento sucker accounted for the remaining seven percent, respectively. The majority of the fishes observed were juveniles, with only four percent of the roach and 15 percent of the pikeminnow being adults. There were no adult suckers observed.

The deepest part of Pool P-6 (4.5-feet) was on the right side. This pool occurs on a bend in the creek, with the deeper side lined with several large boulders and shaded by vegetation. The shallow side of the bend had virtually no vegetation or cover with a bottom composed primarily of silt, sand and detritus. California roach (12 percent adults) accounted for 97 percent of the 1,409 fishes observed. Sacramento pikeminnow and Sacramento sucker accounted for the remaining three percent. This pool had the greatest number of adult Sacramento pikeminnow. Evidence of recent cattle disturbances was noted. There were numerous pockets of undercut, sheltered areas beneath boulders on the right side of the stream, and count estimates may have been low here due to poor visibility.

Pool P-7 was completely isolated from surface flow and deepest in the middle, with less than five percent of the surface shaded. California roach (11 percent adults) accounted for 78 percent of the 395 fishes observed. Sacramento pikeminnow and Sacramento sucker accounted for the remainder. There were five adult pikeminnow and five adult suckers observed.

Pool P-10 was just over six-feet at its deepest point on the right, next to a boulder above the SFPUC/Sunol Regional Park boundary fence. Riparian vegetation along each bank was relatively thick, and 20 percent of the surface was shaded. Although this pool had the fewest documented numbers of fishes (118), thousands of unidentified young-of-year fishes were observed just under a scum layer at the upstream end of the pool. It should also be noted that the majority of the reach was overgrown by extensive macrophytes beds. This, coupled with high turbidity levels, made observations difficult, and the counts likely underestimate relative abundances. Non-native sunfish and largemouth bass comprised 70 and 28 percent of the fishes observed, respectively. Fourteen percent of the sunfish and three percent of the bass were adults. One adult California roach and one adult Sacramento sucker comprised the remainder.

Dense riparian stands shaded almost 80 percent of Pool P-11, with the left side comprised of overhanging branches, root masses and bedrock. The deepest point was located midway downstream near the left bank. This pool had the highest number of California roach (19 percent adults) accounted for 99 percent of the 3,638 fishes observed. Sacramento sucker and Sacramento pikeminnow accounted for the remainder. Ten adult pikeminnow and no adult sucker were observed.

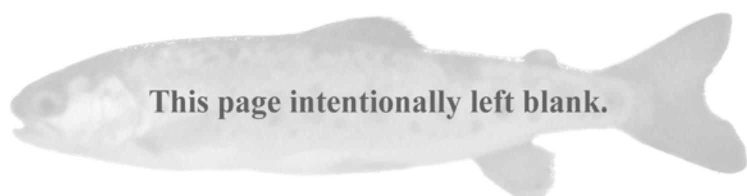
Pool P-12 was added to the survey this year. A large downed sycamore lies directly over the pool. Prior to the survey, numerous adult rainbow trout were observed from atop the pool’s steep left bank. The deepest point, at 2.7-feet, was located in the lower third of the pool and ten percent of the entire surface was shaded. California roach (2 percent adults) accounted for 99 percent of the 2,502 fishes observed. Although this pool contained the greatest number of rainbow trout

(32 total with 28 percent adults), it is likely that adults and juveniles seeking refuge in the root mass of the large sycamore went undetected, and the counts underestimate relative abundances.

Pool P-13 was one of three of the following pools added to the survey this year on Arroyo Hondo, a tributary to Calaveras Reservoir. These pools provided ample cover with rocks, logs, overhanging vegetation and undercut banks. The deep point of Pool P-13 was located next to a large boulder near the end of the pool, and ten percent of the surface was shaded. California roach (three percent adults) accounted for almost 100 percent of the 614 fishes observed, with one adult rainbow trout and one adult Sacramento sucker comprising the remainder.

Located just upstream of the USGS gauging station, Pool P-14 was approximately 4.2-feet deep at the downstream end on the left, with a large gravel bar on the opposing bank. Twenty percent of the surface was shaded. The second fewest number of fishes were observed in this pool with California roach (1 adult) accounting for 96 percent of the 121 fishes observed. Sacramento sucker accounted for the remainder.

Pool P-15 is located about 800-feet downstream of the Marsh Road bridge. Its deepest point was midstream in the upper third of the pool. Approximately 40 percent of the pool was shaded. The third fewest number of fishes were observed in this pool with California roach (41 percent adult) accounting for 99 percent of the 236 fishes. One adult rainbow trout, one juvenile Sacramento sucker and one prickly sculpin accounted for the remainder.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8.0 Electrofishing Survey

Background

Habitat conditions in Alameda and Calaveras creeks are expected to improve once flow requirements, described in the Memorandum of Understanding (MOU) between the San Francisco Public Utilities Commission and the California Department of Fish and Game, are met. The distribution and abundance of rainbow trout should increase in the upper study reach, while maintaining populations of native, warm water fishes in the lower study reach. Meeting the objectives of the MOU, however, does not limit populations of rainbow trout to the upper study reach, nor does it restrict populations of warm water fishes to the lower study reach.

To evaluate the affects of the flow requirements stipulated in the MOU, fish populations in both the upper and lower study reaches must be monitored before and after flow requirements are met. Additionally, fishes from other parts of the watershed, where existing conditions are suspected to be suitable for rainbow trout, should be examined and compared to those areas covered by the MOU. Monitoring for several years prior to water releases from Calaveras Reservoir will document present conditions, while a minimum of five years of post-water release monitoring are anticipated to be necessary to demonstrate the effects of releases.

Procedure

Electrofishing surveys took place at 13 stations between September 29 and October 15, 2003 in Alameda, Calaveras, La Costa and Indian creeks and in Arroyo Hondo (Figure 8-1, Table 8-1). The Indian Creek and Arroyo Hondo stations are both new, being sampled for the first time in 2003 (Figure 8-1, Table 8-1). Distinct habitat types (pools, riffles, runs and glides) at each station were surveyed independently of one another. Not all stations had equal representation of the four habitat types.

Upon arrival at each sampling station, habitat types were isolated with 3/8-inch mesh block-nets. Care was taken to not walk in the selected creek reaches prior to deploying the nets.

Each habitat type was sampled using multiple-pass electrofishing techniques. Depending on the size and complexity of the habitat type, one or two teams of SFPUC biologists and volunteers would make a series of three or more passes from the downstream block-net to the upstream net. Teams typically consisted of four people; one “shocker” with backpack electrofisher unit, two “netters” and one “bucket handler.” Team members kept the same job for all passes through specific habitat types. Sediments stirred up by the crew(s) were allowed to settle for a reasonable amount of time between passes – waters, however, did not clear completely in all cases. Fishes captured were transported by bucket outside of the habitat being surveyed and were either processed immediately or held in live-cars for later processing.

When making a pass through a habitat type, team members would slowly move upstream, working from side to side to cover the entire area. Netters would capture

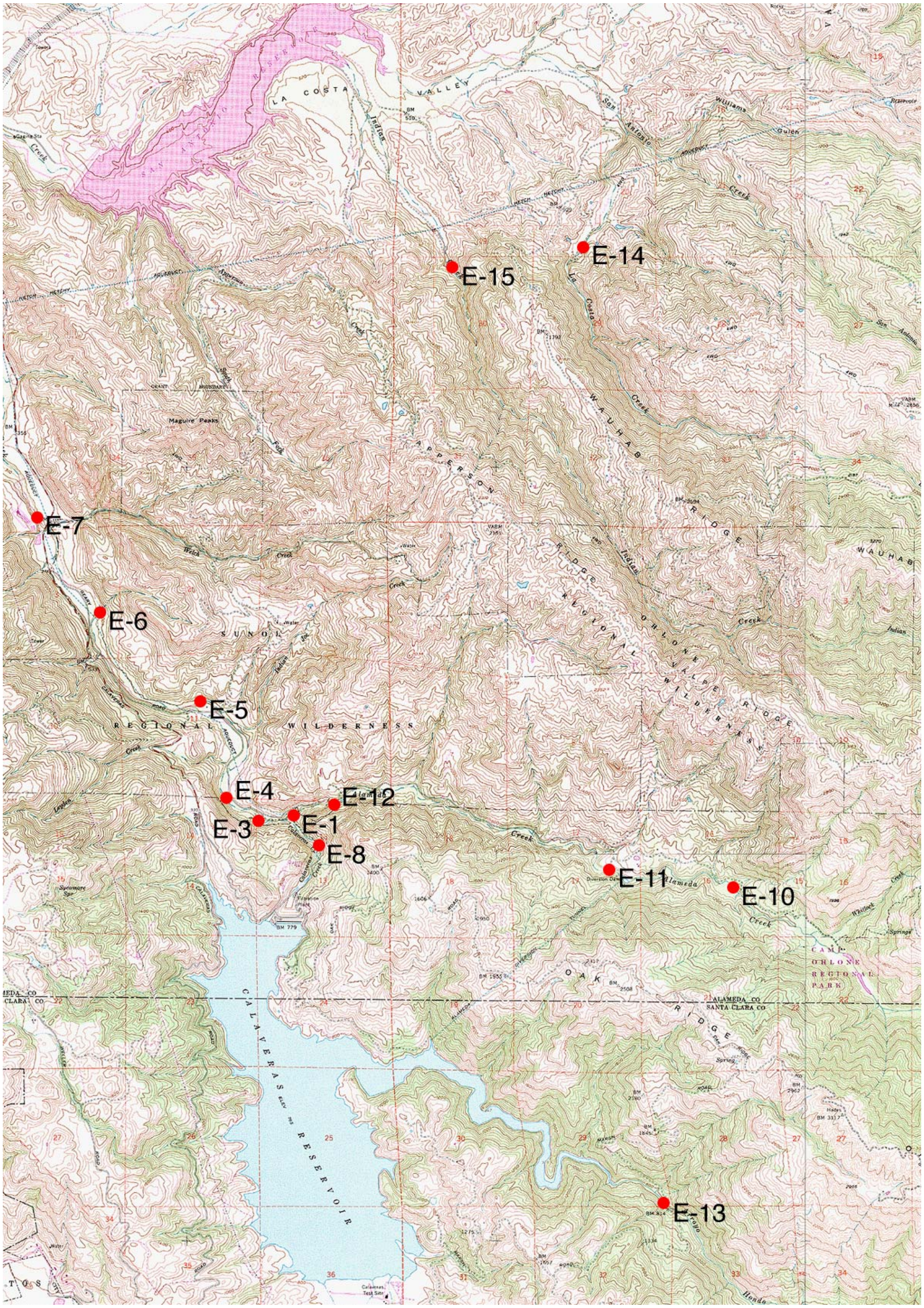


Figure 8-1. *Alameda, Calaveras, La Costa and Indian creeks and Arroyo Hondo 2003 electrofishing survey stations.*

the bulk of the stunned fishes attracted to the anode of the electrofisher and transfer them to a bucket, while the shocker would try to capture fishes missed by the netters – the bucket handler would capture fishes entering the field near the trailing cathode. On subsequent passes through a habitat type, team members would attempt to follow the same paths and perform the same actions that were done during the first pass in an effort to keep catch efficiencies equal between passes.

Table 8-1. *Electrofishing survey station descriptions for 2003.*

Station	Station Location	Habitat Types
E-1	In Alameda Creek, upstream of the confluence of Alameda and Calaveras creeks.	#1 = Pool
E-3	In Alameda Creek, downstream of the confluence of Alameda and Calaveras creeks.	#1 = Glide #2 = Low Gradient Riffle
E-4	In Alameda Creek, upstream of the wooden truss bridge in Sunol Regional Park.	#1 = Glide #2 = Low Gradient Riffle #3 = Glide
E-5	In Alameda Creek, upstream of the Sunol Regional Park / SFPUC boundary fence, near the interpretive center in the Park.	#1 = Pool
E-6	In Alameda Creek, at the downstream most Calaveras pipeline crossing.	#1 = Run #2 = Low Gradient Riffle #3 = Glide #4 = Pool
E-7	In Alameda Creek, downstream of the Calaveras Road bridge, near the Sunol Valley Water Treatment Plant.	#1 = Glide/Pool/Glide #2 = Low Gradient Riffle/Run #3 = Run
E-8	In Calaveras Creek, near the walkway paralleling the Calaveras pipeline.	#1 = Pool #2 = Pool
E-10	In Alameda Creek, upstream of the Alameda Creek Diversion Dam.	#2 = Glide/Low Gradient Riffle #3 = Lateral Scour Pool
E-11	In Alameda Creek, downstream of the Alameda Creek Diversion Dam.	#1 = Lateral Scour Pool #2 = Low/High Gradient Riffle
E-12	In Alameda Creek, in and toward the top of Little Yosemite.	#1 = Step Pools #2 = Low Gradient Riffle
E-13	In Arroyo Hondo, between the USGS gauging station and just downstream of the Marsh Road bridge.	#1 = Glide #2 = Low Gradient Riffle
E-14	In La Costa Creek, at the boundary between SFPUC property and private property.	#1 = Glide #2 = Low Gradient Riffle
E-15	In Indian Creek, upstream of where the canyon becomes relatively narrow and steep.	#1 = Isolated Pool #2 = Isolated Pool #3 = Step Pools

At the end of each pass, all captured fishes were identified to species and measured (fork length or total length for fishes without forked tails). Several individuals from each species were weighed. Scale (from directly below the dorsal fin) and tissue (caudal fin clip) samples were collected from all rainbow trout. Fishes were held after processing in a habitat-specific live-car while additional electrofishing passes were conducted. Once sampling was complete in a specific habitat, all processed fishes from that habitat were returned to the general area where they were caught.

Station Descriptions

Electrofishing station E-1 consisted of a single habitat type: a pool. The pool was 92-feet long, with an average width and depth of 12.9-feet and 1.5-feet, respectively. The maximum depth, located at the upstream end of the pool, was 3.8-feet. The dominant substrate types were cobble, gravel and sand, although there were several large boulders along the right side of the pool and a fair amount of bedrock at the upstream end. There was about 20-feet of undercut bank and 6-feet of overhanging vegetation on both sides of the station. The riparian vegetation was relatively heavy, and although 100 percent of the pool was shaded at the start of the survey, the cover shaded only 15 to 20 percent of the surface by the final pass.

Electrofishing station E-3 consisted of two habitat types: a glide and a low gradient riffle. The glide was 85-feet long, with an average width and depth of 24.3-feet and 0.5-feet, respectively. The maximum depth of the glide, located in the middle of the channel about midway through the section, was 1.5-feet. The majority of the substrate in the glide was cobble, and cover was provided by several boulders, some rubble and about 40-feet of overhanging vegetation along both the left and right banks. There was evidence that cattle had recently grazed some of the vegetation. One hundred percent of the glide was shaded at the start of the survey, dropping to 60 percent by the finish. The riffle was 66.5-feet long, with an average width and depth of 8.8-feet and 0.3-feet, respectively. A maximum depth of one-foot was found mid-channel, at the end of the riffle. The majority of the riffle's substrate was made up of cobble, with some gravel. Several boulders and about 45-feet of overhanging vegetation provided cover in the riffle. There were signs of significant grazing. Forty to 50 percent of the riffle was shaded during the survey.

Electrofishing station E-4 consisted of three habitat types: a glide, a low gradient riffle, and a second glide. The first glide was 35.5-feet long, with an average width and depth of 14.9-feet and 0.5-feet, respectively. The dominant substrate in the glide was bedrock, although about 40 percent of the bottom was covered with a mixture of cobble and gravel. Cover was provided by a few boulders and ten-feet of overhanging vegetation. Approximately 90 percent of the section was shaded at the start of the survey, while only five percent was shaded by the end of the survey. The riffle was 108.5-feet long, with an average width and depth of 11.7-feet and 0.2-feet, respectively. The dominant substrates in the riffle were rubble and cobble. Some cover in the riffle was provided by tules and bunch grass on both the left and right sides of the stream, although cattle had grazed much of the grass at the upstream end of the section. The amount of shading during the survey ranged from five to 80 percent. The second glide was 120-feet long, with an average width and depth of 18.5-feet and 0.7-feet, respectively. The greater length of this glide, in comparison to past years, is due to access facilitated by the elimination of a barbed-wire fence that crossed the creek. The dominant substrates in the glide were gravel, rubble and cobble, while tules along the right bank provided cover. Shading ranged from 30 to 100 percent during the survey.

Electrofishing station E-5 consisted of a single habitat type: a pool. The pool was extremely long, with the lower section too deep to be effectively sampled with electrofishing gear. Consequently, only the upper 74-feet, with an average width and depth of 20.3-feet and 1.6-feet, respectively, were sampled. A maximum depth of 3.0-feet was found on the upstream end of the pool on the right side of the stream. The dominant substrates were cobble and sand. Some boulders, about 37-feet of undercut bank with submerged tree roots, ten-feet of overhanging vegetation and a single log, provided cover. Ninety-five percent of the pool was shaded at the start of the survey, dropping to about 80 percent by the time it was completed.

Figure 8-2. *SFPUC biologists Patricia McGregor (left) and Pat Conroy electrofishing a low gradient riffle on La Costa Creek.*

Electrofishing station E-6 consisted of four habitat types: a run, low gradient riffle, glide and pool. The recent presence of cattle was obvious throughout this station. The run was 87.5-feet long, with an average width and depth of 14.2-feet and 0.6-feet, respectively. The deepest point in the run was 1.8-feet and located about mid-channel toward the upstream end of the habitat. The dominant substrates in the run were gravel and cobble, and cover was provided by a few boulders and 15-feet of overhanging vegetation. Eighty to 100 percent of the run was shaded during the survey. The riffle was 124-feet long, with an average width and depth of 13.4-feet and 0.2-feet, respectively. The dominant substrate in the riffle was cobble, followed by rubble then gravel. Other than a few boulders, there was no cover in the riffle. Thirty percent of the riffle was shaded at the start of the survey, dropping to 20 percent by the time it was completed. The glide was 41-feet long, with an average width and depth of 32.6-feet and 0.6-feet, respectively. A maximum depth of 1.4-feet was found on the left side of the channel at the upstream end of the section. The dominant substrate in the glide was gravel, and other than a single large, submerged boulder and a few smaller rocks, there was no cover. There was no shade on the glide during the majority of the survey. The pool was 116-feet long, with an average width and depth of 23.8-feet and 1.1-feet, respectively. The maximum depth was 2.9-feet, located just past halfway through the pool, to the left of mid-channel. The dominant pool substrates were gravel, cobble and sand. Several boulders, about seven-feet of undercut bank and 15-feet of overhanging vegetation, provided cover. Seventy to 100 percent of the pool was shaded during the survey.

Electrofishing station E-7 consisted of three habitat types: a glide flowing into a deep pool that flowed back into a glide, a low gradient riffle flowing into a run, and a run. The glide/pool/glide complex was 85.5-feet long, with an average width and depth of 21.1-feet and 0.9-feet, respectively. The deepest part of the pool section was 3.6-feet, and was located on the left side of the stream about mid-way between the upstream and downstream nets. The dominant substrates in the glide/pool/glide were cobble and gravel, and there was a significant amount of silt. Cover in the glide/pool/glide was provided by 30-feet of undercut bank in the form of a huge sycamore root mass. The glide/pool/glide was completely shaded during the survey. The low gradient riffle/run was 63.5-feet long, with an average width and depth of 14.3-feet and 0.3-feet, respectively. The deepest part of the run, located at the downstream end, was 0.8-feet. The dominant substrate in this section was cobble, with some gravel. The only cover in the riffle/run consisted of two relatively small patches of emergent vegetation and some algae mats. One hundred percent of the riffle was shaded during the survey. The run was 154.5-feet long, with an average width and depth of 17.9-feet and 0.5-feet, respectively. A maximum depth of 1.2-feet was found to the right of mid-channel about mid-way through the section. The dominant substrate in the run was gravel. A single instream log on right side of the section and an alder lying in the water on the left provided cover in the run. The entire run was shaded during the survey.

Electrofishing station E-8 (Figure 8-2) consisted of two habitat types: both pools. The most downstream pool (pool 1) was 44-feet long, with an average width and depth of 14.4-feet and 1.3-feet, respectively. The deepest part of pool 1, located about mid-channel at the upstream end, was 2.8-feet. The dominant substrate in pool 1 was boulders, and about 55-feet of overhanging vegetation provided additional cover. Shading in pool 1 through the day ranged from 40 to 90 percent. Pool 2 was 21-feet long, with an average width and depth of 6-feet and 1.5-feet, respectively. A maximum depth of 2.3-feet was located at the upstream end of pool 2, about mid-channel. Pool 2 was isolated from Calaveras Creek, with no surface water flowing in or out. The dominant substrate in pool 2 was boulders, with a single log and a small patch of emergent vegetation providing additional cover. Shading in pool 2 ranged from 85 to 95 percent during the survey.

Electrofishing station E-10 consisted of two habitat types: a glide running into a low gradient riffle and a lateral scour pool. An additional low gradient riffle that is typically monitored at this station had too little water to sample. There were signs of recent cattle activity throughout the station. The glide/riffle was 99-feet long, with an average width and depth of seven-feet and 0.4-feet, respectively. The deepest part of the glide portion, located to the left of mid-channel at the downstream end, was 0.7-feet. The dominant substrates were a combination of boulders, rubble and coble, with no other cover available. Ninety to 100 percent of the section was shaded during the survey. The lateral scour pool was 54.5-feet long, with an average width and depth of 9.2-feet and 1.1-feet, respectively. The deepest part of the pool, located mid-channel about halfway between the upstream and downstream nets, was 2.7-feet. The dominant substrates were boulders, cobble and gravel. There was a small amount of bunchgrass scattered along the right side of the section, but because cattle had grazed the area it provided no additional cover. Shading in the lateral scour pool ranged from 80 to 100 percent.

Electrofishing station E-11 consisted of two habitat types: a lateral scour pool and a low gradient riffle flowing into a high gradient riffle. The pool was 30-feet long, with an average width and depth of 7.4-feet and 0.9-feet, respectively. The maximum depth of the scour pool, located near the middle of the channel toward the downstream end the pool, was 2.6-feet. The majority of the substrate in the pool was bedrock, while numerous large boulders and about 6-feet of overhanging vegetation provided cover. Ninety to ninety-five percent of the pool was shaded during the survey. The riffle was 55-feet long, with an average width and depth of 5.4-feet and 0.2-feet, respectively. The majority of the riffle's substrate was of cobble, with some gravel. Some boulders in the high gradient riffle portion of the section provided the only cover. Shade in the riffle ranged from 95 to 100 percent.

Electrofishing station E-12 consisted of two habitat types: a series of step pools and a low gradient riffle. The step pools and connecting water combined for a total length of 98-feet, with an average width of 9.8-feet. The average depth of each pool, from upstream to downstream was 1.3-feet, 0.7-feet, 0.7-feet and 0.8-feet. The maximum depths of the pools were 2.9-feet, 1.6-feet, 1.2-feet and 1.7-feet, respectively. The majority of the substrates in the pools were cobble and gravel. Several boulders provided the only cover in the pools. Dense riparian canopy shaded 100 percent of the section during the survey. The riffle, which was partially braided, was 60-feet long, with an average overall width and depth of 6.4-feet and 0.4-feet, respectively. A maximum depth of 1.4-feet was found on the right side of the channel, at the upstream end of the section. The majority of the riffle's substrate was cobble. Several boulders and a few scattered clumps of bunchgrass provided cover. Ninety to 100 percent of the riffle was shaded during the survey.

Electrofishing station E-13 consisted of two habitat types: a glide and a low gradient riffle. The glide was 102.5-feet long, with an average width and depth of 17.5-feet and 0.7-feet, respectively. The maximum depth of the glide, located just off the left bank about two-thirds of the way downstream, was two-feet. Most of the glide's substrate was cobble and gravel. Some boulders and 40-feet of overhanging vegetation along the left bank provided cover. Although the riparian vegetation along this portion of creek is dense, the large drainage and associated bed load has made this section relatively open, providing only 20 to 60 percent shade during the survey. The low gradient riffle was 84-feet long, with an average width and depth of 18.8-feet and 0.3-feet, respectively. The majority of the riffle's substrate was rubble, followed by cobble and gravel. Several boulders provided the only cover in the riffle. About ninety-five percent of the section was shaded during the survey.

Electrofishing station E-14 consisted of two habitat types: a glide and a low gradient riffle. The glide was 40-feet long, with an average width and depth of 10.6-feet and 0.4-feet, respectively. The maximum depth of the glide, located on the left side of the channel in the upper third of the section, was one-foot. The majority of the glide's substrate was cobble and gravel, while some boulders, rubble, and two-feet of undercut bank at the downstream end of the section, provided cover. The dense riparian canopy over this reach of the creek resulted in 75 to 100 percent shading of the section during the survey. The low gradient riffle was 40.5-feet long, with an average width and depth of 6.2-feet and 0.2-feet, respectively. The majority of the riffle's substrate was cobble, followed by gravel and rubble. Several boulders provided the only cover. Ninety-five to 100 percent of the section was shaded during the survey.

Electrofishing station E-15 consisted of three habitat types: two isolated pools and a series of step pools. The most downstream pool (pool 1) was 19-feet long, with an average width and depth of 5.9-feet and 0.6-feet, respectively. The deepest part of pool 1, located about mid-channel at the upstream end, was 1.6-feet. The dominant substrate in pool 1 was gravel, with several boulders providing cover. Shading in pool 1 through the day ranged from 90 to 100 percent. The second isolated pool was 11-feet long, with an average width and depth of 4.1-feet and 0.6-feet, respectively. A maximum depth of one-foot was located about mid-pool. The dominant substrate in pool 2 was gravel, with numerous boulders providing cover. Shading in pool 2 ranged from 80 to 100 percent during the survey. The step pools and connecting water combined for a total length of 57-feet, with an average width of 4.6-feet. The average depth of each pool, from upstream to downstream was 0.7-feet, 0.6-feet and one-foot. The maximum depths of the pools were 1.6-feet, one-foot and two-feet, respectively. The majority of the substrates in the pools were rubble and cobble. Several boulders provided the only cover in the pools. The relatively steep canyon banks and associated dense riparian canopy shaded 98 to 100 percent of the section during the survey.

Species Composition

A total of seven species were collected from the 13 stations and 29 habitats during the 2003 electrofishing survey (Figure 8-3). Based on population estimates, California roach dominated the catches, accounting for 80 percent of all fishes collected, followed by Sacramento pikeminnow (ten percent of total), Sacramento sucker (four percent of total), rainbow trout (two percent of total), prickly sculpin (two percent of total), Pacific lamprey (one percent of total) and largemouth bass (less than one percent of total each). The number of species found in any single habitat type ranged from zero to five. Appendix D includes a summary of the number of fish caught and population estimates for each species by station and habitat type. Appendix E presents error and goodness of fit statistics for the population estimates.

Four species were collected from electrofishing station E-1 (Figure 8-3). Population estimates (Appendix D) indicate that California roach dominated (329 fish), followed by Sacramento sucker (19 fish), Sacramento pikeminnow (14 fish) and rainbow trout (one fish).

Five species were collected from the glide at station E-3 (Figure 8-3). Population estimates (Appendix D) indicate that California roach dominated (467 fish), followed by Sacramento sucker (25 fish), Sacramento pikeminnow (11 fish), largemouth bass and Pacific lamprey (four fish each). This was the only habitat unit sampled during the survey that produced bass. Only two species were found in the low gradient riffle at station E-3 (Figure 8-3). Population estimates (Appendix D) indicate that there were 96 California roach and three Sacramento sucker.

Three species were collected from the glide at station E-4 (Figure 8-3). Population estimates (Appendix D) indicate that California roach dominated (190 fish), followed by Sacramento pikeminnow (12 fish) and Sacramento sucker (seven fish). Four species were collected from the low gradient riffle at station E-4 (Figure 8-3). Population estimates (Appendix D) indicate that there were 489 California roach, 25 Pacific lamprey, eight Sacramento pikeminnow and one Sacramento sucker. The same four species, in the same order of abundance, were collected from the second glide at station E-4 (Figure 8-3). Population estimates (Appendix D) indicate that California roach once again dominated (524 fish), followed by Pacific lamprey (68 fish), Sacramento pikeminnow (35 fish) and Sacramento sucker (28

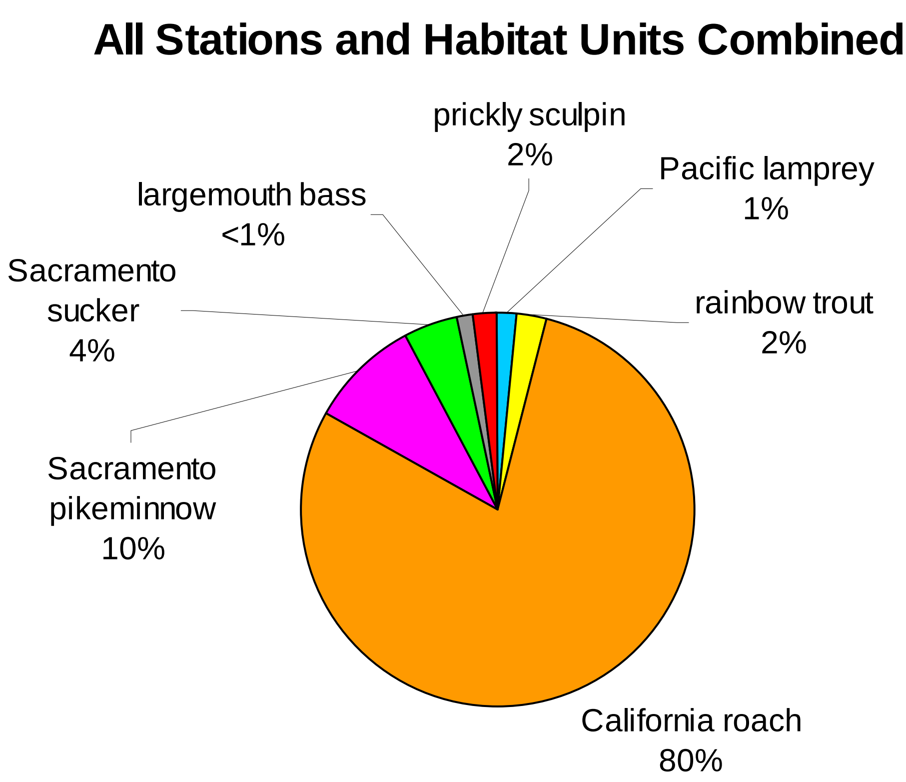
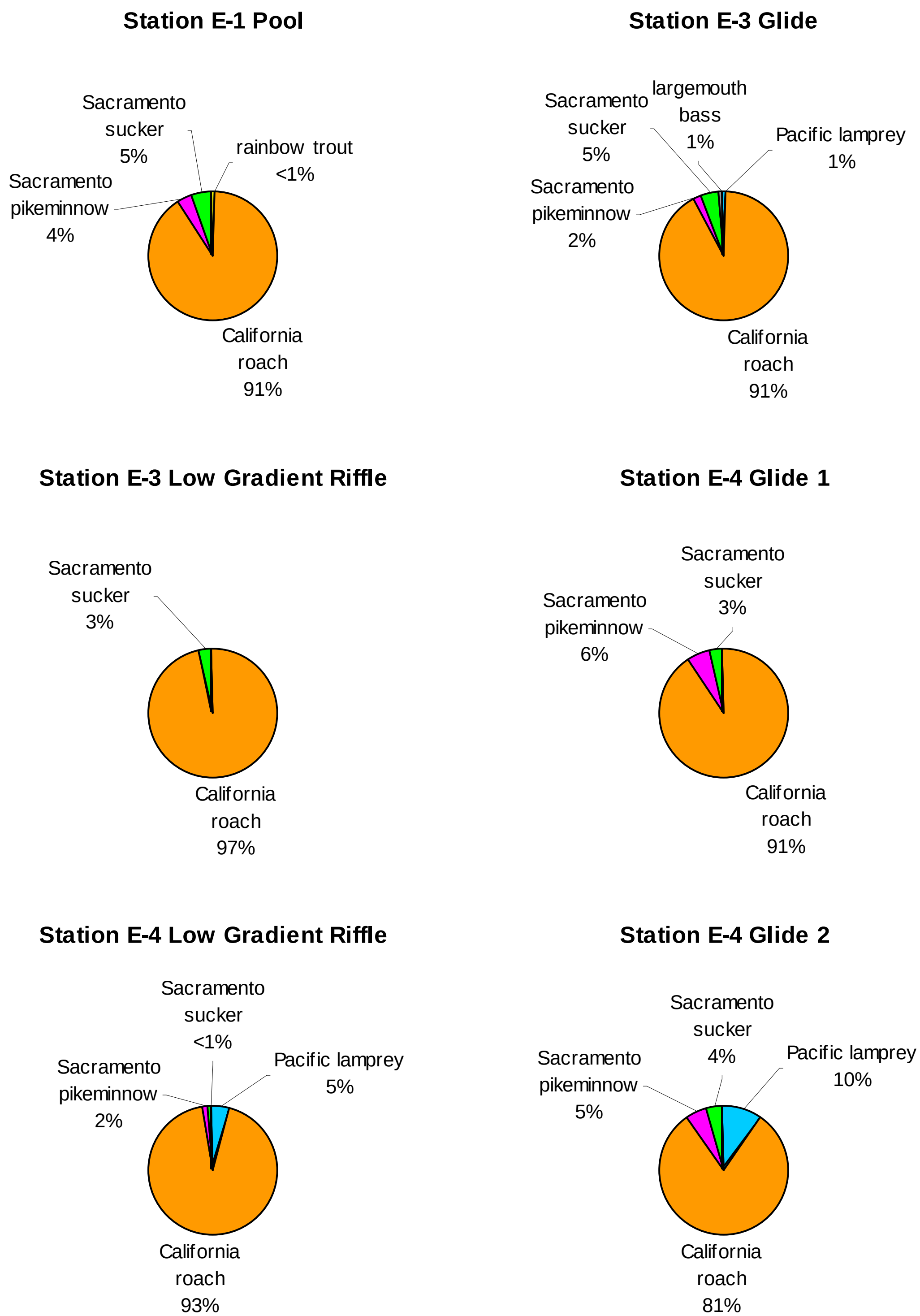


Figure 8-3. *Percent occurrence of each species by station and habitat type, based on population estimates for the autumn 2003 electrofishing surveys.*



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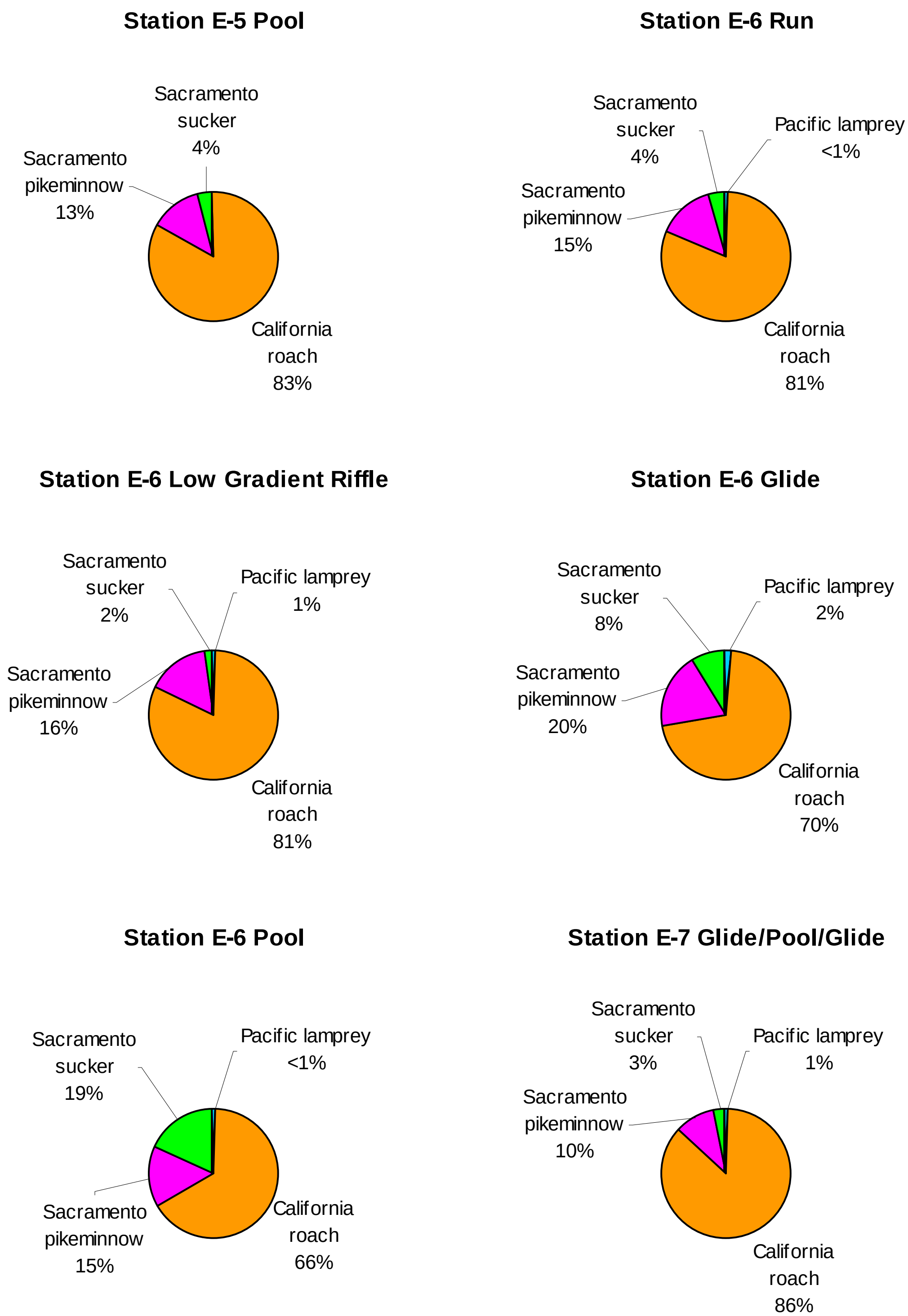

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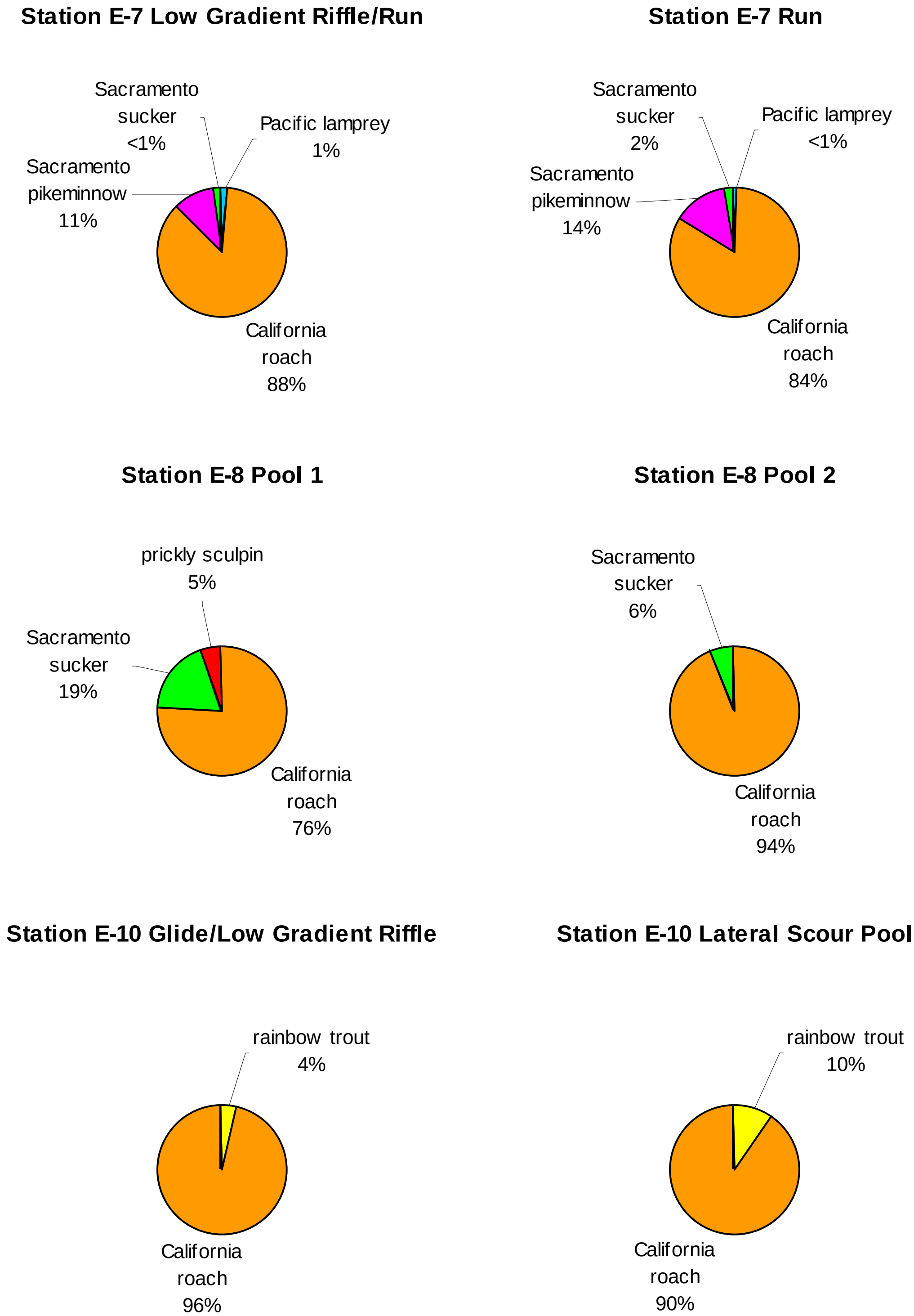

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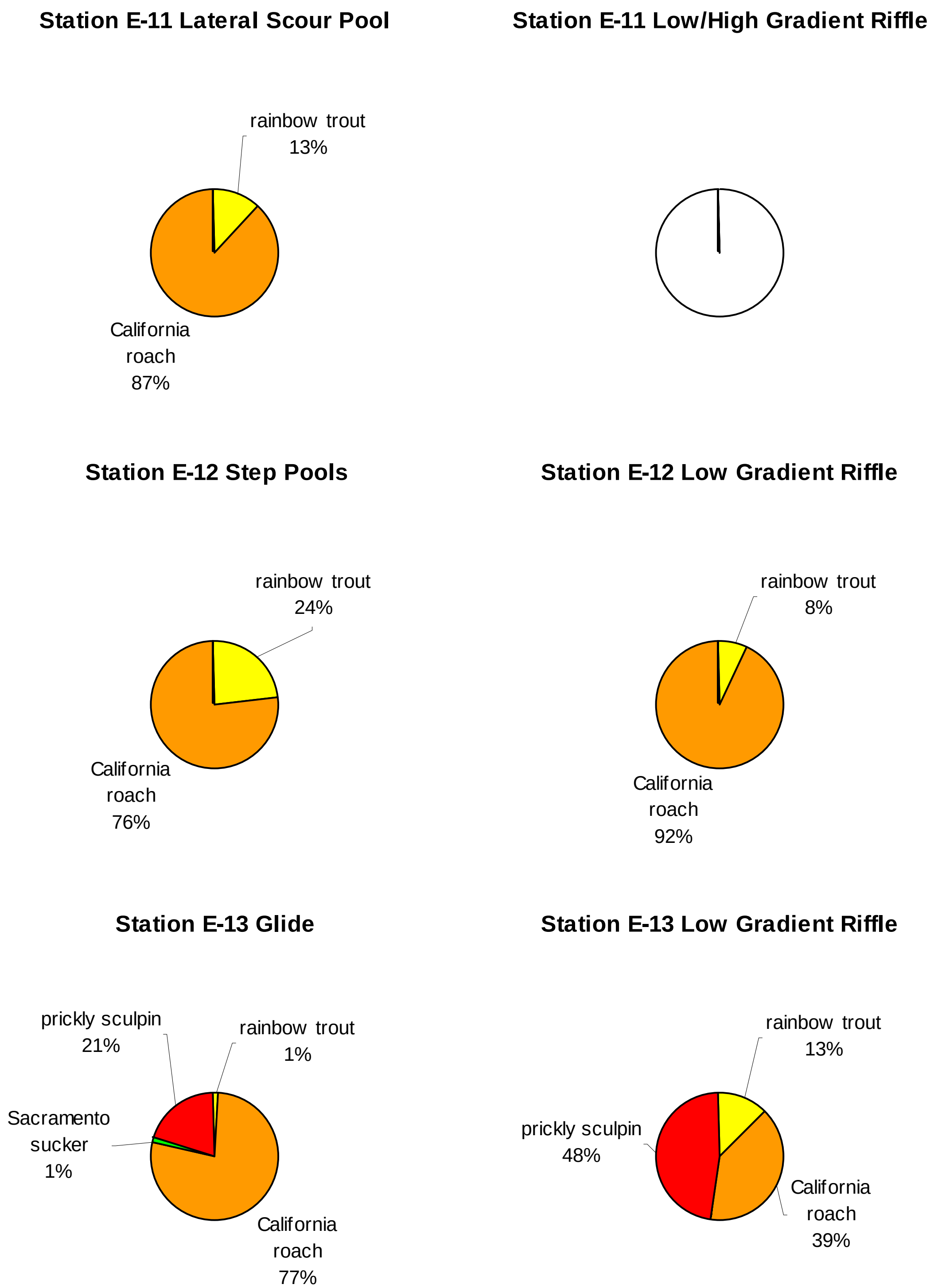

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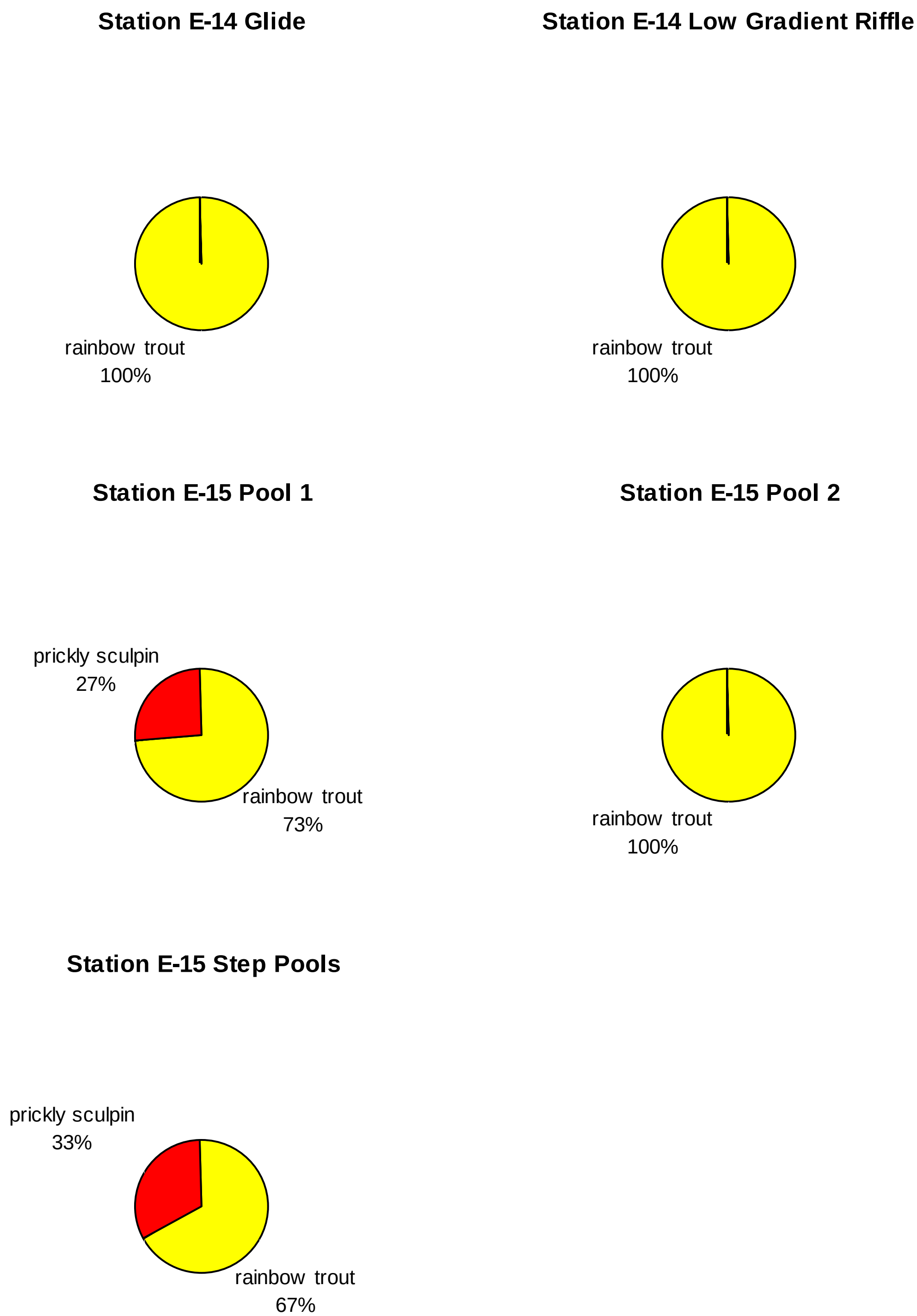


Figure 8-3 continued.

fish). In comparison to all other stations and habitat types sampled, this glide had the greatest number of lamprey ammocetes (52 percent of the total).

Three species were collected from the pool at electrofishing station E-5 (Figure 8-3). Population estimates (Appendix D) indicate that there were 254 California roach, 41 Sacramento pikeminnow and 11 Sacramento sucker.

There were four common species collected from each of the four habitat types at station E-6, with the species in the same order of abundance for three of the four habitats (Figure 8-3). Population estimates (Appendix D) indicated that California roach dominated in the run (671 fish), the low gradient riffle (458 fish), the glide (322 fish) and the pool (543 fish). The remaining species in the four habitats were Sacramento pikeminnow (124, 93, 91 and 128 fish, respectively), Sacramento sucker (35, 10, 38 and 154 fish, respectively) and Pacific lamprey (two, three, eight and three fish, respectively). In comparison to all other stations and habitat types sampled, the pool at station E-6 had the largest number of Sacramento sucker.

Four species were collected from the glide/pool/glide complex at station E-7 (Figure 8-3). Population estimates (Appendix D) indicate that California roach dominated (873 fish), followed by Sacramento pikeminnow (105 fish), Sacramento sucker (28 fish) and Pacific lamprey (nine fish). In comparison to all other stations and habitat types sampled, the glide/pool/glide had the second largest number of individual fishes and the second largest number of California roach. The same four species were found in the low gradient riffle/run at station E-7 (Figure 8-3). Population estimates (Appendix D) indicate that there were 366 California roach, 46 Sacramento pikeminnow, three Pacific lamprey and one Sacramento sucker. These four species were also collected from the run at station E-7 (Figure 8-3). Population estimates (Appendix D) indicate that California roach dominated once again (1,158 fish), followed by Sacramento pikeminnow (202 fish), Sacramento sucker (30 fish) and Pacific lamprey (five fish). In comparison to all other stations and habitat types sampled, the run at station E-7 had the largest number of individual fishes (1,395 fishes). The pool also accounted for the largest overall numbers of California roach and Sacramento pikeminnow.

Three species were collected from the downstream pool (pool 1) at station E-8 (Figure 8-3). Population estimates (Appendix D) indicate that the pool had 43 California roach, 11 Sacramento sucker and three prickly sculpin. California roach (16 fish) also dominated the upstream pool (pool 2), with a single Sacramento sucker the only other fish found.

There were two species collected from each of habitat types sampled at station E-10 (Figure 8-3). Population estimates (Appendix D) indicate that rainbow trout dominated in both the glide/low gradient riffle complex (224 fish) and the lateral scour pool (227 fish). The glide/riffle also had ten California roach, while the pool had 26 roach.

Two species were collected from the lateral scour pool at station E-11, although their numbers were relatively low (Figure 8-3). Population estimates (Appendix D) indicate that California roach dominated (seven fish), followed by a single rainbow trout. No fishes were collected from the low into high gradient riffle at station E-11.

Two species were collected from the series of step pools at station E-12 (Figure 8-3). Population estimates (Appendix D) indicate that California roach dominated

(42 fish), followed by rainbow trout (13 fish). The same two species were collected from the low gradient riffle at station E-12 (Figure 8-3), with 36 California roach and three rainbow trout.

Four species were collected from the glide at station E-13 (Figure 8-3). Population estimates (Appendix D) indicate that California roach dominated (295 fish), followed by prickly sculpin (19 fish), rainbow trout and Sacramento sucker (five fish each). There were three species collected from the low gradient riffle at station E-13 (Figure 8-3). Population estimates (Appendix D) indicate that there were 88 prickly sculpin, 71 California roach and 24 rainbow trout. This was the only California roach-containing habitat unit in which the roach did not dominate. In comparison to all other stations and habitat types sampled, this riffle had the greatest number of prickly sculpin.

A single species was collected from each of the two habitat types sampled at station E-14 (Figure 8-3). Population estimates (Appendix D) indicate that there were 101 rainbow trout in the glide and 15 rainbow trout in the low gradient riffle. In comparison to all other stations and habitat types that contained rainbow trout, the glide had the greatest number of trout (42 percent of the total).

Two species were collected from the downstream pool (pool 1) at station E-15 (Figure 8-3). Population estimates (Appendix D) indicate that there were 11 rainbow trout and four prickly sculpin. Rainbow trout (seven fish) were the only species in the other isolated pool at station E-15. There were two species collected from the series of step pools at station E-15, with population estimates (Appendix D) of 24 rainbow trout and 12 prickly sculpin.

Species Distribution

The distributions of the six species collected during the electrofishing surveys were highly variable. In some cases the number of individuals for a given species was associated with station location, while in others the relationship appeared to be more habitat specific. In many, however, there was no obvious correlation between the number of fish and either location or habitat type. Note that the descriptions below are discussed only in terms of location and habitat, and that it is likely that relationships to other variables play key roles in the distributions patterns observed. Although entire habitat types were sampled in most cases, population estimates are not standardized to the area of each habitat unit.

Pacific Lamprey

With the exception of a low gradient riffle at station E-3, a glide at station E-4 and the pool at station E-5, Pacific lamprey ammocetes were found in every habitat type and at all stations in Alameda Creek downstream of its confluence with Calaveras Creek (Figure 8-4). No lampreys were found in Alameda and Calaveras creeks above their confluence, and none were found in the three creeks upstream of the reservoirs. Although there does not appear to be a strong correlation between lamprey abundance and habitat type, ammocete numbers within any one station were always highest in glides. Due to the nature of electrofishing lamprey ammocetes, where subsequent passes draw greater numbers of fish out of the substrate, population estimate confidence intervals were sometimes very large.

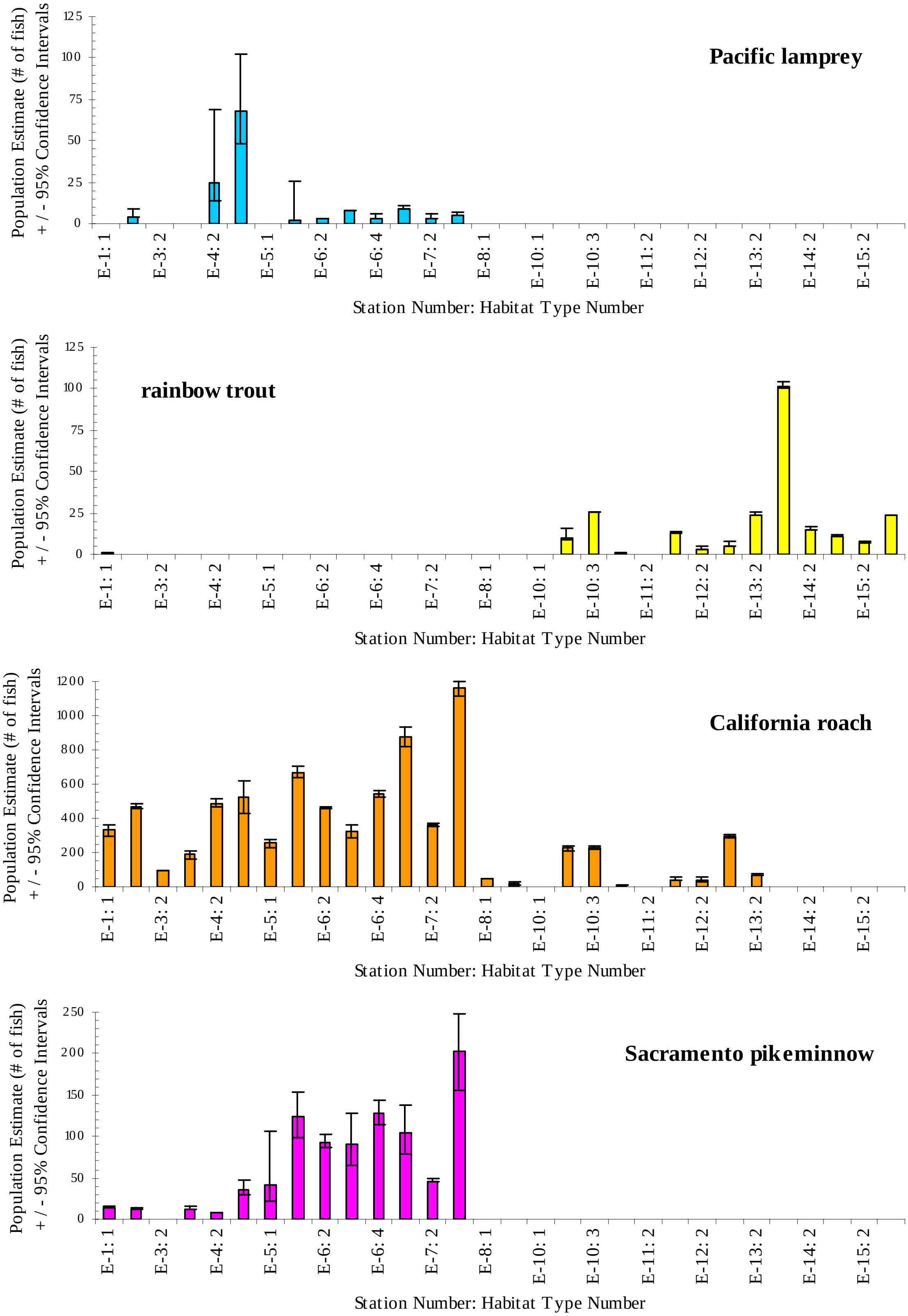


Figure 8-4. *Population estimates and 95 percent confidence intervals for each species by station and habitat type for the autumn 2003 electrofishing surveys.*

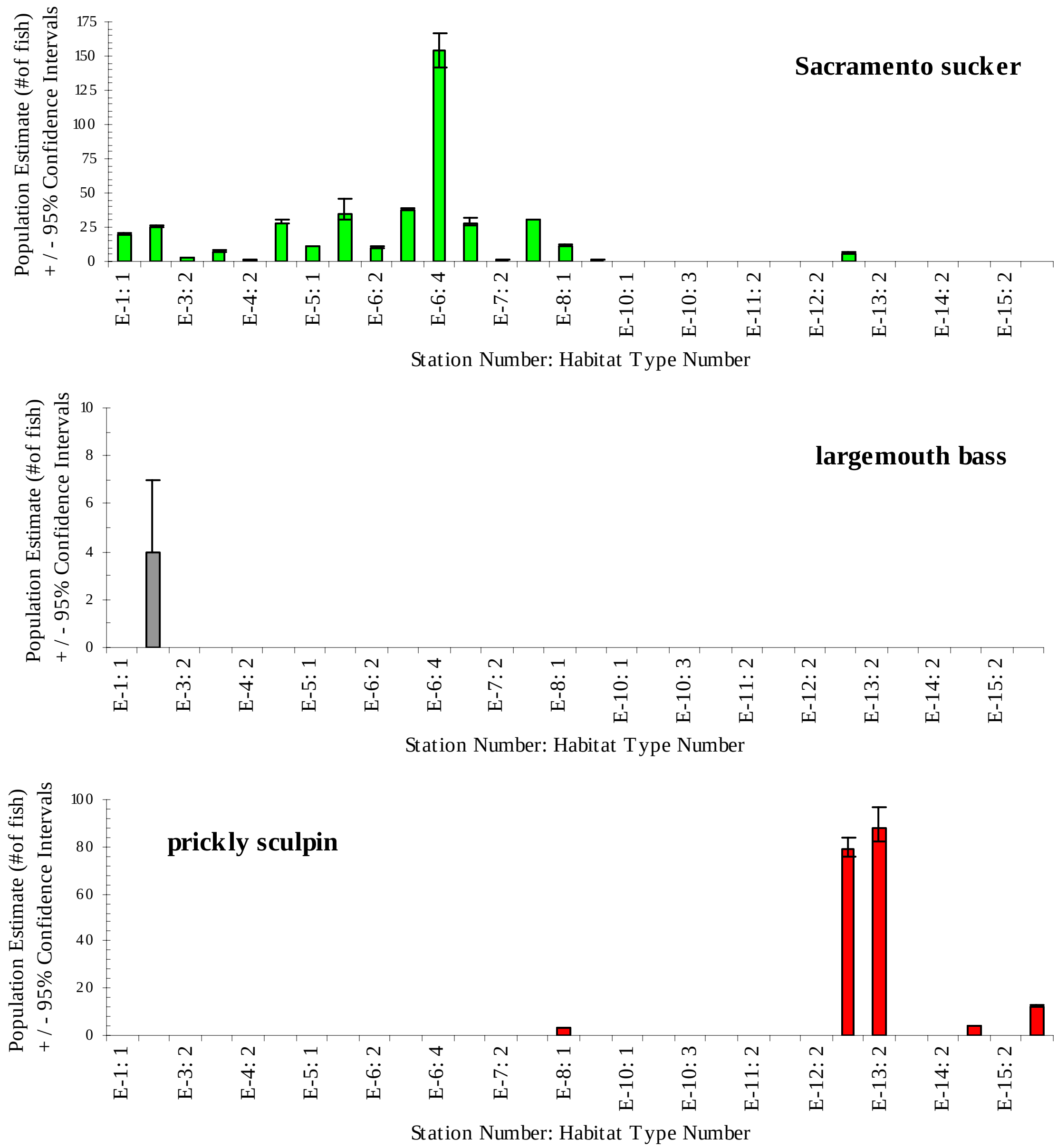


Figure 8-4 continued.

Rainbow Trout

In comparison to the other six species collected, the distribution pattern of rainbow trout was the most specific to station location (Figure 8-4). One hundred percent of the trout found in Alameda Creek were upstream of its confluence with Calaveras Creek. It should also be noted that every Alameda Creek station and habitat type upstream of Calaveras Creek, with the exception of a pool at station E-10 and a riffle at station E-11, had rainbow trout. There were no trout collected in Calaveras Creek. All stations and habitats in La Costa and Indian creeks, which have habitat similar to the uppermost reaches of Alameda Creek, also had rainbow trout. Both of the habitats at the single Arroyo Hondo station had rainbow trout too. With the exception of the Arroyo Hondo station, trout abundances may be positively correlated with slow-water habitat types. The variability in the number of rainbow trout observed, however, may also be a function of the total area available in each habitat and the amount of suitable cover.

California Roach

California roach were the most widespread species, being caught from 23 of the 29 habitats sampled (Figure 8-4). Roach were most abundant in the glide/pool/glide complex and the run at electrofishing station E-7. In general, roach were most abundant in Alameda Creek downstream of the Little Yosemite area. They were also relatively abundant in Alameda Creek upstream of the Diversion Dam and in Arroyo Hondo. California roach were absent from La Costa and Indian creeks. There is no obvious correlation between habitat type and roach abundance.

Sacramento Pikeminnow

Sacramento pikeminnow were found throughout Alameda Creek downstream of Little Yosemite, but were absent from all other areas sampled including Alameda creek in and upstream of Little Yosemite, Calaveras Creek, La Costa Creek, Indian Creek and Arroyo Hondo (Figure 8-4). Sacramento pikeminnow were concentrated in stations E-6 and E-7, although they were not associated with any particular habitat. Where pikeminnow did occur, their abundances were relatively lower at the stations between the Sunol Regional Park/SFPUC boundary fence and the confluence of Alameda and Calaveras creeks.

Sacramento Sucker

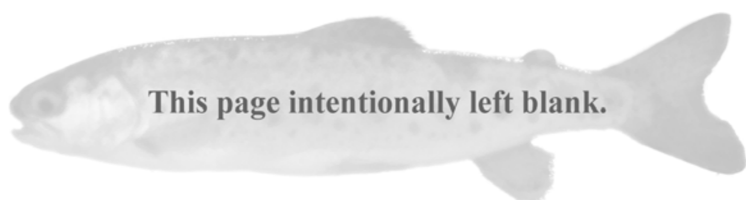
Sacramento sucker were caught at all stations and habitat types in Alameda Creek downstream of Little Yosemite and in Calaveras Creek (Figure 8-4). With the exception of the glide in Arroyo Hondo, suckers were absent from all other areas sampled. While Sacramento sucker were most abundant in the relatively large pool at station E-6, their abundances were generally higher in slower moving waters and lower in both low and high gradient riffles.

Largemouth Bass

Largemouth bass were only found in the glide at station E-3. This habitat is the closest sampled to a large pool at the downstream end of Calaveras Creek, where bass are known to reside.

Prickly Sculpin

Prickly sculpin were collected in relatively large numbers from both habitats sampled in Arroyo Hondo (Figure 8-4). Smaller numbers were also collected from one pool in Calaveras Creek and two of the three pool habitats in Indian Creek. Sculpin were not collected from any of the other stations. It is not prudent to establish a correlation between prickly sculpin abundance and habitat type because Cottids are not efficiently captured with electrofishing gear.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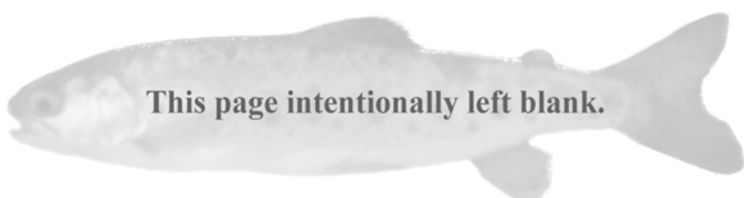
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10.0 Acknowledgments

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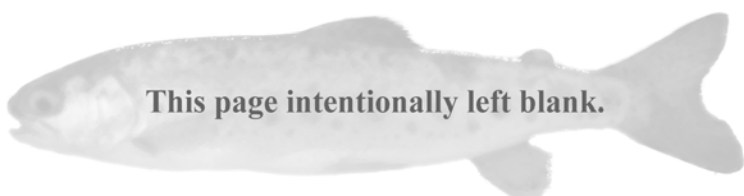
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11.0 Appendices

Appendix A – Target Flow Criteria

To adhere to the requirements of the MOU (1997), the following flow regimes will be met by the release of water, when necessary, from Calaveras Reservoir by the SFPUC:

“ A. Provide a 5-day running average flow of 5 cfs immediately below the confluence of Alameda and Calaveras Creeks from November 1 through January 14, with a minimum flow of not less than 4.5 cfs, except as modified by the ramping schedule set forth in Appendix 2.

B. Provide a 5-day running average spawning flow of 20 cfs immediately below the confluence of Alameda Creek and Calaveras Creek from January 15 through March 15, with a minimum flow of not less than 18 cfs. The SFPUC shall ramp up to and down from the 20 cfs average spawning flow according to the stream flow schedule as described in Appendix 2.

C. Provide a 5-day running average flow of 7 cfs immediately below the confluence of Alameda Creek and Calaveras Creek from March 16 to October 31, with a minimum flow of not less than 6.3 cfs, except as modified by the ramping schedule set forth in Appendix 2. The SFPUC shall also maintain existing base flow conditions in Calaveras Creek above its confluence with Alameda Creek during this period. These flows consist of approximately 0.5 cfs of seepage from Calaveras Dam.

D. The maximum quantity of water which the SFPUC may be called upon to release from Calaveras Reservoir under the terms of this MOU shall not exceed 6300 acre feet annually. CDFG and the SFPUC recognize that the volume and timing of water releases contemplated in sections 5.1 A through C above may be revised in response to pre- and post-project monitoring. However, the cumulative effect of any revisions to these water release schedules shall not cause the total volume of Calaveras Reservoir water releases to exceed 6300 acre feet per year. ”

Appendix B – Calaveras Reservoir Water Quality Data

Date	Depth ft.	Temp °C	pH -log H+	Cond uS/cm	TDS mg/L	DO mg/L	ORP mV	Turb NTU	Alk mg/L	Hard mg/L	Color clr unts	NH3N mg/L	NO3-N mg/L	PO4-P mg/L	Total-P mg/L	Cl- mg/L	TOC mg/L	Fe mg/L	Mn mg/L
1/7/03	0	9.8	7.85	232	148	7.6	555	27.8	86	102	55	0.23	0.14	0.01	0.02	8	5.4	0.84	0.03
	10	9.7	7.82	232	149	7.5	557												
	20	9.7	7.81	231	148	7.5	559	28.7	85	101	71	0.2	0.14	0.02	0.02	8			
	30	9.6	7.8	231	148	7.4	560												
	40	9.6	7.8	231	148	7.4	561	29.4	84	100	83	0.21	0.21	0.02	0.03	8			
	50	9.6	7.8	231	148	7.4	562												
	60	9.6	7.8	231	148	7.3	563	30.6	85	99	76	0.2	0.17	0.03	0.03	7	5.3	1.1	0.07
	70	9.6	7.81	231	148	7.3	563												
	80	9.6	7.81	232	148	7.3	564	28.9	86	100	63	0.2	0.16	0.03	0.03	7			
	90	9.6	7.8	232	149	7.3	564												
	95	9.6	7.73	233	149	7.1	563	30.3	86	100	75	*	0.15	0.04	0.04	7	5.4	1.1	0.1
1/27/03	0	11.1	7.9	238	152	6.8	571	9.6	91	107	41	0.28	0.16	0.02	0.02	8	5.1	0.49	0.07
	10	10.7	7.85	238	152	6.7	574												
	20	10.6	7.84	238	152	6.6	576	10.3	88	104	46	0.37	0.15	0.03	0.03	8			
	30	10.6	7.85	237	152	6.5	577												
	40	10.4	7.82	237	152	6.4	579	10.6	87	103	40	0.2	0.2	0.03	0.03	8			
	50	10.2	7.81	236	151	6.3	580												
	60	10.1	7.8	236	151	6.2	581	10.8	87	103	40	0.2	0.26	0.02	0.02	8	5	0.53	0.09
	70	10	7.77	236	151	6	583												
	80	9.9	7.74	236	151	6	584	12	87	102	34	0.21	0.21	0.01	0.05	8			
	90	9.9	7.71	236	151	5.9	585												
	92	9.8	7.69	236	151	5.9	586	14.5	87	102	35	0.21	0.15	0.01	0.05	8	4.9	0.82	0.13
2/25/03	0	11.8	7.74	247	158	10.3	562	5.2	88	106	30	0.06	0.2	0.04	0.04	8	5.1	0.3	0.08
	10	11.2	7.72	246	157	10.2	563												
	20	11.1	7.68	247	158	10.1	565	5.5	88	106	22	0.05	0.2	0.03	0.03	8			
	30	10.7	7.63	247	158	9.8	565												
	40	10.4	7.56	246	158	9.4	566	6.5	89	107	29	0.04	0.18	0.03	0.03	8			
	50	10.2	7.52	245	157	9.1	566												
	60	10.2	7.53	244	156	9.4	566	7.4	89	107	29	0.18	0.17	0.03	0.03	8	5.1	0.41	0.03
	70	10.2	7.52	244	156	9.2	566												
	80	10.1	7.49	244	156	9.1	565	7.7	89	106	28	0.05	0.19	0.02	0.02	8			
	87	10.1	7.45	244	156	9.1	563	7.8	89	106	35	0.04	0.18	0.02	0.02	8	5.1	0.38	0.1
	0	11.8	7.74	247	158	10.3	562	5.2	88	106	30	0.06	0.2	0.04	0.04	8	5.1	0.3	0.08
3/25/03	0	15.6	8.17	261	167	11.1	562	1.6	92	111	18	0.13	0.04	0.03	0.04	8	4.6	0.07	0.01
	10	14.9	8.18	260	166	11.1	563												
	20	12.6	7.72	258	165	9.2	567	2.7	92	111	19	0.14	0.05	0.03	0.04	8			
	30	11.6	7.62	253	162	8.7	569												
	40	11	7.53	252	161	7.9	571	4.6	91	110	21	0.21	0.06	0.04	0.05	8			
	50	10.8	7.5	251	160	7.6	572												
	60	10.7	7.47	250	160	7.1	573	4.6	91	109	23	0.21	0.05	0.05	0.05	8	4.6	0.16	0.11
	70	10.6	7.45	250	160	7	573												
	80	10.5	7.42	249	160	6.9	573	4.4	91	109	19	0.25	0.14	0.03	0.03	8			
	85	10.5	7.36	252	161	6	574	6.3	91	109	19	0.27	0.19	0.02	0.03	8	4.6	0.23	0.15

Date	Depth ft.	Temp °C	pH -log H+	Cond uS/cm	TDS mg/L	DO mg/L	ORP mV	Turb NTU	Alk mg/L	Hard mg/L	Color clr unts	NH3N mg/L	NO3-N mg/L	PO4-P mg/L	Total-P mg/L	Cl- mg/L	TOC mg/L	Fe mg/L	Mn mg/L
4/8/03	0	16	8.32	265	169	11	561	1.1	96	116	22	0.03	0.09	0.01	0.02	8	4.4	0.06	0.02
	10	15	8.3	264	169	10.9	562												
	20	14.9	8.3	264	169	10.7	561	1.1	96	116	15	0.05	0.09	0.01	0.02	8			
	30	11.9	7.56	256	164	7.8	570												
	40	11.2	7.48	253	162	7.2	572	3.6	94	112	20	0.03	0.23	0.03	0.04	8			
	50	11.1	7.44	253	162	6.7	573												
	60	10.9	7.41	252	161	6.3	574	3.9	93	110	20	0.04	0.23	0.02	0.02	8	4.6	0.27	0.08
	70	10.8	7.38	252	161	6	575												
	80	10.8	7.33	252	161	5.4	576	4.9	92	110	19	0.04	0.22	0.04	0.05	8			
	85	10.8	7.28	253	162	5.2	574	4.7	92	108	19	0.03	0.23	0.05	0.05	8	4.6	0.17	0.18
5/7/03	0	16.4	7.48	270	173	10.1	530	1	94	116	14	0.05	0.08	0.02	0.02	9	4.5	0.06	0.01
	10	15.7	7.42	269	172	9.9	532												
	20	15.3	7.34	268	172	9.3	533	1.4	95	115	13	0.04	0.09	0.02	0.06	9			
	30	13.9	7.15	266	170	8.1	536												
	40	13	7.03	266	170	6.9	539	2.5	95	114	16	0.03	0.08	0.02	0.11	9			
	50	12.3	6.96	263	169	6	540												
	60	11.9	6.92	261	167	5.2	541	2.3	95	112	18	0.01	0.17	0.03	0.08	8	4.6	0.12	0.03
	70	11.6	6.86	260	166	4.4	542												
	80	11.3	6.83	259	166	3.2	543	2.5	94	112	18	0.03	0.21	0.02	0.12	8			
	90	11.3	6.81	261	167	2.6	543	6.4	94	112	16	0.04	0.19	0.02	0.12	8	4.4	0.1	0.17
6/3/03	0	23.2	7.83	279	179	9.1	510	1	101	116	12	<0.01	0.07	0.05	0.12	8	4.4	0.06	<0.01
	10	22.9	7.84	279	179	9	511												
	20	21.7	7.76	278	178	8.8	512	1	101	116	12	0.02	0.04	0.04	0.05	8			
	30	14.6	6.99	267	171	5.5	522												
	40	13.7	6.95	265	170	5.1	523	0.7	98	115	17	0.15	0.04	0.03	0.08	8			
	50	12.9	6.91	264	169	4.6	524												
	60	12.4	6.86	263	168	4	524	0.78	96	114	16	0.17	0.05	0.03	0.09	8	4.1	0.05	<0.01
	70	12.3	6.71	262	168	3.5	524												
	80	11.9	6.67	262	168	2.5	524	3.5	96	112	15	0.33	0.09	0.04	0.08	8			
	90	11.8	6.64	264	169	1.9	516	3.2	96	112	15	0.33	0.08	0.02	0.11	8	4.2	0.06	0.09
6/23/03	0	22	7.73	288	185	8.3	534	1	106	119	12	0.05	0.01	0.07	0.08	7	3.9	0.09	<0.01
	10	21.8	7.73	288	185	8.2	534												
	20	21.6	7.73	288	184	8	536	1.1	106	119	11	0.03	0.01	0.07	0.1	7			
	30	14.7	7.02	269	172	3.6	543												
	40	13.3	6.99	266	170	3.7	544	1.1	98	116	12	0.03	0.14	0.05	0.07	8			
	50	12.5	6.95	264	169	3.1	545												
	60	12.2	6.91	264	169	2.1	546	1.3	97	114	14	0.06	0.19	0.05	0.11	8	4.2	0.07	0.03
	70	11.9	6.87	263	168	0.4	547												
	80	11.9	6.86	264	169	0.3	546	2.7	97	114	14	0.06	0.28	0.08	0.13	8			
	89	11.8	6.86	268	171	0.4	544	2.4	97	114	14	0.05	0.35	0.06	0.16	8	4.4	0.06	0.16
7/9/03	0	24.2	7.93	292	187	8.4	521	1.3	104	126	14	0.01	0.01	0.04	0.05	8	3.7	0.02	<0.01
	10	23.5	7.9	292	187	8.2	522												
	20	22.8	7.89	291	186	7.7	520	1.6	102	123	14	0.01	<0.01	0.05	0.05	8			
	30	15.5	7.03	270	173	2.7	534												

Date	Depth ft.	Temp °C	pH -log H+	Cond uS/cm	TDS mg/L	DO mg/L	ORP mV	Turb NTU	Alk mg/L	Hard mg/L	Color clr unts	NH3N mg/L	NO3-N mg/L	PO4-P mg/L	Total-P mg/L	Cl- mg/L	TOC mg/L	Fe mg/L	Mn mg/L
7/9/03	40	13.6	6.99	267	171	2.3	536	1.7	98	114	15	0.19	0.01	0.04	0.08	8			
	50	12.8	6.98	264	169	2.2	537												
	60	12.3	6.93	264	169	0.9	538	1.9	95	116	16	0.27	0.02	0.05	0.08	8	3.8	0.06	0.1
	70	12	6.92	265	169	0.2	539												
	80	12	6.92	266	170	0.2	539	3.1	96	118	24	0.33	0.13	0.07	0.12	8			
	88	11.9	6.92	269	172	0.3	540	2.7	96	118	19	0.26	0.2	0.09	0.1	8	4.1	0.05	0.85
7/28/03	0	26	8.05	294	188	7.5	490	1.2	110	121	13	<0.01	0.04	<0.01	0.01	11	4	0.06	0.02
	10	25.8	8.1	294	188	7.4	484												
	20	24.4	8.09	290	186	7	480	1.5	107	122	18	<0.01	0.03	0.01	0.01	10			
	30	15.1	7.02	270	173	1.4	507												
	40	13.1	6.99	266	171	0.8	504	1.2	101	115	23	0.12	0.03	<0.01	<0.01	9			
	50	12.6	6.97	266	170	0.6	501												
	60	12.1	6.98	267	171	0.2	495	2.3	99	114	50	<0.01	0.08	0.03	0.03	9	4	0.1	0.36
	70	12	6.98	269	172	0.2	489												
	80	12	6.98	272	174	0.3	472	0.9	104	116	29	0.14	0.28	0.1	0.1	9			
	87	12	6.96	274	175	0.3	464	1	84	117	30	0.12	0.32	0.12	0.12	10	4.2	0.17	1.1
8/12/03	0	23.6	7.89	293	188	7.4	502	0.9	108	122	8	0.02	0.02	0.03	0.03	8	4	0.02	0.02
	10	23.5	7.9	293	188	7.3	500												
	20	23.5	7.96	293	188	7	494	0.9	105	120	8	<0.01	0.02	0.03	0.03	8			
	30	17.3	7.06	273	175	0.8	514												
	40	13.8	7.03	269	172	0.2	515	1.6	102	118	12	<0.01	0.1	0.04	0.08	8			
	50	12.8	7.03	266	170	0.3	510												
	60	12.2	7.04	268	172	0.2	505	1.1	100	116	15	0.12	0.25	0.09	0.09	8	4.1	0.1	0.8
	70	12	7.05	270	173	0.2	503												
	80	12	7.05	272	174	0.2	501												
	85	12	7.05	274	175	0.3	480	5	98	112	16	0.37	0.29	0.19	0.19	8	4.3	0.05	1.4
9/8/03	0	23.3	7.83	267	171	6.7	500	0.8	99	125	9	0.01	0.03	0.03	0.04	9	3.8	<0.01	0.01
	10	23	7.81	249	159	6.6	499												
	20	22.9	7.81	293	187	6.2	495	1	97	123	9	0.04	0.05	0.04	0.04	9			
	30	21	7.12	287	184	0.6	509												
	40	13.4	7.05	269	172	0.2	510	2.1	92	118	13	0.08	0.05	0.08	0.1	8			
	50	12.7	7.05	269	172	0.2	509												
	60	12.2	7.06	270	173	0.2	510	2.9	93	118	13	0.23	0.3	0.14	0.15	8	4.3	0.19	0.86
	70	12.1	7.07	272	174	0.2	508												
	80	12.1	7.06	274	175	0.3	503												
	83	12.1	7.06	274	175	0.3	493	5.1	93	118	14	0.21	0.6	0.21	0.21	8	4.5	0.42	1.5
9/26/03	0	22.1	8.52	299	191	8.5	379	0.8	108	117						10			
	10	22.2	8.51	301	193	8.5	375												
	20	22	8.44	302	194	7.9	372	1	109	120						9			
	30	20.1	7.64	305	195	3.8	364												
	40	14.5	7.35	281	180	0.2	365	2.2	107	119						8			
	50	13	7.35	280	179	0.6	356												
	60	12.4	7.36	281	180	0.2	357	2.6	109	118						8			
	70	12.3	7.36	282	180	0.2	350												
	81	12.2	7.36	287	184	0.2	294	4.3	108	116						8			

Date	Depth ft.	Temp °C	pH -log H+	Cond uS/cm	TDS mg/L	DO mg/L	ORP mV	Turb NTU	Alk mg/L	Hard mg/L	Color clr unts	NH3N mg/L	NO3-N mg/L	PO4-P mg/L	Total-P mg/L	Cl- mg/L	TOC mg/L	Fe mg/L	Mn mg/L
11/3/03	0	17.1	7.65	255	163	6.4	432	2.9	110	131	8	0.04	0.02	0.01	0.04	9	4.1	0.06	0.04
	10	17	7.63	254	162	6.2	423												
	20	17	7.63	264	169	6	412	2.2	109	130	8	0.05	0.04	0.03	0.03	9			
	30	16.9	7.65	259	166	5.7	382												
	40	15.6	7.25	247	158	1.3	345	2.7	108	125	10	0.12	0.02	0.05	0.06	9			
	50	13.1	7.23	240	154	0.2	294												
	60	12.4	7.25	244	156	0.3	244	1.4	112	120	20	0.52	0.02	0.19	0.22	8	4.5	0.13	0.68
	70	12.2	7.26	246	158	0.3	206												
	80	12.2	7.28	248	159	0.6	238	1.3	114	126	22	0.9	0.02	0.33	0.36	8	5	0.61	1
11/10/03	0	16.1	7.69	296	189	6.3	433	3.6											
	10	16	7.68	254	163	6.2	427												
	20	15.9	7.66	262	168	6	415	3.5											
	30	15.8	7.66	263	169	5.6	401												
	40	15.4	7.47	257	165	4.3	386	3.6											
	50	13.2	7.27	242	155	0.3	343												
	60	12.4	7.29	245	157	0.4	290	1.9											
	70	12.3	7.3	246	158	0.5	257												
	80	12.2	7.3	255	163	0.7	246	1.2											
11/12/03	0	15.7	7.73	284	182	6	425	2.2	106	125									
	10	15.4	7.71	253	162	5.9	423												
	20	15.4	7.6	296	189	5.8	417	2.7	106	130									
	30	15.4	7.6	296	189	5.7	406												
	40	15.3	7.6	296	189	5.6	389	2.7	106	129									
	50	13.3	7.45	278	178	0.3	302												
	60	12.3	7.46	281	180	0.3	263	1.4	110	122									
	70	12.2	7.47	283	181	0.3	248												
	80	12.2	7.49	289	185	0.5	239	1.1	112	125									
11/17/03	0	15.1	7.64	295	189	6	382	1.3	109	126									
	10	14.9	7.62	274	175	5.8	377												
	20	14.9	7.63	295	189	5.7	368	1.5	110	129									
	30	14.8	7.57	296	189	5.4	357												
	40	14.6	7.57	296	190	5.4	343	5.2	111	126									
	50	14.4	7.51	294	188	4.6	297												
	60	12.4	7.35	281	180	0.2	150	1.5	112	122									
	70	12.2	7.36	284	182	0.2	125												
	80	12.2	7.37	293	188	0.2	108	1.2	113	127									
11/25/03	0	13.6	7.57	259	166	5.4	386	2.6	110	125									
	10	13.3	7.55	254	162	5.2	381												
	20	13.3	7.55	292	187	5.1	370	3.2	110	127									
	30	13.3	7.56	293	187	5.1	355												
	40	13.3	7.57	293	187	5	342	3	110	126									
	50	13.3	7.57	292	187	4.9	317												
	60	12.8	7.4	284	182	1.9	246	2	112	125									
	70	12.3	7.39	283	181	0.2	151												
	80	12.2	7.4	292	187	0.2	129	1.2	112	125									

Date	Depth ft.	Temp °C	pH -log H+	Cond uS/cm	TDS mg/L	DO mg/L	ORP mV	Turb NTU	Alk mg/L	Hard mg/L	Color clr unts	NH3N mg/L	NO3-N mg/L	PO4-P mg/L	Total-P mg/L	Cl- mg/L	TOC mg/L	Fe mg/L	Mn mg/L
12/1/03	0	12.9	7.99	298	191	7.7	456	2.4											
	10	12.8	7.97	300	192	7.7	455												
	20	12.8	7.95	301	193	7.4	454	2.3											
	30	12.8	7.94	301	193	7.3	452												
	40	12.7	7.93	301	193	7.2	449	2.3											
	50	12.7	7.93	301	193	7.3	446												
	60	12.7	7.92	301	193	7.3	439	2.7											
	70	12.7	7.84	301	193	6.7	418												
	73	12.6	7.78	301	192	6.2	397	2.4											
12/15/03	0	12.2	8.16	300	192	9.3	424	3.3											
	10	12.1	8.13	302	193	9.4	424												
	20	12.1	8.13	302	194	9	417	4.4											
	30	12.1	8.13	303	194	9.1	413												
	40	12.1	8.13	303	194	9	408	4											
	50	12.1	8.12	303	194	9	394												
	60	12.1	8.12	303	194	9.1	369	3.9											
	70	12.1	8.12	303	194	9.1	332												
	80	12	8.11	303	194	8.9	329	4.5											
12/30/03	0	10.7	7.83	311	199	9.1	509	6.5											
	10	10.7	7.81	313	200	8.9	508												
	20	10.7	7.81	314	201	9.1	507	8.4											
	30	10.7	7.81	312	199	9.1	505												
	40	10.6	7.8	308	197	9.1	504	7.8											
	50	10.6	7.79	315	201	9.4	498												
	60	10.7	7.78	317	203	9.3	493	8.2											
	70	10.7	7.76	305	195	9.2	476												
	80	10.7	7.73	319	204	9.1	440	7.5											

Appendix C – Snorkel Survey Data

Species (adults)	Number of Fish Observed													
	Pool Number													
	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-10	P-11	P-12	P-13	P-14	P-15	Total
rainbow trout	0	0	0	0	0	0	0	0	0	9	1	0	1	11
Sacramento sucker	2	10	1	0	0	2	5	1	0	0	0	0	0	21
Sacramento pikeminnow	7	12	6	11	11	16	5	0	0	0	0	0	0	68
California roach	172	409	374	560	735	160	35	1	0	0	0	0	96	2,542
prickly sculpin	0	0	0	0	0	0	0	0	0	0	0	0	1	1
largemouth bass	0	0	0	0	0	0	0	1	0	0	0	0	0	1
unidentified sunfish	0	0	0	0	0	0	0	12	0	0	0	0	0	12
Total	181	431	381	571	746	178	45	15	0	9	1	0	98	2,656

Species (juveniles)	Number of Fish Observed													
	Pool Number													
	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-10	P-11	P-12	P-13	P-14	P-15	Total
rainbow trout	0	0	0	0	0	0	0	0	0	23	0	0	0	23
Sacramento sucker	0	335	35	21	70	3	45	0	5	0	0	1	1	516
Sacramento pikeminnow	20	63	33	52	64	23	30	0	0	0	0	0	0	285
California roach	100	1,180	2,175	1,985	1,090	1,205	275	0	2,910	2,420	595	115	137	14,187
prickly sculpin	0	0	0	0	0	0	0	0	0	0	0	0	1	1
largemouth bass	0	0	0	0	0	0	0	32	0	0	0	0	0	32
unidentified sunfish	0	0	0	0	0	0	0	71	0	0	0	0	0	71
Total	120	1,578	2,243	2,058	1,224	1,231	350	103	2,915	2,443	595	116	139	15,115

Appendix D – Electrofishing Survey Catch Summary and Population Estimates

Alameda Creek catch summary for the autumn, 2003 electrofishing survey.

Species	**Number of Fish Collected**															
	Station Number - Habitat Type Number															
Common Name	**1-1**	**3-1**	**3-2**	**4-1**	**4-2**	**4-3**	**5-1**	**6-1**	**6-2**	**6-3**	**6-4**	**7-1**	**7-2**	**7-3**	**8-1**	**8-2**
Pacific lamprey		4			14	48		2	2	5	3	9	3	5		
rainbow trout	1															
California roach	278	444	96	162	450	364	221	589	455	261	511	731	354	1,044	43	14
Sacramento pikeminnow	14	11		12	8	29	21	98	86	65	114	79	45	151		
Sacramento sucker	19	25	3	7	1	28	11	30	10	38	142	27	1	30	11	1
largemouth bass		4														
prickly sculpin															2	
Total	312	488	99	181	473	469	253	719	553	369	770	846	403	1,230	56	15

Species	**Number of Fish Collected**														
	Station Number - Habitat Type Number														
Common Name	**10-1***	**10-2**	**10-3**	**11-1**	**11-2**	**12-1**	**12-2**	**13-1**	**13-2**	**14-1**	**14-2**	**15-1**	**15-2**	**15-3**	**Total**
Pacific lamprey	- -														95
rainbow trout	- -	9	26	1		13	3	5	24	100	15	11	7	24	239
California roach	- -	209	216	7		36	28	290	65						6,868
Sacramento pikeminnow	- -														733
Sacramento sucker	- -							5							389
largemouth bass	- -														4
prickly sculpin	- -							76	82			4		12	176
Total	- -	218	242	8	0	49	31	376	171	100	15	15	7	36	8,504

** Did not collect at this site due to lack of water.*

Alameda Creek population estimates for the autumn, 2003 electrofishing survey.

Species	**Number of Fish in Population**															
	Station Number - Habitat Type Number															
Common Name	**1-1**	**3-1**	**3-2**	**4-1**	**4-2**	**4-3**	**5-1**	**6-1**	**6-2**	**6-3**	**6-4**	**7-1**	**7-2**	**7-3**	**8-1**	**8-2**
Pacific lamprey		4			25	68		2	**3**	**8**	3	9	3	5		
rainbow trout	1															
California roach	329	467	96	190	489	524	254	671	458	322	543	873	366	1,158	43	16
Sacramento pikeminnow	14	11		12	8	35	41	124	93	91	128	105	46	202		
Sacramento sucker	19	25	3	7	1	28	11	35	10	38	154	28	1	30	11	1
largemouth bass		4														
prickly sculpin															**3**	
Total	363	511	99	209	523	655	306	832	564	459	828	1,015	416	1,395	57	17

Species	**Number of Fish in Population**														
	Station Number - Habitat Type Number														
Common Name	**10-1***	**10-2**	**10-3**	**11-1**	**11-2**	**12-1**	**12-2**	**13-1**	**13-2**	**14-1**	**14-2**	**15-1**	**15-2**	**15-3**	**Total**
Pacific lamprey	- -														130
rainbow trout	- -	10	26	1		13	3	5	24	101	15	11	7	24	241
California roach	- -	224	227	7		42	36	295	71						7,701
Sacramento pikeminnow	- -														910
Sacramento sucker	- -							5							407
largemouth bass	- -														4
prickly sculpin	- -							79	88			4		12	186
Total	- -	234	253	8	0	55	39	384	183	101	15	15	7	36	9,579

** Did not collect at this site due to lack of water.*

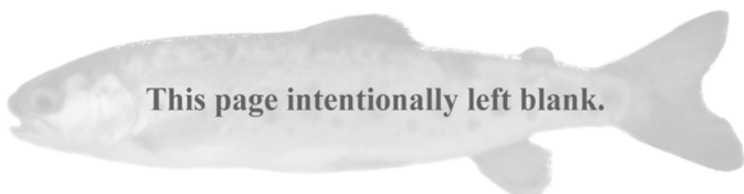
Population estimate is based on a non-descending removal pattern, and should not be considered reliable.

Appendix E – Electrofishing Survey Population Estimate Standard Error and Chi Square Statistics

Standard error and Chi Square statistics for Alameda Creek population estimates for the autumn, 2003 electrofishing survey.

Station Number - Habitat Type Number	Population Estimate Standard Errors							Chi Square Goodness of Fit						
	Pacific lamprey	rainbow trout	California roach	Sacramento pikeminnow	Sacramento sucker	largemouth bass	prickly sculpin	Pacific lamprey	rainbow trout	California roach	Sacramento pikeminnow	Sacramento sucker	largemouth bass	prickly sculpin
1-1		* / **	16.705	1.017	0.770				* / **	0.025	0.930	1.135		
3-1	1.468		7.350	1.270	0.275	0.969		5.571		0.517	1.126	0.779	0.865	
3-2			0.890		**					1.060		**		
4-1			12.075	1.172	0.578					0.265	1.107	0.866		
4-2	21.180		10.919	**	* / **			0.282		0.012	**	* / **		
4-3	16.972		48.677	6.436	1.023			0.100		1.203	0.308	0.487		
5-1			12.029	32.515	0.160					2.088	4.749	1.408		
6-1	1.876		18.681	14.476	5.432			3.240		0.006	1.258	1.648		
6-2	***		2.095	4.724	0.419			***		0.678	1.690	1.203		
6-3	***		20.064	18.231	0.381			***		10.366	9.708	1.170		
6-4	0.709		9.034	7.471	6.134			2.932		1.312	0.026	4.744		
7-1	0.690		28.447	16.465	1.830			3.104		0.285	0.359	1.151		
7-2	0.709		4.911	1.561	*			2.516		0.214	0.172	*		
7-3	0.787		20.081	23.224	0.615			0.760		1.203	2.572	1.062		
8-1			0.890		0.951		***			9.208		15.472		***
8-2			3.888		*					0.442		*		
10-1^														
10-2		2.768	6.334						2.223	0.693				
10-3		0.078	5.005						3.301	5.242				
11-1		* / **	0.578						* / **	0.866				
11-2														
12-1		0.531	5.672						1.472	1.617				
12-2		0.359	8.588						2.620	1.142				
13-1		1.189	3.041		0.787		2.598		7.923	0.119		3.711		0.090
13-2		1.177	4.604				4.282		0.885	2.507				0.132
14-1		1.586							2.668					
14-2		0.768							0.362					
15-1		0.328					**		0.032					**
15-2		0.429							0.076					
15-3		0.190					0.532		0.460					0.371

^ Did not collect at this site due to lack of water.
* No statistics generated because only one fish was captured in all removals.
** No statistics generated because all fish were caught on the first pass.
*** Estimate terminated at 5 times the total catch and reset to 1.5 times the total catch due to a non-descending removal pattern. Results should not be considered reliable.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