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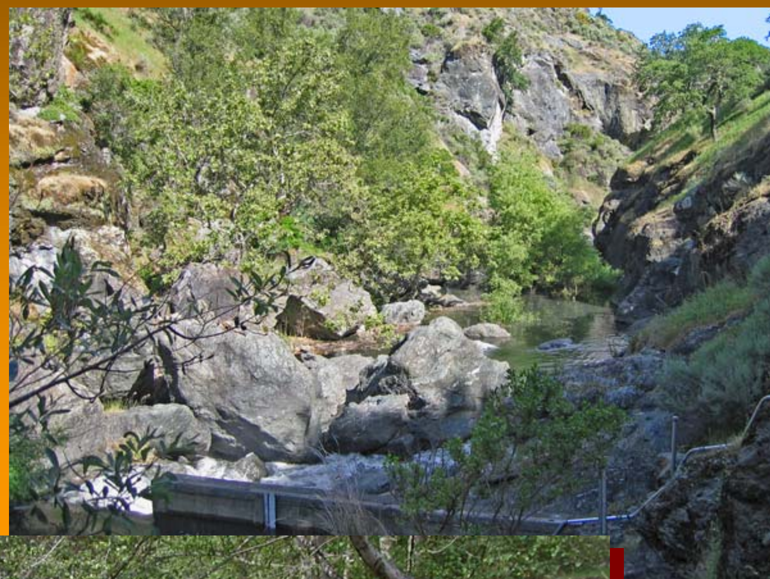
NATURAL RESOURCES DIVISION

Alameda Creek Aquatic Resource Monitoring Report 2004



Alameda Creek
Aquatic Resource Monitoring Report
2004

Prepared by:

San Francisco Public Utilities Commission
Natural Resources Division
Fish and Wildlife Group
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 reach of upper Alameda Creek, while maintaining suitable conditions for native, warm water species in a lower reach of upper Alameda Creek. The SFPUC will recapture for domestic use, at a facility 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 either constructing a water recapture facility or rehabilitating existing recapture infrastructure (infiltration galleries) 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 replaced before the SFPUC can regain 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 replacing Calaveras Dam. Experimental releases are expected to begin in 2006.

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 originally proposed recapture facility (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). 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 seventh year of pre-water release monitoring (January, 2004 through December, 2004). 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 third 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 2004 was recorded in Arroyo Hondo. Although maximum daily mean flows in Alameda Creek proper decreased from above the Alameda Creek Diversion Dam downstream to the Sunol Water Treatment Plant, they actually decreased between the Diversion Dam upstream site and the Sunol Regional Park site. Average annual daily mean flows were also greatest in the Arroyo Hondo. 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, although the maximum daily mean flow in Calaveras Creek was higher than normal due to water releases from Calaveras reservoir.

Water storage volumes in Calaveras Reservoir ranged from a low of 31,203 acre-feet to a high of 47,687 acre-feet. Volumes never dropped below the 30,000 acre-feet minimum storage criteria defined in the MOU.

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 late June. The pH ranged from a low of 7.0 in mid-November to a high of 8.7 in both late May and July. The highest turbidities in Calaveras Reservoir were measured in early January, ranging from about 30 to 41 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. Calaveras Reservoir was treated with copper sulfate one time in mid-July to control an extensive plankton bloom.

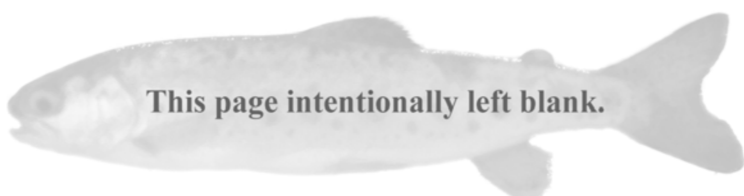
Stream water temperatures were highly variable, both temporally and spatially. Water temperatures in Alameda Creek in the lower study reach were generally higher than temperatures in the upper study reach throughout the year. The highest water temperatures at all stations in both reaches occurred throughout July and August. Following those two months the temperatures in both study reaches gradually decreased over the remainder of the year, with the lowest temperatures measured from late October to early November. The station in Alameda Creek just downstream of the Diversion Dam had the least amount of mean daily water temperature variability, while the Alameda Creek station below the confluence of Alameda and Calaveras creeks had the highest variability.

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 several pools were low enough to stress fishes, with concentrations in one pool in Calaveras Creek low enough to exclude all but the most tolerant fishes.

The trout spawning survey was conducted in Alameda Creek only in the cold water, upper study reach. Although a single rainbow trout juvenile was observed in the Little Yosemite area of Alameda 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 ten pools. California roach were the most abundant species, while roach and Sacramento sucker were the most widely distributed. Largemouth bass and sunfish, which are typically found only in a single pool in Calaveras Creek, were observed in two Alameda Creek pools downstream of its confluence with Calaveras Creek. Prickly sculpin were noted from two pools in Arroyo Hondo and a single pool in Alameda Creek.

Twenty-seven habitat units (riffles, runs, glides and shallow pools) from thirteen stations were sampled using electrofishing gear. A total of eight species of fishes were collected, including, in descending abundances, California roach, rainbow trout, Pacific lamprey ammocetes, prickly sculpin, Sacramento pikeminnow, Sacramento sucker, largemouth bass and bluegill. In Alameda Creek, rainbow trout were not collected downstream of its confluence with Calaveras Creek, while they were found in all stations (but not all habitat types) from Little Yosemite upstream. 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 Alameda Creek site just downstream of Calaveras Creek. Bluegills, on the other hand, were found in Alameda Creek as far downstream as the Calaveras pipeline crossing off of Geary Road.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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 (Figure 1-1) and Tunnel in 1931 (EDAW, 1998).

Figure 1-1. *Alameda Creek Diversion Dam spilling.*

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 through the diversion tunnel and minimal contributions from Calaveras Creek.

Calaveras Dam, and the associated SVWC water delivery system, was 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 2004 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.

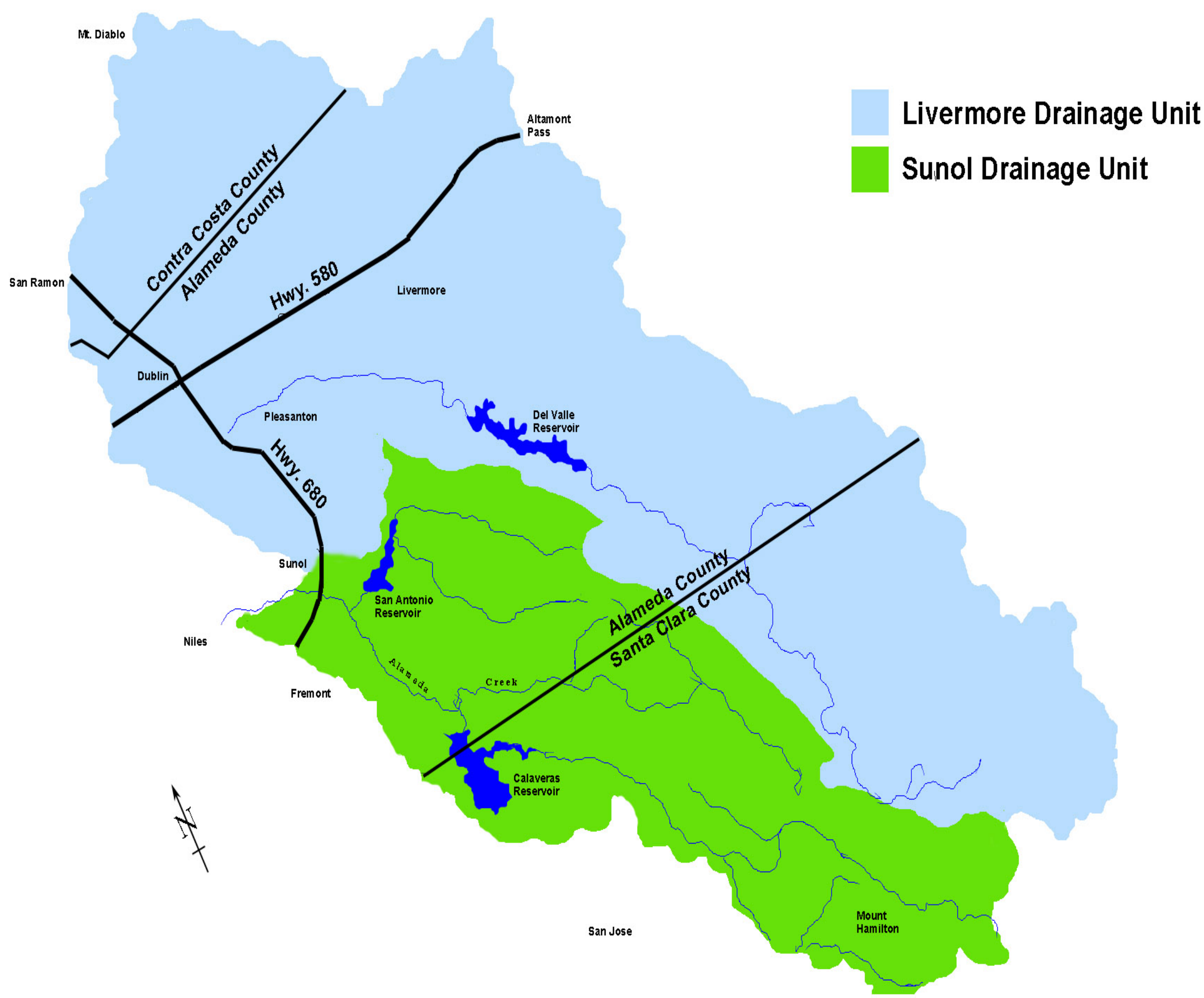


Figure 2-1. *Alameda Creek watershed.*

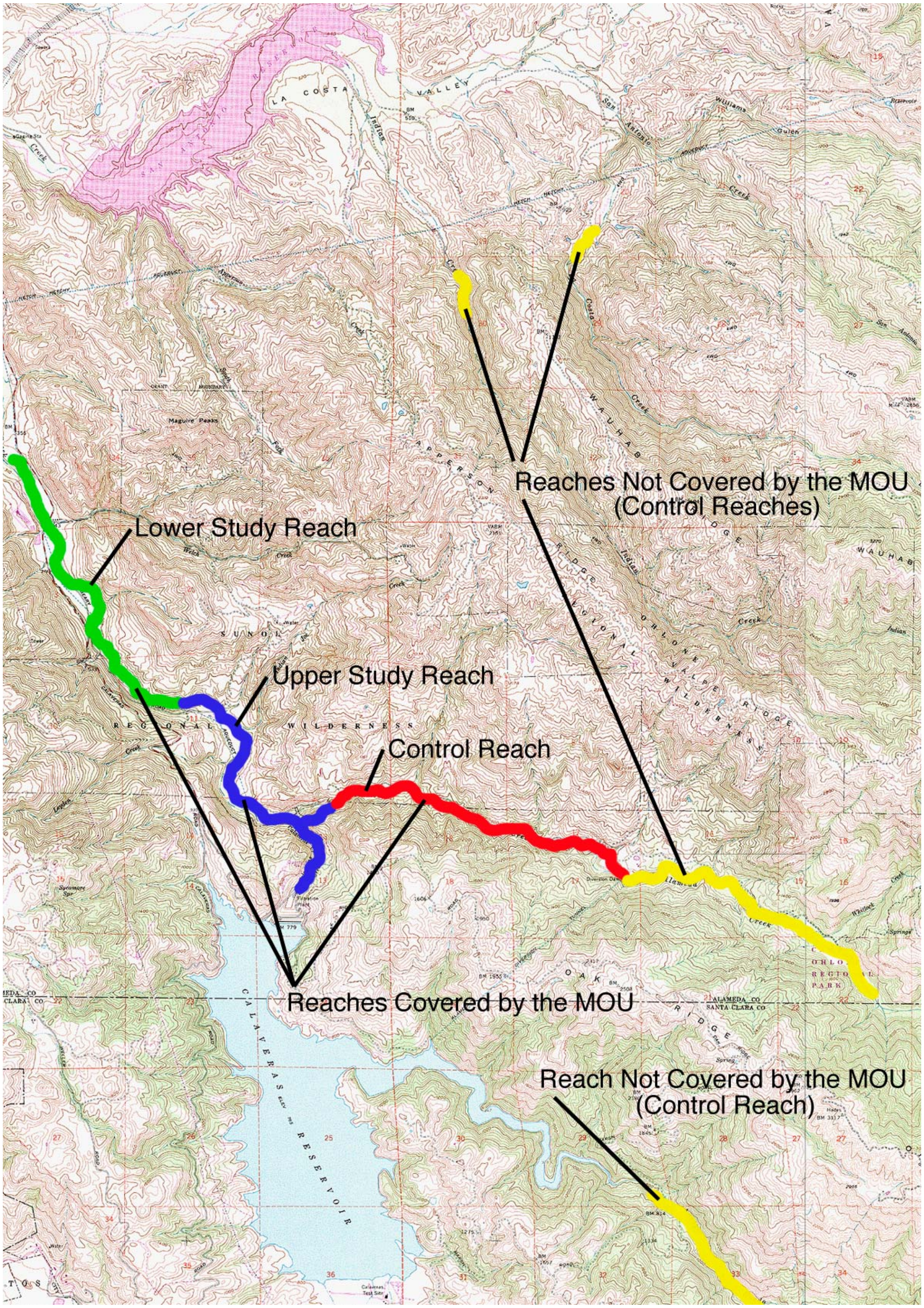
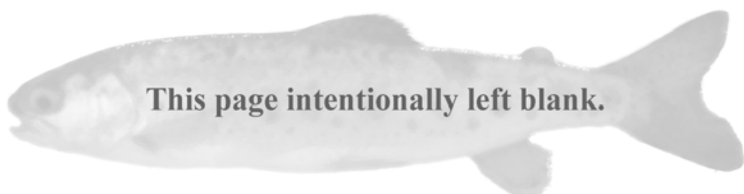


Figure 2-2. *Alameda and Calaveras creek reaches covered by the MOU between the SFPUC and CDFG, plus additional reaches added to the monitoring program to take a watershed approach to restoration.*

The MOU (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 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 in 2003, 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). An upper, or cold water reach extends 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. A 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 third 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 reach in Alameda Creek upstream of the Alameda Creek Diversion Dam and the reaches in La Costa Creek, Indian Creek and Arroyo Hondo (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. Daily mean flow 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 and verified 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 11.7 cfs, with multiple days in September, October and November showing no recordable flow. The maximum daily mean flow, of 552 cfs, was recorded on February 26, 2004 (Figure 3-2).

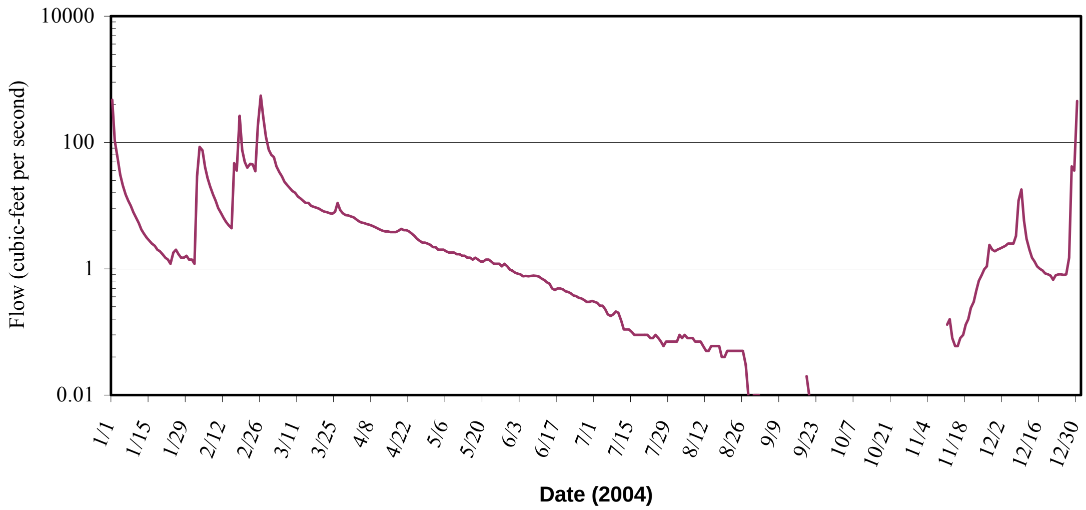


Figure 3-2. *Daily mean streamflows recorded at USGS station 11172945, located in upper Alameda Creek above the Alameda Creek Diversion Dam, for 2004.*

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 32.3 cfs, with minimum and maximum daily mean flows of 0.24 cfs on September 2, 2004 and 1,530 cfs on December 31, 2004, respectively (Figure. 3-3).

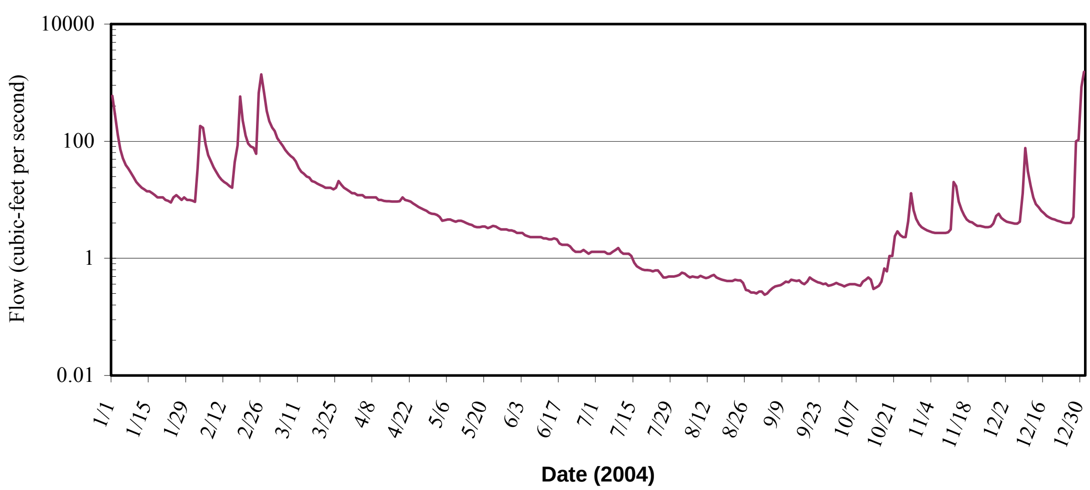


Figure 3-3. *Daily mean streamflows recorded at USGS station 11173200, located in Arroyo Hondo above the Marsh Road bridge, for 2004.*

USGS 11173500 Streamflows

Located in Calaveras Creek at the second weir downstream of Calaveras Dam, this streamflow gauge collected data throughout the year. Daily mean flow measurements averaged 0.05 cfs for all days of the year excluding April 16 through 23, 2004, at which time water releases from Calaveras Reservoir boosted flows to a high of 100 cfs. There were multiple days throughout July, August and September when there were no recordable flows, which were included in the calculation of the average daily mean flow (Figure 3-4).

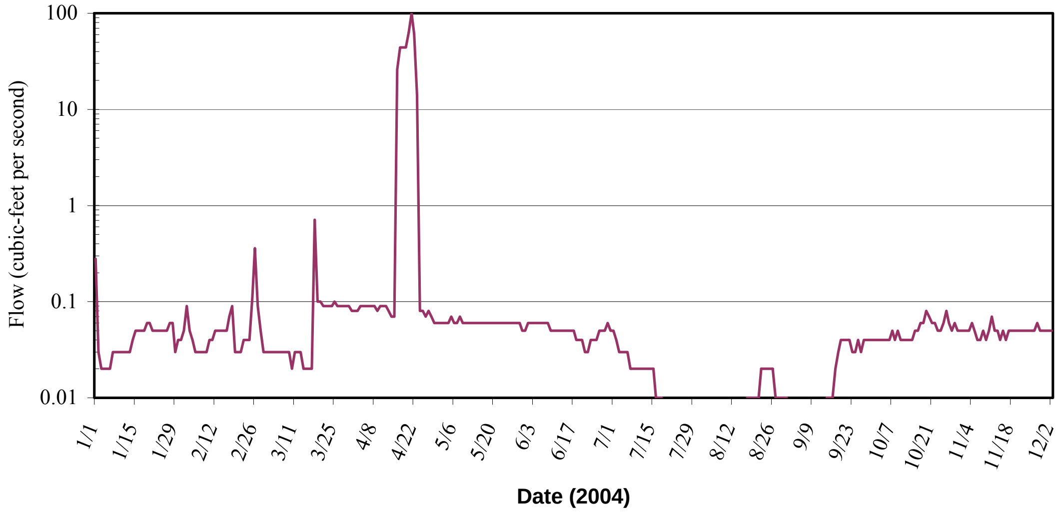


Figure 3-4. *Daily mean streamflows recorded at USGS station 11173500, located in Calaveras Creek below Calaveras Dam, for 2004.*

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. In 2004, data were available from January 2 through December 29 from this USGS gauge. Daily mean flows averaged 2.6 cfs, with a minimum daily mean flow of 0.02 cfs for four days in mid October and a maximum of 97 cfs on April 21, 2004 (Figure 3-5).

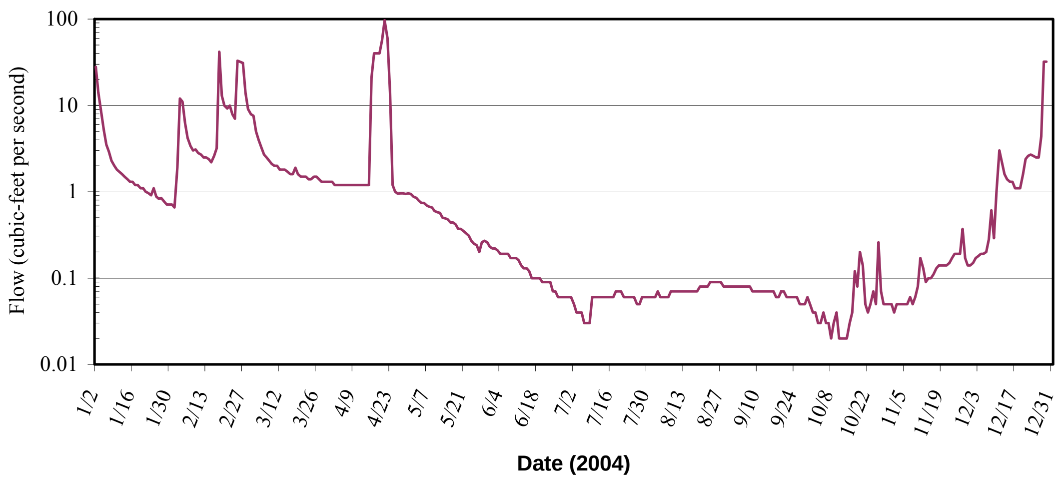


Figure 3-5. *Daily mean streamflows recorded at USGS station 11173510, located in upper Alameda Creek in Sunol Regional Park, for 2004.*

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 year. Measurements averaged 10.4 cfs, with a maximum daily mean flow of 841 cfs on the last day of the year. There were multiple days in August, September and early October with no recordable flows (Figure. 3-6).

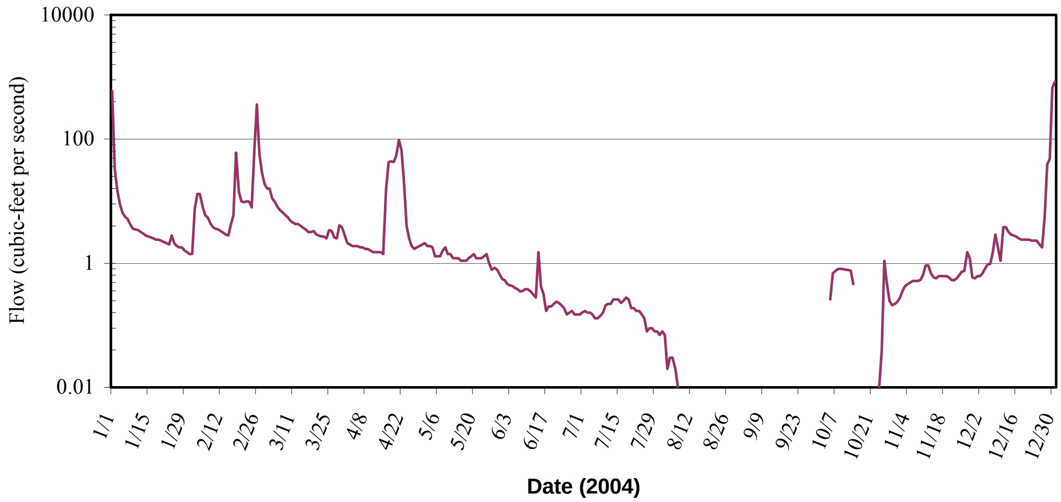
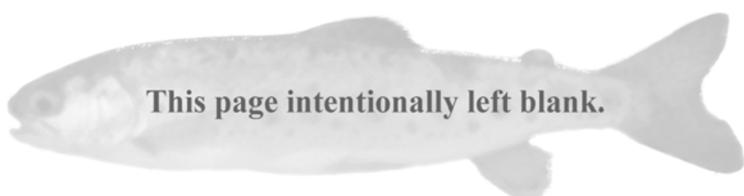


Figure 3-6. *Daily mean streamflows recorded at USGS station 11173575, located in Alameda Creek downstream of Welch Creek, for 2004.*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4.0 Calaveras Reservoir Conditions

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 the depth-related variability of some water quality parameters that can occur in stratified reservoirs, 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. However, in 2001, 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 has made it difficult to maintain the required storage and meet the water quality objectives defined in the Water Quality Control Plan (Basin Plan) for the San Francisco Bay Basin (SFBRWQCB, 2005). Tables 4-1 and 4-2 summarize key components of the Basin Plan.

Table 4-1. *Recommendations for surface water quality in the Alameda Creek Watershed.*

Parameter	Concentration
Dissolved Oxygen	
cold water habitat	7.0 mg/L
warm water habitat	5.0 mg/L
pH	6.5 to 8.5 units
Sulfide	less than ambient
Unionized Ammonia	< 0.4 mg/L (NH3-N)
Copper	< 13 *u*g/L
Total Dissolved Solids (TDS)	< 250 mg/L
Chlorides	< 60 mg/L

Table 4-2. *Existing beneficial uses for Alameda Creek and Calaveras Reservoir.*

	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 about 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. Biologists from SFPUC Natural Resources Division 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 (DO), 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. Grab samples from the surface, twenty-, and forty-feet, are also analyzed in the lab for chlorophyll-*a* concentration, and a plankton sample is collected by towing an 80-micron mesh net through the upper fifty feet of the water column. When the reservoir is treated with copper sulfate (to control noxious algae blooms), additional samples are collected and analyzed for copper.

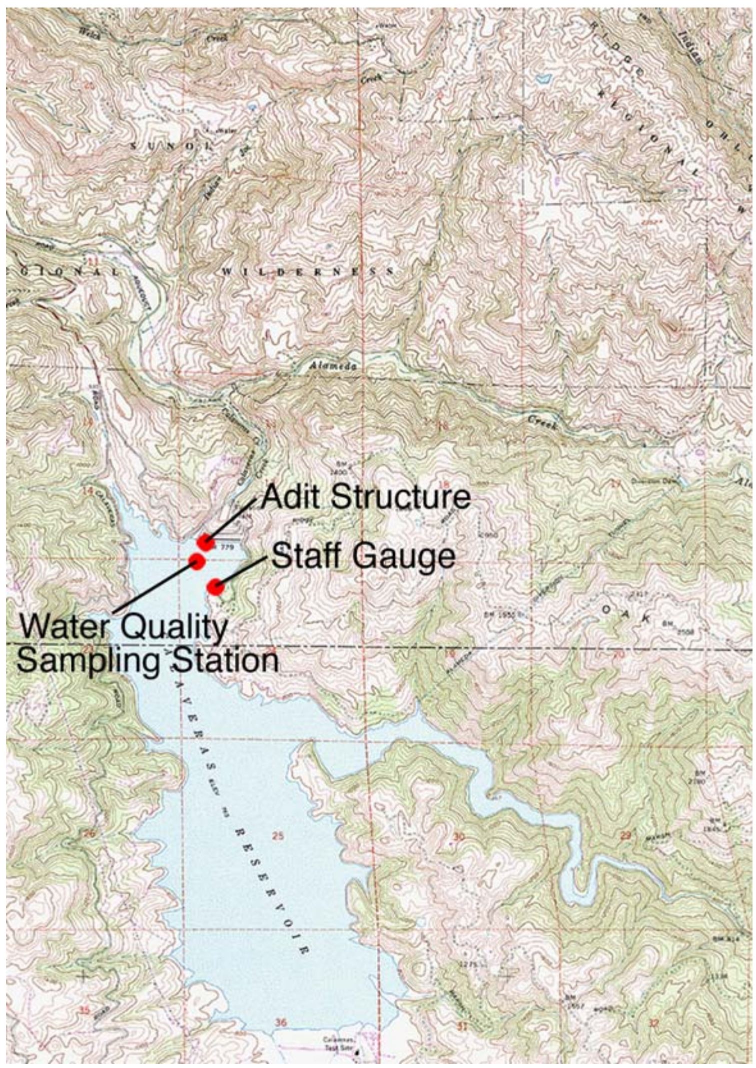


Figure 4-1. *Reservoir sampling locations.*

Water Storage

In 2004, Calaveras Reservoir was operated to comply with the DSOD restrictions. Additionally, the reservoir was operated to maintain the recommended 30,000 acre-feet of storage (Figure 4-2). At the beginning

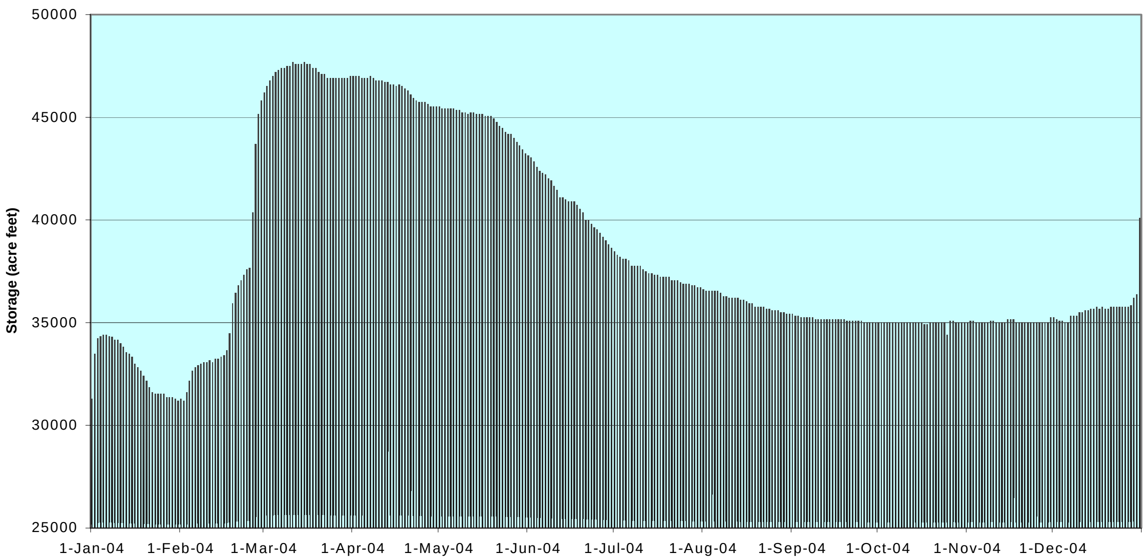


Figure 4-2. *Calaveras Reservoir 2004 daily (8:00 a.m.) water storage volume.*

of 2004, Calaveras Reservoir was just experiencing a peak in storage due to December 2003 storms that brought seven inches of rain to parts of the watershed and raised the reservoir elevation by five feet in five days. Storage was decreased by exporting water for treatment. In February, the reservoir experienced another rapid increase in storage when an additional seven inches of rain fell in some parts of the watershed. A peak flow of 2,360 cfs was experienced in the Arroyo Hondo, Calaveras Reservoir's main tributary, on February 25. For several days following the February storms, the reservoir rose three feet per day. The storage was again decreased through exports for treatment and by releases into Calaveras Creek. Minimum storage was 31,203 acre feet on January 31, and maximum storage was 47,687 acre feet on March 12.

Water Quality

Calaveras Reservoir water temperatures were typically isothermal from January through February and again following the fall turnover in December (Figure 4-3). The reservoir stratified with the most intense period between June and September. During this period, the thermocline was between 20- and 30-feet with a maximum water temperature of 24.7°C in the epilimnion on August 13, and a minimum temperature of 9.3°C in the hypolimnion on January 13.

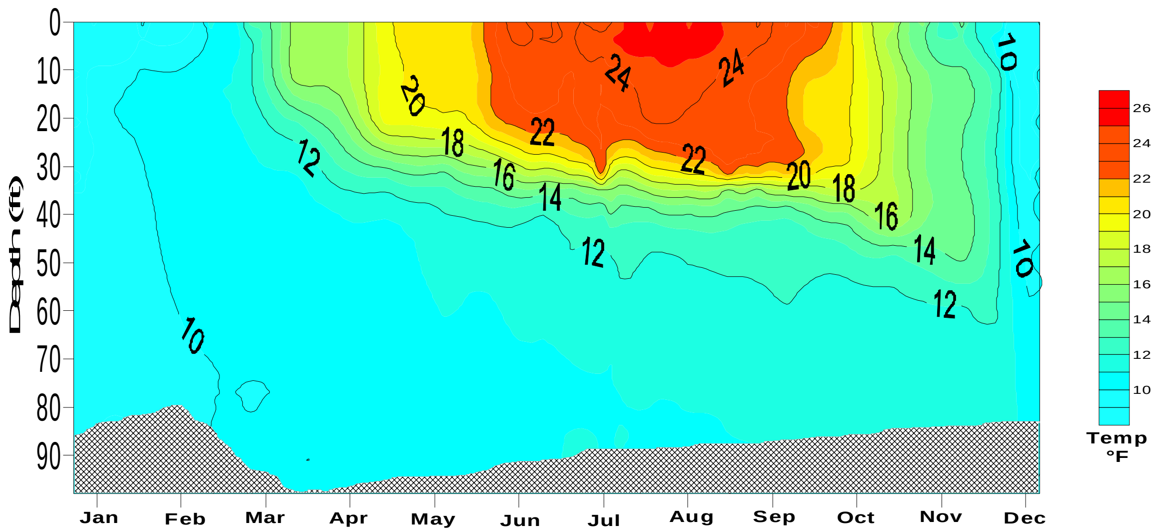


Figure 4-3. *Calaveras Reservoir water temperature profile for 2004.*

Dissolved oxygen concentrations were near saturation during the periods when the reservoir was isothermal (Figure 4-4). Between May and November, DO concentrations in the hypolimnion were less than 3 mg/L. From July through October, most of the water below the thermocline was anoxic, with DO concentrations dropping to less than 1 mg/L. For a period in August and September, the DO concentrations near the surface were greater than 100 percent saturation due to a substantial algae bloom. With the DSOD restrictions in place, the anoxic conditions are likely to recur annually due to the reduced volume of oxygenated water available at the onset of stratification. However, a

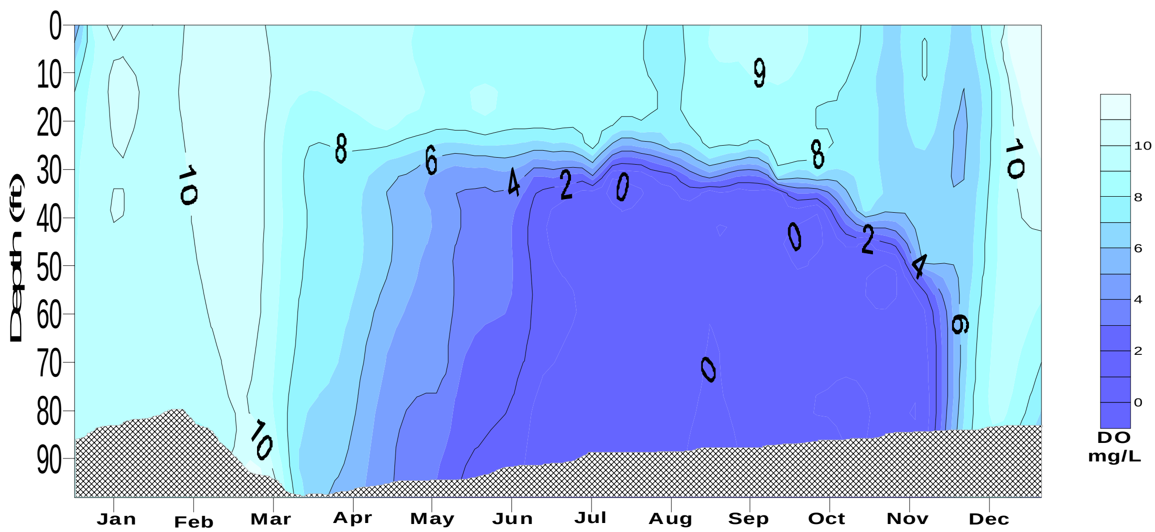


Figure 4-4. *Calaveras Reservoir dissolved oxygen profile for 2004.*

hypolimnetic oxygenation system due to be installed in 2005 is expected to remedy this situation.

Calaveras Reservoir pH values ranged from 6.99 to 8.72 (Figure 4-5). These values are slightly higher (more basic) than the 2003 values. After the reservoir completed its annual turnover in the fall, the pH trend was similar to previous years with higher pH water near the surface mixing with the lower pH epilimnetic water causing it to stabilize at an isograde condition with a pH of 7.6 units.

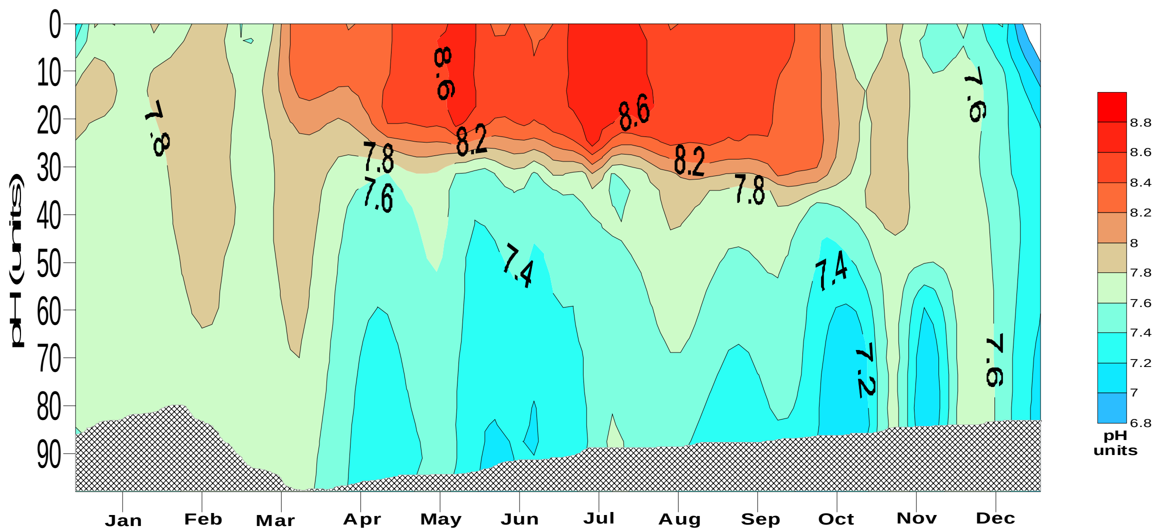


Figure 4-5. *Calaveras Reservoir pH profile for 2004.*

Turbidities in Calaveras Reservoir in 2004 were affected by a combination of storms, anoxia, and plankton (Figure 4-6). As the year started, turbidities were elevated throughout the water column due to rainfall and increased runoff from the storms of December 2003. The highest measured turbidity was 41.1 NTU on

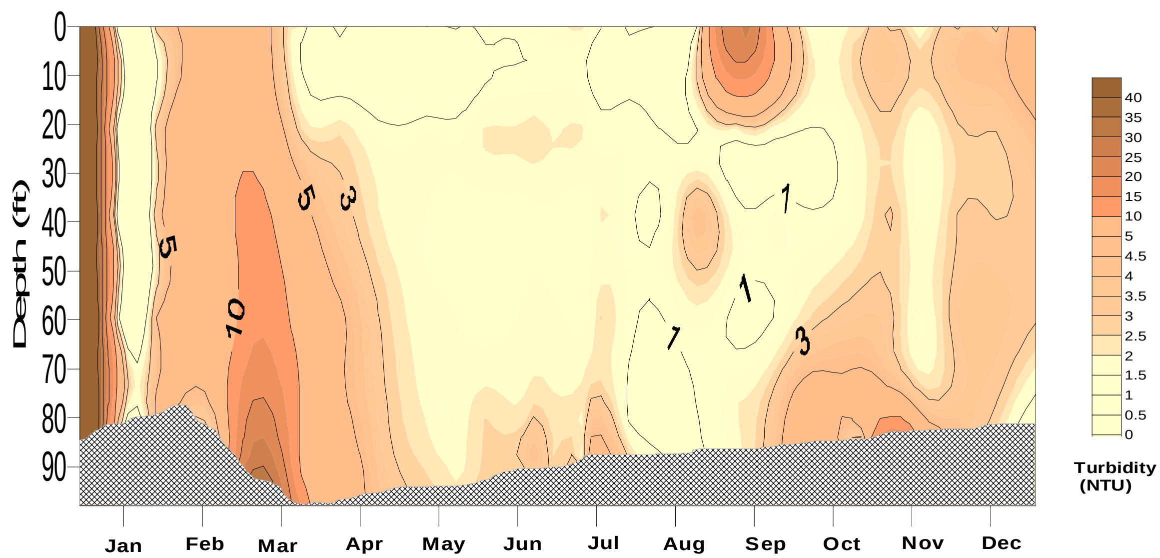


Figure 4-6. *Calaveras Reservoir turbidity profile for 2004.*

January 7. After this peak, a settling pattern continued until the February storms raised turbidities for several weeks. In addition to the storm related turbidity increases, a substantial algae bloom in September raised turbidities near the surface, and anoxia related turbidity caused an increase near the bottom in November. The anoxia related turbidity typically results from iron and manganese which becomes soluble under anoxic conditions and subsequently forms complexes with a variety of organic molecules.

Ammonia concentrations in 2004 (Figure 4-7) were similar to those of previous years during the DSOD imposed restrictions. In January, concentrations were moderate due to ammonia made available from the fall overturn and

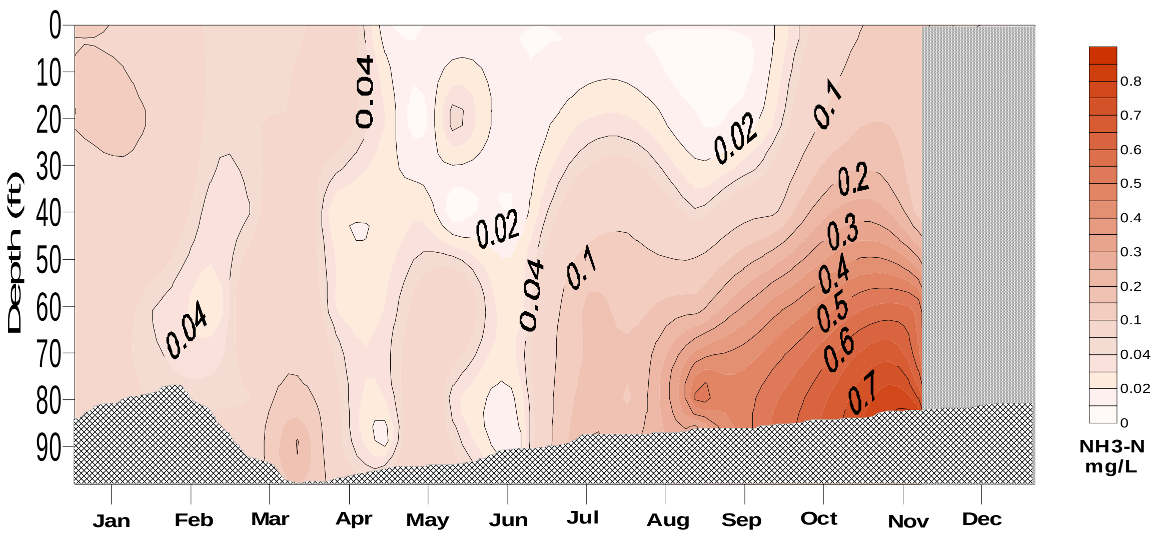


Figure 4-7. *Calaveras Reservoir ammonia concentration profile for 2004. The shaded area on the right is blanked due to lack of laboratory data.*

possibly from some external sources. Beginning in April, the ammonia concentrations, especially near the surface, began to decline due to biological uptake. As the anoxia intensified (after August) ammonia began to build up in the hypolimnion.

In 2004, Calaveras Reservoir had several episodes of high plankton counts, but was treated only once with copper sulfate. The reservoir was treated on July 15 with 1,900 pounds of copper sulfate to control a blue-green algae bloom. The treatment effectively reduced several species, but one of the problem species, *Lyngbya*, continued to thrive immediately after the treatment due to a sheath that protects the organism. However, by July 30, most of the blue-green species were only present in small numbers.

The reservoir experienced a second episode of increased blue-green algae populations throughout September. The Anabaena count reached 30 million colony forming units (cfu) per ml/m^3 on September 7, and peaked at 33 million cfu per ml/m^3 on September 23. Another blue-green algae, *Aphanizomenon*, reached a high of 21 million cfu per ml/m^3 during the same period. Due to the fact that the reservoir was not being used for domestic water supply during this period, treatment with copper sulfate was not considered. Pre- and post-treatment monitoring for the July 15 copper application are presented in Table (4-3).

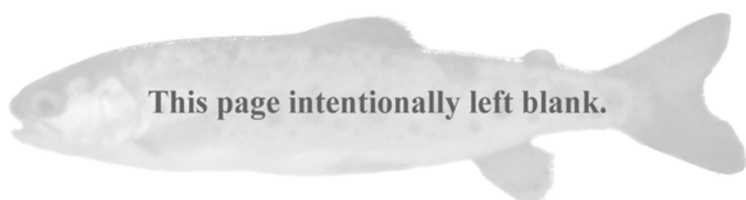
Table 4-3. *Copper concentrations before and after treatment.*

Calaveras Reservoir Copper Concentrations (*u*g/L or ppb)			
Depth	**Date** (mm/dd)		
	7/15 (pre treatment)	7/15 (post treatment)	7/19
Surface	3.8	164.8	13.8
20 feet	3.1	37.7	11.6
40 feet	3.0	4.1	3.5
60 feet	2.6	3.9	3.6
80 feet	2.0	5.0	3.1
Bottom	2.4	4.7	4.3

Hydrogen sulfide odors were detectable in grab samples from July 30 through November 16. Concentrations were estimated in the field with a Hach®, HS-C hydrogen sulfide test kit. The results are presented in Table 4-4.

Table 4-4. *Hydrogen sulfide odor detection and concentrations for 2004.*

Calaveras Reservoir Hydrogen Sulfide Testing + = odor detected nd = not detected nt = not tested value = mg/L										
Depth	**Date** (mm/dd)									
	7/30	8/13	8/25	9/7	9/23	10/7	10/25	11/04	11/16	11/30
40	+	+	+	+	nd	nd	nd	nd	nd	nd
60	+	+	0.3	0.5	0.7	+	0.5	+	2.0	nd
80	+	0.5	0.7	2.0	nt	nt	1.0	+	nt	nd
BTM	+	nt	4.0	nt	3.0	+	0.3	+	4.0	nd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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 unsuitable thermal 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 stream reach.

Figure 5-1. *Natural Resources Division biologist Jason Bielski downloads StowAway temperature data for analysis.*

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 an upper study reach, while maintaining sufficiently warm water in a 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 5-1)) were deployed by slipping foam bumpers over the ends of the recorders for shock protection, then placing them in pieces of 10-inch by 2-inch perforated PVC pipe. PVC end caps were glued to one end, and threaded end caps were screwed into the other. Lengths of steel cable were threaded through holes in the threaded end caps and body housings, and crimped secure with aluminum ferrules such that the only way to retrieve the sensors from the housings would be to cut the cables. The other end of the cables were then wrapped around secure structures in or next to the creek and crimped in place with aluminum ferrules.

Thirteen water temperature loggers, set to record at 30-minute intervals, were installed at thirteen locations in Alameda, Calaveras, La Costa and Indian creeks and Arroyo Hondo on various days between June 3 and 8, 2004 (Table 5-1, Figure 5-2). The water temperature sensors were removed from the creeks on various dates between November 10 and 15, 2004 (Table 5-1). The creek at site T-4 had dried up such that there was no surface water by early August, 2004, at which time the sensor was moved to a pool about 100-feet downstream. Due to sensor malfunctions, incomplete data sets were collected at sites T-4, T-17 and T-18 (Figures 5-7, 5-13 and 5-14 respectively).

Four air temperature/relative humidity loggers (Onset, Hobo Pro Series Recorders), 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 3 and 14, 2004 (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 between November 10 and 15, 2004.

Discrete water temperature, turbidity, pH, conductivity and dissolved oxygen concentrations were measured in each of the electrofishing habitat units (Figure 8-1) during the 2004 autumn survey. All water quality parameters were measured prior to electrofishing activities. Temperature, pH, conductivity and dissolved oxygen were recorded with a Hydrolab Surveyor and DataSonde water quality multiprobe unit. Turbidity was measured with a Hach 2100P turbidimeter.

Table 5-1. *Remote recording device deployment descriptions for 2004.*

Station	Logger	Parameters	Deployed	Retrieved	Location	Site Description
T-1	1	Water Temp.	6/7/04	11/10/04	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.	6/7/04	11/10/04	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.	6/7/04	11/10/04	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.	6/7/04	Moved downstream 8/12/04 Retrieved 11/10/04	In Alameda Creek, about 1,200-feet downstream of the Sunol Regional Park / SFPUC property 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-10	1	Water Temp.	6/7/04	11/15/04	In Calaveras Creek, downstream of Calaveras Dam, behind the most downstream 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 weir.

Table 5-1 continued.

Station	Logger	Parameters	Deployed	Retrieved	Location	Site Description
T-12	1	Water Temp.	6/3/04	11/10/04	In Alameda Creek, near Camp Ohlone. 37°29.28′ N 121°44.67′ W	Attached to a root-ball in a rock dam created pool near a park cabin.
T-13	1	Water Temp.	6/3/04	11/10/04	In Alameda Creek, upstream of the Diversion Dam. 37°29.77′ N 121°45.62′ W	Attached to a boulder in the middle of the channel.
T-14	1	Water Temp.	6/3/04	11/10/04	In Alameda Creek, downstream of the Diversion Dam. 37° 29.97′ N 121° 46.67′ N	Attached to the base of a small tree growing out of a boulder. Sensor located in the deepest part of the pool.
T-16	1	Water Temp.	6/8/04	11/15/04	In Arroyo Hondo, about ½-mile upstream of the landslide. 37°27.02′ N 121°44.21′ W	Attached to a boulder in the middle of the channel.
T-17	1	Water Temp.	6/8/04	11/15/04	In Arroyo Hondo, about 150-feet downstream of USGS streamflow station 11173200. 37°27.79′ N 121°46.33′ W	Attached to a root-ball, on the left side of the stream, downstream of the Marsh Road bridge.
T-18	1	Water Temp.	6/3/04	11/10/04	In La Costa Creek, about 100-feet downstream of the private property boundary. 37°33.89′ N 121°46.88′ W	Attached to a root-ball in a small pool.
T-19	1	Water Temp.	6/3/04	11/10/04	In La Costa Creek, about 400-feet upstream of its confluence with San Antonio Creek. 37°34.57′ N 121°46.51′ W	Attached to small boulder at the bottom of a bedrock scour pool.
T-21	1	Water Temp.	6/3/04	11/10/04	In Indian Creek, upstream of the Coast Tunnel crossing. 37°33.67′ N 121°47.85′ W	Attached to a small boulder at the bottom of bedrock scour pool.
TR-1	1	Air Temp. & Rel. Humidity	6/7/04	11/10/04	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	6/8/04	11/15/04	Adjacent to Arroyo Hondo, about 150-feet downstream of USGS streamflow station 11173200. 37°27.79′ N 121°46.33′ W	Attached to a laurel tree on the left bank of the creek, downstream of the Marsh Road bridge, in the shade.
TR-5	1	Air Temp. & Rel. Humidity	6/14/04	11/10/04	Adjacent to La Costa Creek, about 100-feet downstream of the private property boundary. 37°33.89′ N 121°46.88′ W	Attached to a willow tree, on the left bank, in the shade.
TR-6	1	Air Temp. & Rel. Humidity	6/3/04	11/10/04	Adjacent to Indian Creek, upstream of the Coast Tunnel crossing. 37°33.67′ N 121°47.84′ W	Attached to a laurel tree, on the right bank of creek, in the shade.

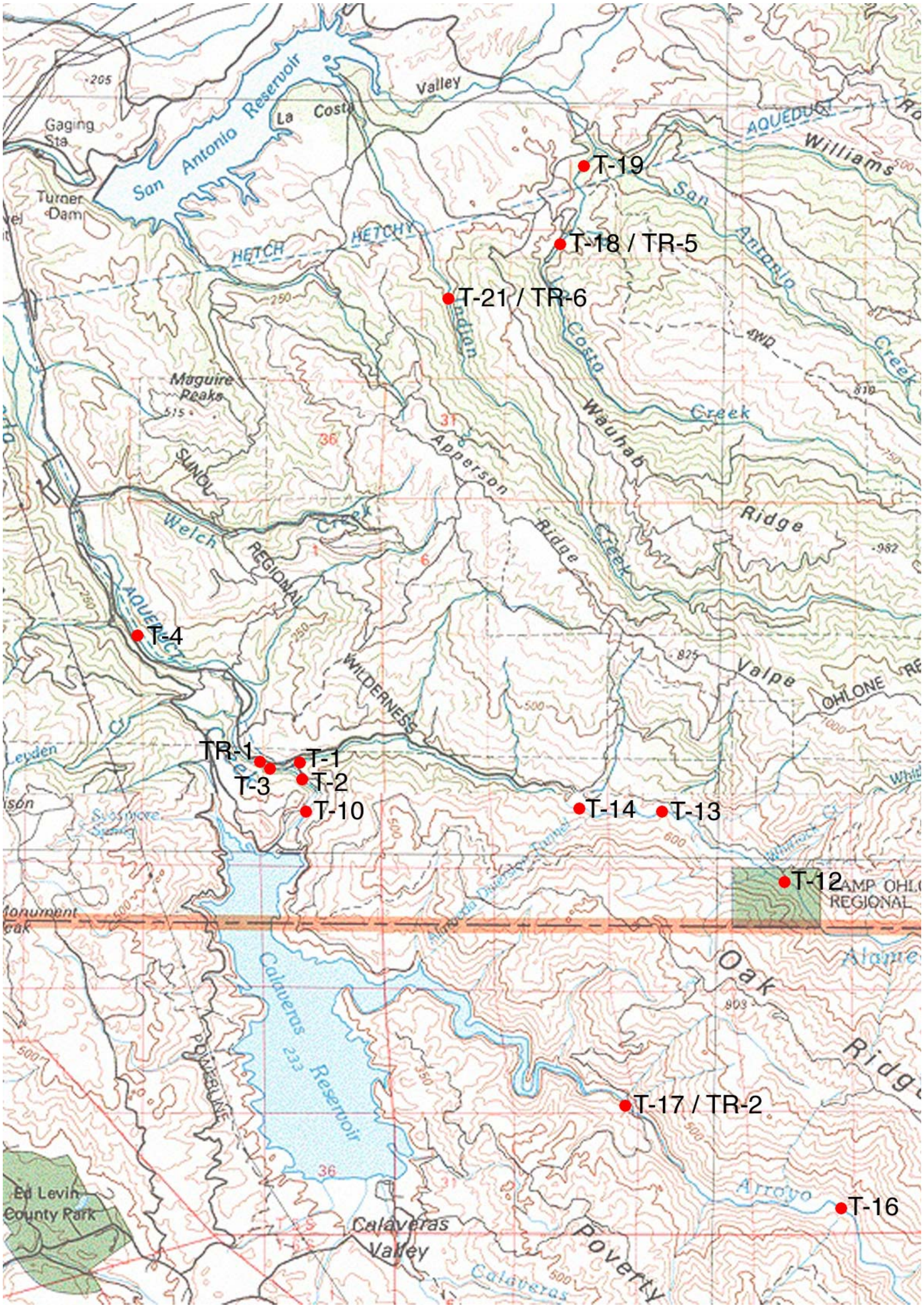


Figure 5-2. *Temperature sensor locations in Alameda, Calaveras, La Costa and Indian creeks and Arroyo Hondo.*

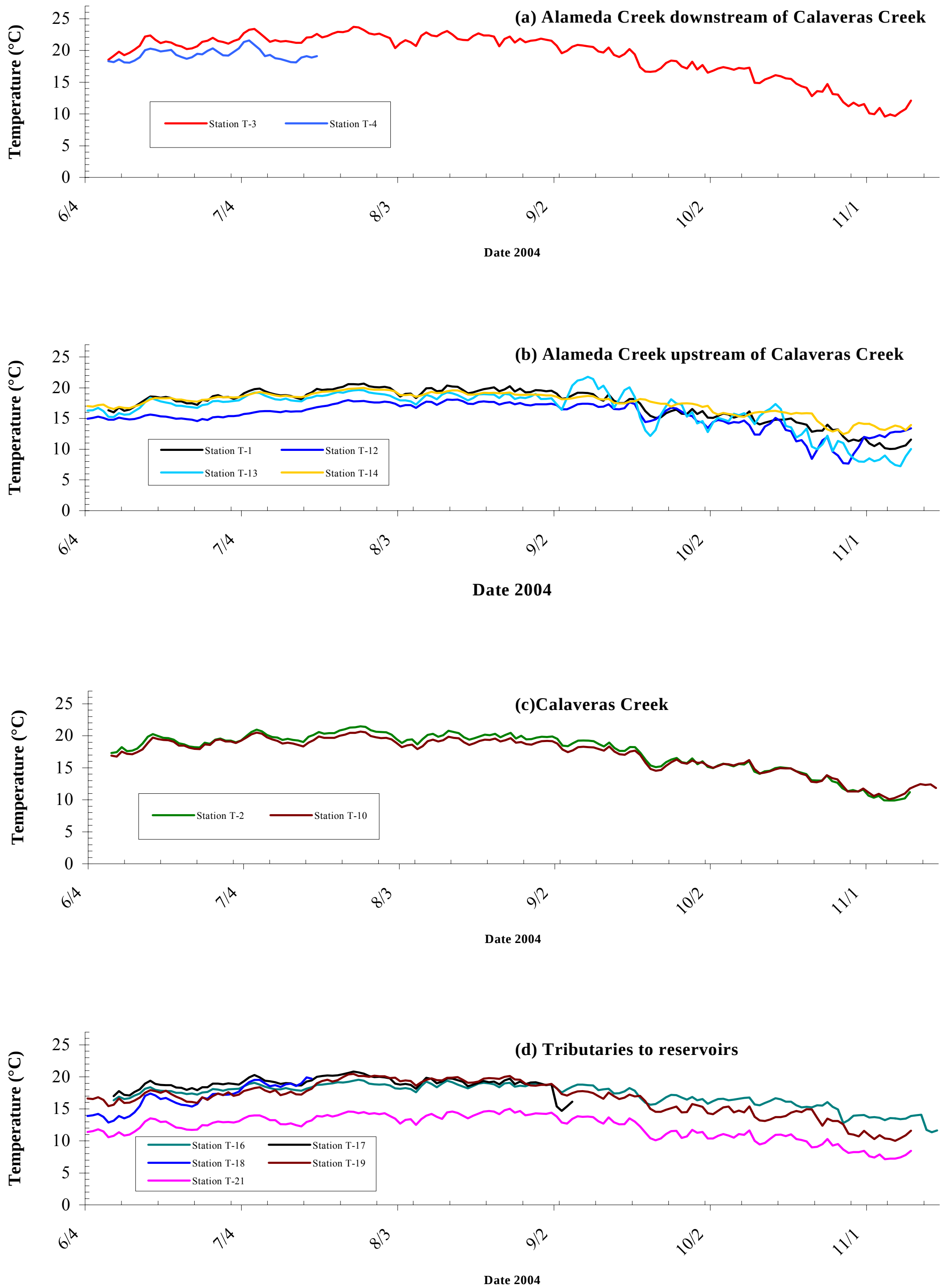


Figure 5-3. *Daily mean water temperatures at the monitoring stations in Alameda, Calaveras, La Costa and Indian creeks and Arroyo Hondo.*

Water Temperature

Graphs for the sites with complete data sets showed the same general trend (Figure 5-3 a-d), with the warmest temperatures occurring in late July and early August, and then tapering off to the coolest temperatures in November. The single exception was station T-13, in Alameda Creek upstream of the Diversion Dam, which had higher and lower temperatures in comparison to the other sites in September (Figure 5-3b).

Considering only sites with complete data sets, station T-21, located in Indian Creek, had the lowest daily minimum, daily maximum and daily average mean water temperatures at 7.1°C, 15.0°C and 12.1°C, respectively (Table 5-2, Figure 5-16). Stations T-12 and T-13, located at sites upstream of the Alameda Creek Diversion Dam, had similarly low minimum daily mean water temperatures at 7.6°C and 7.2°C, respectively (Table 5-2, Figures 5-9 and 5-10). Station T-14, located downstream of the Alameda Creek Diversion Dam, had the highest minimum daily mean water temperature at 12.4°C (Table 5-2, Figure 5-11). Station T-3, located in Alameda Creek downstream of its confluence with Calaveras Creek, had the highest maximum and average daily mean water temperatures at 23.7°C and 19.2°C, respectively (Table 5-2, Figure 5-6).

Station T-3 also had the highest average daily water temperature fluctuation at 8.4°C (Table 5-2, Figure 5-6), while station T-14 had the lowest at 0.9°C (Table 5-2, Figure 5-11). Station T-12, located in a relatively large pool upstream of the Alameda Creek Diversion Dam, had the largest maximum daily water temperature fluctuation at 13.6°C on October 16, 2004 (Table 5-2, Figure 5-9), while Station T-10, located in Calaveras Creek below Calaveras Dam, had the lowest maximum daily water temperature fluctuation at 2.2°C (Table 5-2, Figure 5-8). Station T-13, located upstream of the Alameda Creek Diversion Dam, had the highest minimum daily water temperature fluctuation at 1.4°C (Table 5-2, Figure 5-10), while station T-14, located just below the Diversion Dam, had several days in the summer with essentially no daily fluctuation (Table 5-2, Figure 5-11).

Table 5-2. *Daily water temperature (°C) statistics for 2004.*

	Daily Mean Water Temperature			Average Daily Water Temperature Fluctuation		
Station	**Minimum**	**Maximum**	**Average**	**Minimum**	**Maximum**	**Average**
T-1	10.0	20.6	17.2	0.6	3.0	1.6
T-2	9.9	21.5	17.6	0.6	3.2	2.0
T-3	9.6	23.7	19.2	2.0	12.0	8.4
T-4	18.1*	21.5*	19.3*	1.0*	3.9*	2.0*
T-10	10.1	20.7	17.0	0.5	2.2	1.3
T-12	7.6	18.1	15.4	0.6	13.6	3.0
T-13	7.2	21.8	16.4	1.4	10.2	4.3
T-14	12.4	20.0	17.5	0.0	3.0	0.9
T-16	11.3	19.6	17.2	0.4	4.9	3.2
T-17	14.7*	20.8*	19.0*	1.9*	5.7*	3.8*
T-18	12.8*	20.0*	16.7*	0.7*	5.9*	4.1*
T-19	10.0	20.5	16.6	0.3	4.3	1.8
T-21	7.1	15.0	12.1	0.4	3.6	2.1

* *Based on partial data set.*

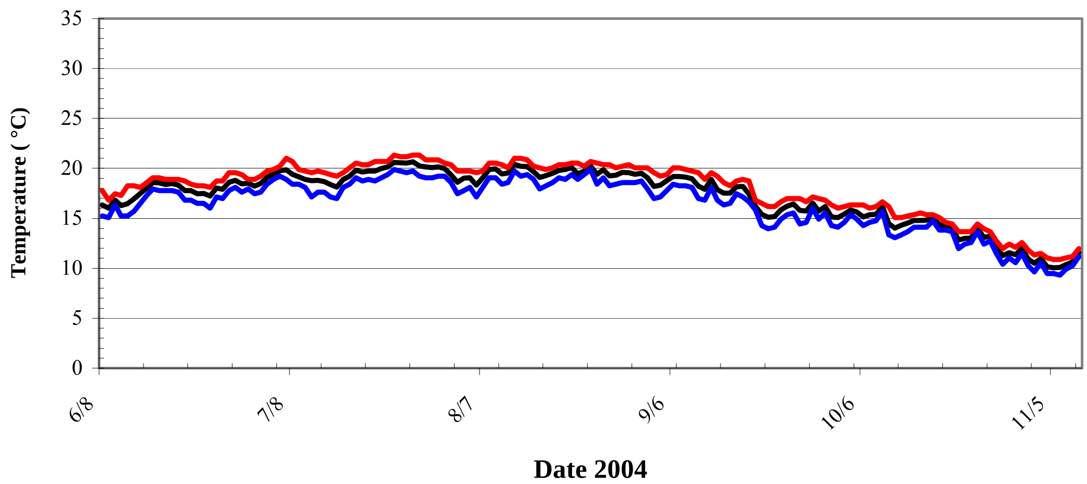


Figure 5-4. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-1 in Alameda Creek.*

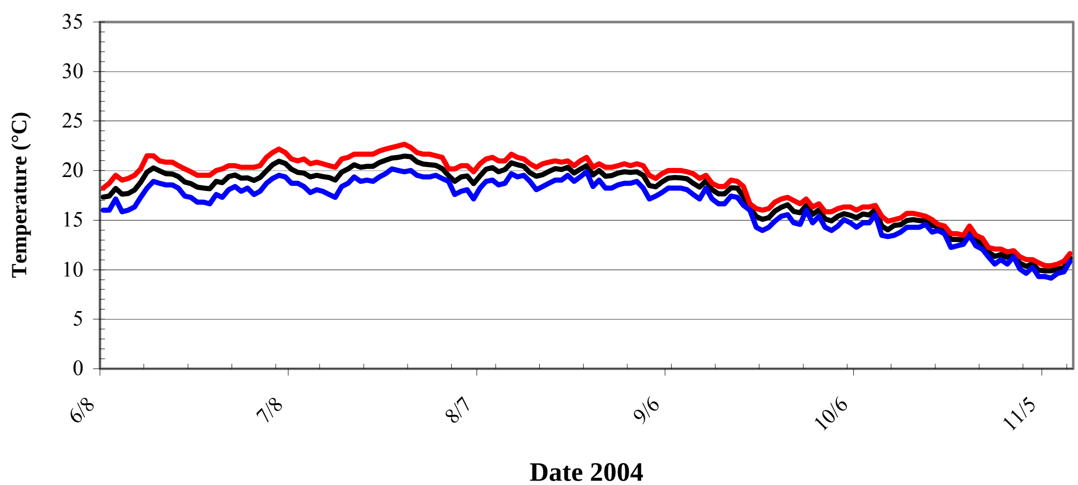


Figure 5-5. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-2 in Calaveras Creek.*

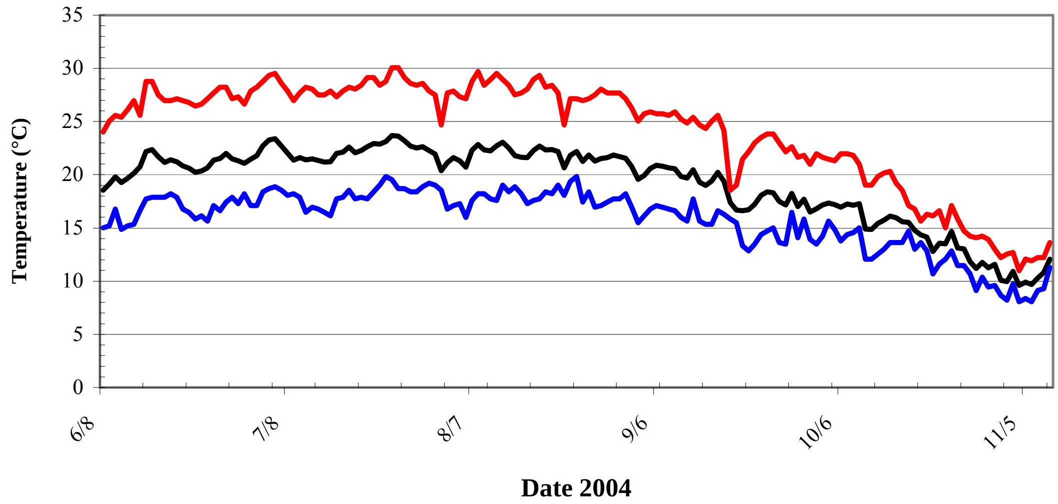


Figure 5-6. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-3 in Alameda Creek.*

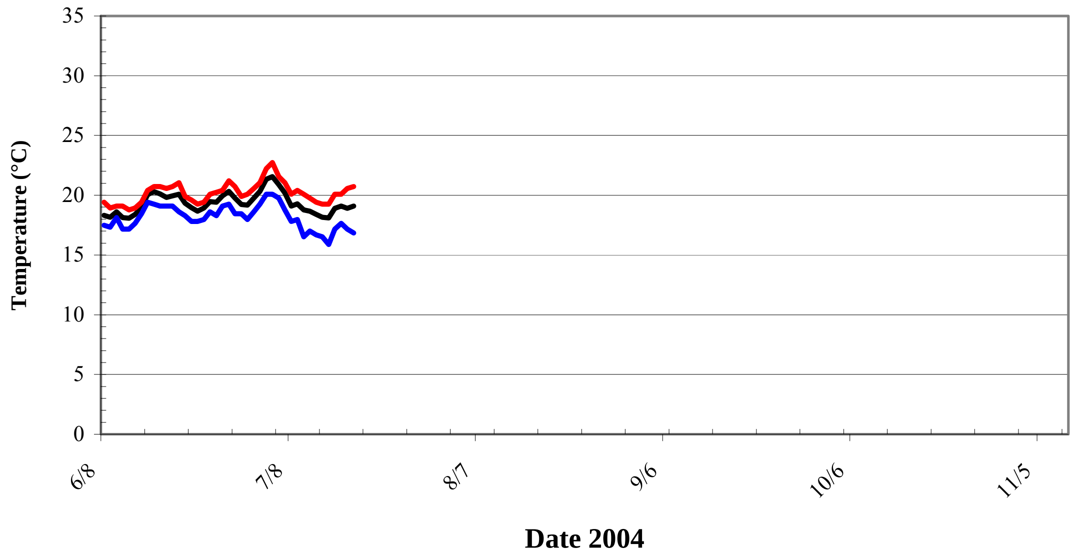


Figure 5-7. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-4 in Alameda Creek.*

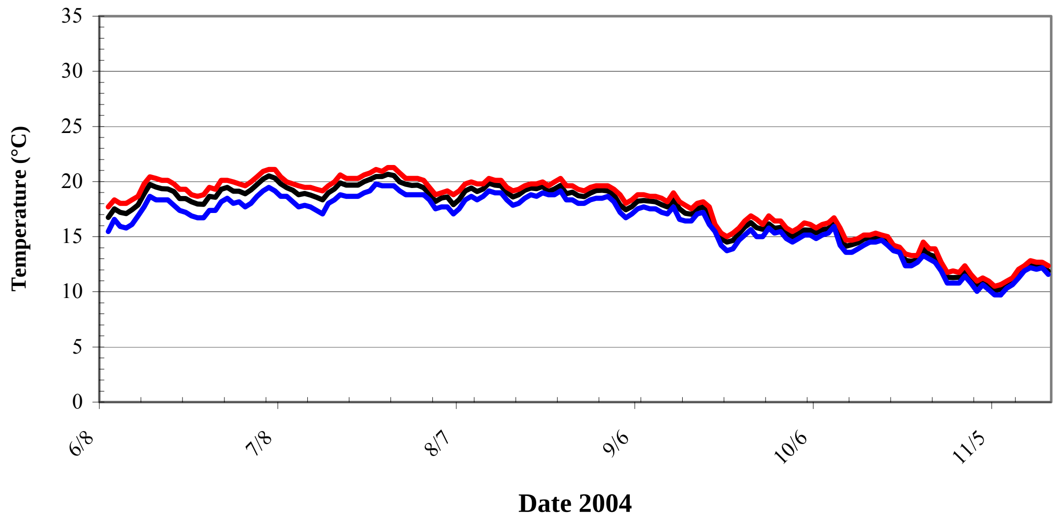


Figure 5-8. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-10 in Calaveras Creek.*

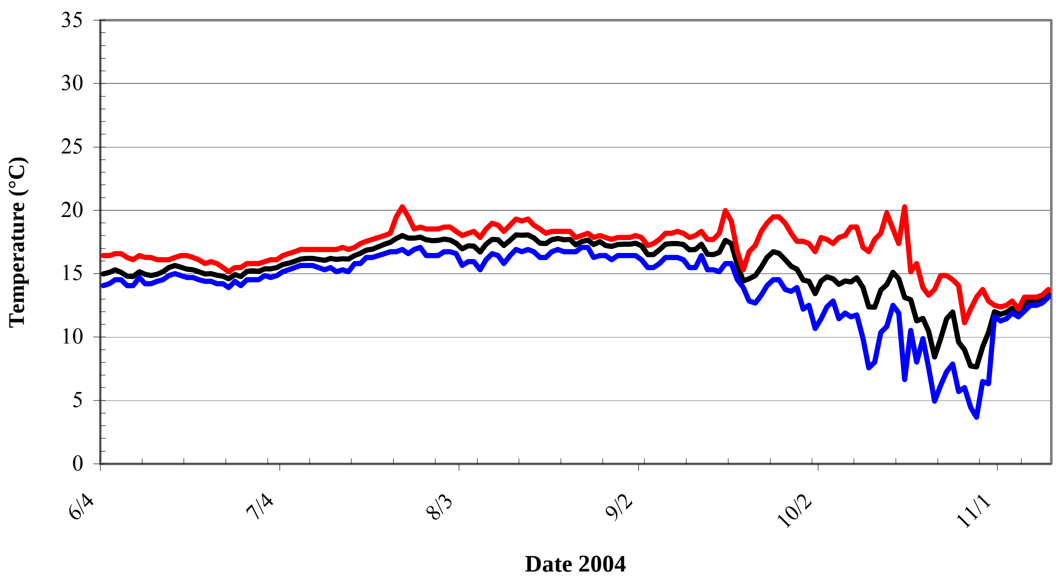


Figure 5-9. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-12 in Alameda Creek.*

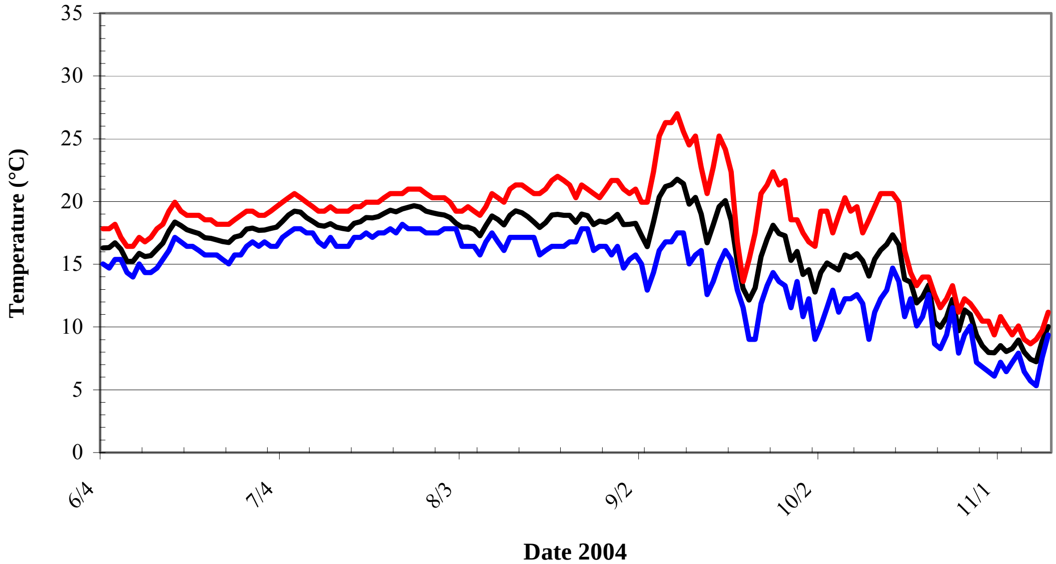


Figure 5-10. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-13 in Alameda Creek.*

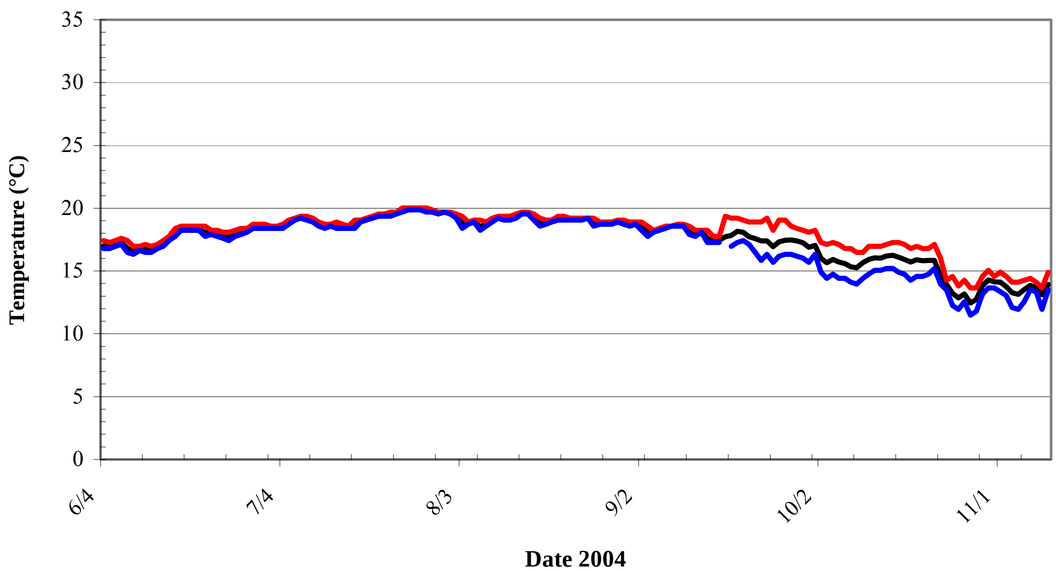


Figure 5-11. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-14 in Alameda Creek.*

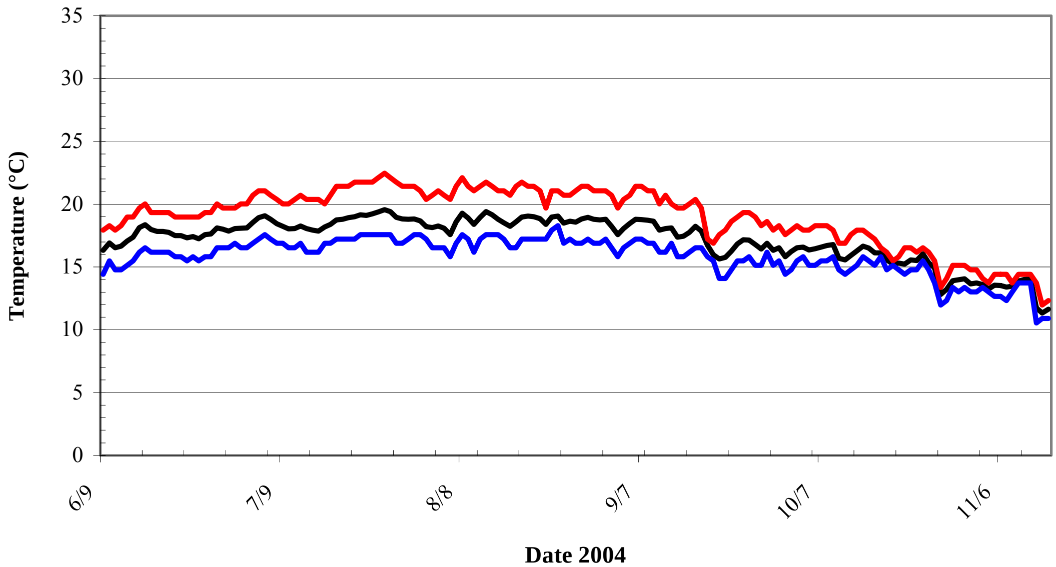


Figure 5-12. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-16 in Arroyo Hondo.*

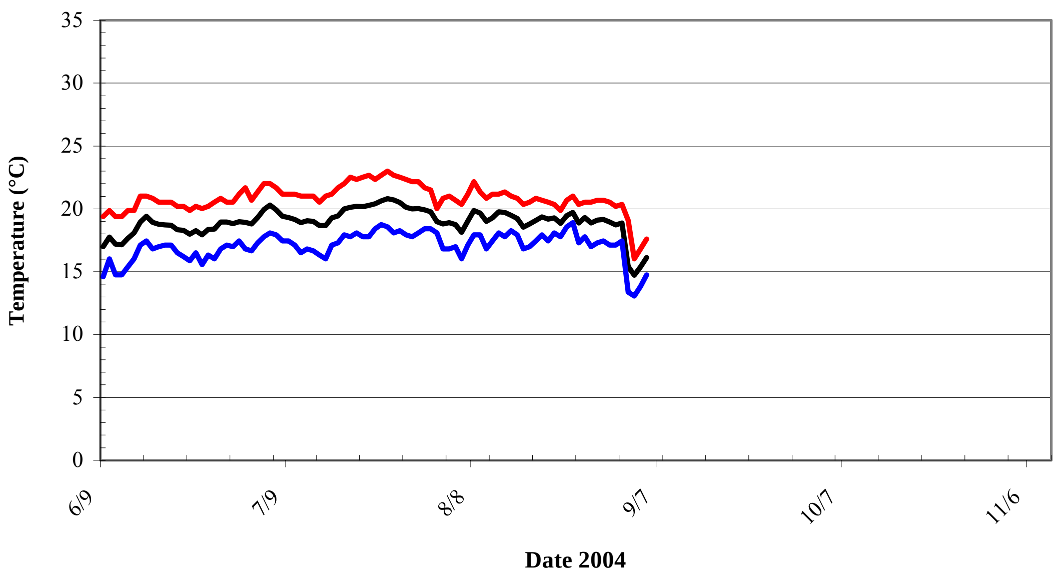


Figure 5-13. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-17 in Arroyo Hondo.*

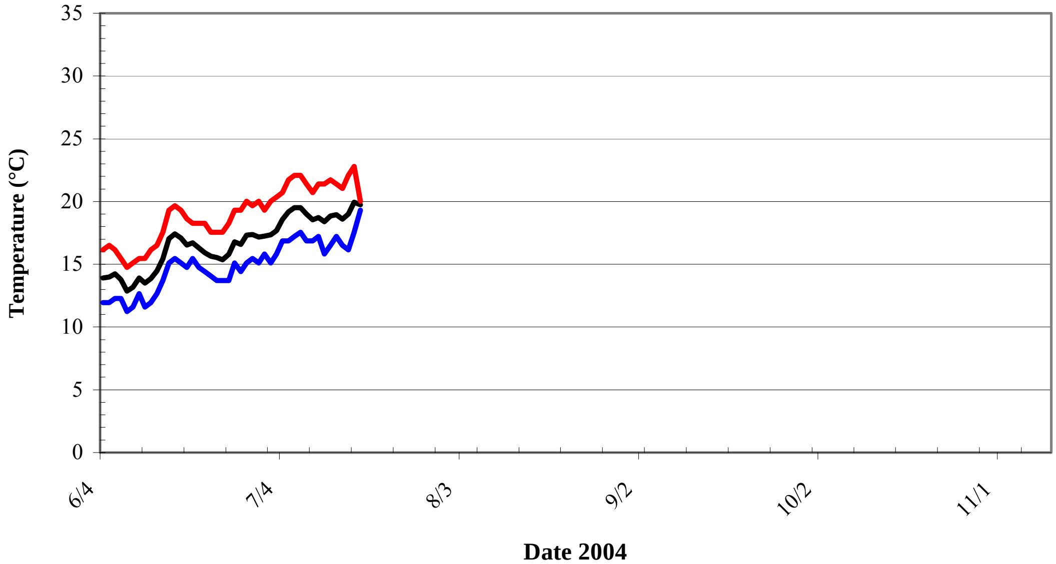


Figure 5-14. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-18 in La Costa Creek*

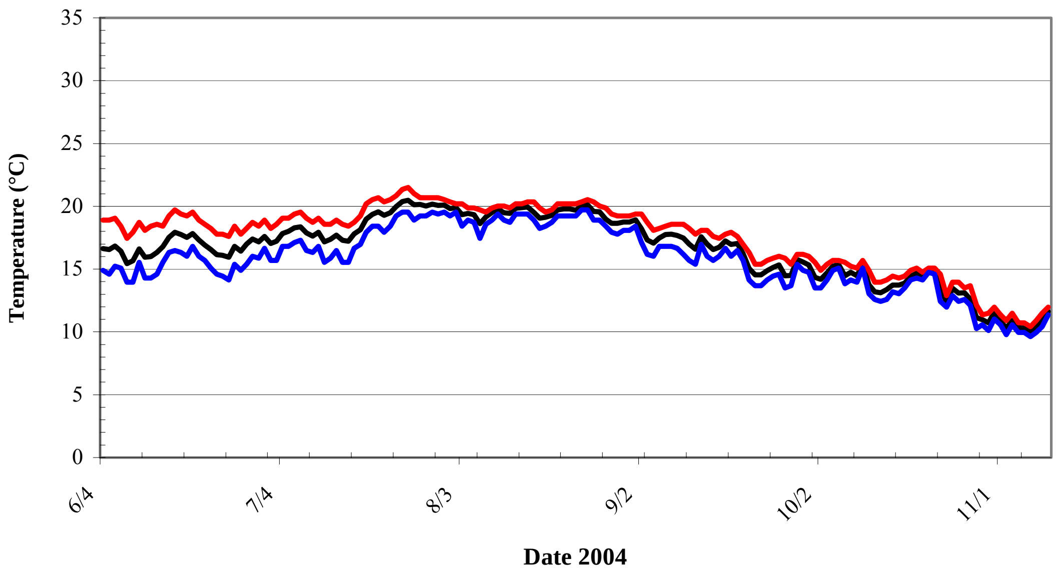


Figure 5-15. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-19 in La Costa Creek.*

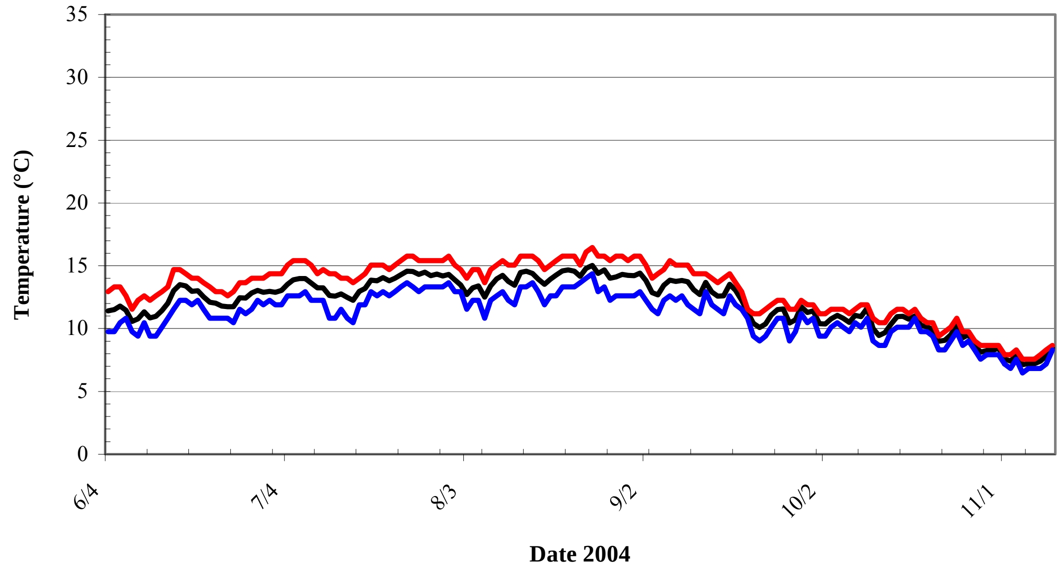


Figure 5-16. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-21 in Indian Creek.*

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. All four sites (TR-1, TR-2, TR-5 and TR-6) were included in last year's report (SFPUC, 2003).

All sites had similar minimum, maximum and average daily mean air temperatures (Table 5-3, Figures 5-17, 5-19, 5-21 and 5-23). While sites TR-2, TR-5 and TR-6 showed similar minimum, maximum and average daily air temperature fluctuations, site TR-1, located along Alameda Creek downstream of its confluence with Calaveras Creek, had slightly higher maximum and average daily air temperature fluctuations at 25.4°C and 16.0°C, respectively (Table 5-3).

Site TR-1 measured the highest minimum relative humidity at 33.0%, and site TR-2 measured the lowest at 19.5%. The sensors at sites TR-2, TR-5 and TR-6 recorded several measurements greater than 100% that appear to be associated with concurrent rain events. Average daily mean relative humidity readings for all sites were similar at about 62% (Table 5-4, Figures 5-18, 5-20, 5-22 and 5-24).

Site TR-2, located along the Arroyo Hondo, had three days during the monitoring period with no daily fluctuation, and site TR-6, located along Indian Creek, had a single day with no fluctuation. The highest minimum, maximum and average daily relative humidity fluctuations of 20.6%, 81.5% and 51.7%, respectively, were each measured at site TR-1 along Alameda Creek. The lowest maximum and average fluctuations (67.5% and 42.1%, respectively) were measured at site TR-6 along La Costa Creek (Table 5-4).

Table 5-3. *Daily air temperature (°C) statistics for 2004.*

	Daily Mean Air Temperature			Average Daily Air Temperature Fluctuation		
Station	**Min.**	**Max.**	**Avg.**	**Min.**	**Max.**	**Avg.**
Alameda Creek (TR-1)	7.0	24.7	18.2	2.8	25.4	16.0
Arroyo Hondo (TR-2)	7.4	24.1	16.8	3.2	19.3	12.3
La Costa Creek (TR-5)	6.7	24.9	17.3	2.9	21.8	13.3
Indian Creek (TR-6)	7.2	23.8	17.0	2.5	21.0	12.0

Table 5-4. *Daily relative humidity (%) statistics for 2004.*

	Daily Mean Relative Humidity			Average Daily Relative Humidity Fluctuation		
Station	**Min.**	**Max.**	**Avg.**	**Min.**	**Max.**	**Avg.**
Alameda Creek (TR-1)	33.0	93.5	60.5	20.6	81.5	51.7
Arroyo Hondo (TR-2)	19.5	103.7*	62.1	0.0	90.3	48.5
La Costa Creek (TR-5)	20.9	102.9*	62.3	10.2	83.5	49.8
Indian Creek (TR-6)	25.1	103.9*	65.4	0.0	67.5	42.1

**RH readings greater than 100% are associated with concurrent rain events.*

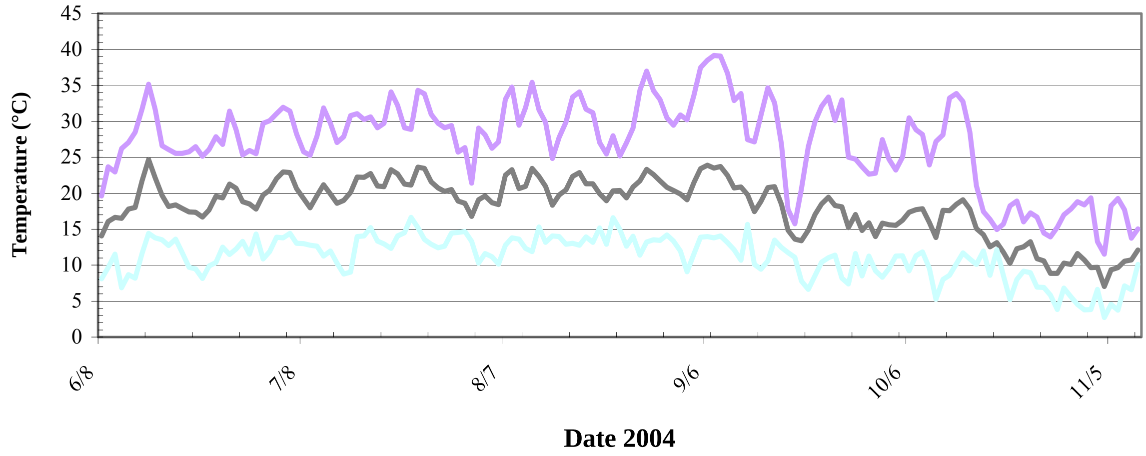


Figure 5-17. *Daily mean (gray), maximum (lavender) and minimum (turquoise) air temperatures at Station TR-1 near Alameda Creek.*

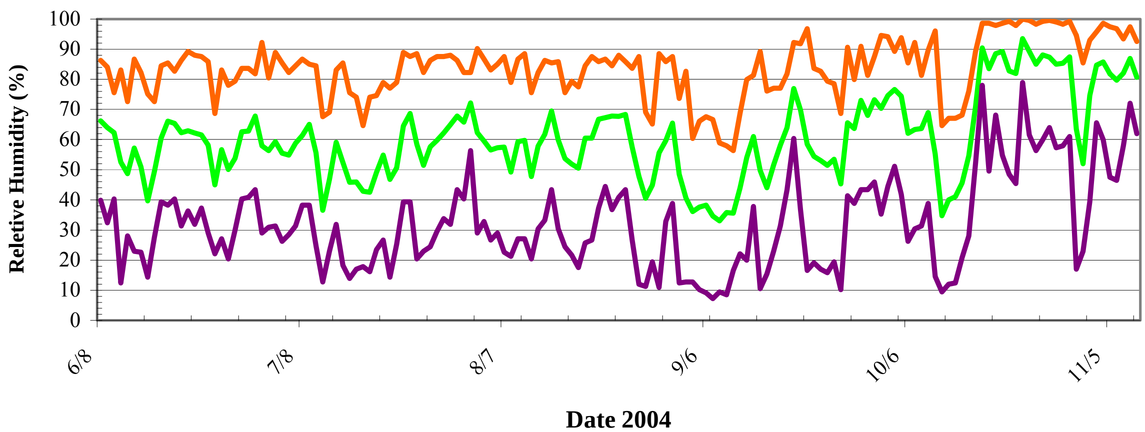


Figure 5-18. *Daily mean (green), maximum (orange) and minimum (purple) relative humidities at Station TR-1 near Alameda Creek.*

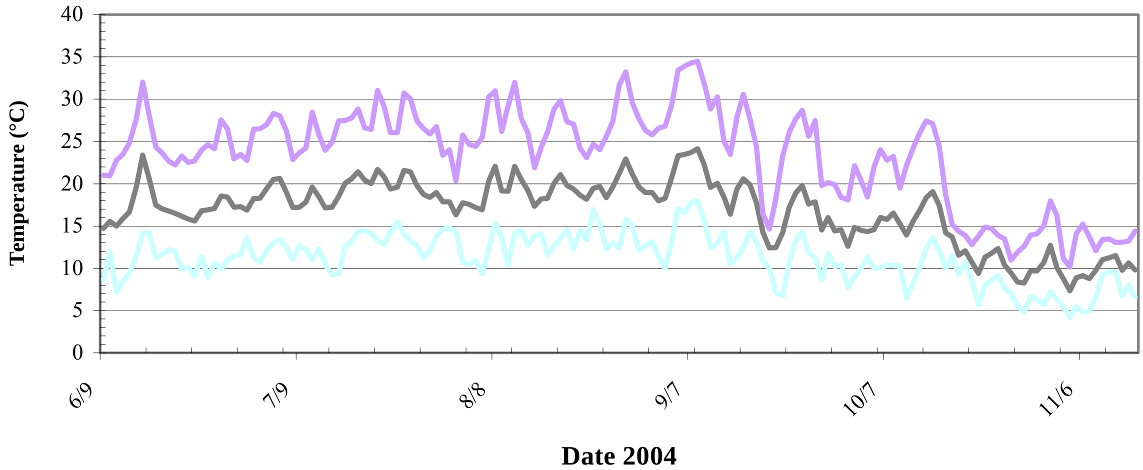


Figure 5-19. *Daily mean (gray), maximum (lavender) and minimum (turquoise) air temperatures at Station TR-2 near Arroyo Hondo.*

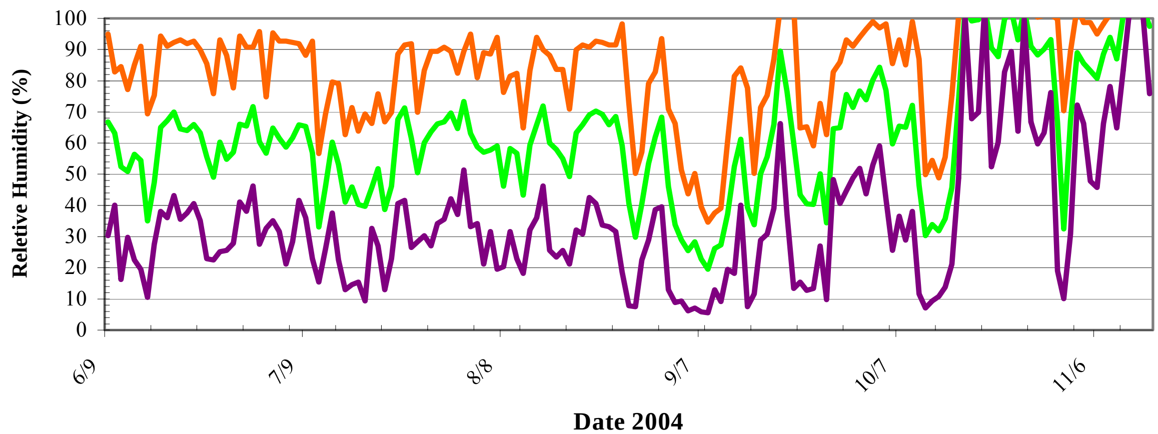


Figure 5-20. *Daily mean (green), maximum (orange) and minimum (purple) relative humidities at Station TR-2 near Arroyo Hondo.*

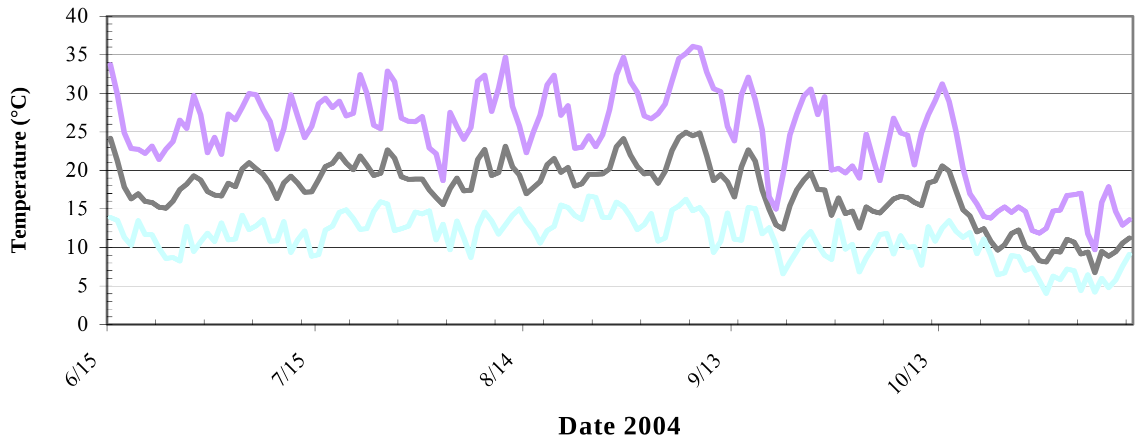


Figure 5-21. *Daily mean (gray), maximum (lavender) and minimum (turquoise) air temperatures at Station TR-5 near La Costa Creek.*

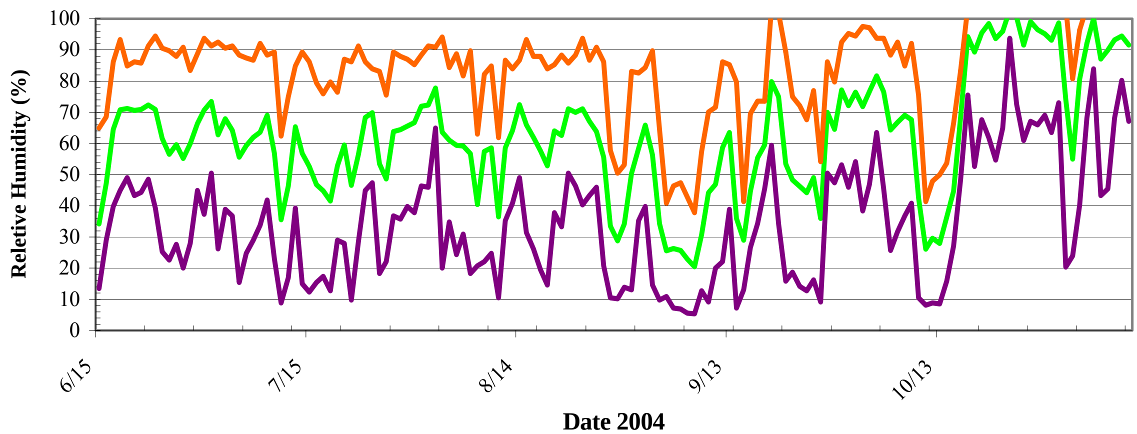


Figure 5-22. *Daily mean (green), maximum (orange) and minimum (purple) relative humidities at Station TR-5 near La Costa Creek.*

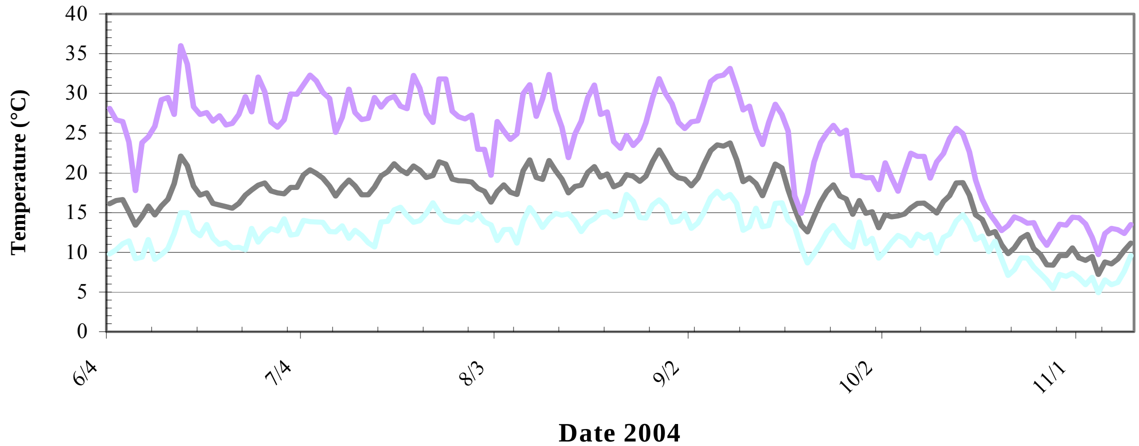


Figure 5-23. *Daily mean (gray), maximum (lavender) and minimum (turquoise) air temperatures at Station TR-6 near Indian Creek.*

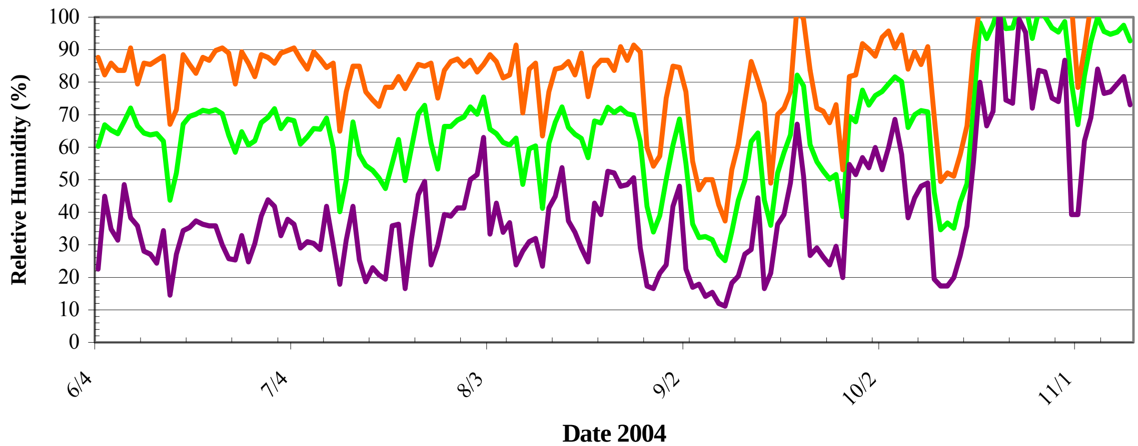


Figure 5-24. *Daily mean (green), maximum (orange) and minimum (purple) relative humidities at Station TR-6 near Indian Creek.*

Electrofishing Water Quality Measurements

During the autumn 2004 electrofishing survey, discrete water quality monitoring was conducted within Alameda, Calaveras, La Costa and Indian creeks and Arroyo Hondo (Figure 8-1). A total of twenty-three habitat units were sampled between October 4 and 14, 2004.

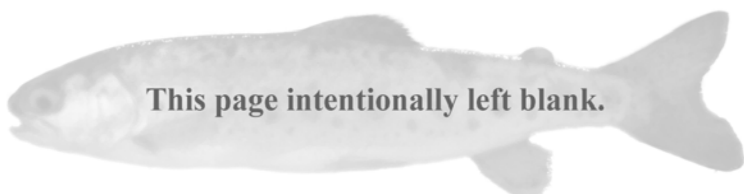
Survey pH readings ranged from 7.07 to 7.91, with the lowest observed values coming from two relatively stagnant pools in Calaveras Creek (Stations E8:1 and E8:2). Conductivity readings were highest in those same two Calaveras Creek pools at 1033 and 1059 µS/cm, respectively, and lowest at the two Arroyo Hondo stations (Stations E13:1 and E13:2) at just over 380 µS/cm each. Dissolved oxygen concentrations were below 5 mg/L at six stations: Stations E5:1, E6:1 and E7:1 in Alameda Creek in and downstream of the Sunol Regional Park; Station E8:2, a relatively stagnant pool in Calaveras Creek; and two relatively small step-pools in Indian Creek (Stations E15:1 and E15:4). Turbidity readings were less than 1.0 NTU at all locations, with the exception of stations E5:1, E6:4, E8:1, E12:1 and E15:1 (Table 5-5).

The average dissolved oxygen concentration for all sites in Alameda Creek combined was 6.64 mg/L, while the average conductivity was 625 µS/cm and the average turbidity was 0.74 NTU. Stations within the Sunol Regional Park reach had higher conductivity readings and lower dissolved oxygen readings in most cases. In general, overall water quality conditions were best in the Arroyo Hondo and worst in Calaveras Creek.

Table 5-5. *Alameda Creek water quality measurements for the 2004 autumn electrofishing survey. See Chapter 8 for details about site locations and habitat descriptions.*

	Water Quality Measurement											
	Site Number:Habitat Number											
Water Quality Parameter	E1:1	E3:1	E4:1	E5:1	E6:1	E6:4	E7:1	E7:2	E8:1	E8:2	E10:1	E10:2
Time Measured	0921	0825	845	0905	0840	1250	1233	1432	1248	1302	0911	0915
Temperature (°C)	15.2	13.9	12.1	18.0	16.3	17.2	15.5	16.5	16.5	17.1	15.8	15.2
Turbidity (NTU)	0.19	0.67	0.60	1.40	0.35	1.10	0.47	0.36	1.30	0.53	0.69	0.64
pH	7.91	7.44	7.43	7.10	7.49	7.83	7.37	7.33	7.07	7.08	7.83	7.80
Dissolved Oxygen (mg/L)	8.6	6.1	7.2	3.1	3.1	8.7	4.7	9.0	5.8	2.0	5.9	6.8
Conductivity (µS/cm)	489	1030	832	1031	599	586	596	595	1033	1059	452	449

	Water Quality Measurement											
	Site Number:Habitat Number											
Water Quality Parameter	E11:1	E11:2	E12:1	E13:1	E13:2	E14:1	E14:2	E15:1	E15:2	E15:3	E15:4	Mean
Time Measured	1345	1345	1230	0953	1249	0913	0908	1258	1305	1405	1551	--
Temperature (°C)	15.8	15.8	16.0	13.0	16.2	13.3	13.4	14.0	13.9	13.5	14.3	15.2
Turbidity (NTU)	0.48	0.44	2.19	0.46	0.66	0.94	0.94	1.57	0.35	0.37	0.51	0.75
pH	7.77	7.77	7.49	7.24	7.36	7.68	7.67	7.70	7.80	7.90	7.65	7.55
Dissolved Oxygen (mg/L)	7.7	7.7	7.7	7.9	9.2	6.8	5.9	3.9	5.4	7.3	4.2	6.3
Conductivity (µS/cm)	519	519	422	384	388	523	524	842	841	833	848	699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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 document any rainbow trout spawning activity that is currently occurring in upper Alameda Creek.

Procedure

A single spawning survey was conducted on March 11, 2004. 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 redds, paired adults and fry. Each biologist was required to wear a visored hat and a pair of polarized sunglasses to optimize their ability to view redds and fish in the water.

11 March 2004

This year’s survey was conducted later in the spawning season than desired. Consequently, observations focused on looking for young-of-year rainbow trout as opposed to redds and actively spawning adults.

Water temperatures ranged from a low of 14 °C at the upstream-most pool surveyed above Little Yosemite, to a high of 18 °C at the “swimming pool” located 1,200-feet upstream of the wooden truss bridge in Sunol Regional Park. No adult rainbow trout, trout redds or young-of-year were observed during the survey. A single 1+ aged fish was sited in a pool in Little Yosemite. It should be noted that the relatively high flow conditions at the time of the survey, along with the geomorphic characteristics of Little Yosemite (many large boulders providing ample places for trout to hide), 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, 2004, 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 and flows at their lowest. This component of the study is designed to evaluate the extent to which pools in these three streams provide suitable habitat to fishes. A series of selected pools have been routinely monitored and the data will help 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 lower Calaveras Creek.*

Procedure

Ten pools were snorkeled on August 25 and 26, 2004 in Alameda and Calaveras creeks and Arroyo Hondo (Figure 7-2, Table 7-1). Due to lower than average flows in Alameda Creek in 2004, three of the thirteen typically snorkeled pools (P6, P7 and P11) were not evaluated. 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 partially in the water. The snorkelers moved slowly upstream as a group, identifying species by size class, and counting fish only as they were encountered

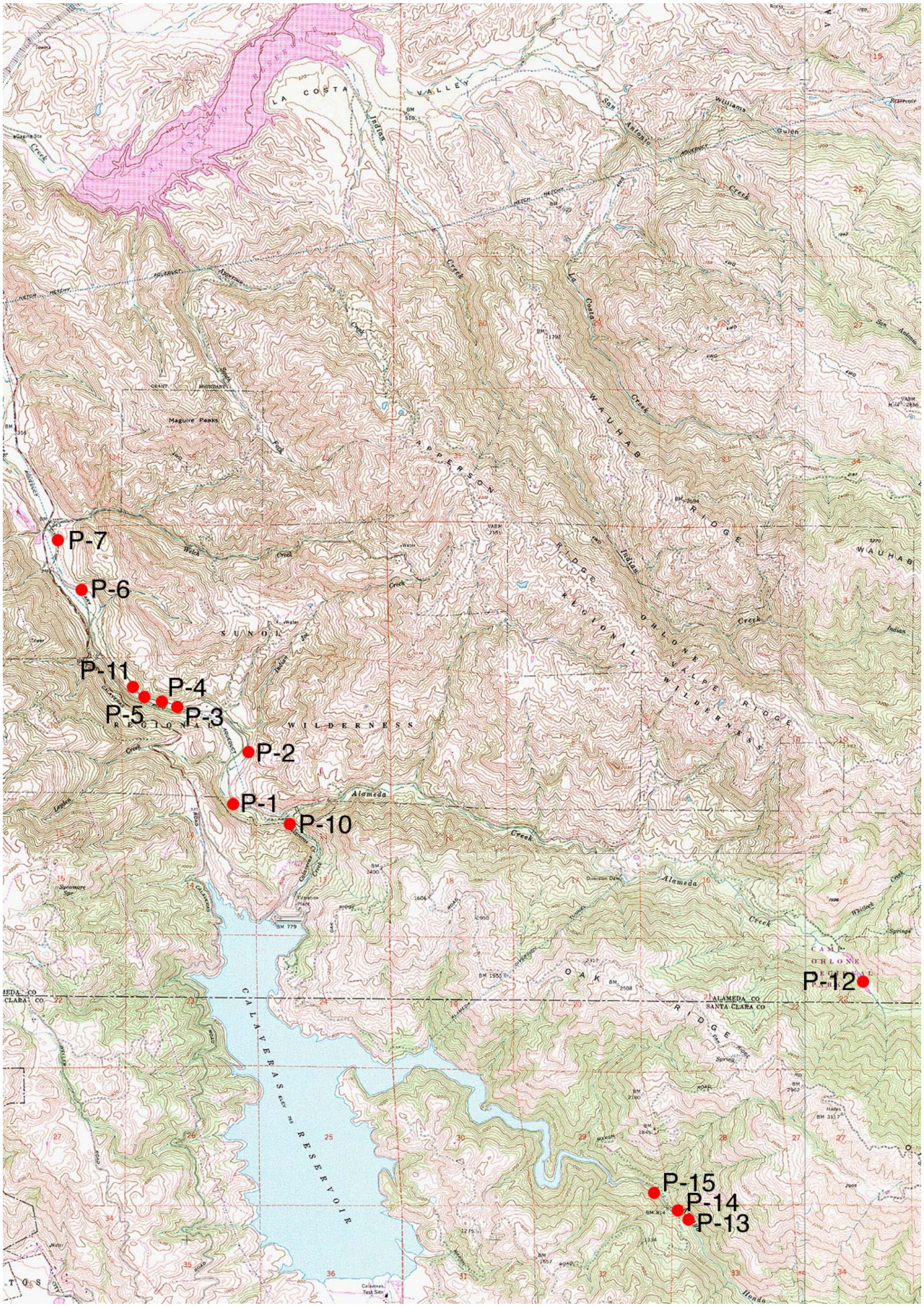
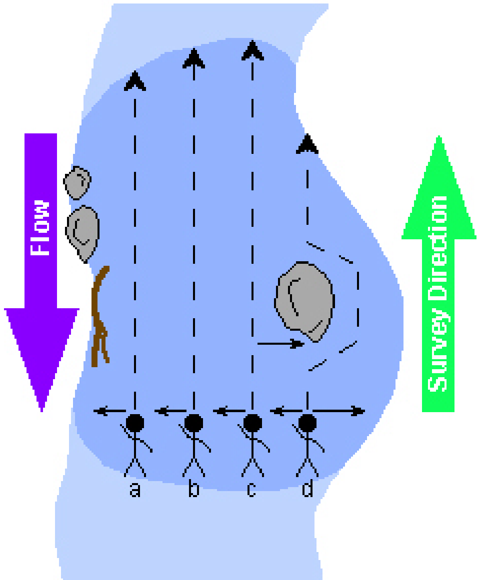


Figure 7-2. *Snorkel survey sites in Alameda and Calaveras creeks and Arroyo Hondo.*



passing between biologists or between a biologist and the bank (Figure 7-3). One snorkeler was selected to count fishes 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 fishes).

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 fishes to the right and left whenever they became separated by an obstruction (Figure 7-3).

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.*

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 of fishes were observed in ten pools during the 2004 snorkel survey (Figure 7-4). California roach was the most abundant species, accounting for 96.6 percent of all fishes observed, followed by largemouth bass and sunfish (1.8 percent of total), Sacramento sucker (1.2 percent of total) and Sacramento pikeminnow (0.3 percent of total). Rainbow trout and prickly sculpin accounted for 0.05 percent of the total respectively, and were each observed in three pools, two of which were in Arroyo Hondo. California roach were present in all of the pools surveyed while Sacramento sucker were found in seven of the ten pools. Sacramento pikeminnow were present in six of the ten pools and largemouth bass and sunfish were each present in two of the ten pools.

Pool P-1

The maximum depth (located along the right side about halfway through the pool) of this Alameda Creek pool, which is frequented by Sunol Regional Park swimmers, was only two-feet this year. Fifty percent of the surface was shaded during the survey. California roach (94 percent adults) accounted for 88 percent of the 97 fishes observed. The remaining fishes counted were juvenile largemouth bass and juvenile Sacramento pikeminnow. This pool had the second lowest number of both total fish and roach when compared with each of the other pools surveyed (Figure 7-4, Appendix C).

Table 7-1. *Snorkel survey station descriptions for 2004.*

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.	8/25/04	1005	18.9 °C	18.7 °C
P-2	Rat Pool	In Alameda Creek, ~ 900-feet downstream of the wooden truss bridge in Sunol Regional Park.	8/25/04	1100	19.0 °C	18.0 °C
P-3	Fence Pool	In Alameda Creek, just downstream of the Sunol Regional Park / SFPUC boundary fence.	8/25/04	1705	27.1 °C	25.3 °C
P-4	Lunch Pool	In Alameda Creek, ~ 3,000-feet downstream of the Sunol Regional Park / SFPUC boundary fence.	8/25/04	1635	21.5 °C	19.5 °C
P-5	Sycamore Pool	In Alameda Creek, ~ 4,000-feet downstream of the Sunol Regional Park / SFPUC boundary fence.	8/25/04	1555	22.4 °C	--
P-6*	S-Bend Pool	In Alameda Creek, ~ 3,000-feet upstream of the Calaveras Road bridge.	8/26/04	--	--	--
P-7*	Bathing Pool	In Alameda Creek, ~120-feet upstream of the Calaveras Road bridge.	8/26/04	--	--	--
P-10	Bass Pool	In Calaveras Creek, ~50-feet upstream of the Alameda Creek / Calaveras Creek Confluence.	8/25/04	1355	25.4 °C	21.2 °C
P-11*	Shade Pool	In Alameda Creek, ~4,500-feet downstream of the Sunol Regional Park / SFPUC boundary fence.	8/25/04	--	--	--
P-12	Sycamore Camp Pool	In Alameda Creek, ~1,000-feet upstream of the Camp Ohlone southern boundary.	8/25/04	1220	20.1 °C	17.3 °C
P-13	Butterfly Pool	In Arroyo Hondo, ~800-feet upstream of the USGS gauging station.	8/26/04	1425	21.1 °C	20.0 °C
P-14	USGS Gauge Pool	In Arroyo Hondo, just upstream of the USGS gauging station.	8/26/04	1350	20.3 °C	19.1 °C
P-15	Raccoon Pool	In Arroyo Hondo, ~800-feet downstream of the USGS gauging station.	8/26/04	1240	21.2 °C	20.2°C

* Pools not snorkeled during the 2004 survey.

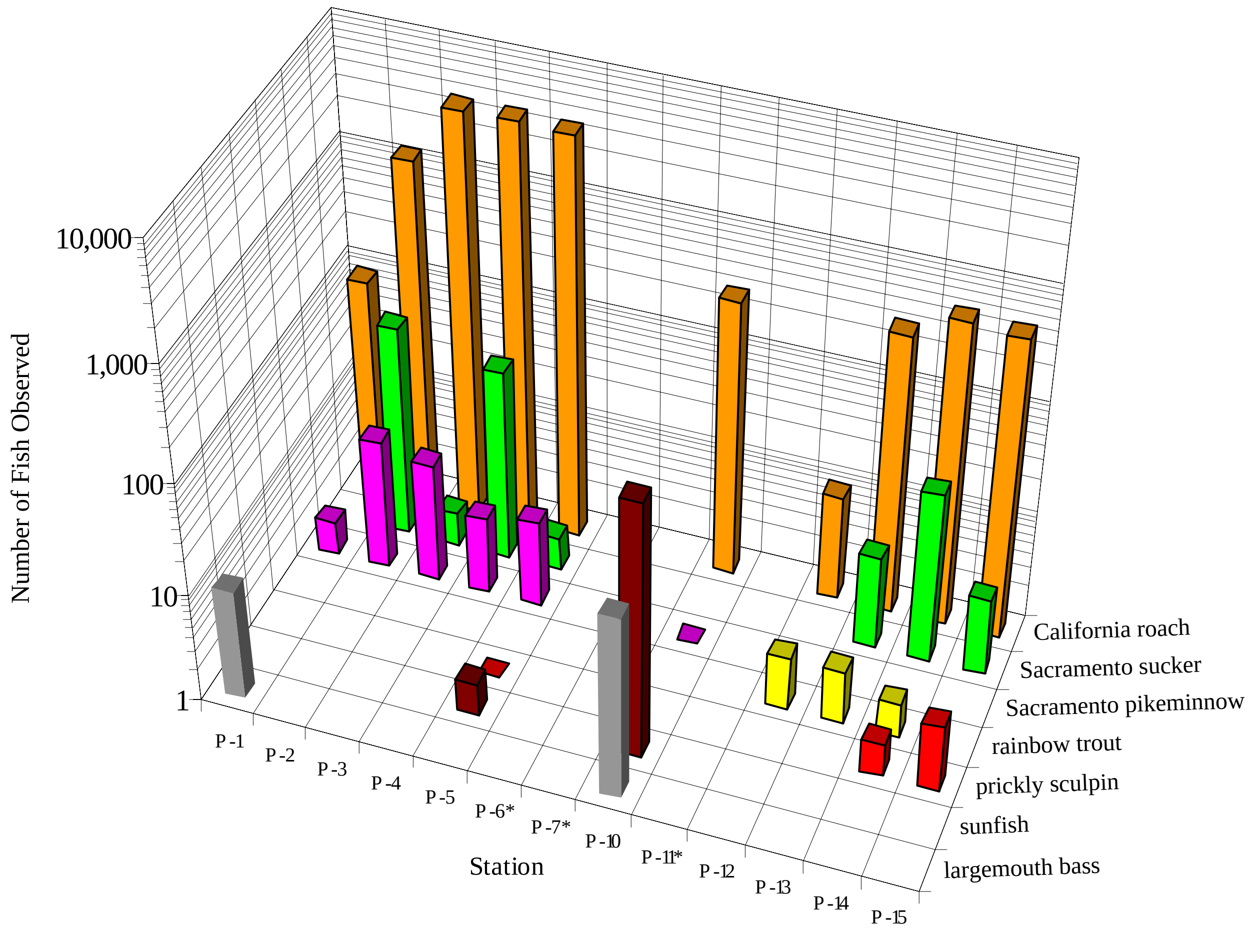


Figure 7-4. *Number of fishes observed by pool during snorkel surveys for 2004 (*Pools not snorkeled during this year's survey).*

Pool P-2

This Alameda Creek pool, located in Sunol Regional Park downstream of the wooden truss bridge, had no surface flow in or out. The deepest point, at 3 ½-feet, was on the right side approximately one-third through the pool. The downstream half of the pool was bisected into two arms by a large gravel bar. Riparian vegetation shaded approximately 95 percent of the pool's surface during the survey. California roach (18 percent adults) accounted for 93 percent of the 1,285 fishes counted. Sacramento pikeminnow (seven percent adults) and Sacramento sucker (no adults) combined for the remainder of the fishes observed. This pool contained the greatest number of both Sacramento sucker and Sacramento pikeminnow.

Pool P-3

There were several large boulders in this Alameda Creek pool, located near the proposed cold water/warm water transition zone, and like Pool P-2 it was isolated from surface flows. A mid-pool gravel bar necessitated two snorkelers exiting and re-entering the water to complete their observations. The deepest section, at about three-feet, was one-third of the way downstream, adjacent to a large boulder on the left bank. This pool had the second highest number of California roach (three 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 ten adult pikeminnow and no adult sucker.

Pool P-4

Located well into the Alameda Creek warm water study reach, this pool was deepest (just over 3 ½-feet) along the relatively steep, left bank, about one-third of the way downstream. One hundred percent of the surface was shaded during the survey. This pool had both the greatest number of fishes and the greatest number of California roach (eight percent adults), with the roach accounting for 98 percent of the 3,954 individuals observed. Sacramento sucker and Sacramento pikeminnow made up the remaining two percent of the fishes counted.

Pool P-5

This Alameda Creek pool was deepest along the left bank, one-third the way downstream. The left bank also had the majority of the riparian cover that shaded 98 percent of the surface during the survey. This pool had the third highest total number of fishes in comparison to each of the other pools surveyed, with California roach (seven percent adults) accounting for almost all of the 3,711 fishes counted. Sacramento pikeminnow, Sacramento sucker, sunfish and prickly sculpin made up the remainder. Five of the six Sacramento pikeminnow observed were adults, as were one of each pair of Sacramento sucker and sunfish.

Pool P-6

Pool P-6 was not snorkeled due to high turbidity. Observations would have been minimal at best. Dissolved oxygen concentrations were measured at less than one milligram per liter at both the surface and bottom. Large numbers of juvenile roach were observed at the surface, apparently gasping for atmospheric oxygen.

Pool P-7

Then downstream-most pool in Alameda Creek had too little water to snorkel, with a maximum depth of approximately three inches. The watered portion was also clogged with algae and leaf litter, making observation difficult.

Pool P-10

The deepest part of this large Calaveras Creek pool, located upstream the SFPUC/Sunol Regional Park boundary fence on the right side of the stream, was six- to seven-feet. Riparian vegetation along each bank was relatively thick, shading 60 percent of the pool's surface during the survey. It should also be noted that the majority of the pool was overgrown with macrophytes and mats of floating algae. These conditions, coupled with relatively high turbidity, made observations difficult and the fish counts likely underestimate abundances. California roach accounted for the majority of observed fishes (all juveniles) at just over 54 percent, while non-native sunfishes and largemouth bass made up 37 and eight percent of the remainder, respectively. Nineteen percent of the sunfishes and 44 percent of the bass were adults. There was also a single adult Sacramento pikeminnow.

Pool P-11

This Alameda Creek pool was dry and therefore not surveyed.

Pool P-12

The root mass of a large downed sycamore lying over this relatively small isolated pool presented an area that was inaccessible to snorkelers. It was therefore necessary to count fishes while remaining fixed in a static position to survey this pool. Twenty-five percent of the pool’s surface was shaded during the survey. This pool had the lowest total number of fishes, although it is likely that both adult and juvenile fishes seeking refuge in the large sycamore’s roots went undetected. California roach (all adults) accounted for 75 percent of the 12 fishes observed, with three adult rainbow trout accounting for the remainder.

Pool P-13

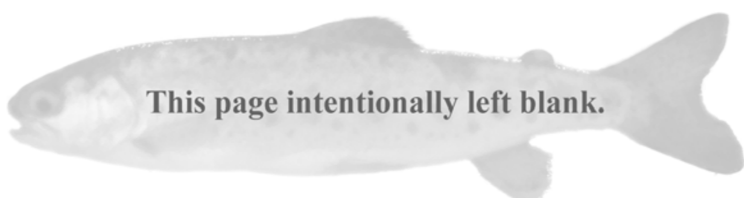
This Arroyo Hondo pool provided fishes with ample cover in the form of rocks, logs, overhanging vegetation and undercut banks. Its deep point was located adjacent to a large boulder on the right bank, one-third through the pool. Forty percent of the surface was shaded during the survey. California roach (11 percent adults) accounted for 97 percent of the 337 fishes observed, with one adult Sacramento sucker, one adult rainbow trout and two juvenile rainbow trout comprising the remainder.

Pool P-14

Located just upstream of USGS streamflow station 11173200, this Arroyo Hondo pool was from five to six feet deep at the downstream end along the left bank. Forty percent of the surface was shaded during the survey. California roach (31 percent adults) accounted for just over 93 percent of the 579 fishes observed. Thirty-five adult Sacramento sucker were also observed, along with two adult rainbow trout and two prickly sculpin.

Pool P-15

Pool P-15 is located about 800-feet downstream of the Marsh Road bridge. Its deepest point, at 3 ½-feet, was located approximately mid-channel halfway through the pool. Fifty percent of the pool was shaded during the survey. California roach (15 percent adult) accounted for just over 98 percent of the 509 fishes observed. Two adult and three juvenile Sacramento sucker and four 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 October 4 and October 14, 2004 in Alameda, Calaveras, La Costa and Indian creeks and in Arroyo Hondo (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. Some habitat types changed from what was surveyed in previous years due to the low water conditions found in 2004.

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

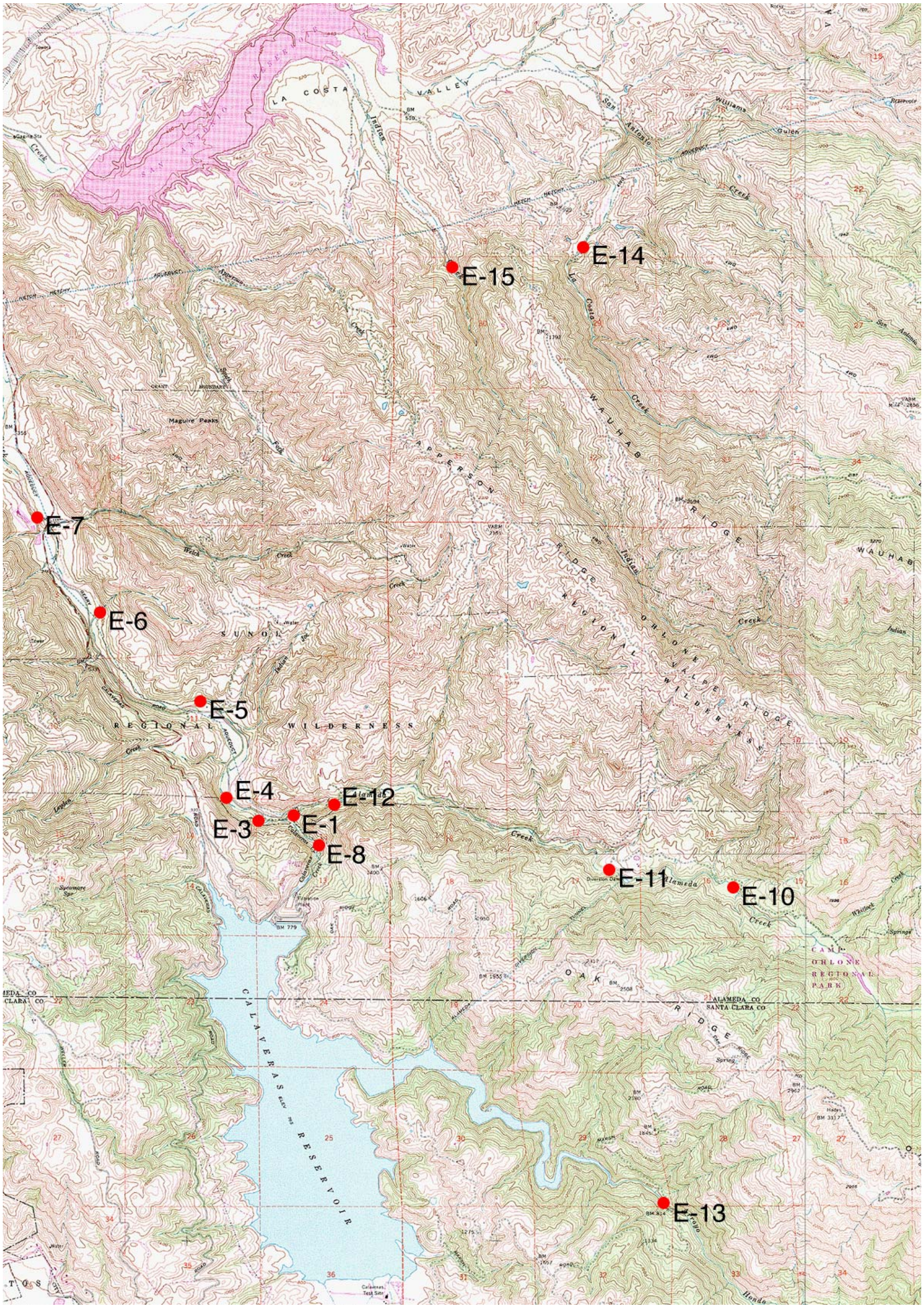


Figure 8-1. *Alameda, Calaveras, La Costa and Indian creeks and Arroyo Hondo 2004 electrofishing survey stations.*

the bulk of the stunned fishes attracted to the anode of the electrofisher and transfer them to a bucket, while the bucket handler would attempt to 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 2004.*

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/Glide 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 = Isolated Pool 4 = Pool
E-7	In Alameda Creek, downstream of the Calaveras Road bridge, near the Sunol Valley Water Treatment Plant.	1 = Isolated Pool 2 = Isolated Pool
E-8	In Calaveras Creek, near the walkway paralleling the Calaveras pipeline.	1 = Isolated Pool 2 = Isolated Pool
E-10	In Alameda Creek, upstream of the Alameda Creek Diversion Dam.	1 = Run 2 = Step Pools
E-11	In Alameda Creek, downstream of the Alameda Creek Diversion Dam.	1 = 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 = Pool 2 = Step Pools 3 = Step Pools 4 = Pool

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 area where they were caught.

Station Descriptions

Electrofishing station E-1 consisted of a single habitat type: a pool. The pool was 82.5-feet long, with an average width and depth of 9.1-feet and 1.0-feet, respectively. The maximum depth, located at the upstream end of the pool, was 4.2-feet. The dominant substrate types were cobble and gravel, although there was a fair amount of sand along the left side of the pool and several large boulders and bedrock to the right and at the upstream end. The undercut bank and overhanging vegetation that are typically found on both sides of the station were absent due to the lower than normal stream conditions. The riparian vegetation was relatively heavy. The entire pool was shaded during the survey due to overcast skies.

Electrofishing station E-3 consisted of two habitat types: a glide and a low gradient riffle. The glide was 66-feet long, with an average width and depth of 24.9-feet and 0.6-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 sand, and cover was provided by boulders, some rubble and about 20-feet of overhanging vegetation along both the left and right banks. Ninety percent of the glide was shaded at the start of the survey, dropping to 50 percent by the finish. The riffle was 70.0-feet long, with an average width and depth of 6.0-feet and 0.4-feet, respectively. A maximum depth of 0.7-feet was found mid-channel, at the end of the riffle. The majority of the riffle's substrate was made up of cobble, with some rubble and gravel. Several boulders and about 15-feet of overhanging vegetation provided cover in the riffle. Eighty to 100 percent of the riffle was shaded during the survey.

Electrofishing station E-4 consisted of three habitat types: a glide, a low gradient riffle flowing into a glide, and a second glide. The first glide was 41-feet long, with an average width and depth of 13.5-feet and 0.5-feet, respectively. The dominant substrates in the glide were cobble, boulder, rubble and gravel. Cover was provided by the boulders and 20-feet of overhanging vegetation. Approximately 75 percent of the glide was shaded at the start of the survey, while only 25 percent of the section was shaded by the end of the survey. The riffle/glide was 77-feet long, with an average width and depth of 14.0-feet and 0.3-feet, respectively. The dominant substrates in the riffle were boulder, 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. The amount of shading during the survey ranged from 50 to 75 percent. The second glide was 60.5-feet long, with an average width and depth of 11.4-feet and 0.3-feet, respectively. The shorter length of this glide, in comparison to last year, is due to access being limited by the re-installation of a barbed-wire fence that crosses the creek. The dominant substrates in the glide were rubble, cobble and gravel, while tules along the right bank provided cover. Shading ranged from ten to 20 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 72-feet, with an average width and depth of 20.3-feet and 1.3-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 substrate was sand, followed by gravel, rubble and cobble. Some boulders, about ten-feet of undercut bank with submerged tree roots, and eight-feet of overhanging vegetation 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.

Electrofishing station E-6, which normally consists of four habitat types, only had two wetted reaches: an isolated pool and a second pool with water flowing both in and out. The isolated pool was 90-feet long, with an average width and depth of 13.7-feet and 0.7-feet, respectively. The deepest point in the isolated pool was 1.7-feet and located on the right side of the channel toward the upstream end of the habitat. The dominant substrate in the isolated pool was cobble, with a few boulders, five-feet of undercut bank and five-feet of overhanging vegetation, providing cover. One hundred to ninety percent of the isolated pool was shaded during the survey. The second pool was 117-feet long, with an average width and depth of 22.9-feet and 1.2-feet, respectively. The maximum depth was 3.0-feet, located just past halfway through the pool, to the left of mid-channel. The dominant substrates in the second pool were cobble and gravel. Other than a few boulders and a single log, there was little cover in the pool. Ninety percent of the second pool was shaded at the start of the survey, dropping to 50 percent by the time it was completed.

Electrofishing station E-7, which typically consists of three habitat types, only had two wetted areas: both isolated pools with no water flowing in or out. The downstream most pool (pool 1) was 43.5-feet long, with an average width and depth of 15.6-feet and 1.4-feet, respectively. The deepest part of the downstream pool was 3.1-feet, and was located on the left side of the stream about mid-way through the section. The dominant substrates in the downstream pool were silt and sand. Cover in the pool was provided by 20-feet of undercut bank in the form of a huge sycamore root mass. Shading in the downstream pool ranged from ninety percent at the start of the survey to eighty percent when completed. The upstream isolated pool (pool 2) was 24-feet long, with an average width and depth of 8.1-feet and 0.2-feet, respectively. The deepest part of the upstream pool, located at the middle of the pool, was 0.4-feet. The dominant substrate in this pool was cobble, with some gravel. The only cover in the upstream pool consisted of a few rubble-sized rocks and algae. One hundred percent of the upstream pool was shaded during the survey.

Electrofishing station E-8 consisted of two habitat types: both isolated pools with no water flowing in or out. The most downstream pool (pool 1) was 42-feet long, with an average width and depth of 15.4-feet and 1.3-feet, respectively. The deepest part of pool 1, located at the upstream end of the channel to the right, was

3.2-feet. The dominant substrate in pool 1 was boulders, and about 45-feet of overhanging vegetation provided additional cover. Shading in pool 1 through the day ranged from 40 to 90 percent. Isolated pool 2 was 21.5-feet long, with an average width and depth of 8.8-feet and 1.4-feet, respectively. A maximum depth of 2.9-feet was located at about mid-pool. The dominant substrate in pool 2 was rubble, with several boulders providing cover. Shading in pool 2 ranged from 50 to 40 percent during the survey.

Electrofishing station E-10, which typically consists of three habitat types, had only two wetted reaches: a broken run and a series of step pools. The run was 53-feet long, with an average width and depth of seven-feet and 0.3-feet, respectively. The deepest part of the run, located about mid-channel halfway through the reach, was 0.6-feet. The dominant substrates were a combination of rubble, boulders and coble, with no other cover available. One hundred percent of the section was shaded at the start of the survey, dropping to 25 percent by the finish. The step pools combined for a length of 41-feet, with an average width and depth of 4.8-feet and 0.6-feet, respectively. The deepest part of the reach, located on the right side of the channel about halfway through the series of pools, was 1.4-feet. The dominant substrates were boulders, cobble, rubble and gravel. Other than the abundance of boulders and rubble, there was no additional cover. Shading in the step pools was constant throughout the survey, at approximately 75 percent.

Electrofishing station E-11 consisted of two habitat types: a pool and a low gradient riffle flowing into a high gradient riffle. The pool was 47-feet long, with an average width and depth of 11.8-feet and 1.2-feet, respectively. The maximum depth of the pool, located near the middle of the channel toward the upstream end the pool, was 2.5-feet. The majority of the substrate in the pool was bedrock, while numerous large boulders provided cover. Seventy-five to 100 percent of the pool was shaded during the survey. The riffle was 28.5-feet long, with an average width and depth of 5.2-feet and 0.5-feet, respectively. The majority of the riffle’s substrates were a mix of boulder, rubble and cobble. There was no other cover in the riffle. Shade in the riffle was constant throughout the survey at 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 84.5-feet, with an average width and depth of 8.4-feet and 0.9-feet, respectively. The maximum depths of the reach, located in the upstream most pool, was 1.9-feet. The majority of the substrates in the pools were boulder, rubble and cobble. The boulders and rubble provided the only cover in the pools. Dense riparian canopy shaded from 90 to 100 percent of the section during the survey. The riffle was 31.5-feet long, with an average width and depth of 6.7-feet and 0.2-feet, respectively. A maximum depth of 0.6-feet was found on the right side of the channel, at about mid-way through the section. The majority of the riffle’s substrates were gravel, cobble and rubble. Several boulders, a few scattered clumps of bunchgrass and a single log provided cover. Percent shading was not recorded for this riffle.

Electrofishing station E-13 (Figure 8-2) consisted of two habitat types: a glide and a low gradient riffle. The glide was 97-feet long, with an average width and depth of 25.4-feet and 0.8-feet, respectively. The maximum depth of the glide, located just off the left bank about two-thirds of the way downstream, was 2.2-feet. Most of the glide's substrate was rubble, gravel and cobble. Some boulders and 47-feet of overhanging vegetation along the left bank provided cover. Although the riparian vegetation along this portion of creek is dense, the bed load from a large drainage entering the stream from the right has made this section relatively open, providing only 40 percent shade during the survey. The low gradient riffle was 85-feet long, with an average width and depth of 23.8-feet and 0.3-feet, respectively. The majority of the riffle's substrate was rubble and cobble, with a small amount of gravel. There was little cover in the riffle. About ninety-five percent of the section was shaded during the survey.

Figure 8-2. *SFPUC biologists electrofishing a low gradient riffle on Arroyo Hondo.*

Electrofishing station E-14 consisted of two habitat types: a glide and a low gradient riffle. The glide was 48-feet long, with an average width and depth of 10.6-feet and 0.5-feet, respectively. The maximum depth of the glide, located at mid-channel channel about halfway through the section, was 0.8-feet. The majority of the glide's substrate was rubble, while several boulders, some overhanging vegetation and a single instream log provided cover. The dense riparian canopy over this reach of the creek resulted in 80 percent shading of the section during the survey. The low gradient riffle was 31-feet long, with an average width and depth of 7.2-feet and 0.4-feet, respectively. The majority of the riffle's substrate was rubble, silt and cobble. Several boulders provided the only cover. Ninety to 100 percent of the section was shaded during the survey.

Electrofishing station E-15 consisted of four habitat types: two pools (the upstream most pool added new this year) and two series of step pools. The most downstream pool (pool 1) was 20.8-feet long, with an average width and depth of 8.9-feet and 0.6-feet, respectively. The deepest part of pool 1, located about mid-channel halfway through the pool, was 1.8-feet. The dominant substrate in pool 1 was cobble, with several boulders and a small amount of overhanging vegetation providing cover. Shading in pool 1 through the day was constant at 100 percent. The most downstream series of step pools (step pool 1) combined for a total length of 13.2-feet, with an average width and depth of 4.3-feet and 0.6-feet, respectively.

A maximum depth of one-foot was located just off the right bank, about mid-way through the upstream most pool in the two pool series. The dominant substrate in step pool 1 was cobble, with numerous boulders providing cover. Shading in step pool 1 was 100 percent throughout the survey. Step pool 2 and connecting water combined for a total length of 20.8-feet, with an average width and depth of 3.8-feet and 0.8-feet, respectively. The maximum depth of step pool 2, located on the left bank halfway through the section, was 1.5-feet. The majority of the substrates in step pool 2 were rubble, silt and cobble. Several boulders provided the only cover in the section. The relatively steep canyon banks and associated dense riparian canopy shaded 90 to 100 percent of the section during the survey. The upstream most pool (pool 2), which was sampled for the first time this year, was 21.7-feet long, with an average width and depth of 4.3-feet and 1.4-feet, respectively. The deepest part of pool 2, located on the left side of the stream at the upstream end, was 2.7-feet. Most of the substrate of pool 2 was gravel, with a very large boulder at the upstream end providing cover. One hundred percent of pool 2 was shaded during the survey.

Species Composition

A total of eight species were collected from the 13 stations and 27 habitats sampled during the 2004 electrofishing survey (Figure 8-3). Based on population estimates (Microfish 3.0), California roach dominated the catches, accounting for 88 percent of all fishes collected, followed by Pacific lamprey (five percent of total), rainbow trout (three percent of total), prickly sculpin (two percent of total), Sacramento sucker (one percent of total), Sacramento pikeminnow (one percent of total), largemouth bass and bluegill (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.

Three species were collected from electrofishing station E-1 (Figure 8-3). Population estimates (Appendix D) indicate that California roach dominated (123 fish), followed by Sacramento sucker and Sacramento pikeminnow (one fish each).

Four species were collected from the glide at station E-3 (Figure 8-3). Population estimates (Appendix D) indicate that California roach dominated (703 fish), followed by largemouth bass (ten fish), Sacramento sucker (five fish) and Sacramento pikeminnow (two fish). 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 43 California roach and a single Pacific lamprey ammocete.

Four species were collected from the first glide sampled at station E-4 (Figure 8-3). Population estimates (Appendix D) indicate that California roach dominated (227 fish), followed by Sacramento pikeminnow (six fish), Pacific lamprey (three fish) and Sacramento sucker (two fish). Only two species were collected from the low gradient riffle/glide at station E-4 (Figure 8-3). Population estimates (Appendix D) indicate that there were 198 California roach and five Pacific lamprey. The same two 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 (129 fish), followed closely by Pacific lamprey (116 fish). In comparison to all other stations and habitat types sampled, this glide had the greatest number of lamprey ammocetes (42 percent of the total).

Four species were collected from the pool at electrofishing station E-5 (Figure 8-3). Population estimates (Appendix D) indicate that there were 220 California roach, 12 Sacramento sucker, five Sacramento pikeminnow and three bluegill.

There were four species collected from the isolated pool at station E-6 (Figure 8-3). Population estimates (Appendix D) indicated that California roach dominated in the isolated pool (760 fish), followed by Pacific lamprey (three fish), Sacramento pikeminnow (two fish) and Sacramento sucker (one fish). The isolated pool had the second largest number of roach, accounting for 15 percent of the total collected from all stations combined. The second pool at station E-6 was the only habitat with five species (Figure 8-3). Population estimates (Appendix D) indicate that there were 1,291 California roach, 44 Sacramento pikeminnow, 20 Pacific lamprey, six Sacramento sucker and a single bluegill. This pool had the largest number of roach, accounting for 25 percent of the total collected during the 2004 survey.

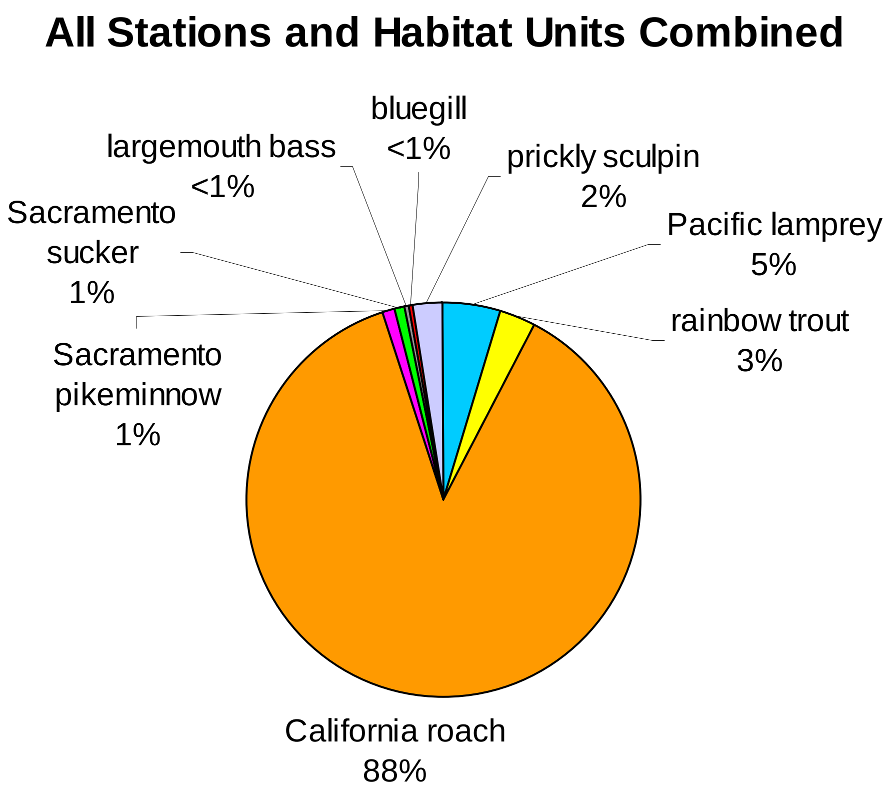
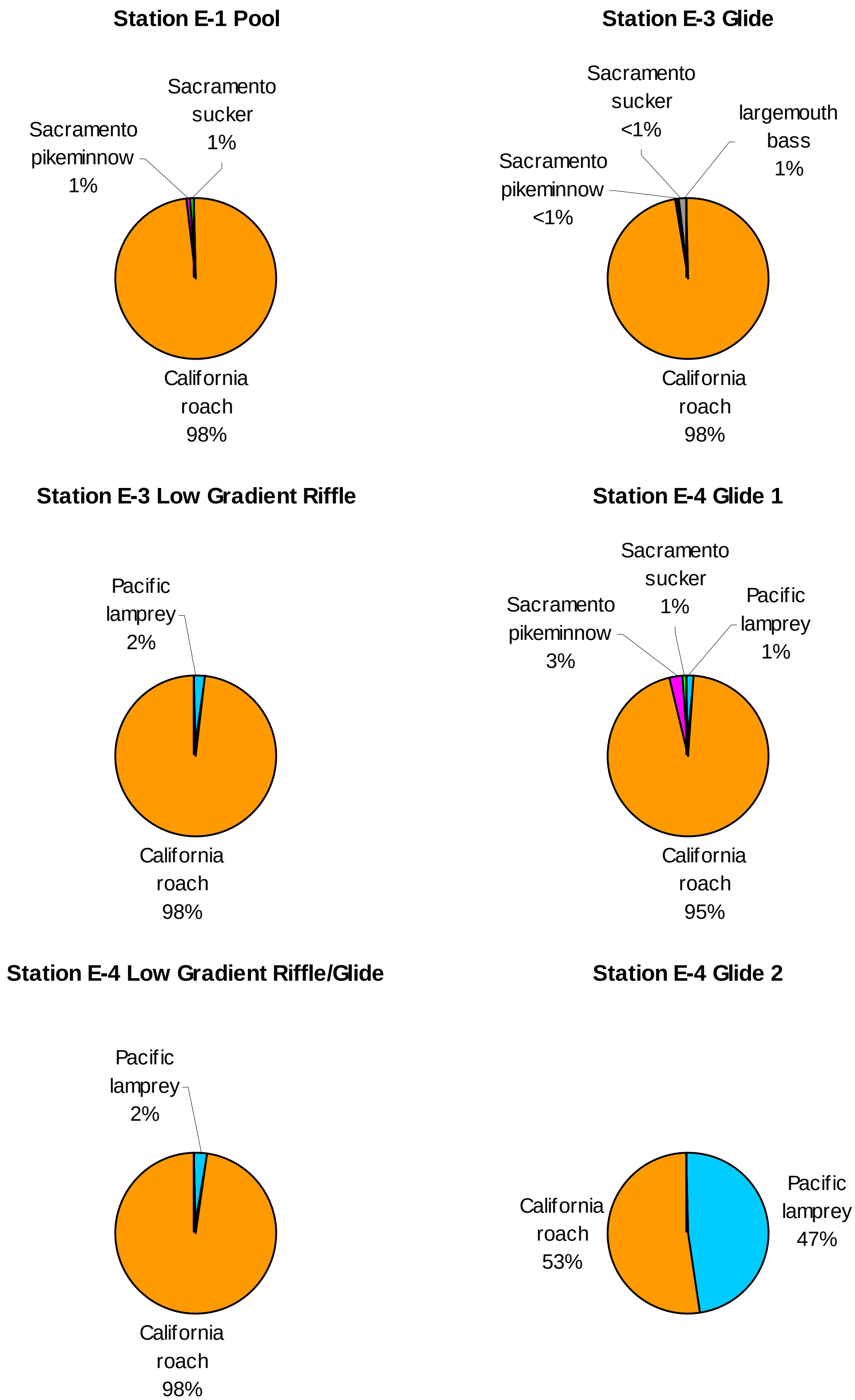


Figure 8-3. *Percent occurrence of each species by station and habitat type, based on population estimates for the autumn 2004 electrofishing surveys.*



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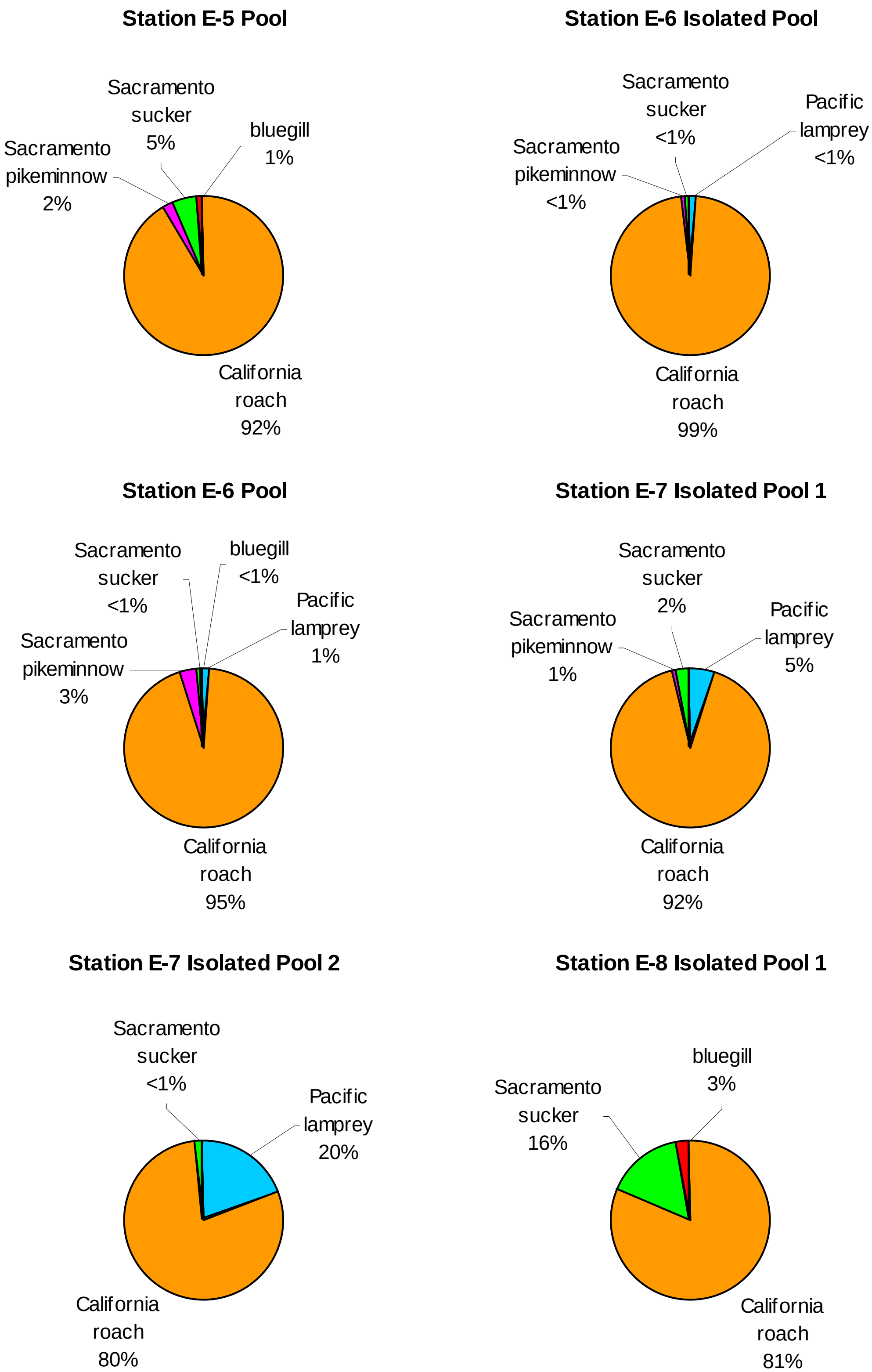

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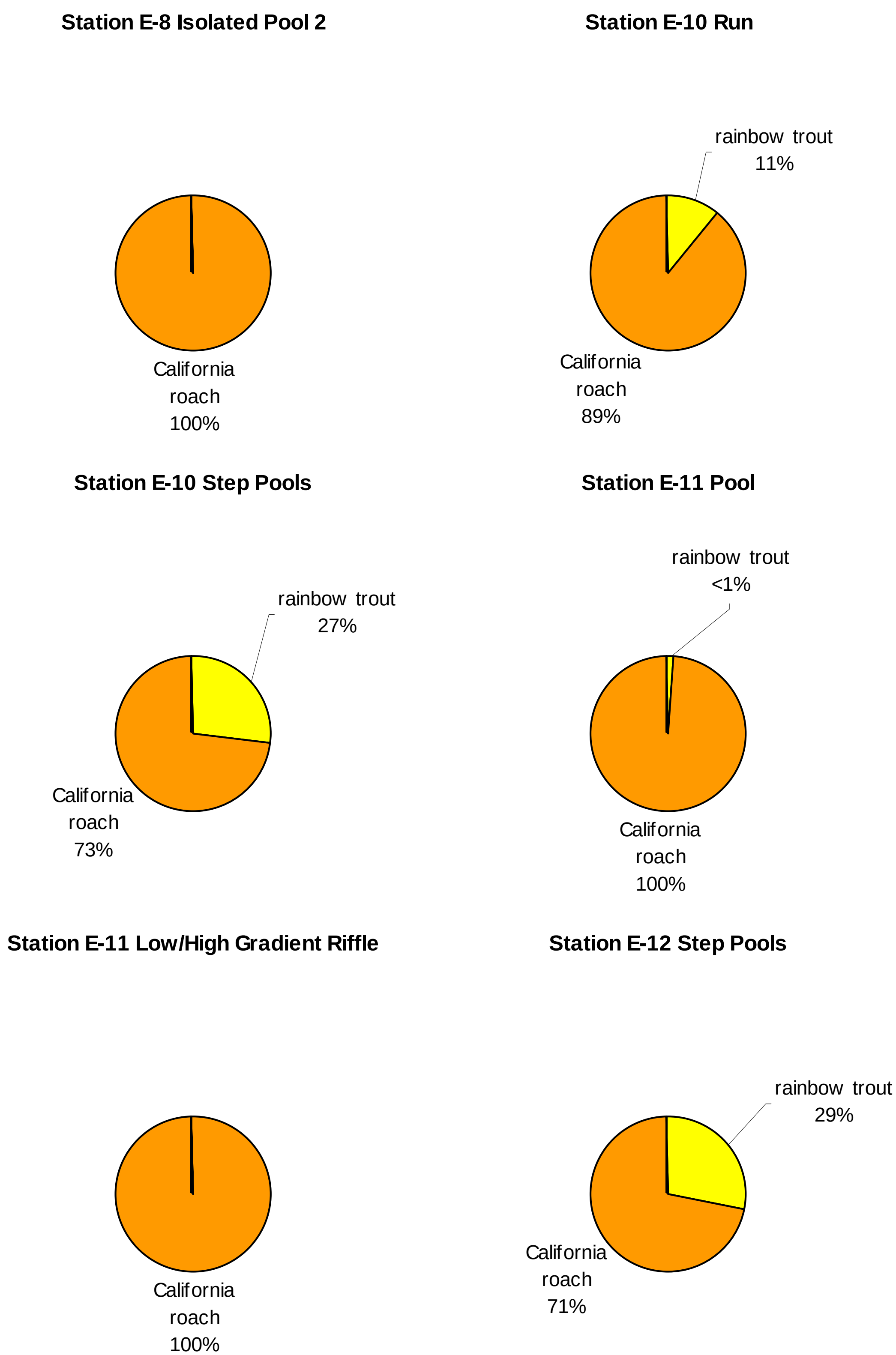
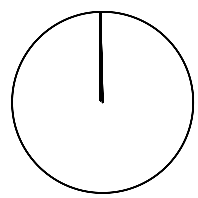
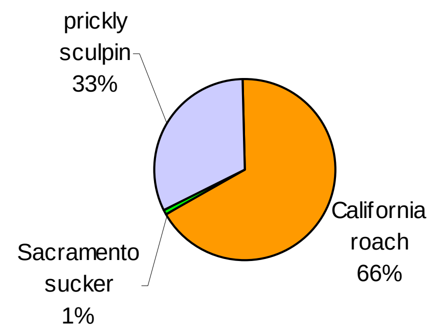


Figure 8-3 continued.

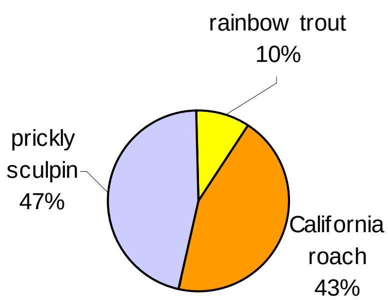
Station E-12 Low Gradient Riffle



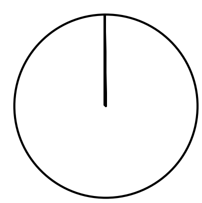
Station E-13 Glide



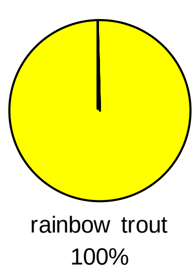
Station E-13 Low Gradient Riffle



Station E-14 Glide



Station E-14 Low Gradient Riffle



Station E-15 Pool 1

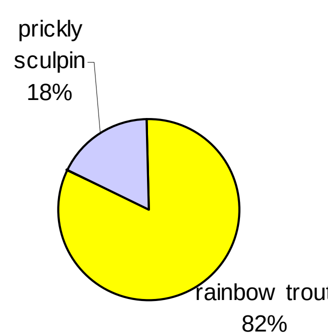


Figure 8-3 continued.

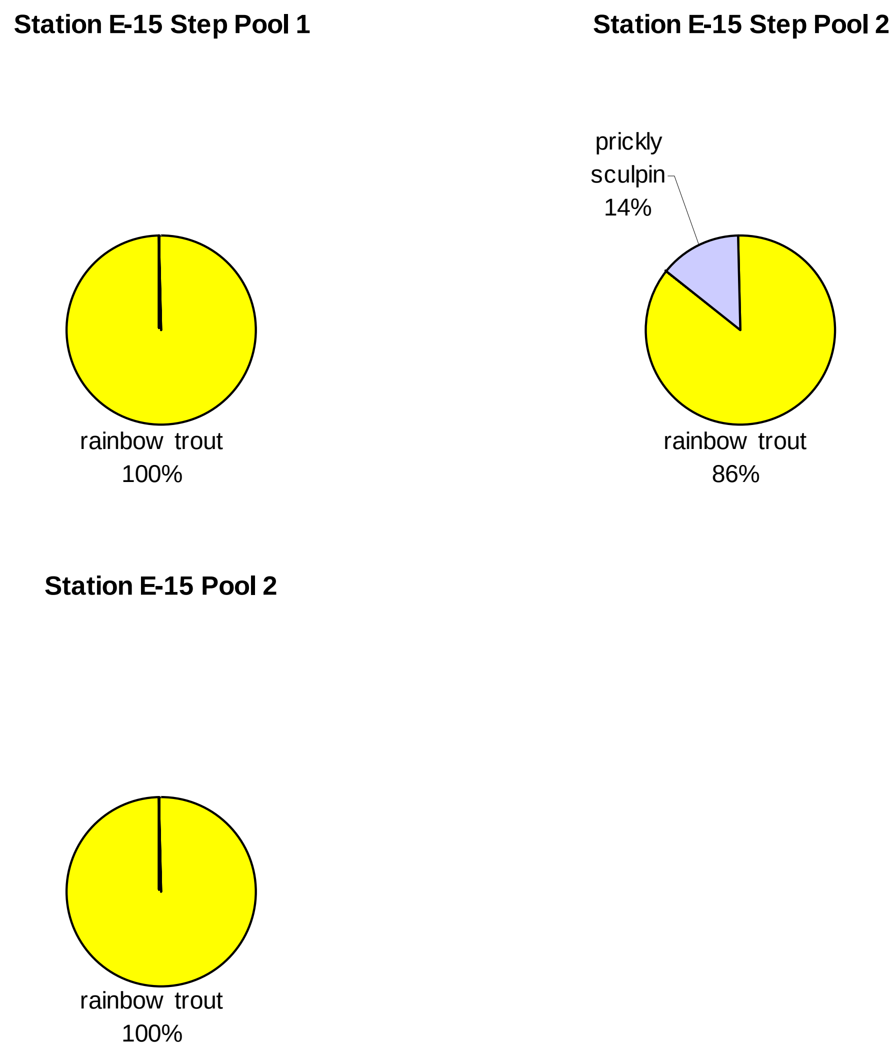


Figure 8-3 continued.

Four species were collected from the downstream most isolated pool (isolated pool 1) at station E-7 (Figure 8-3). Population estimates (Appendix D) indicate that California roach dominated (372 fish), followed by Pacific lamprey (21 fish), Sacramento sucker (ten fish) and Sacramento pikeminnow (four fish). There were only three species found in the upstream isolated pool (isolated pool 2) at station E-7 (Figure 8-3). Population estimates (Appendix D) indicate that there were 416 California roach, 105 Pacific lamprey and two Sacramento sucker. In comparison to all other stations and habitat types sampled, isolated pool 2 had the second largest number of Pacific lamprey ammocetes (38 percent of the total). The population size reported for Pacific lamprey from this habitat, however, may be an overestimate due to a non-descending removal pattern.

Three species were collected from the downstream isolated pool (isolated pool 1) at station E-8 (Figure 8-3). Population estimates (Appendix D) indicate that the pool had 30 California roach, six Sacramento sucker and a single bluegill. California roach (25 fish) was the only species collected from the upstream isolated pool (isolated pool 2).

There were two species collected from each of habitat types sampled at station E-10 (Figure 8-3). Population estimates (Appendix D) indicate that California roach dominated in both the run (71 fish) and the series of step pools (59 fish). The run also had nine rainbow trout, while the pools had 22 trout.

Two species were collected from the pool at station E-11 (Figure 8-3). Population estimates (Appendix D) indicate that California roach dominated (247 fish), followed by a single rainbow trout. Only 30 California roach 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 again dominated (50 fish), followed by rainbow trout (20 fish). This habitat had the second largest number of trout, accounting for 11 percent of the total number collected from all stations. There were no fishes collected from the low gradient riffle at station E-12 (Figure 8-3).

Three species were collected from the glide at station E-13 (Figure 8-3). Population estimates (Appendix D) indicate that California roach dominated (133 fish), followed by prickly sculpin (66 fish) and Sacramento sucker (two fish). The glide had the second greatest number of sculpin collected, accounting for 47 percent of the total. There were also three species collected from the low gradient riffle at station E-13 (Figure 8-3). Population estimates (Appendix D) indicate that there were 72 prickly sculpin, 66 California roach and 15 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 (51 percent of the total).

There were no fishes collected from the glide at station E-14, while a single species was present in the low gradient riffle (Figure 8-3). Population estimates (Appendix D) indicate that there were 17 rainbow trout in the riffle.

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 nine rainbow trout and two prickly sculpin. Rainbow trout (four fish) were the only species in the downstream series of step pools (step pool 1) at station E-15, while there were six trout and a single prickly sculpin in the other series of step pools (step pool 2). Only rainbow trout were found in the upstream pool, sampled for the first time in 2004, at station E-15. Population estimates (Appendix D) indicate that there were 80 fish. This was the greatest number of trout found in a single habitat, accounting for 44 percent of all trout collected during this year’s survey.

Species Distribution

The distributions of the seven 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

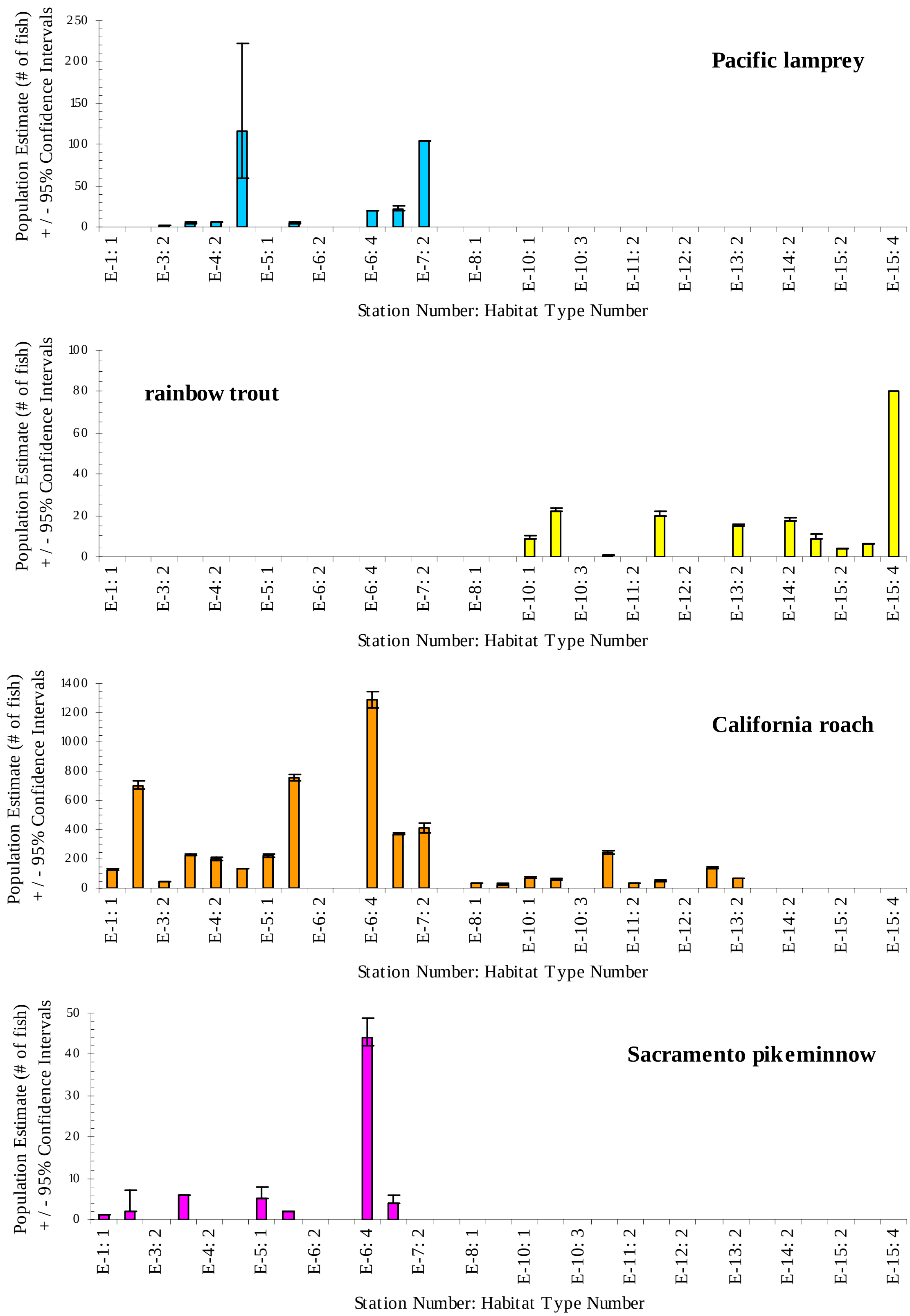


Figure 8-4. *Population estimates and 95 percent confidence intervals for each species by station and habitat type for the autumn 2004 electrofishing surveys.*

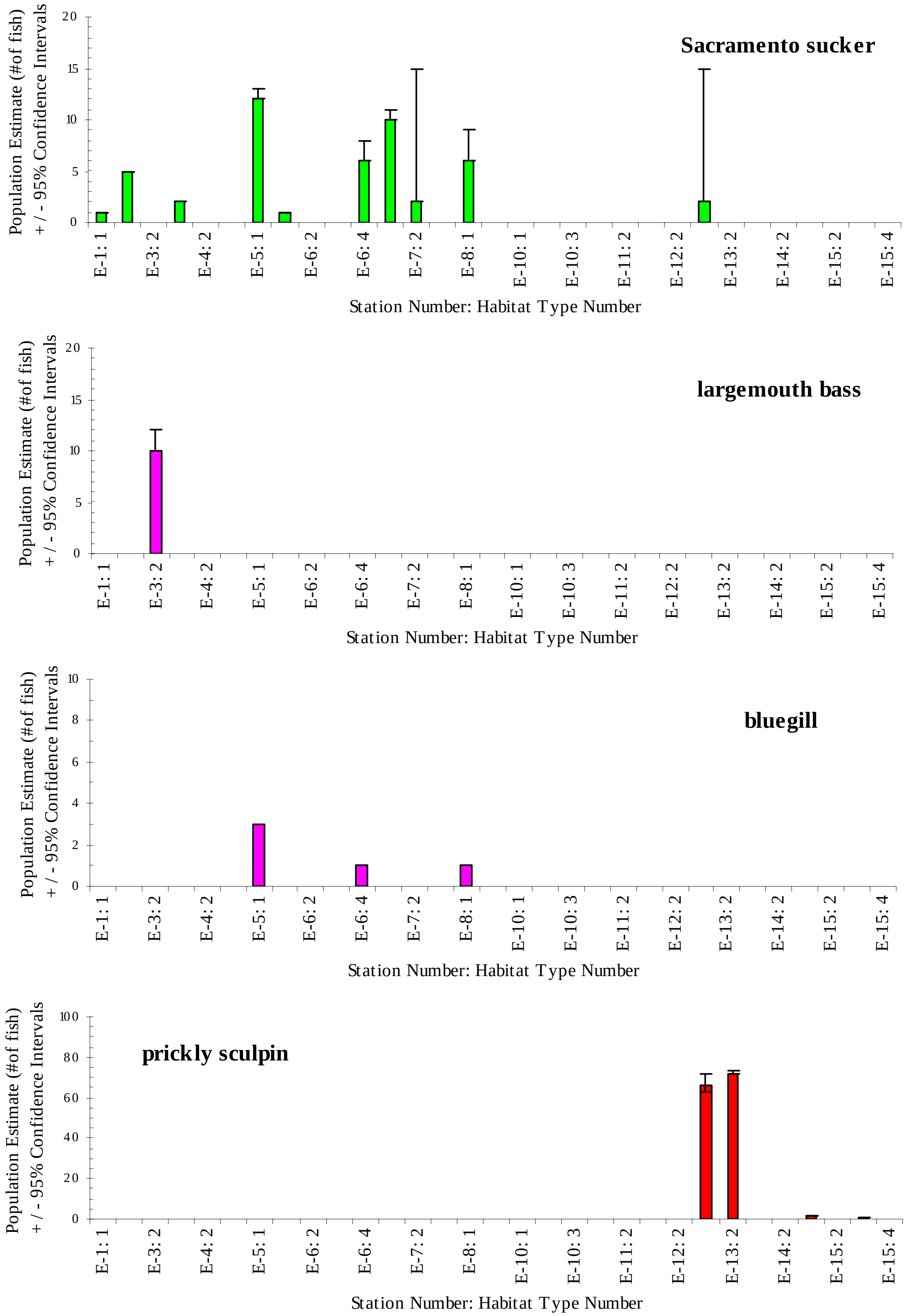


Figure 8-4 continued.

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 glide at station E-3 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 tended to be higher in deeper water areas. 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.

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 the pool at station E-1 and riffles at stations E-11 and E-12, had rainbow trout. There were no trout collected in Calaveras Creek. All stations and habitats in La Costa and Indian creeks (with the exception of a glide in La Costa), which have habitat similar to the uppermost reaches of Alameda Creek, also had rainbow trout. Only the riffle in Arroyo Hondo had rainbow trout. With the exception of the riffles in the La Costa Creek and Arroyo Hondo stations, trout abundances may be positively correlated with slow-water habitat types.

California Roach

California roach were the most widespread species, being caught from 20 of the 27 habitats sampled (Figure 8-4). Roach were most abundant in the pool at electrofishing station E-6 and the glide at station E-3. In general, roach were most abundant in Alameda Creek downstream of the Little Yosemite area. They were also relatively abundant in Alameda Creek both downstream and upstream of the Diversion Dam and in Arroyo Hondo. California roach were absent from La Costa and Indian creeks.

Sacramento Pikeminnow

Sacramento pikeminnow were found throughout Alameda Creek downstream of Little Yosemite, but were absent from all other areas sampled (Figure 8-4). The Sacramento pikeminnow in Alameda Creek were confined to relatively deep-water pool and glide habitats, and were especially concentrated in the pool at station E-6.

Sacramento Sucker

Sacramento sucker were caught sporadically at 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. The presence of Sacramento sucker was restricted to slower moving waters, and they were most abundant in the relatively large pools at stations E-5 and E-7. Although suckers were not present in every pool or glide throughout the reaches where they were generally found, they were never collected from riffles.

Largemouth Bass

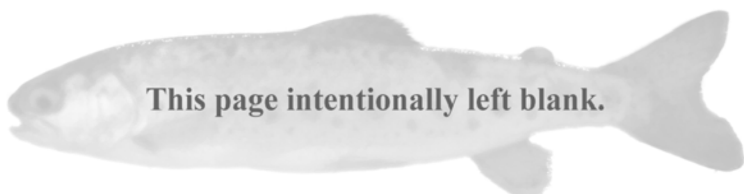
Largemouth bass were only found in the glide at station E-3. This habitat is in close proximity to a large pool at the downstream end of Calaveras Creek, where bass are known to reside.

Bluegill

Bluegills were only found in a single habitat in Calaveras Creek and two habitats in Alameda Creek downstream of its confluence with Calaveras Creek. Bluegills, present in relatively low numbers, were only collected from pool habitats.

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 two pools 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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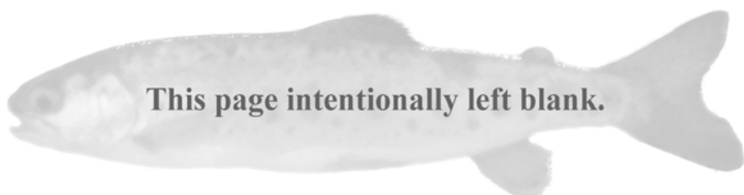
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10.0 Acknowledgments

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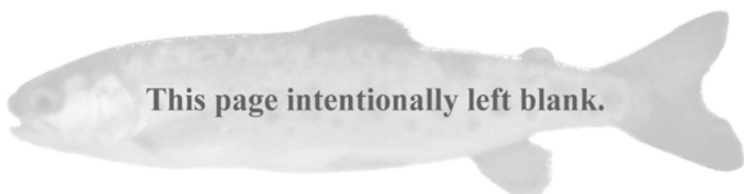
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11.0 Appendices

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

	Depth	Temp	pH	Cond	TDS	DO	ORP	Turb	Alk	Hard	Color	NH3N	NO3-N	PO4-P	Total-P	Cl-	TOC	Fe	Mn
Date	ft.	°C	-log H+	uS/cm	mg/L	mg/L	mV	NTU	mg/L	mg/L	clr unts	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1/7/04	0	9.51	7.82	281	180	9.46	425	30.1											
	10	9.47	7.9	280	179	9.35	432												
	20	9.46	7.8	278	178	9.47	423	36.8											
	30	9.44	7.78	276	177	9.62	415												
	40	9.44	7.77	276	177	9.36	411	38.3											
	50	9.43	7.76	276	177	9.31	406												
	60	9.43	7.75	277	177	9.31	400	40.8											
	70	9.42	7.73	275	176	9.43	387												
	80	9.43	7.68	275	176	9.42	349												
	83	9.43	7.65	276	177	9.41	318	41.1											
1/13/04	0	9.5	7.81	276	177	10.4	440	10.2											
	10	9.5	7.8	276	177	10.2	440												
	20	9.5	7.78	276	176	10.2	441	11.2											
	30	9.5	7.78	275	176	10.1	441												
	40	9.5	7.77	274	176	10	440	11.1											
	50	9.3	7.73	271	174	9.7	440												
	60	9.3	7.73	271	173	9.5	439	12.6											
	70	9.3	7.73	271	173	9.6	438												
	80	9.3	7.71	271	173	9.4	438												
	83	9.3	7.71	272	174	9.5	437	13.2											
1/30/04	0	10.3	7.86	284	182	10	434	3.7	96	120	41	0.09	0.1	0.02	0.03	8		0.13	0.01
	10	10.2	7.82	284	182	9.9	436												
	20	10.2	7.8	284	181	9.8	435	3.5	98	121	42	0.1	0.08	0.01	0.03	8			
	30	10.1	7.77	283	181	9.7	436												
	40	9.6	7.74	282	180	9.4	436	4.1	97	121	42	0.09	0.1	0.01	0.03	8			
	50	9.6	7.73	282	180	9.3	436												
	60	9.6	7.73	282	180	9.3	436	5	95	120	51	0.04	0.11	0.02	0.02	8		0.16	0.03
	70	9.5	7.72	282	180	9.3	436												
	80	9.5	7.68	283	181	9.7	436	5.3	96	119	58	0.05	0.12	0.02	0.02	7		0.16	0.05
2/24/04	0	11.5	7.94	271	174	11	392	7.4	92	115	62	0.04	0.05	0.02	0.02	12		0.38	0.03
	10	11	7.9	270	173	10.9	392												
	20	10.8	7.88	271	173	10.8	393	8.4	98	117	66	0.04	0.05	0.02	0.03	12			
	30	10.7	7.87	271	174	10.8	392												
	40	10.7	7.86	272	174	10.6	392	9	98	116	67	0.03	0.06	0.02	0.03	12			
	50	10.1	7.8	280	179	10.4	394												
	60	10.1	7.79	283	181	10.2	394	6.3	103	119	51	0.02	0.08	0.01	0.03	12		0.28	0.03
	70	10	7.76	284	182	10	394												
	80	10	7.74	285	182	9.8	394												
	88	10	7.71	285	182	9	397	6.4	104	122	59	0.06	0.1	0.02	0.03	13		0.31	0.09
3/8/04	0	13.2	7.68	283	181	10.5	427	7.6	98	111	67	0.05	0.07	0.03	0.03	14		0.25	0.03
	10	11.9	7.72	280	180	10.7	427												
	20	11.4	7.72	278	178	10.7	427	8.9	96	113	80	0.05	0.07	0.02	0.03	13			
	30	11	7.72	274	175	10.7	427												

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
3/8/04	40	10.7	7.72	271	174	10.5	427	11.4	97	108	95	0.04	0.06	0.02	0.03	11			
	50	10.3	7.71	263	168	10.4	427												
	60	10.1	7.68	253	162	10.3	427	14.1	95	109	148	0.08	0.06	0.02	0.04	12		0.89	0.04
	70	10.1	7.66	249	160	10.1	427												
	80	10	7.65	244	156	10	426	22.7	90	100	175	0.05	0.04	0.03	0.04	10			
	98	9.8	7.63	227	145	9.8	426	32.4	85	94	242	0.05	0.06	0.03	0.05	10		1.17	0.09
3/25/04	0	16.8	8.35	278	178	9.6	411	2	100	111	33	0.04	0.04	0.01	0.02	13		0.09	0.01
	10	16.8	8.34	275	176	9.4	412												
	20	13.1	8.05	267	171	8.4	419	2.5	94	114	34	0.05	0.04	0.01	0.03	12			
	30	11.2	7.92	255	163	8.2	424												
	40	10.5	7.88	247	158	8.1	425	6	95	105	61	0.08	0.08	0.02	0.03	11			
	50	10.3	7.85	243	155	8	426												
	60	10.2	7.83	240	153	7.9	426	7.6	89	102	72	0.09	0.08	0.03	0.04	11		0.28	0.02
	70	10.1	7.8	238	152	7.7	425												
	80	10.1	7.76	237	152	7.3	425	9.2	90	102	94	0.12	0.1	0.02	0.04	10			
	90	10.1	7.71	237	152	7	423	9.4	90	101	93	0.22	0.1	0.02	0.07	11		0.34	0.11
4/8/04	0	16.8	8.23	273	175	9.6	432	1.9	98	113	28	0.08	0.01	0	0.02	12		0.07	0.01
	10	16.6	8.26	272	174	9.6	430												
	20	14.8	7.97	269	172	8.5	433	2.4	103	113	30	0.07	0	0	0.02	12			
	30	12.8	7.75	259	166	7.8	436												
	40	10.9	7.64	246	158	7.5	439	3.6	99	101	41	0.02	0.08	0.01	0.03	11			
	50	10.7	7.59	244	156	7.6	440												
	60	10.5	7.55	241	154	7.3	439	5.4	98	100	58	0.03	0.11	0.02	0.03	11		0.18	0.03
	70	10.4	7.52	240	153	7	439												
	80	10.4	7.49	238	153	6.7	437	5.5	95	102	59	0.06	0.11	0.04	0.04	12			
	90	10.3	7.46	238	152	6.4	437												
	91	10.3	7.47	239	153	6	431	6.3	91	98	69	0.06	0.12	0.05	0.05	12		0.23	0.07
4/28/04	0	19.6	8.36	278	178	9.5	422	1	95	116	22	0.01	0	0	0.01	13		0.1	0.01
	10	19.4	8.39	282	180	9.4	420												
	20	19.3	8.41	281	180	9.3	420	1.1	106	114	25	0.03	0	0	0.01	12			
	30	13.5	7.61	263	168	6.2	428												
	40	11.1	7.48	247	158	6	431	1.8	97	107	35	0.02	0.02	0.01	0.02	11			
	50	10.7	7.45	245	157	6.1	432											0.14	0.02
	60	10.6	7.4	243	156	5.4	432	2.6	95	103	45	0.03	0.1	0.03	0.03	10			
	70	10.5	7.36	242	155	4.9	431												
	80	10.4	7.34	242	155	4.5	430												
	88	10.4	7.31	243	155	4.2	430	3.2	90	104	56	0.01	0.1	0.04	0.04	11		0.17	0.11
5/11/04	0	20.3	8.53	298	191	9	409	1.1	103	118	18	0.01	0	0	0.01	12		<0.01	<0.01
	10	20.1	8.54	295	189	8.9	412												
	20	19.5	8.45	293	188	8.6	415	1.5	101	119	24	0	0	0	0.02	11			
	30	14.3	7.81	274	175	5.2	424												
	40	11.6	7.64	257	165	5	430	1.6	97	110	32	0.03	0.1	0	0.01	12			
	50	11	7.59	253	162	4.8	433												
	60	10.8	7.55	251	161	4.6	434	1.7	95	103	31	0.06	0.12	0.02	0.02	12		0.05	0.01

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
5/11/04	70	10.7	7.5	251	160	4.3	435												
	80	10.6	7.46	249	159	3.8	435	2	98	102	30	0.08	0.11	0.02	0.03	11			
	90	10.5	7.42	250	160	3.4	435												
	96	10.5	7.41	249	160	3.2	434	2.8	95	110	34	0.1	0.15	0.02	0.03	10		0.05	0.11
5/18/04	0	20.8	8.56	305	196	8.7	529	1.1											
	10	20.3	8.57	299	191	8.6	523												
	20	19.8	8.47	296	189	8.3	522	1.3											
	30	14	7.72	273	175	4.6	524												
	40	12	7.63	260	167	4.6	524	1.2											
	50	11.2	7.58	255	163	4.6	524												
	60	11	7.54	253	162	4.3	523	1.7											
	70	10.8	7.52	252	161	4.2	522												
	80	10.8	7.48	251	160	3.7	520	1.5											
	90	10.6	7.44	249	160	2.9	519	2.1											
5/24/04	0	20.3	8.72	292	188	8.6	380	1.2	99	115	21	0.01	0.01	0.01	0.01	11		0.01	<0.01
	10	20.2	8.71	292	187	8.6	380												
	20	19.8	8.66	292	187	8.4	379	1.2	110	115	22	0.05	0.01	0.01	0.01	12			
	30	15.1	7.61	274	175	4.3	384												
	40	12.2	7.5	258	165	4	387	1.2	96	113	25	0	0.1	0.01	0.03	12			
	50	11.1	7.46	252	161	3.7	385												
	60	10.9	7.46	250	160	3.8	383	1.5	103	105	26	0.09	0.07	0.02	0.03	12		0.04	0.01
	70	10.7	7.43	250	160	3.3	377												
	80	10.7	7.41	250	160	2.8	367	1.6	95	100	30	0.03	0.08	0.02	0.02	11			
	90	10.6	7.41	251	161	2.4	351												
	91	10.6	7.42	252	161	2.3	327	1.8	102	111	42	0.05	0.14	0.01	0.02	11		0.05	0.05
6/4/04	0	22.4	8.42	292	187	8.7	398	1.9											
	10	22.2	8.45	290	186	8.9	396												
	20	21.8	8.44	290	186	8.8	396	2											
	30	15.5	7.52	268	172	4.3	405												
	40	12.6	7.41	254	162	3.8	407	1.2											
	50	11.2	7.34	246	157	3.7	408												
	60	10.9	7.28	244	156	3.1	408	1.2											
	70	10.8	7.24	243	156	2.5	407												
	80	10.7	7.21	243	155	2.2	407	2.5											
	90	10.7	7.19	242	155	1.8	406												
	93	10.7	7.18	243	156	1.5	402	2.7											
6/17/04	0	23.2	8.4	307	196	8.4	375	1.8	105	123	21	<0.01	<0.01	0.01	0.02	12	4.4	0.08	0.01
	10	23.1	8.45	304	195	8.4	374												
	20	22.9	8.44	307	196	8.3	376	2.1	108	122	23	0.01	<0.01	0.01	0.01	11			
	30	17.7	7.73	292	187	4.1	385												
	40	12.4	7.52	265	170	2.3	392	1.3	102	117	26	0.01	0.06	<0.01	0.02	12			
	50	11.5	7.43	259	166	2.4	394												
	60	11.2	7.36	260	166	2.5	396	1.7	95	109	30	0.02	0.14	0.04	0.04	11	4.6	0.06	0.04
	70	10.9	7.32	258	165	2	397												
	80	10.8	7.28	255	163	1.6	397	2.3	95	108	43	0.02	0.17	0.03	0.05	11			

	Depth	Temp	pH	Cond	TDS	DO	ORP	Turb	Alk	Hard	Color	NH3N	NO3-N	PO4-P	Total-P	Cl-	TOC	Fe	Mn
Date	ft.	°C	-log H+	uS/cm	mg/L	mg/L	mV	NTU	mg/L	mg/L	clr unts	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
6/17/04	90	10.8	7.23	255	163	1.1	396												
	91	10.8	7.22	256	164	1	395	2.8	99	108	33	0.01	0.15	0.02	0.05	11	4.5	0.06	0.16
6/22/04	0	23.3	8.37	308	197	8.5	380	1.8											
	10	23.2	8.41	305	195	8.3	377												
	20	22.9	8.39	304	194	8.2	377	2.2											
	30	17.4	7.58	286	183	3.1	383												
	40	12.2	7.42	261	167	1.6	388	1.4											
	50	11.4	7.36	257	165	1.6	388												
	60	11.1	7.29	255	163	1.8	388	1.9											
	70	10.9	7.23	254	163	1.4	387												
	80	10.8	7.19	254	162	0.9	386	3.1											
	87	10.8	7.17	254	162	0.7	383	4.6											
6/30/04	0	23	8.4	312	200	8.5	401	1.8											
	10	23	8.5	305	195	8.5	395												
	20	22.8	8.51	303	194	8.3	393	1.9											
	25	21.9	8.28	300	192	7	393												
	30	18.5	7.83	287	184	3.2	397												
	35	14.5	7.59	270	173	1.3	400												
	40	13.2	7.51	264	169	0.8	401	1.4											
	50	11.8	7.43	256	164	0.9	403												
	60	11.4	7.39	254	163	1.3	404	1.6											
	70	11	7.36	253	162	1	405												
	80	10.9	7.33	252	161	0.4	405	2.2											
	89	10.9	7.31	252	162	0.3	402	2.5											
7/8/04	0	23.7	8.65	299	191	8.6	390	2.1											
	10	23.7	8.66	299	191	8.5	389												
	20	23.3	8.62	298	191	8.3	390	2											
	30	19.2	7.75	288	184	2.6	397												
	40	13.5	7.57	262	168	0.4	403	1.2											
	50	11.6	7.45	252	161	0.7	404												
	60	11.3	7.42	251	161	0.9	404	1.4											
	70	11.1	7.39	250	160	0.5	403												
	80	10.9	7.37	249	160	0.2	403	2.3											
	89	10.9	7.32	256	162	0.1	399	3											
7/12/04	0	23.3	8.66	297	190	8.9	386	2.1											
	10	23.1	8.7	297	190	8.8	385												
	20	23	8.72	296	190	8.9	385	2											
	25	23	8.72	296	190	8.8	385												
	30	22.4	8.44	297	190	7	386												
	35	15.8	7.78	273	175	0.5	395												
	40	13.2	7.73	261	167	0.4	397	1											
	50	11.7	7.65	253	161	0.6	399												
	60	11.3	7.58	251	161	0.6	400	1.1											
	80	10.8	7.28	255	163	1.6	397	2.3	95	108	43	0.02	0.17	0.03	0.05	11			
	88	10.9	7.42	254	163	0.2	400	1.7											

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
7/15/04	0	23.9	8.71	272	174	8.7	365	1.6	106	125	9	<0.01	0.06	0.04	0.04	7	4.4	0.06	0.02
	10	23.8	8.69	281	180	8.5	363												
	20	22.9	8.54	282	180	7.6	364	1.2	107	127	13	<0.01	0.05	0.03	0.08	7			
	30	18.8	7.58	272	174	0.8	379												
	40	14.4	7.49	254	162	0.2	383	1.2	96	115	15	<0.01	0.03	0.03	0.09	7			
	50	11.8	7.48	241	154	0.4	386												
	60	11.3	7.48	239	153	0.5	386	1.6	96	110	17	0.17	0.02	0.05	0.11	8	4.4	0.07	0.1
	70	11	7.49	238	153	0.2	387												
	80	11	7.49	241	154	0.3	388	4.1	96	110	18	0.18	0.12	0.05	0.14	8			
	88	10.9	7.49	242	155	0.3	390	6.4	96	99	18	0.21	0.15	0.04	0.14	8	4.6	0.02	0.8
7/19/04	0	24.5	8.7	265	169	8.3	341	1	104	126									
	10	23.8	8.66	281	180	8.5	341												
	20	23.2	8.61	281	180	8.1	339	1.1	108	123									
	30	17.6	7.61	266	170	0.2	356												
	40	13.7	7.59	251	161	0.2	359	2.1	97	115									
	50	12.3	7.58	243	156	0.2	368												
	60	11.6	7.57	240	154	0.3	368	2.5	93	109									
	70	11.3	7.57	239	153	0.3	369												
	80	11	7.6	242	155	0.2	371	4.1	91	109									
	88	11	7.63	242	155	0.2	372	6	90	109									
7/30/04	0	24.5	8.58	307	197	8.2	389	1.2	112	124	14	0.01	0.01	<0.01	0.01	11	4.2	0.12	0.01
	10	24.5	8.63	307	196	8.2	387												
	20	24.1	8.6	306	196	7.9	388	1.4	113	122	19	0.03	<0.01	<0.01	0.01	12			
	25	22.9	8.33	307	196	5.8	387												
	30	19.3	7.74	295	190	0.4	388												
	40	13.9	7.69	272	174	0.3	323	1.1	109	119	29	0.09	0.01	0.01	0.02	12	4.3	0.2	0.17
	50	11.8	7.61	261	167	0.3	358												
	60	11.4	7.54	258	165	0.2	373	1.2	108	110	30	0.13	0.02	0.01	0.02	12			
	70	11.1	7.47	258	165	0.1	338												
	80	11	7.42	260	166	0.1	285	0.8	103	112	44	0.14	<0.01	0.04	0.04	12	4.3	0.11	0.2
	81	11	7.4	261	167	0.1	282												
8/13/04	0	24.7	8.38	310	198	7.6	378	0.8											0
	10	24.6	8.48	309	198	7.6	379												
	20	23.9	8.52	308	197	7.6	380	0.9											0.01
	25	23.6	8.47	307	197	7	380												
	30	20.3	7.98	298	191	1.5	384												
	35	16.9	7.83	286	183	0.7	369												
	40	14.4	7.82	275	176	0.6	330	1.3											0.33
	50	12	7.75	266	170	0.5	324												
	60	11.5	7.69	264	169	0.4	304	1.1											0.34
	70	11.2	7.59	262	168	0.2	280												
	80	11.1	7.52	266	170	0.2	258	0.7											0.64
8/25/04	0	24.2	8.47	288	184	9	377	1.2	111	118	19	<0.01	<0.01	<0.01	0.01	13	3.7	0.05	<0.01
	10	23.7	8.47	287	183	8.8	377												
	20	23.3	8.45	286	183	8.6	377	0.9	115	124	17	<0.01	<0.01	<0.01	<0.01	12			<0.01

	Depth	Temp	pH	Cond	TDS	DO	ORP	Turb	Alk	Hard	Color	NH3N	NO3-N	PO4-P	Total-P	Cl-	TOC	Fe	Mn
Date	ft.	°C	-log H+	uS/cm	mg/L	mg/L	mV	NTU	mg/L	mg/L	clr unts	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
8/25/04	25	23.2	8.45	285	183	8.5	378												
	30	22.5	8.06	284	182	4.5	385												
	35	15.6	7.8	261	167	0.2	391												
	40	14.1	7.73	254	163	0.1	375	4.5	108	119	99	0.04	<0.01	0.02	0.06	12	3.9	0.31	0.47
	50	12.2	7.63	244	156	0.1	271												
	60	11.5	7.55	242	155	0	251	1.7	104	110	48	0.17	<0.01	0.06	0.07	12			0.3
	70	11.2	7.47	241	155	0	229												
	80	11.1	7.38	243	155	0	217	0.9	107	112	33	0.57	<0.01	0.1	0.11	12			0.46
	86	11.1	7.34	243	156	0	213	0.8	107	113	34	0.26	<0.01	0.08	0.09	12	4.6	0.3	0.67
9/7/04	0	23.9	8.44	290	186	9	407	22.3										0.04	0.01
	10	23.2	8.44	288	184	8.8	408												
	20	23.1	8.44	287	184	8.7	407	1.9											
	25	23	8.4	286	183	8.4	410												
	30	21.5	8	283	181	3	415												
	35	15.6	7.72	261	167	0.2	403												
	40	13.7	7.64	253	162	0.1	387	1.5										0.04	0.01
	50	12.2	7.58	246	158	0.1	319												
	60	11.6	7.47	244	156	0.1	285	0.7											
	70	11.3	7.37	246	157	0.1	260												
	78	11.2	7.31	247	158	0	245	2										0.23	0.71
9/16/04	0	22.9	8.49	290	186	9.5	399												
	10	22.5	8.46	289	185	9.1	400												
	20	22.4	8.45	288	185	9	400												
	30	22.4	8.42	288	184	8.5	400												
	32	21.3	7.97	285	182	2.4	403												
	33	20	7.85	279	178	0.5	402												
	34	17.6	7.83	270	173	0.3	401												
	35	16.3	7.76	264	169	0.2	396												
	40	13.6	7.74	255	163	0.2	384												
	50	12.3	7.61	249	159	0.1	301												
	60	11.9	7.55	247	158	0.1	282												
	70	11.3	7.47	245	157	0.1	257												
	80	11.3	7.39	245	157	0.1	248												
	85	11.2	7.36	246	158	0.1	240												
9/23/04	0	23	8.4	294	188	9.1	409	7.7	110	121	35	0.02	<0.01	<0.01	0.03	12	4.7	0.05	0.01
	10	21.3	8.41	291	186	9.2	412												
	20	21	8.36	291	186	8.3	413	1.5	113	124	21	0.03	<0.01	<0.01	0.01	11			
	30	20.9	8.3	291	186	7.6	412												
	33	20.5	8.18	291	186	6.4	413												
	35	16.9	7.84	270	173	0.3	412												
	40	14.3	7.78	260	166	0.2	407	1.6	110	115	24	0.09	0.05	0.07	0.07	11	4.5	0.07	0.16
	50	12.3	7.62	252	161	0.1	308												
	60	11.6	7.57	249	160	0.1	287	1	107	109	30	0.38	0.02	0.14	0.14	13			
	70	11.3	7.52	250	160	0.1	272												
	80	11.3	7.46	251	160	0.1	259												

	Depth	Temp	pH	Cond	TDS	DO	ORP	Turb	Alk	Hard	Color	NH3N	NO3-N	PO4-P	Total-P	Cl-	TOC	Fe	Mn
Date	ft.	°C	-log H+	uS/cm	mg/L	mg/L	mV	NTU	mg/L	mg/L	clr unts	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
9/23/04	83	11.3	7.39	250	160	0.1	250	3.8	102	111	39	0.56	<0.01	0.24	0.25	12	4.6	0.35	0.95
10/7/04	0	20.8	8.27	280	179	8.4	408	1.1											
	10	20.6	8.26	279	179	8.3	408												
	20	20.3	8.27	278	178	8	407	0.9											
	30	19.9	8.18	278	178	7.1	407												
	35	19.4	8.01	276	177	4.9	409												
	36	17.1	7.61	258	165	0.5	411												
	37	16.2	7.54	254	162	0.1	409												
	40	14.6	7.49	249	160	0.1	405	1.1											
	50	12.4	7.4	242	155	0.1	306												
	60	11.5	7.31	242	155	0	231	2.6											
	70	11.3	7.27	242	155	0.1	216												
	80	11.3	7.23	243	156	0	205												
	84	11.3	7.22	247	158	0.1	204	9											
10/24/04	0	17.2	7.74	280	179	7.7	400	2.1											0.09
	10	17.2	7.78	279	179	7.5	401												
	20	17.2	7.78	278	178	7.6	401	2											0.09
	30	17.1	7.78	278	178	7.2	401												
	40	17.1	7.78	278	178	7.2	401	1.9											0.09
	43	16.5	7.63	273	175	4	399												
	45	14.5	7.58	257	165	0.7	388												
	50	12.6	7.51	249	159	0.3	304												
	60	11.9	7.29	246	157	0.1	221	3.6											0.89
	70	11.5	7.15	245	157	0.1	193												
	80	11.4	7.13	245	157	0	189	6.8											0.75
	84	11.4	7.1	247	158	0	184	2.9											0.23
11/4/04	0	15.3	7.93	243	156	6.7	172	2.8											
	10	15.3	7.93	244	156	6.6	165												
	20	15.3	7.93	243	156	6.7	154	2.8											
	30	15.3	7.93	243	156	6.7	137												
	40	15.2	7.9	242	155	6.1	101	3.2											
	50	13.3	7.7	222	142	0.2	50												
	60	11.8	7.69	217	139	0.2	41	3.3											
	70	11.5	7.69	218	140	0.2	45												
	80	11.4	7.69	219	140	0.3	57	10.9											
	86	11.4	7.7	220	141	0.3	71	29.3											
11/16/04	0	14.4	7.67	290	185	7.8	416	1.2	113	123	19	0.13	0.05	0.03	0.05	12	4.4	0.04	0.06
	10	14.3	7.65	289	185	8.1	417												
	20	14.2	7.65	289	185	7.6	417	1.3	115	123	20	0.13	0.05	0.03	0.03	12			
	30	14.2	7.65	288	184	6.7	417												
	40	14.2	7.65	288	184	6.4	417	1.3	111	117	24	0.13	0.03	0.07	0.07	11	4.4	0.03	0.06
	50	14	7.65	285	182	6.4	417												
	52	13.5	7.5	276	177	3.2	412												
	60	11.8	7.19	258	165	0.9	271	1.4	109	114	41	0.54	0.02	0.15	0.15	12			
	70	11.4	7.05	259	166	0.6	236												

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
11/16/04	80	11.4	7.01	259	166	0.4	231												
	85	11.4	6.99	261	167	0.4	226	9.6	109	117	67	0.84	<0.01	0.31	0.35	12	4.9	0.45	1.29
11/30/04	0	11.9	7.7	240	154	6.5	447	2.8	110	122	10	0.03	0.38	0.05	0.08	9	4.2	0.14	0.28
	10	11.9	7.7	281	180	6.1	447												
	20	11.8	7.69	281	180	5.9	448	2.9	110	123	10	0.05	0.18	0.08	0.08	9			
	30	11.8	7.69	281	180	6.1	449												
	40	11.8	7.7	281	180	6.1	450	3.1	110	124	10	0.04	0.21	0.09	0.1	9	4.2	0.17	0.26
	50	11.8	7.71	282	180	6.2	451												
	60	11.8	7.72	282	180	6.5	452	3.7	110	126	10	0.05	0.21	0.09	0.09	9			
	70	11.7	7.72	282	180	6.6	454												
	80	11.6	7.73	282	181	7	456	4.1	111	126	10	0.05	0.1	0.09	0.09	8			
	86	11.6	7.74	283	181	7.4	458	4.9	112	126	11	0.06	0.13	0.08	0.08	8	4.2	0.23	0.21
12/15/04	0	11	7.43	288	184	9.7	411	2.5											
	10	10.9	7.44	287	184	9.4	413												
	20	10.9	7.45	287	184	9.3	413	3											
	30	10.9	7.46	287	184	9.4	412												
	40	10.9	7.48	286	183	9.3	413	3											
	50	10.9	7.5	286	183	9.3	412												
	60	10.9	7.51	286	183	9.3	412	3.7											
	70	10.9	7.5	286	183	9.3	411												
	80	10.9	7.52	286	183	9.2	410	2.7											
	86	10.9	7.51	287	184	8.5	408												

Appendix C – Snorkel Survey Count Summary

Alameda Creek count summary for the summer, 2004 snorkel survey.

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	--	3	1	2	0	6
Sacramento sucker	0	0	0	1	1	--	--	0	--	0	0	0	3	5
Sacramento pikeminnow	0	1	10	3	5	--	--	1	--	0	0	0	0	20
California roach	80	220	100	325	250	--	--	0	--	0	0	0	75	1,050
prickly sculpin	0	0	0	0	1	--	--	0	--	0	0	2	4	7
largemouth bass	0	0	0	0	0	--	--	20	--	0	0	0	0	20
unidentified sunfish	0	0	0	0	1	--	--	40	--	0	0	0	0	41
Total	80	221	110	329	258	--	--	61	--	3	1	4	82	1,149

** Did not collect at this site due to unsuitable conditions.*

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	2	0	0	23
Sacramento sucker	0	80	2	53	1	--	--	0	--	0	0	1	2	516
Sacramento pikeminnow	2	14	2	2	1	--	--	0	--	0	0	0	0	285
California roach	5	970	3,750	3,570	3,450	--	--	303	--	0	290	370	425	14,187
prickly sculpin	0	0	0	0	1	--	--	0	--	0	0	2	4	1
largemouth bass	10	0	0	0	0	--	--	25	--	0	0	0	0	32
unidentified sunfish	0	0	0	0	1	--	--	168	--	0	0	0	0	71
Total	17	1,064	3,754	3,625	3,454	--	--	496	--	0	292	372	431	13,505

** Did not collect at this site due to unsuitable conditions.*

Appendix D – Electrofishing Survey Catch Summary and Population Estimates

Alameda Creek catch summary for the autumn, 2004 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			1	3	5	60		3	- -	- -	13	20	70	- -		
rainbow trout									- -	- -				- -		
California roach	120	642	41	223	186	128	210	713	- -	- -	1,113	363	358	- -	29	24
Sacramento pikeminnow	1	2		6			5	2	- -	- -	42	4		- -		
Sacramento sucker	1	5		2			12	1	- -	- -	6	10	2	- -	6	
largemouth bass		10							- -	- -				- -		
bluegill							3		- -	- -	1			- -	1	
prickly sculpin									- -	- -				- -		
Total	122	659	42	234	191	188	230	719	- -	- -	1,175	397	430	- -	36	24

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**	**15-4**	**Total**
Pacific lamprey			- -													175
rainbow trout	9	22	- -	1		20			15		17	9	4	6	79	182
California roach	70	58	- -	235	30	50		129	66							4,788
Sacramento pikeminnow			- -													62
Sacramento sucker			- -					2								47
largemouth bass			- -													10
bluegill			- -													5
prickly sculpin			- -					63	72			2		1		138
Total	79	80	- -	236	30	70	0	194	153	0	17	11	4	7	79	5,407

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

Alameda Creek population estimates for the autumn, 2004 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			1	3	5	116		3	- -	- -	20	21	105	- -		
rainbow trout									- -	- -				- -		
California roach	123	703	43	227	198	129	220	760	- -	- -	1,291	372	416	- -	30	25
Sacramento pikeminnow	1	2		6			5	2	- -	- -	44	4		- -		
Sacramento sucker	1	5		2			12	1	- -	- -	6	10	2	- -	6	
largemouth bass		10							- -	- -				- -		
bluegill							3		- -	- -	1			- -	1	
prickly sculpin									- -	- -				- -		
Total	125	720	44	238	203	245	240	766	- -	- -	1,362	407	523	- -	37	25

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**	**15-4**	**Total**
Pacific lamprey			- -													274
rainbow trout	9	22	- -	1		20			15		17	9	4	6	80	183
California roach	71	59	- -	247	30	50		133	66							5,193
Sacramento pikeminnow			- -													64
Sacramento sucker			- -					2								47
largemouth bass			- -													10
bluegill			- -													5
prickly sculpin			- -					66	72			2		1		141
Total	80	81	- -	248	30	70	0	201	153	0	17	11	4	7	80	5,917

** 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, 2004 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	bluegill	prickly sculpin	Pacific lamprey	rainbow trout	California roach	Sacramento pikeminnow	Sacramento sucker	largemouth bass	bluegill	prickly sculpin
1-1			2.462	*/**	*/**						6.679	*/**	*/**			
3-1			14.070	0.384	**	0.859					0.062	0.929	**	2.844		
3-2	*		2.498						*		1.850					
4-1	0.709		2.746	0.142	**				2.516		1.692	0.205	**			
4-2	**		5.692						**		0.926					
4-3	53.728		1.321						1.470		0.525					
5-1			4.815	1.189	0.355		0.266				0.211	1.106	1.030		0.509	
6-1	0.709		11.034	**	*/**				2.932		7.035	**	*/**			
6-2^																
6-3^																
6-4	***		29.127	2.577	0.666		*/**		***		3.147	0.256	2.786		*/**	
7-1	1.809		4.080	0.544	0.419				0.240		3.144	2.608	1.203			
7-2	***		16.822		1.038				***		0.108		2.786			
7-3^																
8-1			1.866		1.002		*/**				0.927		5.031		*/**	
8-2			2.152								0.411					
10-1		0.622	1.312							1.887	11.711					
10-2		0.814	1.414							0.664	0.233					
10-3^																
11-1		*/**	5.367							*/**	3.242					
11-2			0.615								1.062					
12-1		0.887	1.025							3.992	0.373					
12-2																
13-1			2.896		1.038			2.775			7.170		2.786			0.431
13-2		0.435	1.091					0.738		1.497	2.147					0.619
14-1																
14-2		1.028								0.633						
15-1		0.947						**		2.736						**
15-2		**								**						
15-3		**						*/**		**						*/**
15-4		1.572								0.387						

^ 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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