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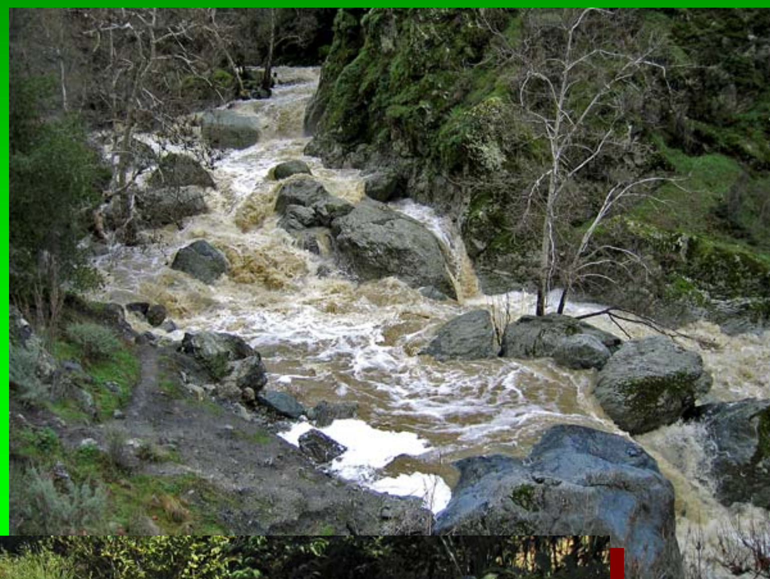
NATURAL RESOURCES DIVISION

Alameda Creek
Aquatic Resource Monitoring Report
2005



Alameda Creek
Aquatic Resource Monitoring Report
2005

Prepared by:

San Francisco Public Utilities Commission
Water Enterprise
Natural Resources and Lands Management Division
Fisheries and Wildlife Section
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. Given sufficient precipitation, experimental releases are expected to begin following the 2007-2008 wet weather season.

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 its Habitat Conservation Plan (HCP). These negotiations are expected to occur on a schedule consistent with the proposed modifications of downstream barriers that may permit fish passage to the upper watershed as early as 2010.

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 eighth year of pre-water release

monitoring (January, 2005 through December, 2005). 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 fourth year of the additional monitoring.

Peak flows in Alameda and Calaveras creeks and Arroyo Hondo occurred between mid-winter and early spring, when seasonal storms resulted in dramatic fluctuations in the amount of water moving through stream channels. Regulated releases from Calaveras Reservoir, to comply with DSOD restrictions, were evident in gauge readings downstream of the dam during March, April and May. The greatest maximum daily mean flow in 2005 was recorded in Arroyo Hondo. Average annual daily mean flows were also greatest in the Arroyo Hondo. Average annual flows in Calaveras Creek downstream of Calaveras Dam, once adjusted for releases, were drastically lower that those measured at all other sites within the Alameda Creek watershed.

Water storage volumes in Calaveras Reservoir never dropped below the 30,000 acre-feet minimum storage criteria defined in the MOU. Minimum and maximum volumes ranged from 35,2483 acre-feet to 58,810, respectively.

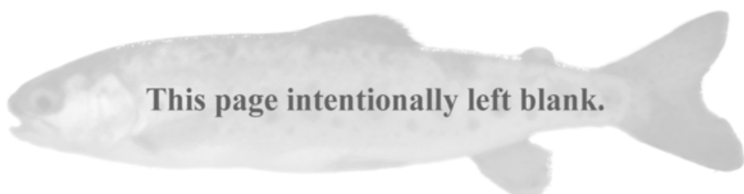
Water quality conditions in Calaveras Reservoir were typical of a relatively deep temperate lake, with stratification occurring during the summer months. Dissolved oxygen concentrations remained near saturation throughout the water column until the stratification process was well under way. Oxygen concentrations began to drop below the thermocline by the end of March, falling to less than 3 mg/L in the deepest waters by late May. The installation of a hypolimnetic oxygenation system (HOS), with testing that began in September, increased oxygen concentrations below the thermocline earlier than in previous years. The pH ranged from a low of 6.8 in early September to a high of 8.7 in late September. The highest turbidities in Calaveras Reservoir were measured in early January, with a high of 260 NTUs near the bottom, and are 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 0.25 mg/L. Calaveras Reservoir was treated with copper sulfate one time in late September to control an extensive plankton bloom dominated by *Anabaena*.

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 from mid- to late July. Following that month the temperatures in both study reaches gradually decreased over the remainder of the year, with the lowest temperatures measured in early November. The stations in Alameda Creek just upstream of the Diversion Dam and in Indian Creek 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 four 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.

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 the fourteen pools surveyed. California roach were the most abundant species, while roach and Sacramento sucker were the most widely distributed. Largemouth bass and sunfish, the only non-native fishes observed, were found only in a single pool in Calaveras Creek. Prickly sculpin were noted from two pools in Arroyo Hondo.

Thirty 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, Sacramento sucker, rainbow trout, Sacramento pikeminnow, Pacific lamprey ammocetes and prickly sculpin (tied), largemouth bass and bluegill. In Alameda Creek, rainbow trout were not collected below the station just downstream of its confluence with Calaveras Creek, while they were found in most 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.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1.0 Introduction

Storage of water at Calaveras Dam (Figure 1-1) 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 debilitating slide along its upstream face. 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, to secure the storage of runoff from the upper Alameda Creek Watershed in Calaveras Reservoir. The SFPUC began acquiring water from Alameda Creek, several miles above its confluence with Calaveras Creek, with the completion of the Diversion Dam and Tunnel in 1931 (EDAW, 1998).

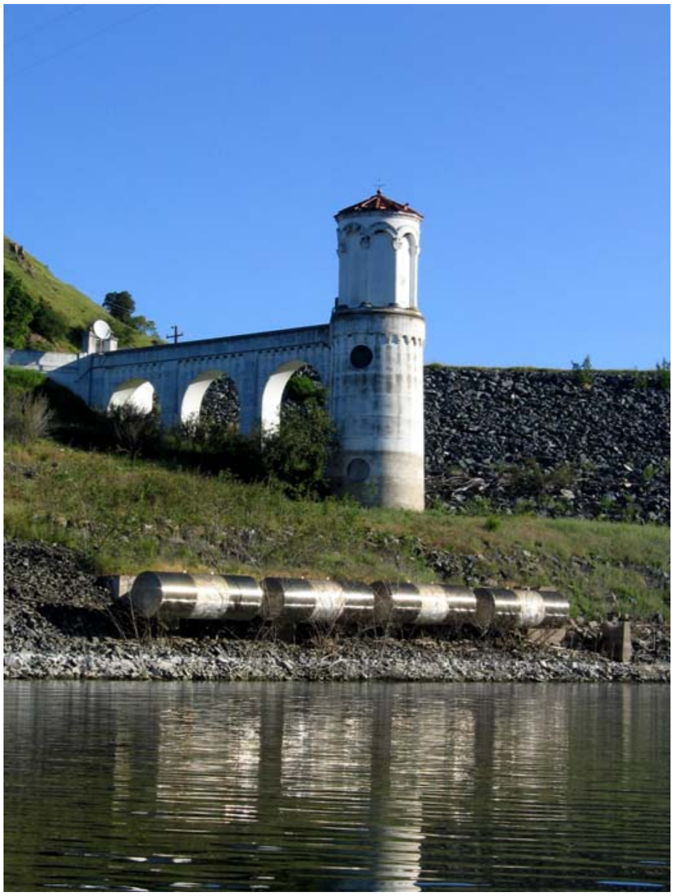


Figure 1-1. *Calaveras Dam adit structure and exposed upper adit.*

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 contributions from Calaveras Creek and other smaller tributaries.

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 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 intermittent occurrences 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 release and recapture water 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 coldwater 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 2005 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.

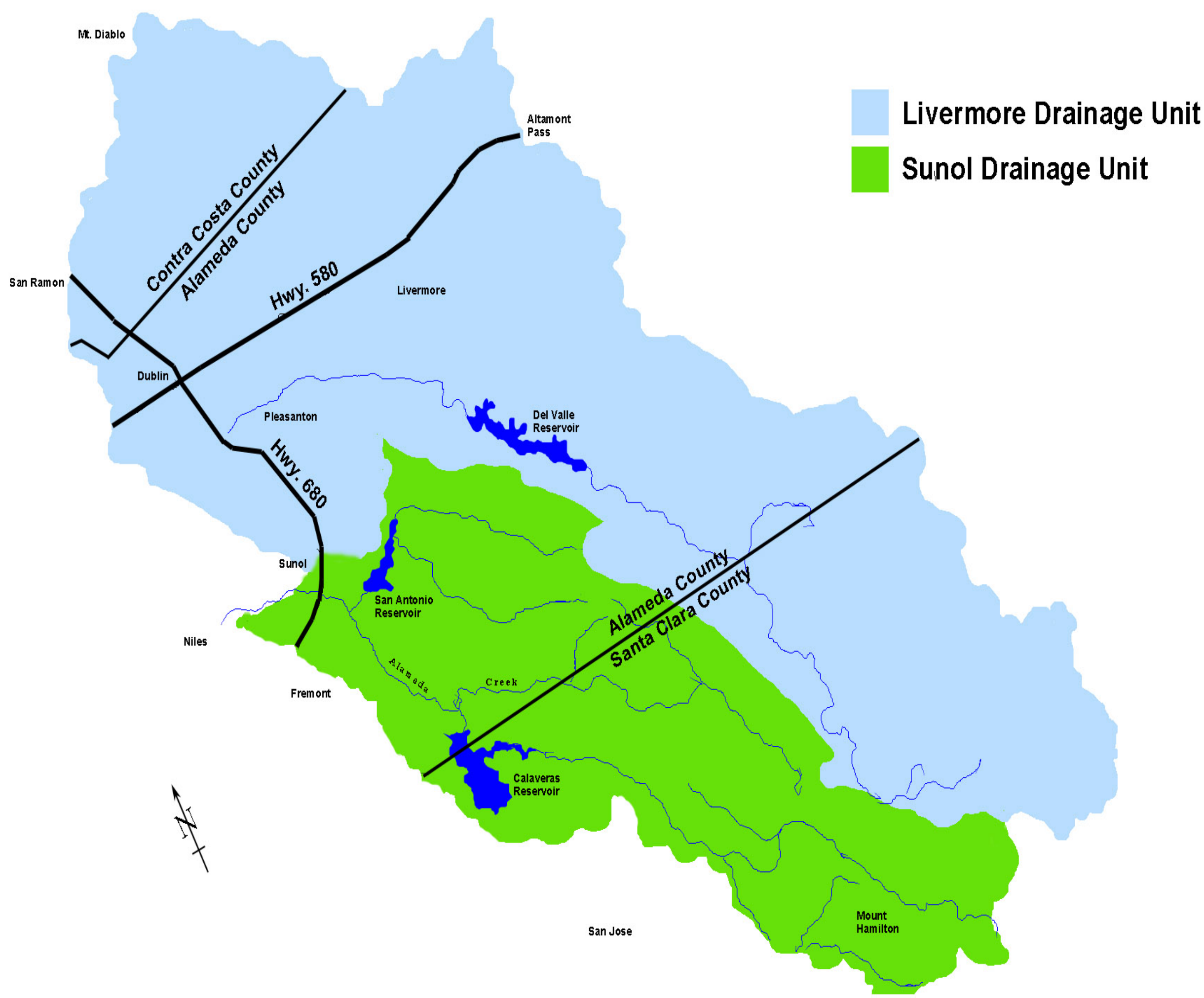


Figure 2-1. *Alameda Creek watershed.*

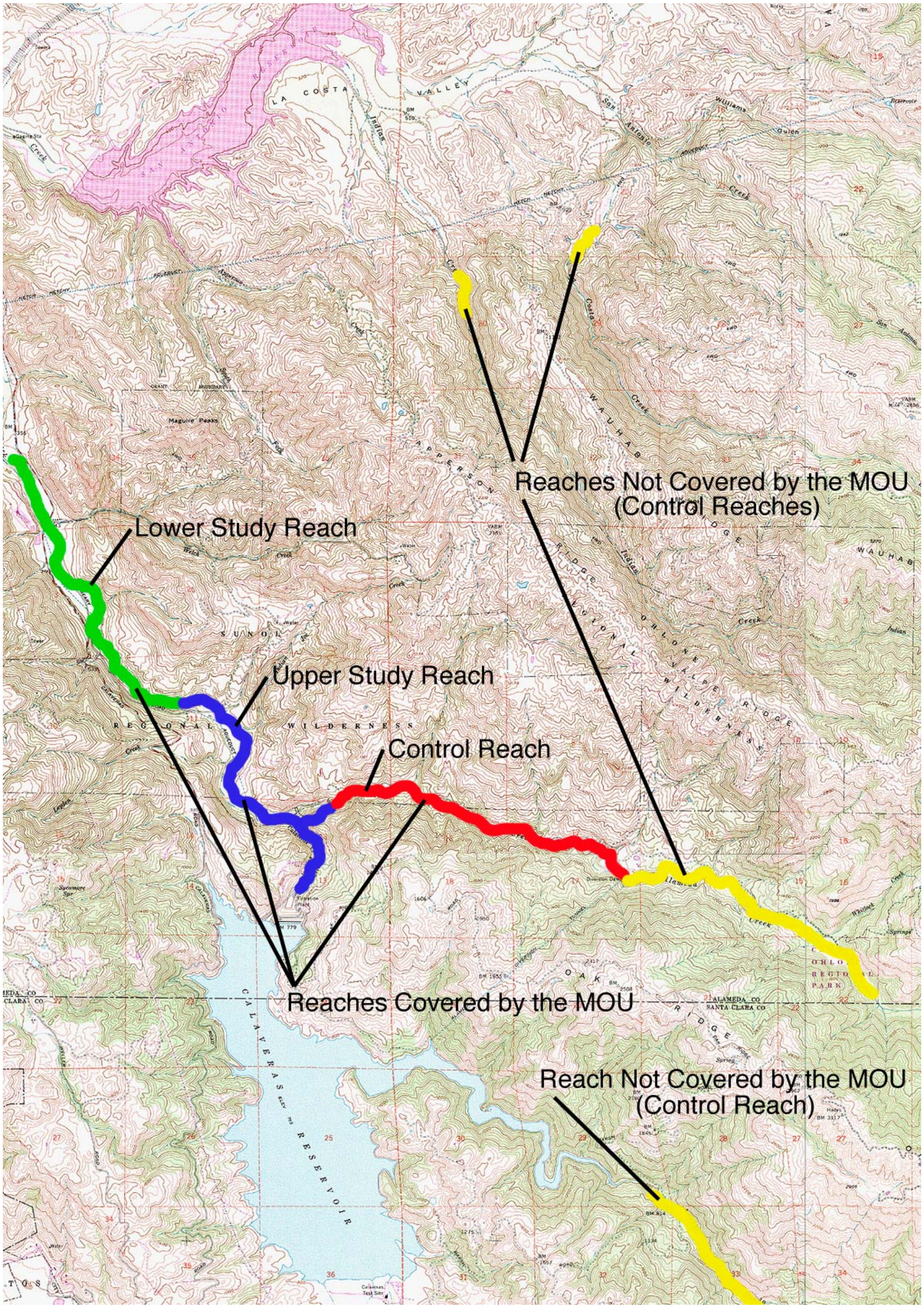
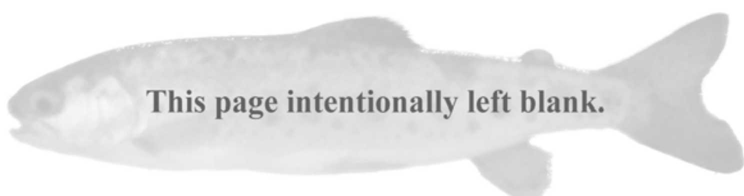


Figure 2-2. *Alameda and Calaveras creek reaches covered by the MOU between the SFPUC and CDFG, plus additional reaches added to the monitoring program to take a watershed approach to restoration.*

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, with known populations of resident 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 resident 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 is 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). Provisional daily mean streamflow values, in cubic-feet per second (cfs), were downloaded from the United States Geological Survey (USGS) website for streamflow data: http://nwis.waterdata.usgs.gov/usa/nwis/discharge.

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

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

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

USGS 11172945 Streamflows

Located in Alameda Creek upstream of the SFPUC operated Alameda Creek Diversion Dam, this streamflow gauge collected data for the entire year. Measurements averaged 28.7 cfs. The minimum daily mean flow for the year was 0.08 cfs, recorded in late September, and a maximum daily mean flow of 552 cfs was recorded on March 23, 2005 (Figure 3-2).

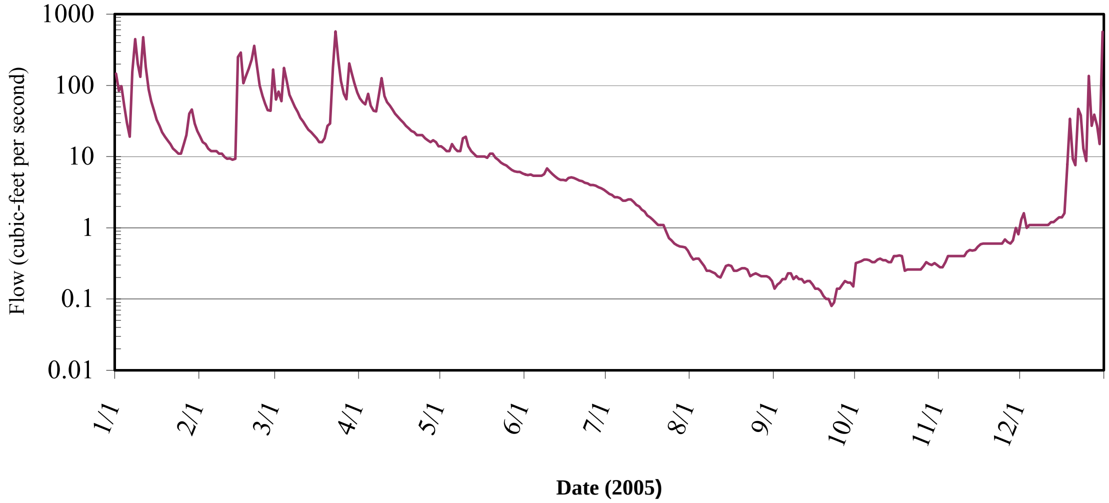


Figure 3-2. *Daily mean streamflows recorded at USGS station 11172945, located in upper Alameda Creek above the Alameda Creek Diversion Dam, for 2005.*

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 66.7 cfs; with minimum daily mean flows of 1.0 cfs for several days in late September and a maximum daily mean flow of 1,190 cfs on March 23, 2005 (Figure 3-3).

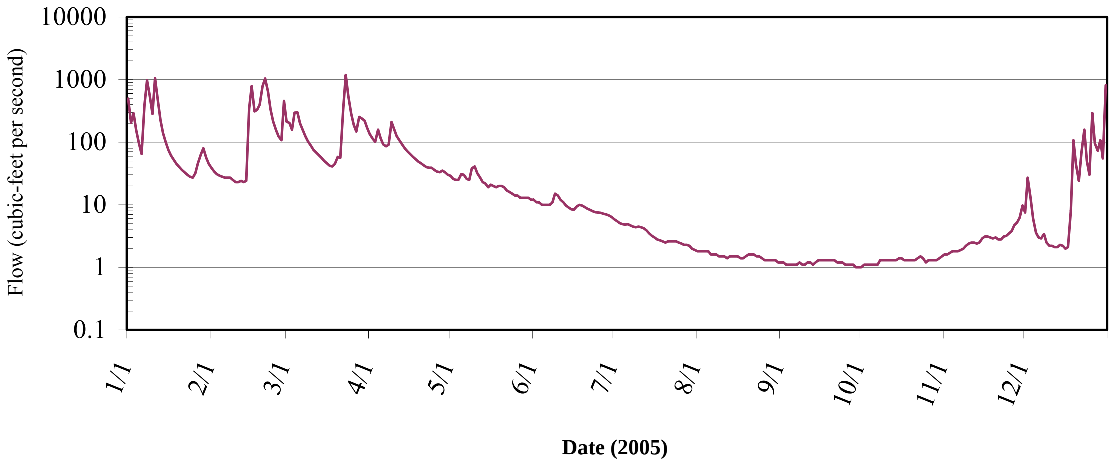


Figure 3-3. *Daily mean streamflows recorded at USGS station 11173200, located in Arroyo Hondo above the Marsh Road Bridge, for 2005.*

USGS 11173500 Streamflows

Located in Calaveras Creek at the second weir downstream of Calaveras Dam, this streamflow gauge collected data throughout the year. Excluding the flows created by four releases from Calaveras Dam in late winter/spring, the average daily mean flow was 0.26 cfs. The intentional releases boosted the flows to a high of 373 cfs. In general, flows in this relatively quiet creek increased by three orders of magnitude during the releases. There were several days in early October when there were no recordable flows, which were included in the calculation of the average daily mean flow (Figure 3-4).

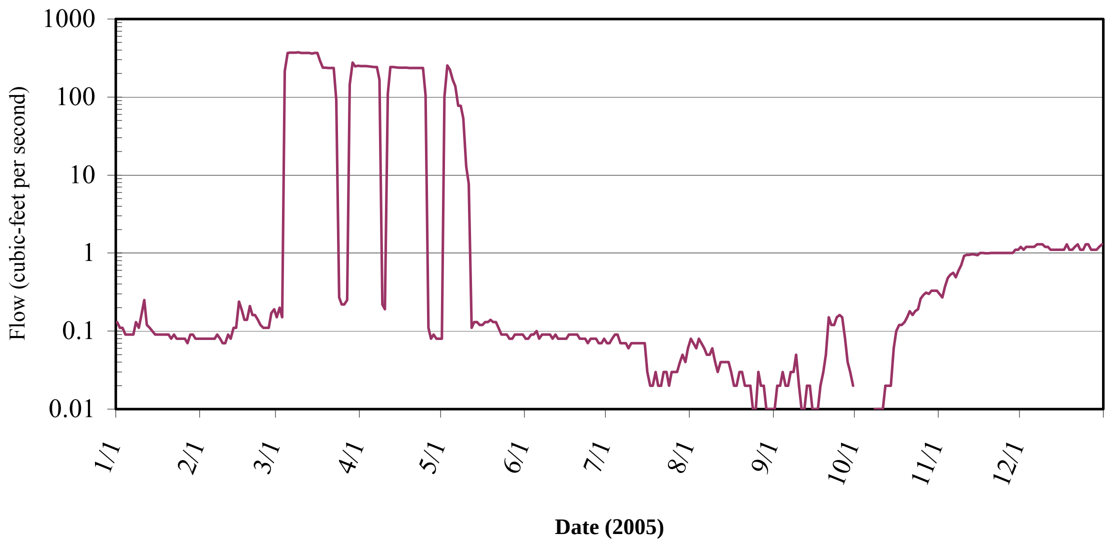


Figure 3-4. *Daily mean streamflows recorded at USGS station 11173500, located in Calaveras Creek below Calaveras Dam, for 2005.*

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. Because this particular gauge does not function when flows exceed 200 cfs, there were 48 days in 2005 with no recorded data. Most, but not all, of the missing data points correlate with surges caused by the releases from Calaveras Reservoir. Consequently, the average daily mean flow cannot be calculated accurately for this gauge. The minimum daily mean flow, of 0.22 cfs, occurred on August 19, 2005 (Figure 3-5).

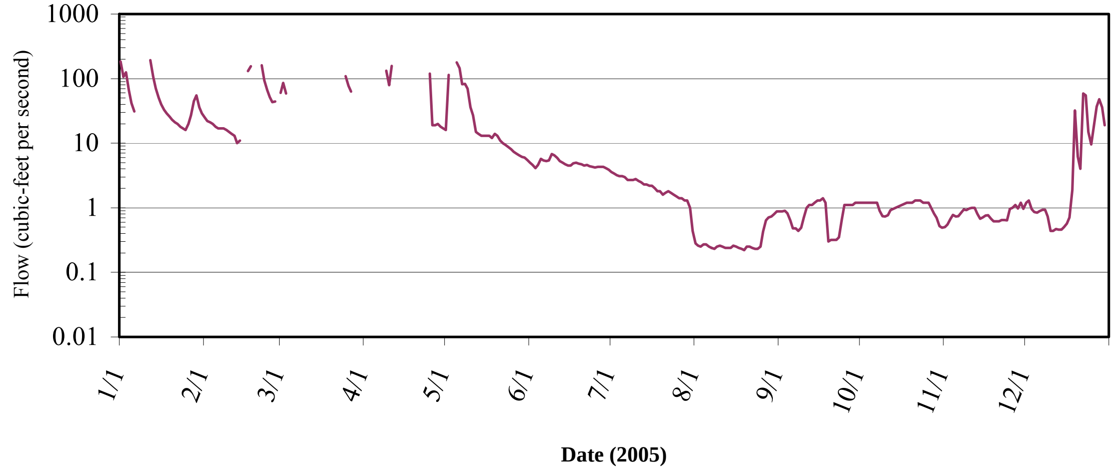


Figure 3-5. *Daily mean streamflows recorded at USGS station 11173510, located in upper Alameda Creek in Sunol Regional Park, for 2005.*

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. Excluding measurements taken during the releases from Calaveras Dam, the average daily mean was 30.2 cfs for the year, with a minimum of 0.17 cfs on September 20. Measurements taken during the 57 days of releases averaged 314 cfs, with a maximum of 1,070 cfs on March 23, 2005 (Figure. 3-6).

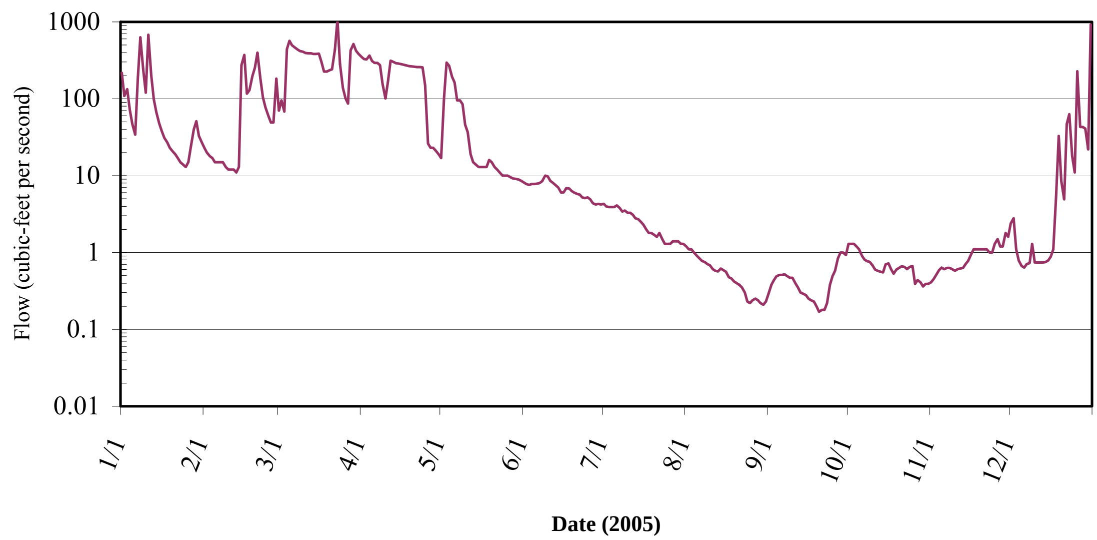


Figure 3-6. *Daily mean streamflows recorded at USGS station 11173575, located in Alameda Creek downstream of Welch Creek, for 2005.*

Two of the five streamflow gauges examined in this year's report recorded their maximum daily mean flow on March 23, and another recorded its second highest reading of the year on the same date. A total of 1.3 inches of rain had fallen on the area during the preceding 72 hours, and although a release from Calaveras Dam was also taking place on this day, two of these gauges were located upstream of the reservoir.

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) (Table 4-1).

Table 4-1. *Basin Plan objectives 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 (1-hr Average)	< 13 *u*g/L
Copper (4-day Average)	< 9 *u*g/L
Total Dissolved Solids (**)	< 250 mg/L
Chlorides (**)	< 60 mg/L

* specific to Lower Bay
** specific to Alameda Creek Watershed above Niles

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. Natural Resources Division biologists monitor Calaveras Reservoir water quality conditions approximately twice monthly (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 for the analysis of 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. Additionally, a plankton sample is collected by towing an 80-micron mesh net vertically 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.

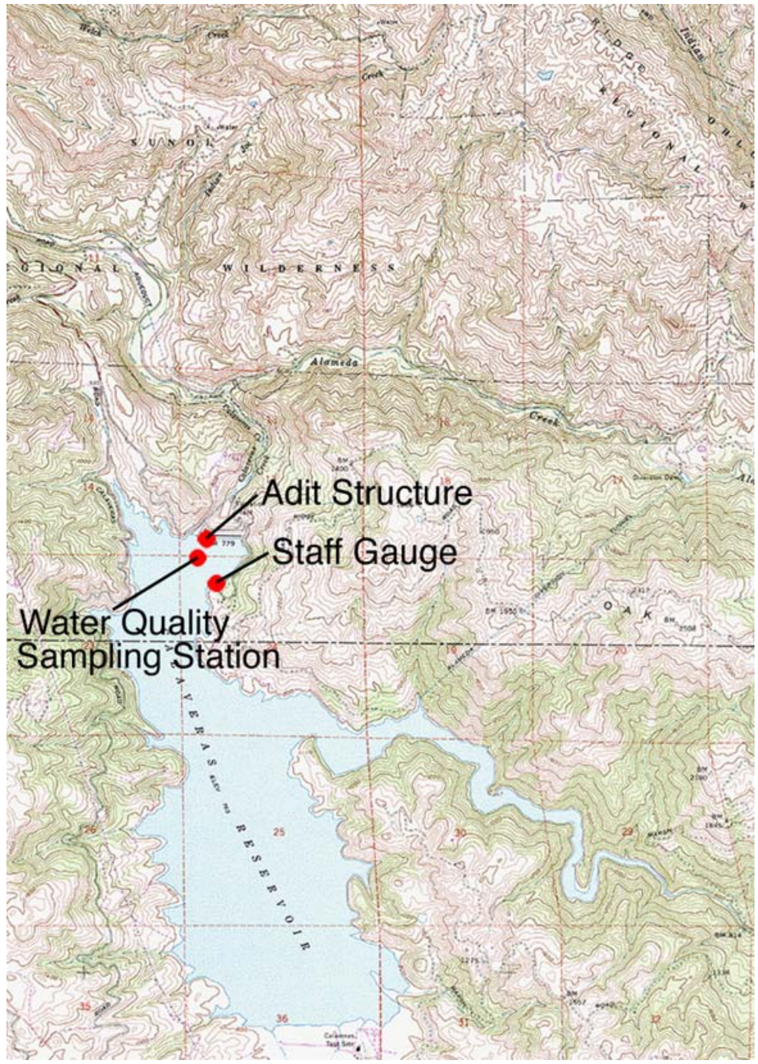


Figure 4-1. *Reservoir sampling locations.*

Water Storage

In 2005, 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 of 2005, Calaveras Reservoir was experiencing a significant increase in storage due to December 2004 storms that produced a peak flow of 4,300 cubic feet per second (cfs) in Arroyo Hondo. Between December 30, 2004 and January 16, 2005, the reservoir elevation increased 16 feet. Between February 15 and March 4, another series of storms raised the reservoir elevation by 10 feet. The last significant storms of 2005 raised the elevation by 4.3 feet between March 22 and March 27. In all cases, storage was decreased by exporting water for treatment and by releases into Calaveras Creek during March, April and May. Minimum storage was 35,248 acre feet on December 7, and maximum storage was 58,810 acre feet on March 4.

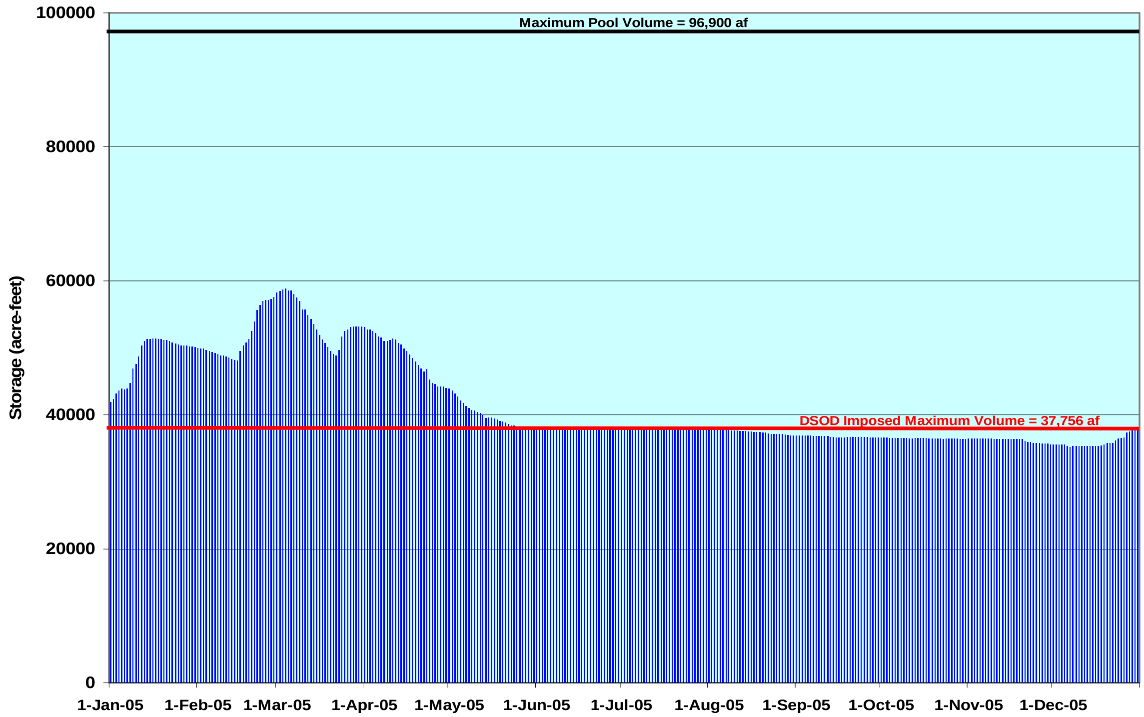


Figure 4-2. *Calaveras Reservoir daily (8:00 a.m.) water storage volume for 2005.*

Water Quality

Temperature

Calaveras Reservoir water temperatures were typically isothermal from January through February and again following the fall turnover in December (Figure 4-3). Thermal stratification began in March with the most intense period occurring between June and September. The thermocline developed between 20 and 30 feet and gradually deepened during the fall as waters near the surface started to cool and mix with the waters below. The maximum water temperature recorded in 2005 (26.8°C) occurred on July 20, and is one of the highest on record. The lowest temperature recorded in 2005 was 8.7°C on January 26.

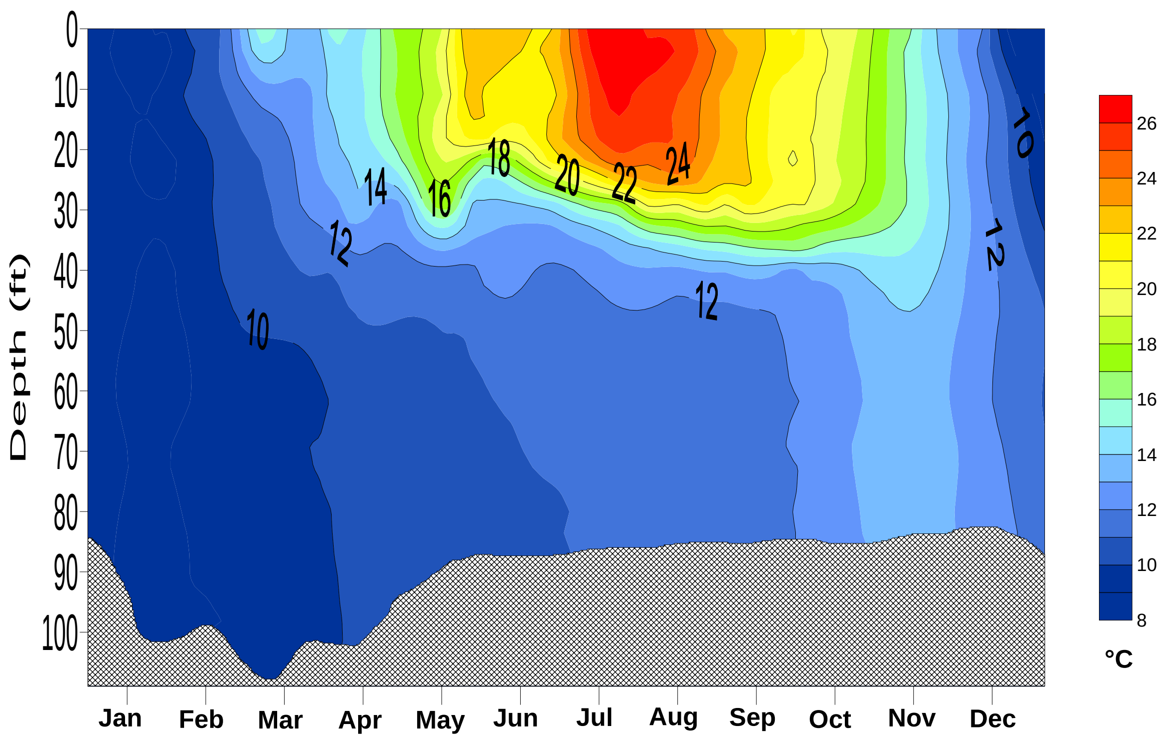


Figure 4-3. *Calaveras Reservoir water temperature profile for 2005.*

Dissolved Oxygen

To improve the quality of the water stored in Calaveras Reservoir, the SFPUC had a hypolimnetic oxygenation system (HOS) installed at Calaveras Reservoir in 2005. Liquid oxygen from a storage tank located near the dam is converted to a gaseous phase before being delivered via two distribution lines to diffusers placed near the bottom of the reservoir (Figures 4-4 and 4-5. *Courtesy Mobley Engineering*).

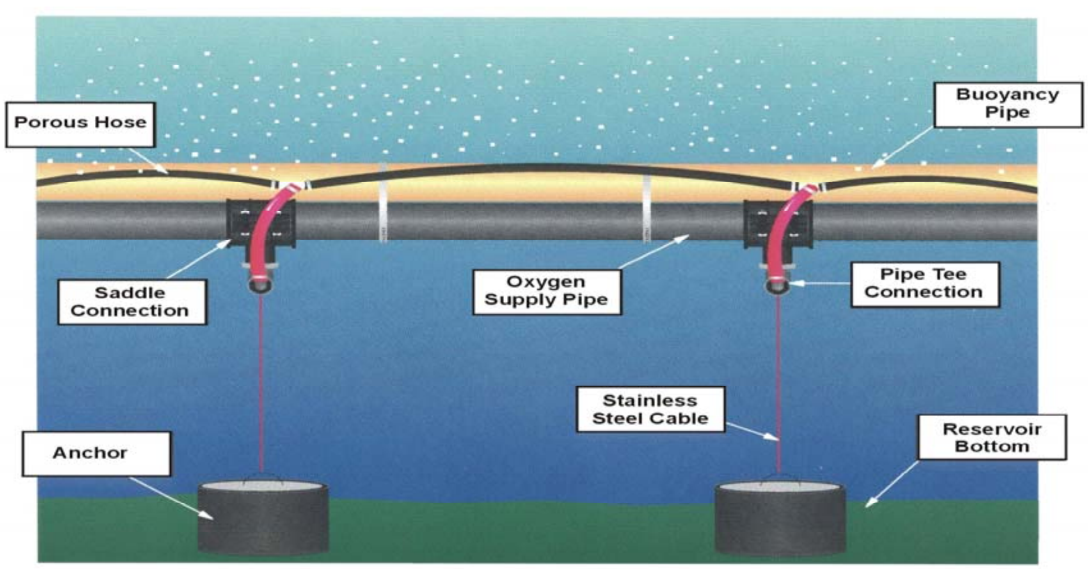


Figure 4-4. *Oxygen supply and distribution lines located near bottom of reservoir.*

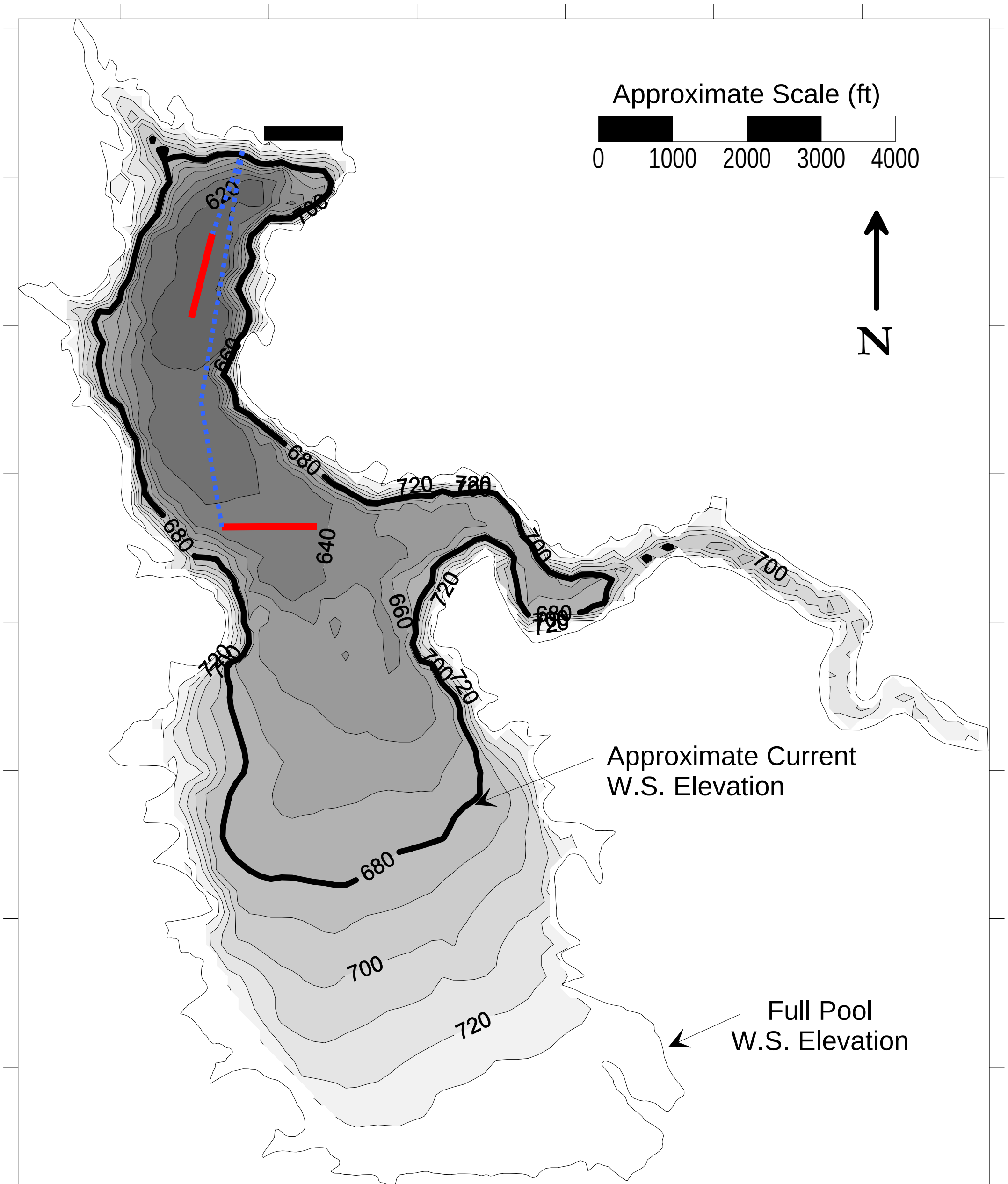


Figure 4-5. *Location of distribution lines (blue) and diffusers (red).*

The system will be operated to overcome the oxygen demand that depletes the hypolimnion of dissolved oxygen after the reservoir stratifies. By increasing the DO concentration; more suitable habitat will be created for cold-water species, the quality of water available for release into Calaveras Creek will be improved, and the release of nutrients from the anoxic sediments should be reduced. The benefit of the reduction in nutrients is expected to inhibit the occurrence of algal blooms. Preliminary results of the operation of the HOS will be discussed in this section.

Dissolved oxygen concentrations were near saturation during the periods when the reservoir was isothermal (Figure 4-6). Between May and October, DO concentrations in the hypolimnion were less than 3 mg/L. Most of the water below

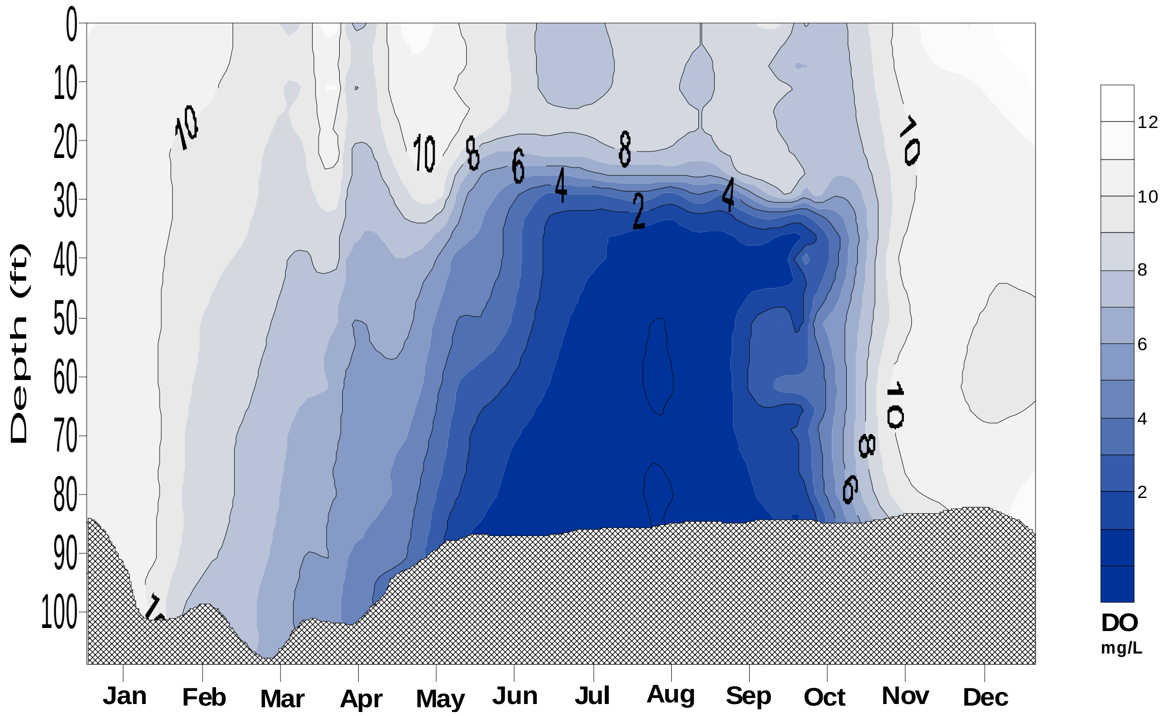


Figure 4-6. *Calaveras Reservoir dissolved oxygen profile for 2005.*

the thermocline was anoxic from July through August, with DO concentrations dropping to less than 1 mg/L. In recent years, the period of anoxic conditions extended well into November. However, in September, testing of the newly

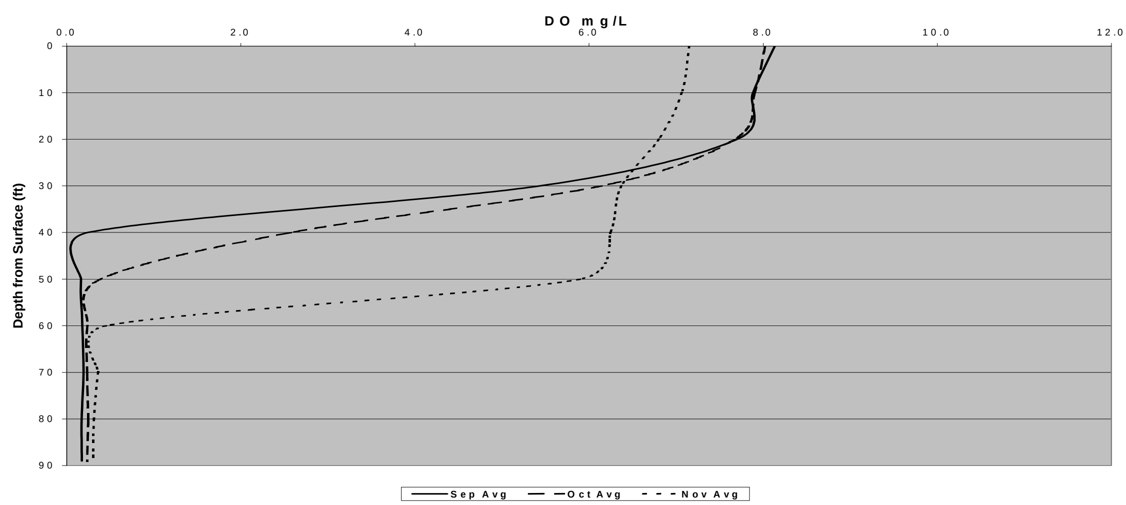


Figure 4-7. *Calaveras Reservoir 2002-2004 average DO concentrations.*

installed HOS began. In the three years prior to 2005, the average DO concentration in the hypolimnion remained near zero during September, October and November (Figure 4-7).

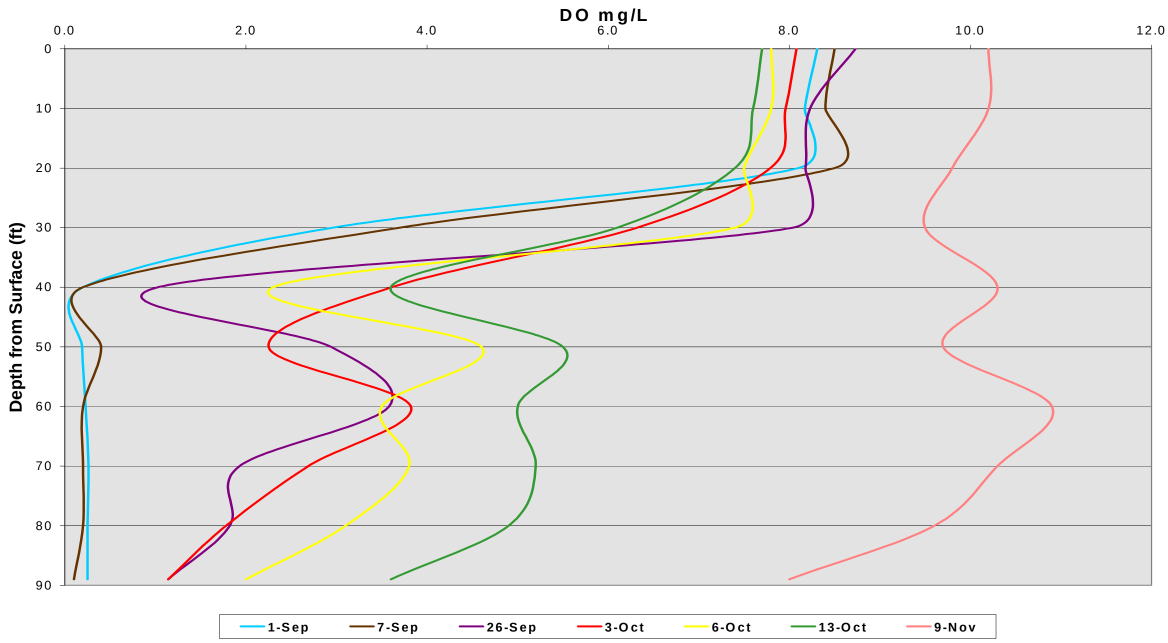


Figure 4-8. *Calaveras Reservoir DO increases after start-up of HOS in 2005.*

After the HOS was put into operation in September, the dissolved oxygen concentration increased (Figure 4-8). The SFPUC expects to operate the system annually to prevent anoxic conditions from forming in spring, thereby increasing the suitable habitat for resident rainbow trout within the reservoir and improving the quality of water available for release into Calaveras Creek.

pH

Calaveras Reservoir pH values in 2005 ranged from 6.85 near the bottom on September 7, to 8.71 near the surface on September 29 (Figure 4-9). The lower pH values near the bottom of the reservoir are usually associated with biological respiration that increases the carbon dioxide available. This affects the equilibrium reactions occurring and allows the formation of carbonic acid, which lowers the pH. Near the surface, the process of photosynthesis consumes carbon dioxide and the affect is to raise the pH, especially during intense blooms of algae. As in past years, the higher pH water near the surface mixes throughout the water column after the reservoir completes its annual turnover. This results in a more isograde condition with pH near 8.00 from top to bottom.

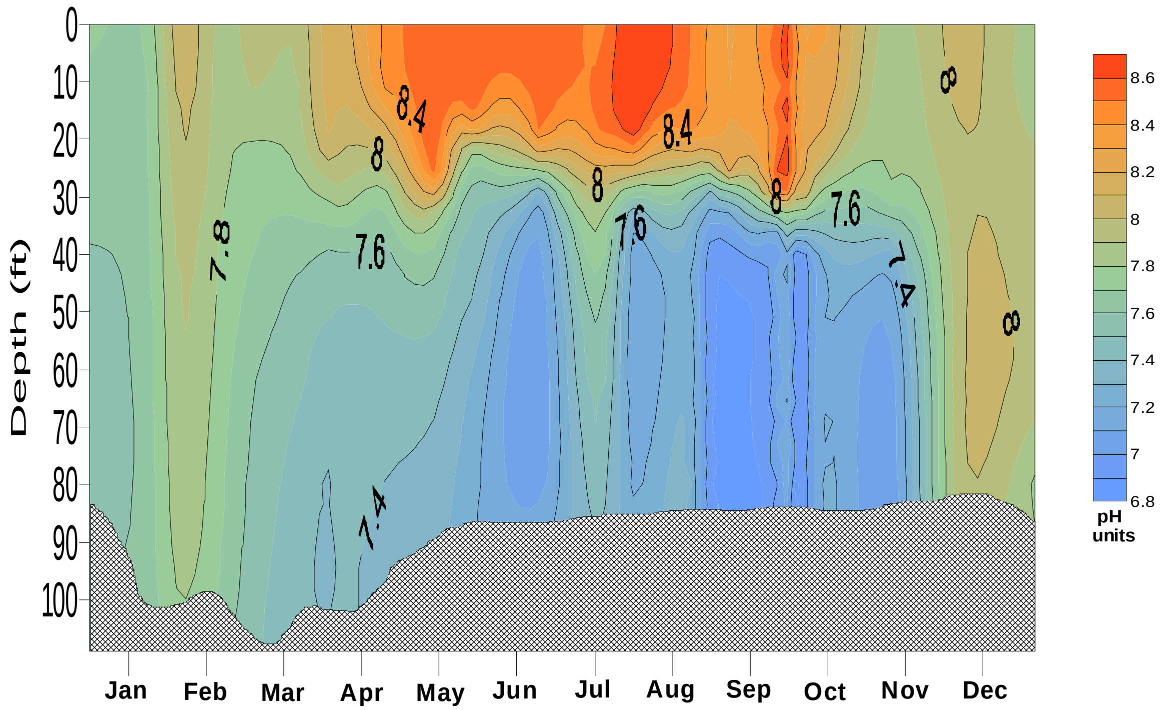


Figure 4-9. *Calaveras Reservoir pH profile for 2005.*

Turbidity

Turbidity in Calaveras Reservoir is affected by a combination of storms, anoxia and plankton. In January 2005, turbidity was elevated due to significant storms in December 2004 that contributed to high flows in Arroyo Hondo, the major tributary

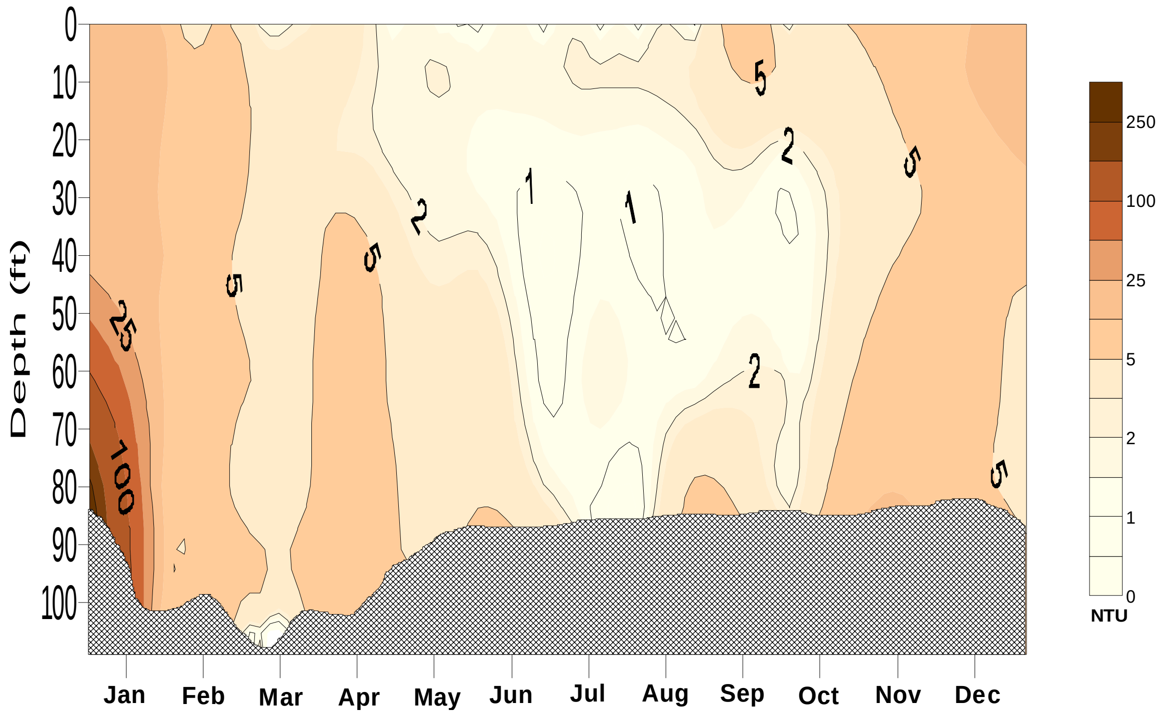


Figure 4-10. *Calaveras Reservoir turbidity profile for 2005.*

to the reservoir (Figure 4-10). Typically, the first significant storm of the rainy season produces the highest turbidity due to the re-suspension of alluvial deposits near the Arroyo's confluence with the reservoir. Subsequent storms do not have the same affect if the elevated water level of the reservoir covers the alluvial deposits. The highest measured turbidity (260 NTU) came from samples taken near the bottom of the reservoir on January 4. The turbidity remained above 10 NTU at all depths throughout the remainder of that month. After January, turbidities decreased and generally stayed below 5 NTU. There was a slight increase during a plankton bloom in September, and again after the reservoir turned over in autumn.

Ammonia

Ammonia concentrations in 2005 (Figure 4-11) followed a similar pattern to what was previously observed during the DSOD imposed restrictions. In January, concentrations were moderate as a result of ammonia made available following the fall turnover, and possibly from additional external sources. Ammonia

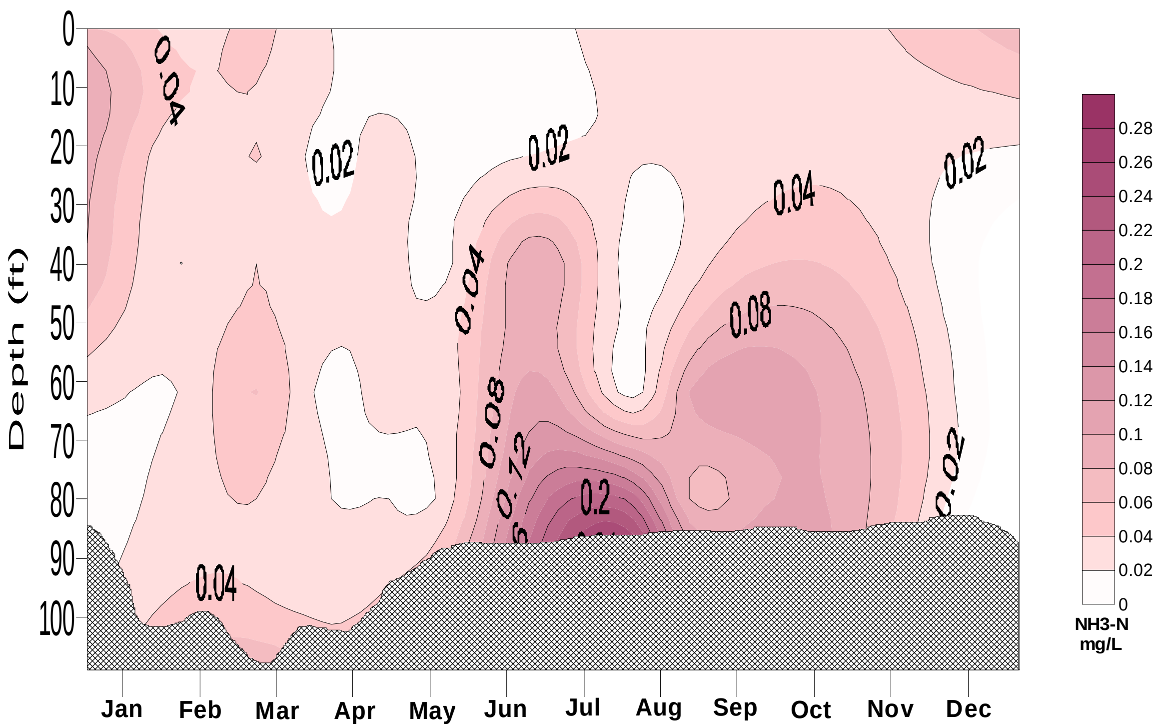


Figure 4-11. *Calaveras Reservoir ammonia profile for 2005.*

concentrations in early April, especially near the surface, began to decline due to biological uptake. The highest ammonia concentration measured was from samples taken near the bottom (0.25 mg/L) following the intensification of anoxia in July.

Plankton

Calaveras Reservoir plankton counts were dominated by green algae and diatoms throughout most of the year, with *Staurastrum* and *Fragilaria* the most common genera. However, in September, a bloom of the genus *Anabaena* reached a count of 20 million colony-forming units (cfu) per ml/m^3. To control the bloom the reservoir was treated with 2,800 pounds of an algaecide (copper sulfate). Monitoring of the September 29 copper application was conducted both pre- and post treatment (Table 4-2).

Table 4-2. *Copper concentrations before and after algaecide treatment.*

Calaveras Reservoir Copper Concentrations (*ug*/L or ppb)				
Depth	**Date** (mm/dd)			
	26 Sep pre-treatment	29 Sep treatment + 2 hrs	3 Oct treatment + 72 hrs	13 Oct treatment + 1 wk
Surface	2.0	56.0	23.7	13.5
20 feet	1.4	3.7	26.9	12.9
40 feet	<1.0	<1.0	8.3	11.9
60 feet	1.3	<1.0	7.8	5.4
80 feet	1.2	<1.0	8.9	5.4
Bottom	<1.0	<1.0	4.5	7.3

Hydrogen Sulfide

Hydrogen sulfide can form in the hypolimnion during periods of severe anoxia. No hydrogen sulfide odors were detected during sampling in 2005, and no tests were conducted.

5.0 Stream Water Quality

Background

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

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

Figure 5-1. *Natural Resources Division biologist Jason Bielski deploying StowAway® temperature sensor in Alameda Creek.*

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 elevated water temperatures in a lower study reach to support native, warm water species. Areas monitored that are not defined 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 attaching foam bumpers to the recorders and 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 onto the other. A length of stainless steel cable was threaded through holes in the threaded end cap and the body of the housing and crimped secure with aluminum ferrules such that the only way to retrieve the sensors from the housings was 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.

Water temperature loggers, set to record at 30-minute intervals, were installed at 15 locations in Alameda, Calaveras, La Costa and Indian creeks and Arroyo Hondo between June 15 and July 27, 2005 (Table 5-1, Figure 5-2). The water temperature sensors were removed from the creeks between November 10 and 22, 2005 (Table 5-1). Because of a sensor malfunction, only a partial data set was collected at site T-2 in Calaveras Creek (Figure 5-5). Due to complete sensor failures, no data were collected at sites T-4 and T-10 (Table 5-1, Figure 5-2).

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 July 13, 2005 (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 22, 2005 (Table 5-1).

Instantaneous water temperature, turbidity, pH, conductivity and dissolved oxygen concentrations were measured in each of the electrofishing habitat units (Figure 8-1) during the 2005 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 5-5).

Table 5-1. *Remote recording device deployment descriptions for 2005.*

Station	Parameters	Deployed	Retrieved	Location	Site Description
T-1	Water Temp.	6/24/05	11/10/05	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	Water Temp.	6/24/05	11/10/05	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	Water Temp.	6/24/05	11/10/05	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	Water Temp.	6/27/05	11/22/05	In Alameda Creek, about 1,200-feet downstream of the Sunol Regional Park / SFPUC boundary. 37° 31.11´ N 121° 50.60´ W	Hanging from a large tree on the left stream bank, in the shade, with flowing water.
T-5	Water Temp.	6/27/2005	11/22/05	In Alameda Creek, about 250-feet upstream of the Sunol Valley Water Treatment Plant bridge. 37° 32.40´ N 121° 51.41´ W	Hanging from a root-ball on the right stream bank, in the shade, with flowing water.
T-7	Water Temp.	7/5/05	11/22/05	In Alameda Creek, downstream of Welsh Creek. 37° 32.16´ N 121° 51.28´ W	Attached to a root-ball on the left stream bank, at the bottom of a pool, in the shade, with little flow.

Table 5-1 *cont.*

Station	Parameters	Deployed	Retrieved	Location	Site Description
T-10	Water Temp.	6/27/05	11/23/05	In Calaveras Creek, downstream of the dam, behind the downstream most concrete weir. 37° 29.87´ N 121° 49.05´ W	Attached to a rock, in the middle of the channel, just to the left of the opening in the concrete weir.
T-12	Water Temp.	6/24/05	11/10/05	In Alameda Creek at Camp Ohlone. 37°29.28´ N 121°44.67´ W	Attached to root-ball in dam pool near cabin.
T-13	Water Temp.	6/24/05	11/10/05	In Alameda Creek upstream from Diversion Dam. 37°29.77´ N 121°45.62´ W	Attached to boulder in mid-channel.
T-14	Water Temp.	6/24/05	11/10/05	In Alameda Creek downstream of Diversion Dam. 37° 29.97´ N 121° 46.67´ N	Attached to base of small tree growing out of boulder. Sensor located in deepest part of boulder pool.
T-16	Water Temp.	6/28/05	11/17/05	Arroyo Honda about ½ mile upstream from slide. 37°27.02´ N 121°44.21´ W	Attached to boulder in mid-channel.
T-17	Water Temp.	7/27/05	11/17/05	Arroyo Hondo about 150' downstream of USGS station (Marsh Rd. bridge) 37°27.79´ N 121°46.33´ W	Attached to root-ball near trapping site.
T-18	Water Temp.	7/5/05	11/10/05	La Costa Creek 100' below private property line. 37°33.89´ N 121°46.88´ W	Attached to root-ball in small pool.
T-19	Water Temp.	6/15/05	11/10/05	La Costa Creek 400' upstream from confluence with San Antonio Creek. 37°34.57´ N 121°46.51´ W	Attached to small boulder at bottom of bedrock scour pool.
T-21	Water Temp.	6/15/05	11/10/05	Indian Creek upstream of where it crosses over Coast Tunnel. 37°33.67´ N 121°47.85´ W	Attached to small boulder at bottom of bedrock scour pool.
TR-1	Air Temp. & Rel. Humidity	7/13/05	11/22/05	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	Air Temp. & Rel. Humidity	7/13/05	11/17/05	Arroyo Hondo about 150' downstream of USGS station (Marsh Rd. bridge) 37°27.79´ N 121°46.33´ W	Attached to laurel tree left bank of creek near trapping site.
TR-5	Air Temp. & Rel. Humidity	7/13/05	11/10/05	La Costa Creek 100' below private property line. 37°33.89´ N 121°46.88´ W	Attached to willow tree on left bank.
TR-6	Air Temp. & Rel. Humidity	7/13/05	11/10/05	Indian Creek upstream of where it crosses over Coast Tunnel. 37°33.67´ N 121°47.84´W	Attached to laurel tree right bank of creek near temperature sensor.

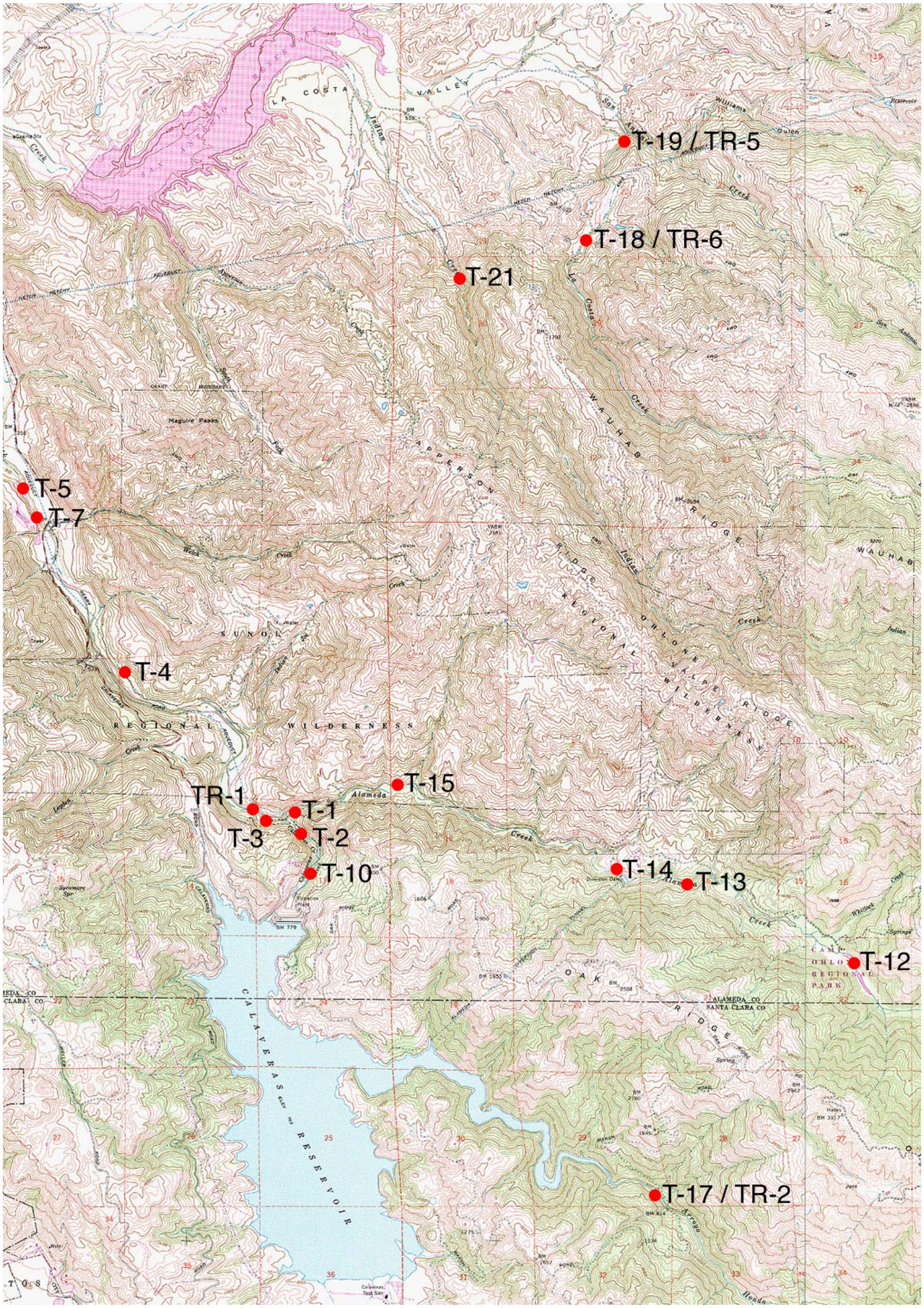


Figure 5-2. *Temperature sensor locations in Alameda, Calaveras, La Costa and Indian creeks and Arroyo Hondo.*

Water Temperature

For the period of record, graphical analyses of the sites with complete data sets showed the same general trends with the warmest temperatures occurring from mid-July to early August, tapering off to the coolest temperatures in November (Figure 5-3).

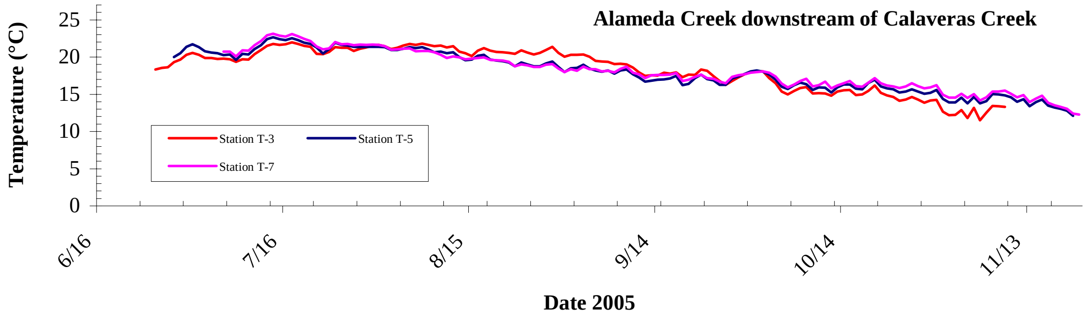
Considering only sites with complete data sets, Station T-21, located in Indian Creek, had the lowest daily minimum, daily maximum and daily average mean water temperatures at 9.6°C, 19.9°C and 14.9°C, respectively (Table 5-2, Figure 5-16). Nearby station T-18, located in La Costa Creek, also had a relatively low minimum daily mean water temperatures of 9.6°C (Table 5-2, Figures 5-14). Station T-16, located upstream of the Arroyo Hondo slide, had the highest minimum and average daily water temperatures at 13.6°C and 18.5°C, respectively (Table 5-2, Figure 5-12). Station T-7, located in Alameda Creek downstream of its confluence with Welsh Creek, had the highest maximum daily mean water temperature at 26.8°C (Table 5-2, Figure 5-8).

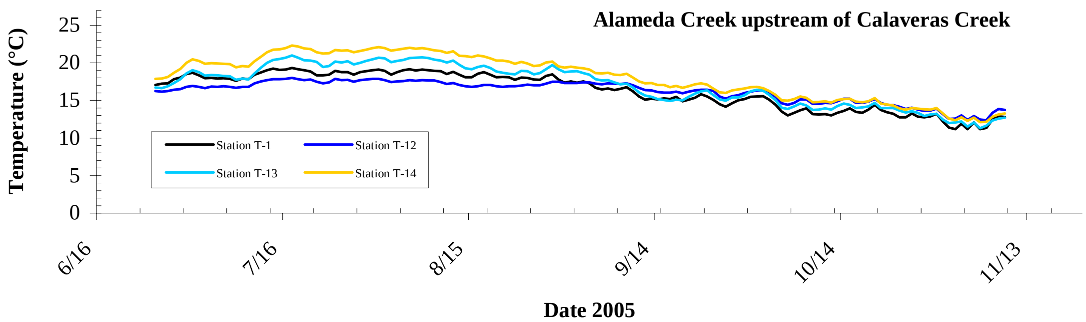
Station T-3, located in Alameda Creek downstream of its confluence with Calaveras Creek, had the highest minimum, maximum and average daily water temperature fluctuations at 1.7°C, 8.2°C and 6.0°C, respectively (Table 5-2, Figure 5-6). Station T-14, located just below the diversion dam on Alameda Creek, had the lowest minimum average daily water temperature fluctuation at 0.2°C (Table 5-2, Figure 5-11). The lowest overall average temperature of 1.9°C was observed at station T-12, located in a rootball pool in Alameda Creek upstream of the diversion dam (Table 5-2, Figure 5-9). Station T-13, also located upstream of the diversion, had the lowest maximum average daily water temperature fluctuation at 2.9°C (Table 5-2, Figure 5-10).

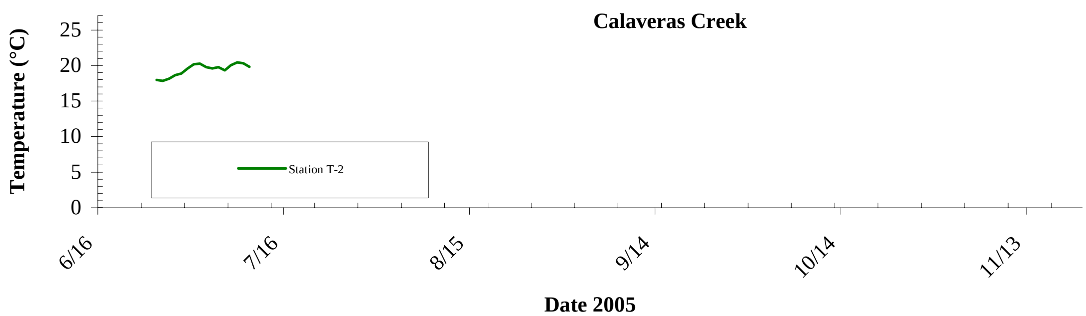
Table 5-2. *Daily water temperature (°C) statistics for 2005.*

	Daily Mean Water Temperature			Average Daily Water Temperature Fluctuation		
Station	**Minimum**	**Maximum**	**Average**	**Minimum**	**Maximum**	**Average**
T-1	10.5	21.7	16.3	0.7	5.6	3.0
T-2	17.1*	21.4*	19.4*	1.3*	2.9*	1.8*
T-3	10.2	26.1	18.4	1.7	8.2	6.0
T-5	11.1	24.6	18.1	0.5	5.6	2.8
T-7	11.7	26.8	18.1	0.3	7.3	2.3
T-12	11.9	20.5	16.2	0.3	4.6	1.9
T-13	10.7	22.2	17.0	0.6	2.9	2.1
T-14	11.8	24.3	18.1	0.2	4.7	2.3
T-16	13.6	23.1	18.5	0.6	4.6	2.7
T-17	10.5	22.5	16.0	0.7	4.9	2.9
T-18	9.6	21.2	15.4	1.2	5.1	3.2
T-19	10.4	22.6	16.4	0.3	5.3	2.2
T-21	9.6	19.9	14.9	0.6	3.8	2.0

* *Based on partial data set.*







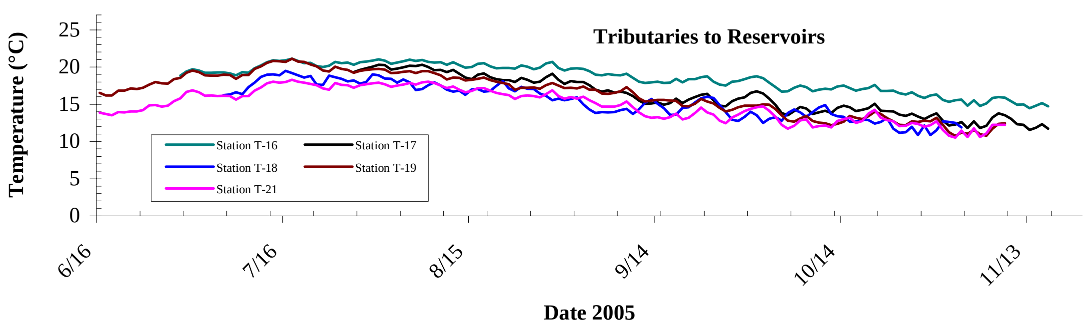


Figure 5-3. *Daily mean water temperatures at the monitoring stations in Alameda, Calaveras, La Costa and Indian creeks and Arroyo Hondo.*

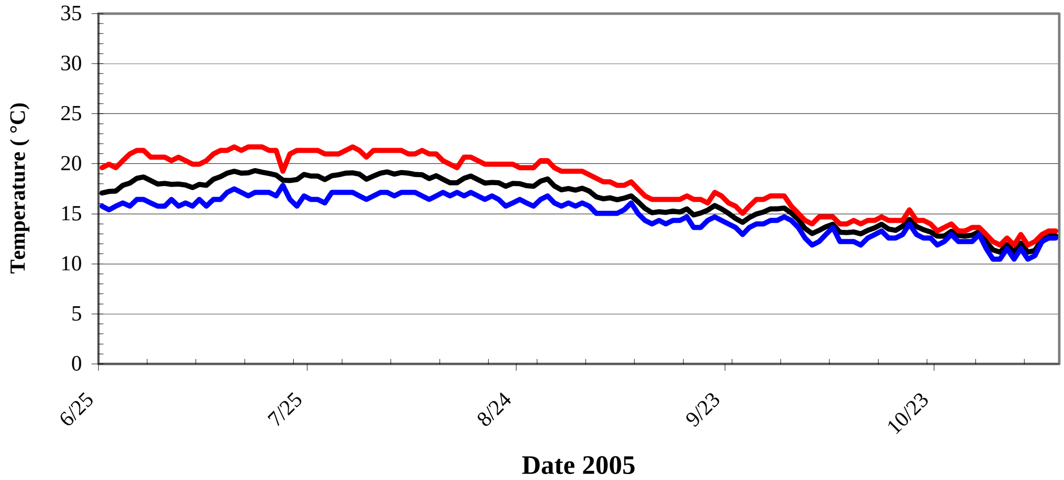


Figure 5-4. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-1 in Alameda Creek.*

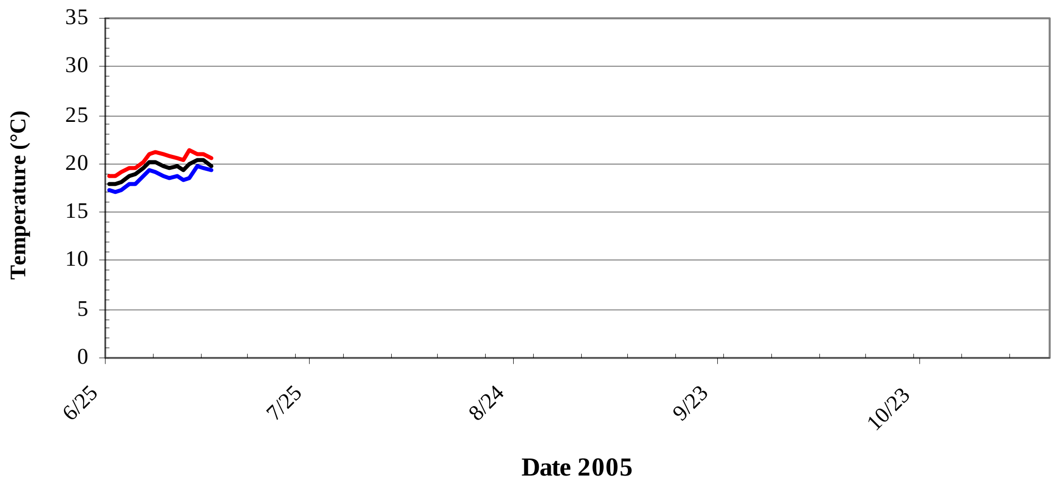


Figure 5-5. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-2 in Calaveras Creek.*

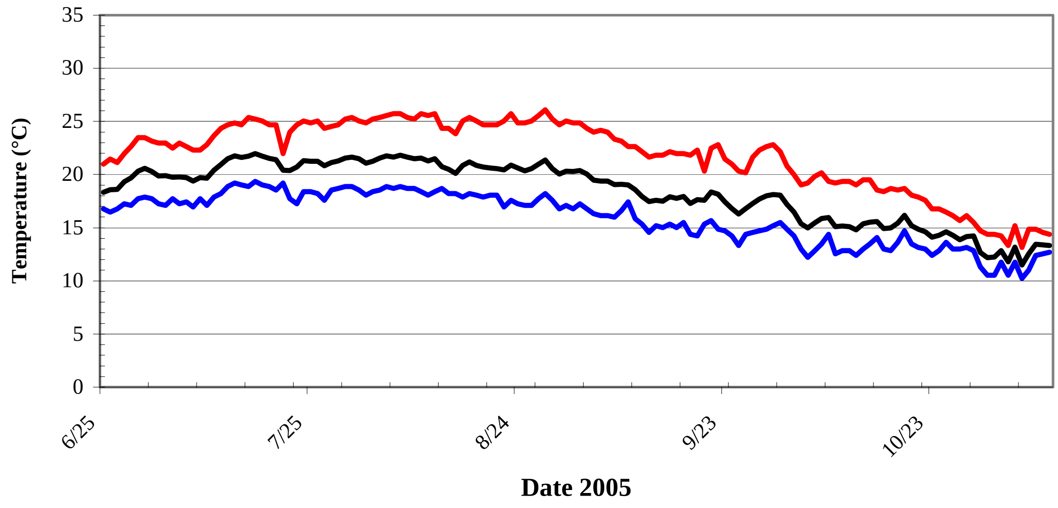


Figure 5-6. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-3 in Alameda Creek.*

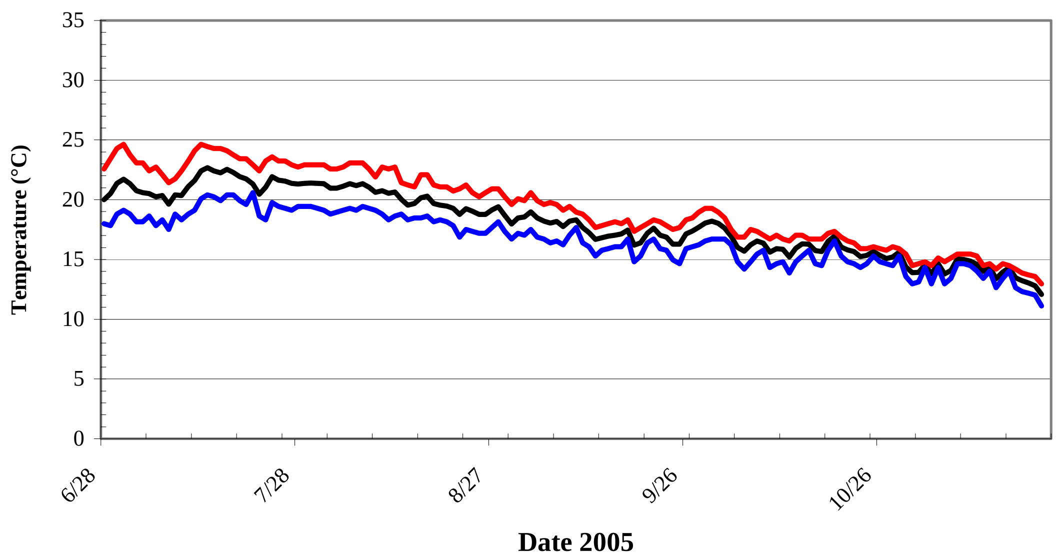


Figure 5-7. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-5 in Alameda Creek.*

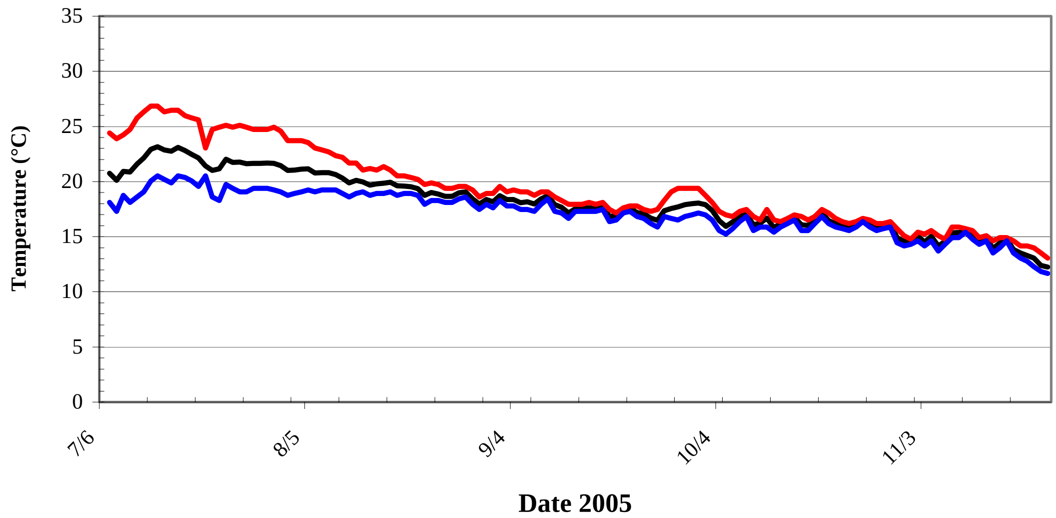


Figure 5-8. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-7 in Alameda Creek.*

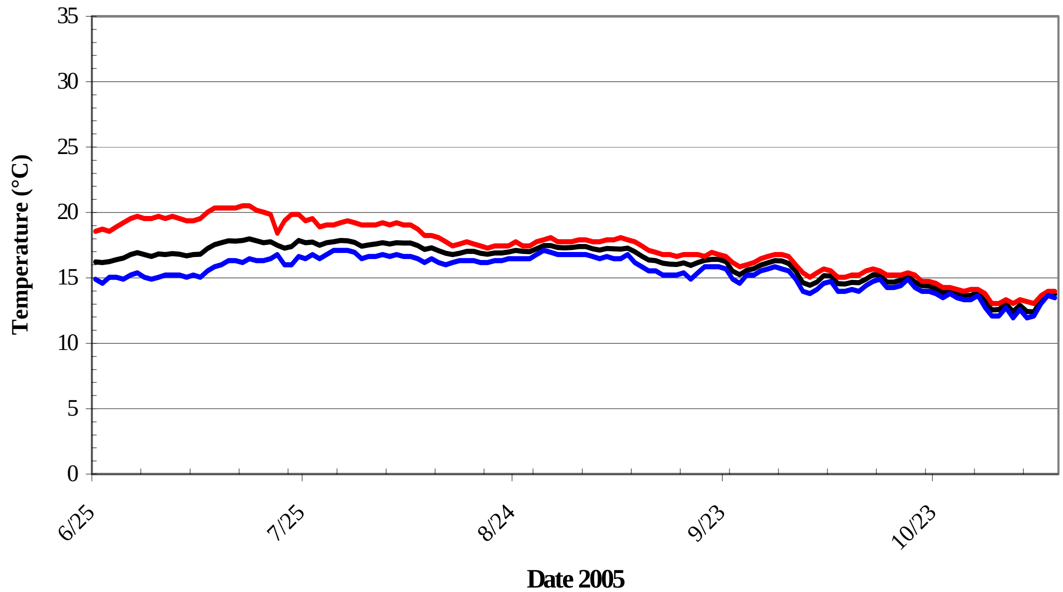


Figure 5-9. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-12 in Alameda Creek.*

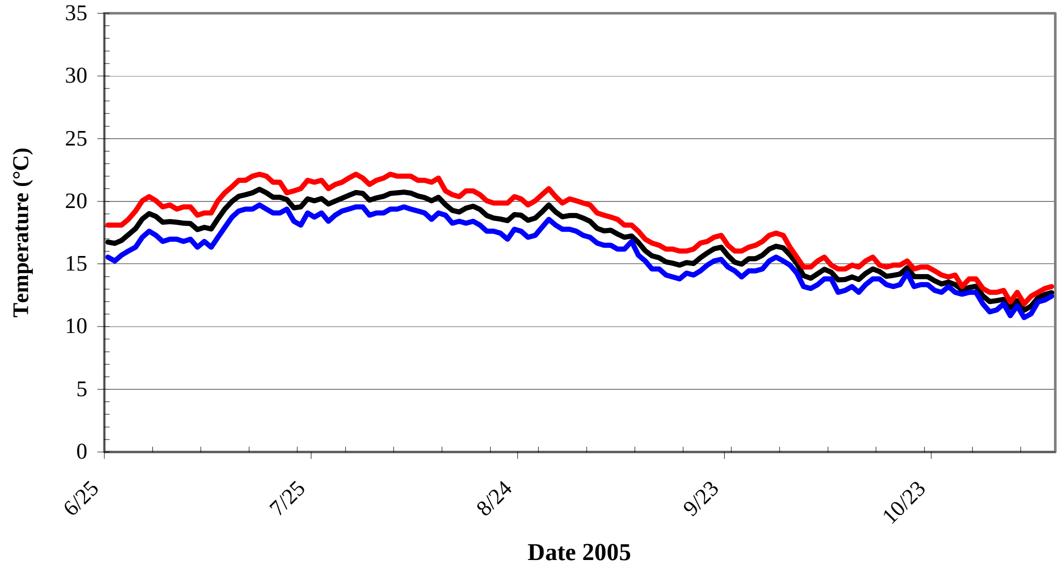


Figure 5-10. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-13 in Alameda Creek.*

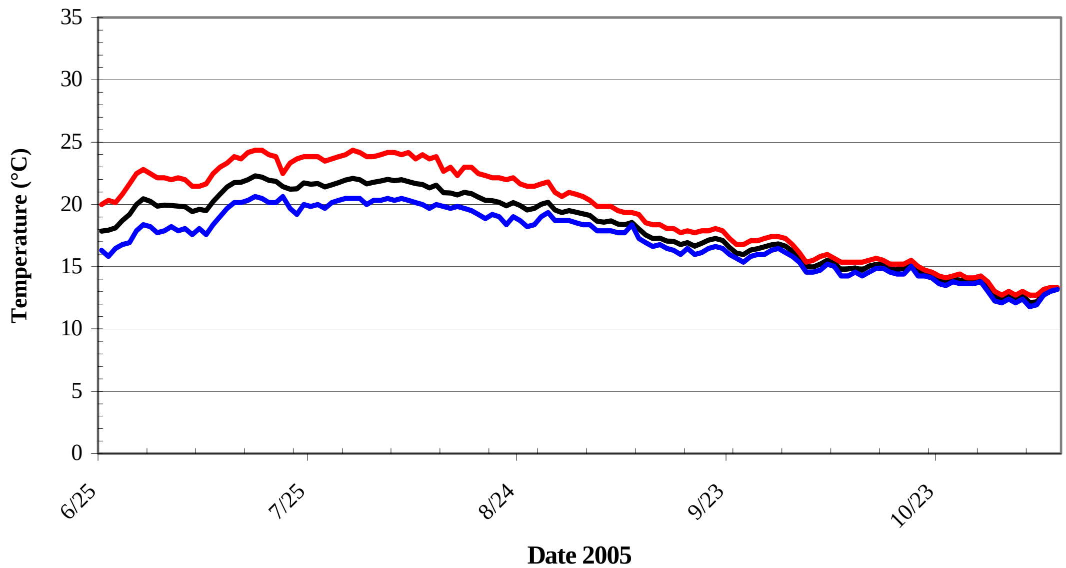


Figure 5-11. *Daily mean (black), maximum (red) and minimum(blue) water temperatures at Station T-14 in Alameda Creek.*

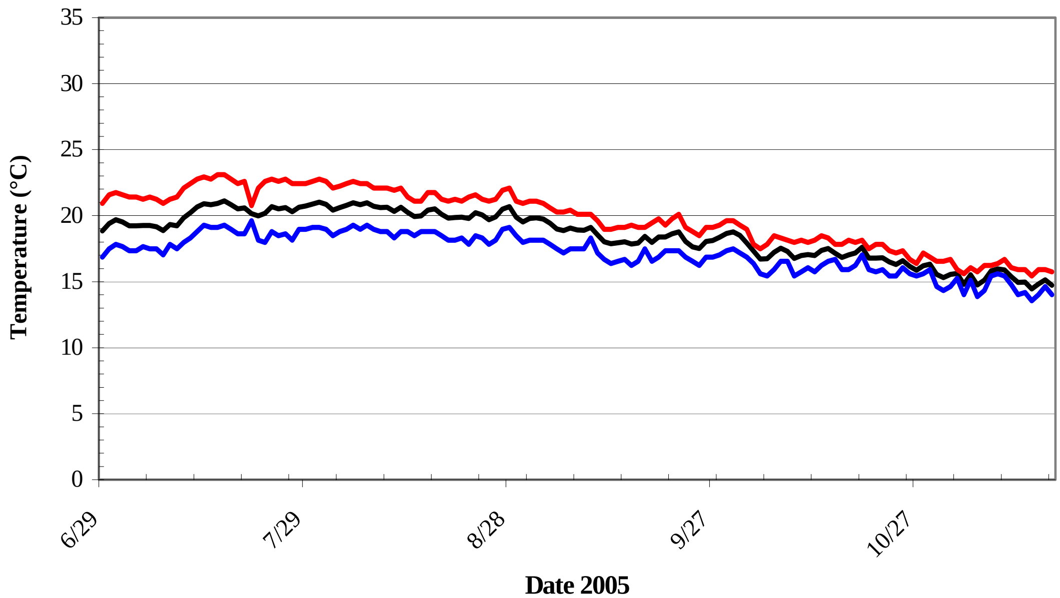


Figure 5-12. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-16 in Arroyo Hondo.*

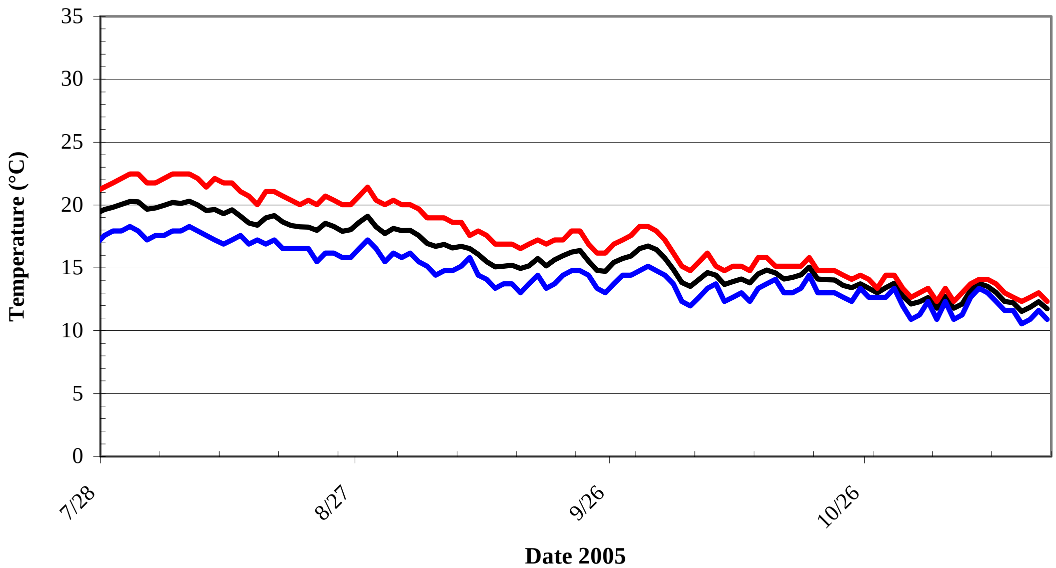


Figure 5-13. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-17 in Arroyo Hondo.*

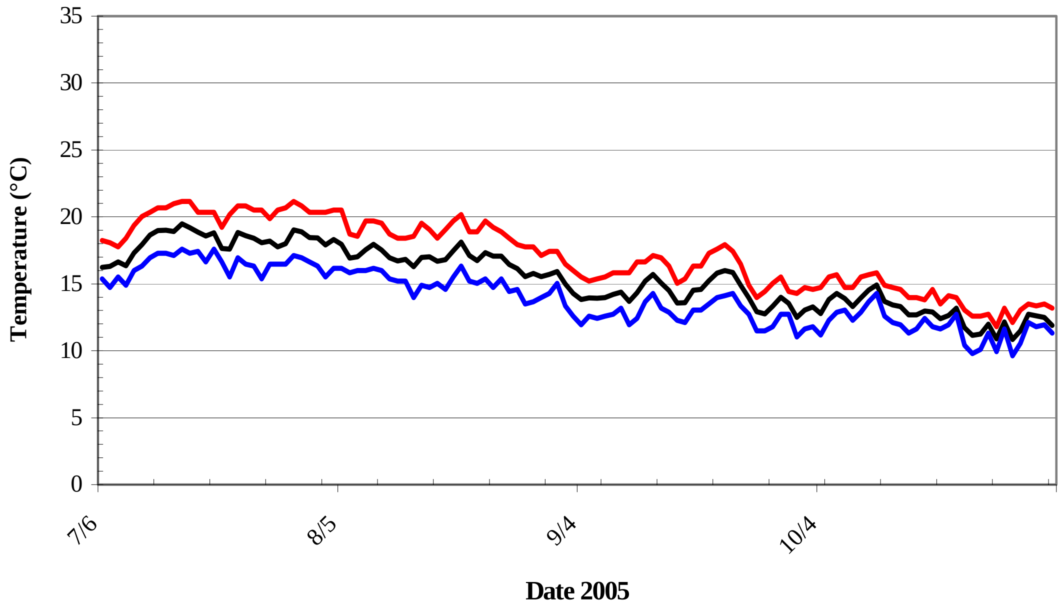


Figure 5-14. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-18 in La Costa Creek.*

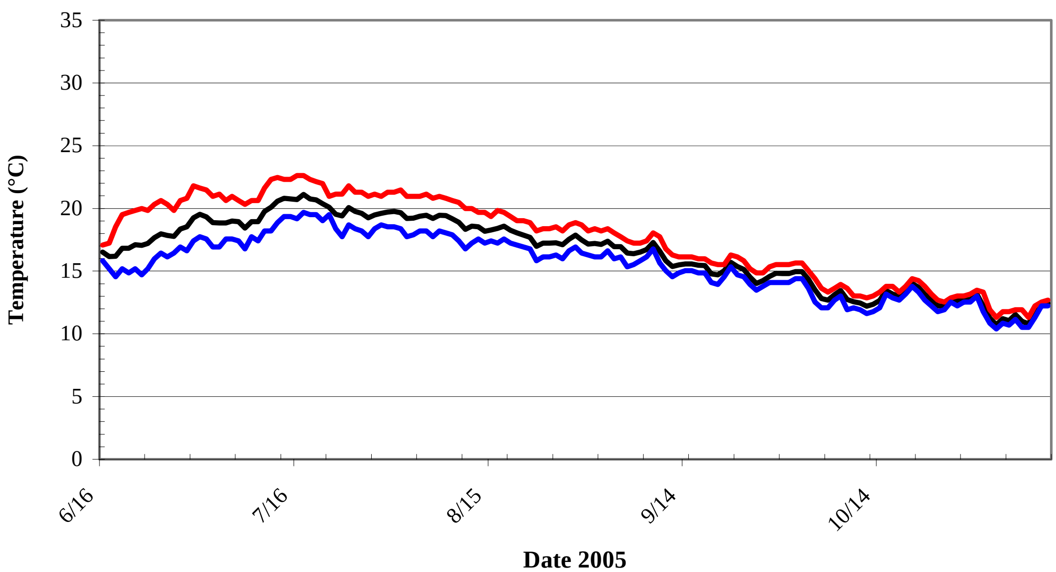


Figure 5-15. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-19 in La Costa Creek.*

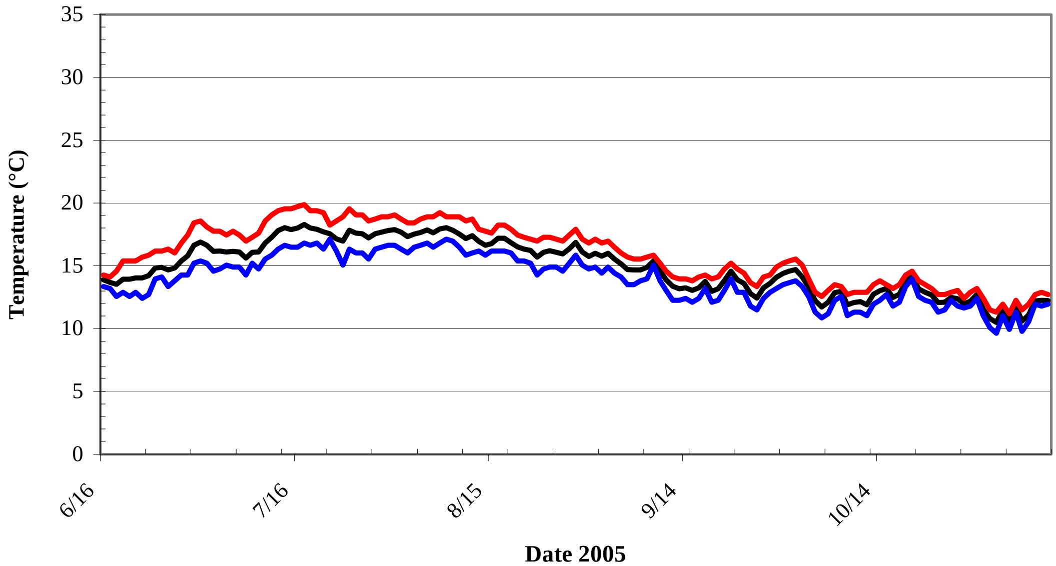


Figure 5-16. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-21 in Indian Creek.*

Air Temperature and Relative Humidity

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 (Alameda Creek Aquatic Resource Monitoring Report 2004, SFPUC Natural Resources Division).

Sites TR-2, TR-5 and TR-6 all had similar minimum, maximum and average daily mean air temperatures (Table 5-3, Figures 5-19, 5-21 and 5-23). Site TR-1, however, had a lower minimum daily mean air temperature than the other sites at 0.7°C, and a higher maximum and average daily air temperature at 37°C and 17°C, respectively (Table 5-3, Figure 5-17). Sites TR-2, TR-5 and TR-6 all showed similar minimum, maximum and average daily air temperature fluctuations (Table 5-3, Figures 5-19, 5-21 and 5-23), while site TR-1 had noticeably higher minimum, maximum and average daily air temperature fluctuations at 7°C, 27°C and 17°C, respectively (Table 5-3, Figure 5- 17).

Site TR-6, located in the upper portion of La Costa Creek, showed the highest minimum daily mean relative humidity reading at 12% (Table 5-4, Figure 5- 24), while TR-2, located along Arroyo Hondo, had the lowest at 6% (Table 5-4, Figure 5-20). Maximum daily mean relative humidity values for all sites were greater than 100%, which may be due to concurrent rain events (Table 5-4). The average daily mean relative humidity was highest at site TR-1 at 65%, and lowest at site TR-5 at 57% (Table 5-4, Figures 5-18 and 5-22).

Site TR-1 had the lowest minimum average daily relative humidity fluctuation at 18%, while having the highest maximum and average at 92% and 64%, respectively. The highest minimum average daily relative humidity fluctuation was observed at site TR-2 at 29%. Sites TR-5 and TR-6, both located in the San Antonio Reservoir Watershed, registered identical maximum daily relative humidity fluctuations at 67%, and nearly identical average daily relative humidity fluctuations at 44% and 43%, respectively (Table 5-4, Figures 5-18, 5-20, 5-22 and 5-24).

Table 5-3. *Daily air temperature (°C) statistics for 2005.*

	Daily Mean Air Temperature			Average Daily Air Temperature Fluctuation		
Station	Minimum	Maximum	Average	Minimum	Maximum	Average
TR-1	0.7	37	17	7	27	17
TR-2	4	34	16	5	22	13
TR-5	5	31	17	4	19	11
TR-6	7	35	17	5	19	11

Table 5-4. *Daily relative humidity (%) statistics for 2005.*

	Daily Mean Relative Humidity			Average Daily Relative Humidity Fluctuation		
Station	Minimum	Maximum	Average	Minimum	Maximum	Average
TR-1	8	104*	65	18	92	64
TR-2	6	104*	61	29	84	56
TR-5	7	102*	57	21	67	44
TR-6	12	101*	61	19	67	43

**RH readings above 100% may be associated with concurrent rain events.*

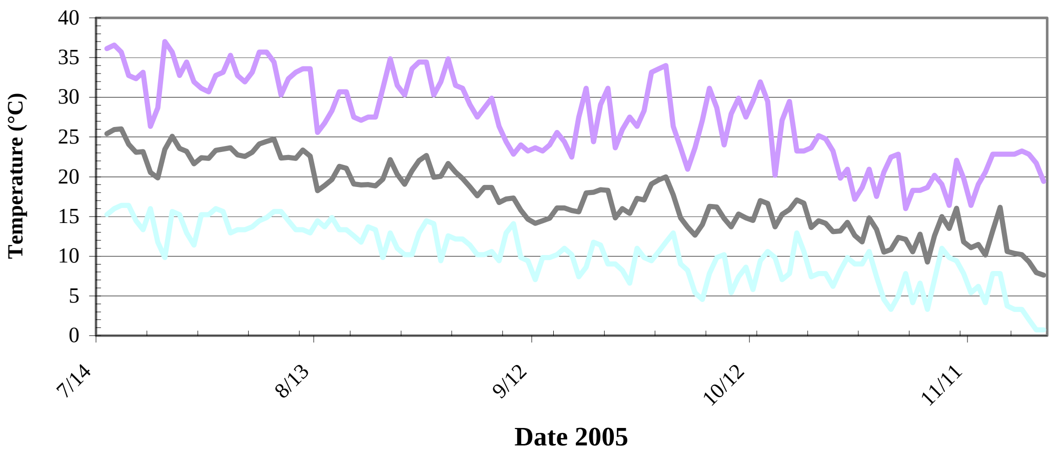


Figure 5-17. *Daily mean (gray), maximum (lavender) and minimum (turquoise) air temperatures at Station TR-1 near Alameda Creek.*

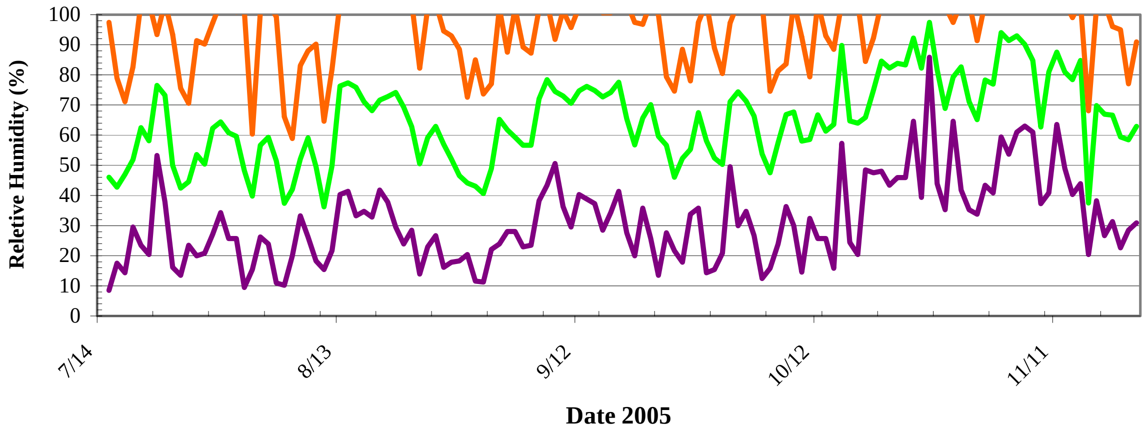


Figure 5-18. *Daily mean (green), maximum (orange) and minimum (purple) relative humidities at Station TR-1 near Alameda Creek.*

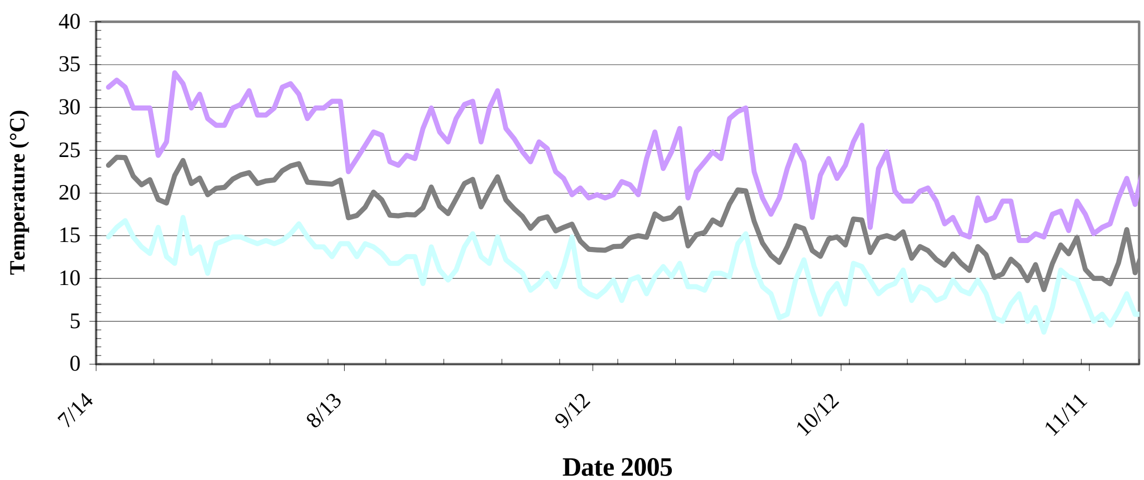


Figure 5-19. *Daily mean (gray), maximum (lavender) and minimum (turquoise) air temperatures at Station TR-2 near Arroyo Hondo.*

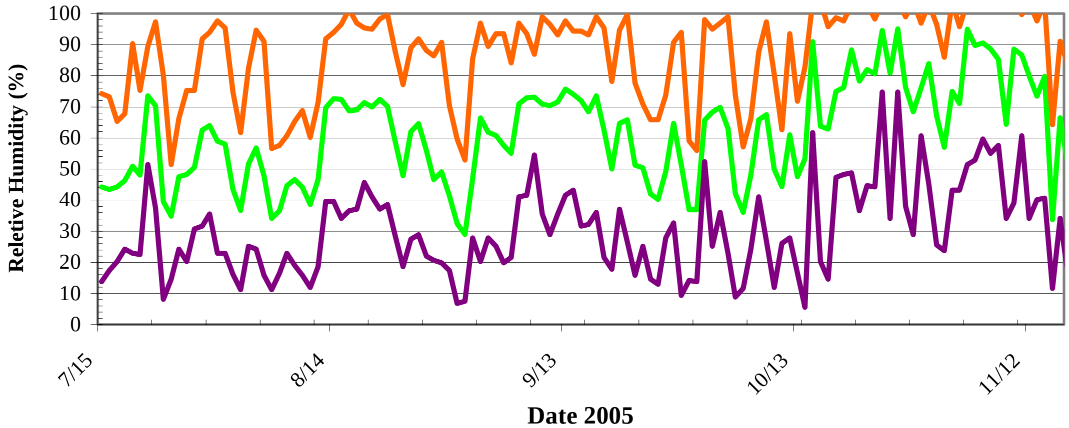


Figure 5-20. *Daily mean (green), maximum (orange) and minimum (purple) relative humidities at Station TR-2 near Arroyo Hondo.*

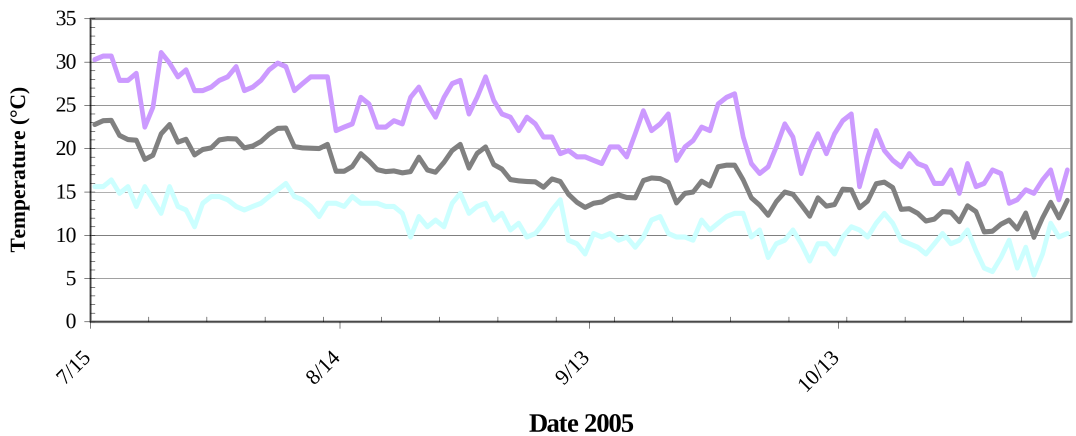


Figure 5-21. *Daily mean (gray), maximum (lavender) and minimum (turquoise) air temperatures at Station TR-5 near La Costa Creek.*

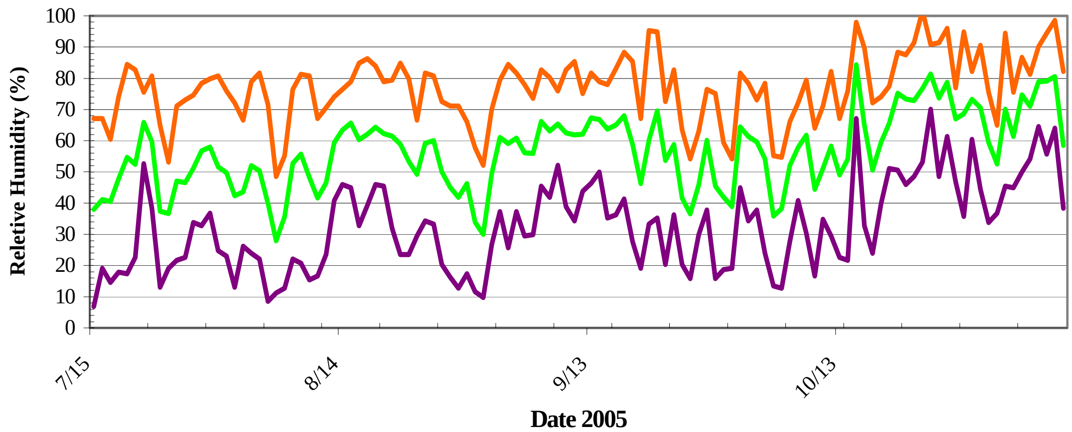


Figure 5-22. *Daily mean (green), maximum (orange) and minimum (purple) relative humidities at Station TR-5 near La Costa Creek.*

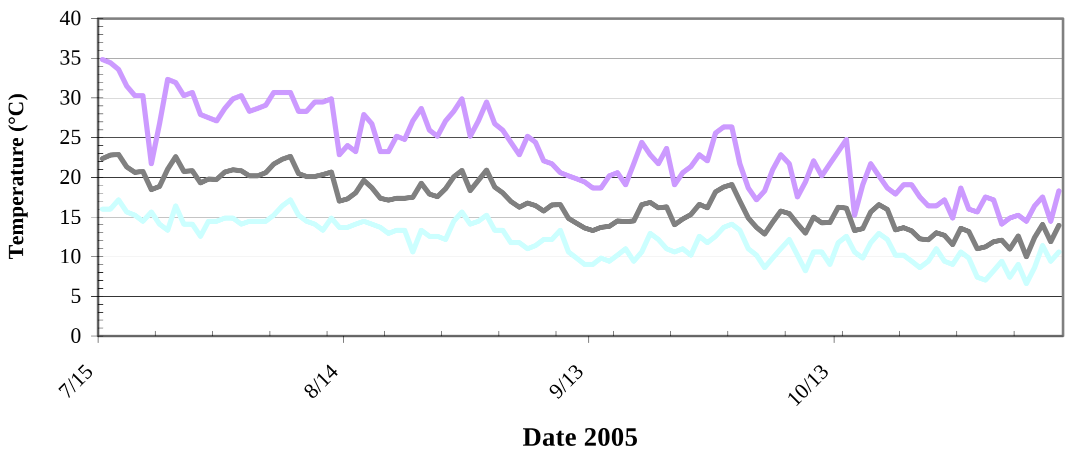


Figure 5-23. *Daily mean (gray), maximum (lavender) and minimum (turquoise) air temperatures at Station TR-6 near Indian Creek.*

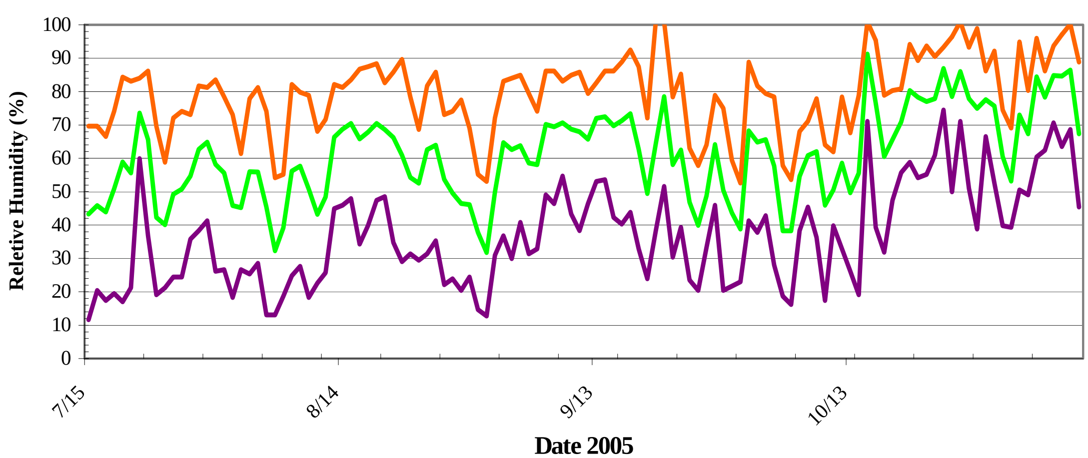


Figure 5-24. *Daily mean (green), maximum (orange) and minimum (purple) relative humidities at Station TR-6 near Indian Creek.*

Electrofishing Water Quality Measurements

During the 2005 electrofishing survey, discrete water quality monitoring was conducted in 30 habitat units within Alameda, Calaveras, La Costa and Indian creeks and Arroyo Hondo (Table 5-5, Figure 8-1).

Survey pH readings ranged from 7.19 to 8.52, with three of the lowest values being measured in three contiguous sites in Alameda Creek just upstream of the Sunol Valley Water Treatment Plant (sites 7-1, 7-2 and 7-3). Conductivity readings ranged from 433 µS/cm^2 to 1537 µS/cm^2, with the highest measurements in two pools in Calaveras Creek downstream of Calaveras Dam (sites 8-1 and 8-2), and the lowest in Alameda Creek at Little Yosemite (sites 12-1 and 12-2). The only site to have a dissolved oxygen concentration less than 5.0 mg/L was one of the pools in Calaveras Creek (site 8-2). Turbidity readings ranged from 0.22 to 4.70 NTU, with only two of the 30 sites measuring above 1.0 NTU.

Table 5-5. *Alameda Creek water quality measurements for the 2005 electrofishing survey. See Section 8 for details about site locations and habitat descriptions.*

	Sites in Alameda Creek Below Confluence with Calaveras Creek											
	Site Number - Habitat Number											
Water Quality Parameter	3-1	3-2	4-1	4-2	4-3	5-1	6-1	6-2	6-4	7-1	7-2	7-3
Time Measured	0910	1215	0905	1135	1300	1200	0820	0825	1345	0900	1230	1424
Temperature (°C)	12.5	14.6	13.7	15.4	16.2	15.5	12.1	11.8	16.3	15.9	18.0	18.5
Turbidity (NTU)	0.35	0.59	0.32	0.57	0.30	0.53	0.54	0.85	4.70	0.51	0.24	2.90
pH	7.95	7.99	7.96	8.12	8.14	7.92	8.19	8.52	7.80	7.60	7.38	7.19
Dissolved Oxygen (mg/L)	8.3	9.6	8.0	10.5	11.0	8.2	7.8	8.1	8.9	5.4	7.2	6.7
Conductivity (µS/cm)	804	783	822	825	825	766	699	689	593	533	529	551

	Sites in Alameda and Calaveras Creeks Above Confluence									
	Site Number - Habitat Number									
Water Quality Parameter	1-1	8-1	8-2	10-1	10-2	10-3	11-1	11-2	12-1	12-2
Time Measured	0835	0905	1301	1134	1130	1137	0905	0910	0845	1025
Temperature (°C)	13.4	13.8	16.4	15.0	14.8	14.8	14.9	14.8	14.4	15.1
Turbidity (NTU)	0.31	0.76	0.37	0.49	0.30	0.73	0.79	0.22	0.35	0.32
pH	8.18	7.74	7.46	7.94	7.99	7.95	7.90	7.92	8.13	7.93
Dissolved Oxygen (mg/L)	9.0	5.1	3.3	8.3	8.4	8.1	7.6	7.7	9.3	8.8
Conductivity (µS/cm)	519	1537	1534	508	507	505	586	584	466	433

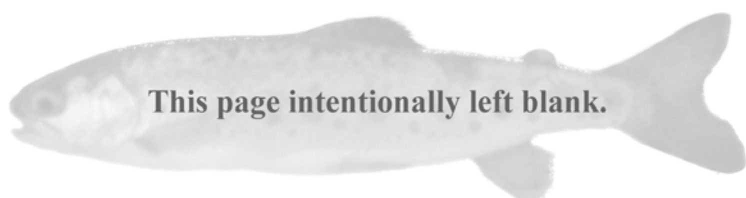
	Sites in Arroyo Hondo, La Costa and Indian Creeks								
	Site Number - Habitat Number								
Water Quality Parameter	13-1	13-2	14-1	14-2	15-1	15-2	15-3	15-4	Mean all sites
Time Measured	0905	1215	0904	0900	1255	1300	1311	1316	--
Temperature (°C)	12.7	13.8	12.0	12.3	12.6	12.7	13.0	13.4	14.3
Turbidity (NTU)	0.45	0.50	0.53	0.43	0.85	0.56	0.57	0.83	0.73
pH	8.07	8.02	7.73	7.70	7.70	8.30	7.80	7.60	7.89
Dissolved Oxygen (mg/L)	9.0	9.9	6.7	6.7	6.5	6.8	7.0	5.5	7.8
Conductivity (µS/cm)	490	485	499	497	851	847	852	863	699

6.0 Spawning Survey

Background

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

No surveys were conducted this year due to circumstances that included staffing limitations and frequent, heavy rains that caused prohibitive stream flows, sustained turbidity, and compromised safety.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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 for fishes. A series of 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 pool in Arroyo Hondo.*

Procedure

Fourteen pools were snorkeled on August 9,10 and 11, 2005 in Alameda and Calaveras creeks and Arroyo Hondo (Figure 7-2, Table 7-1). Upon arrival at each pool, the team of biologists visually inspected the area from the bank and discussed how the survey would be conducted. Issues determined at each site included the number of snorkelers, starting positions, the count direction and path, and the end-point of the survey. The number of snorkelers required for each survey was dependent on the width and depth of the pool, such that complete coverage of the pool was ensured. Spacing between snorkelers was always small enough so that fish counts were accurate, yet large enough so that the ability to swim or count fishes was not impeded. Each snorkel survey began at the downstream end of the pool being examined. In many cases, the water depth at the survey starting point was so shallow that snorkelers were essentially crawling on their bellies with only their facemask partially in the water. The snorkelers moved slowly upstream as a group, identifying species by size class, and counting fishes only as they were encountered

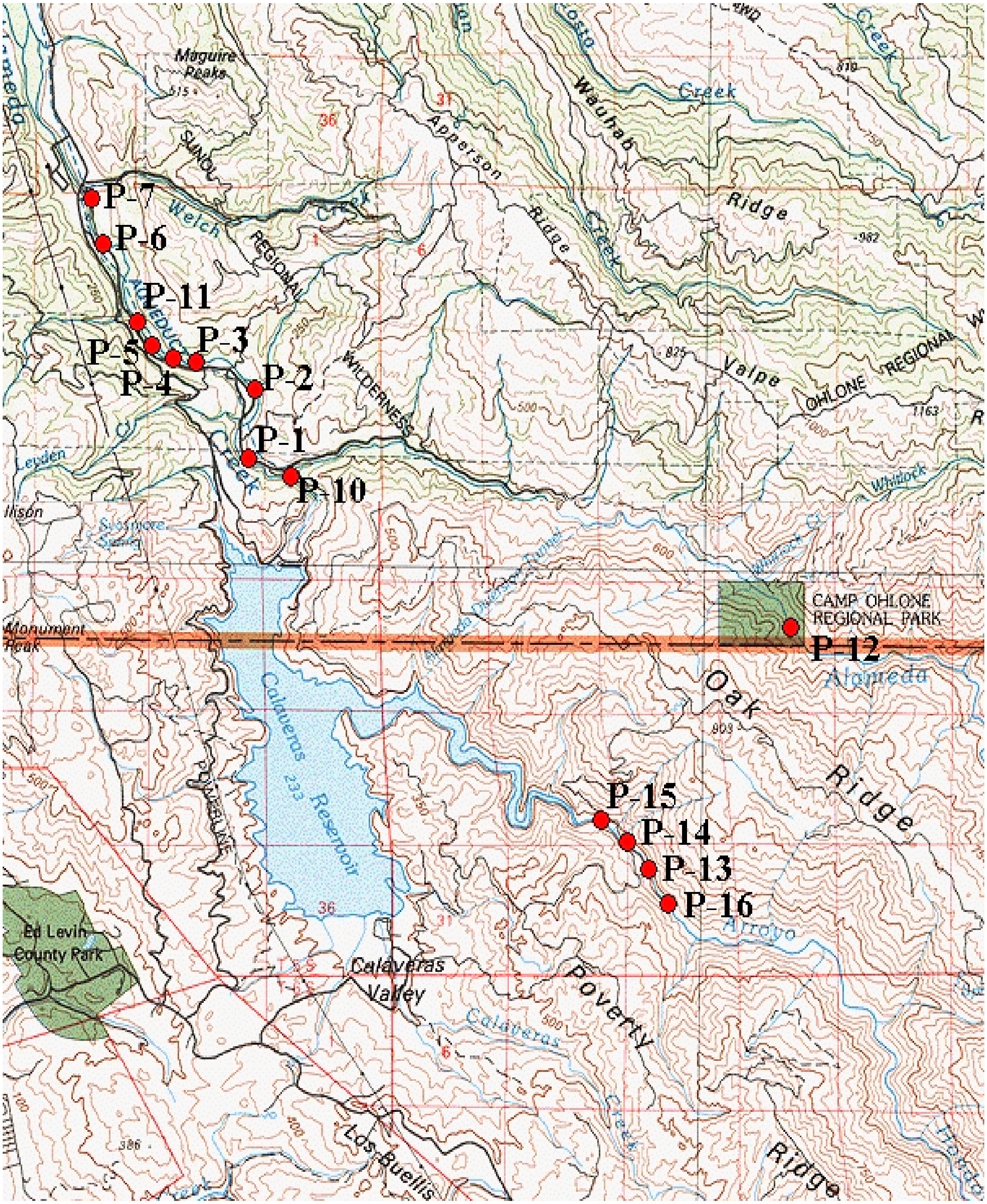


Figure 7-2. *Snorkel survey sites in Alameda and Calaveras Creeks and Arroyo Hondo.*

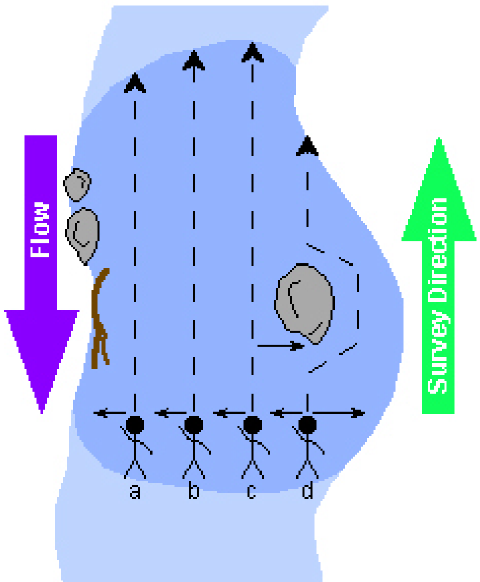


Figure 7-3. *Typical snorkel survey strategy. Snorkelers count fish in the direction the arrows indicate, from their arm to the bank or to the snorkeler next to them.*

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

When necessary, snorkelers utilized underwater lights to illuminate any available cover where fishes may be hiding or difficult to see. This included undercut bank, large boulders, logs and tree roots and shaded areas. 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 fourteen pools during the 2005 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 sunfishes (2.0 percent of total), Sacramento sucker (1.1 percent of total) and rainbow trout (0.18 percent of total). Sacramento pikeminnow and prickly sculpin combined for 0.11 percent of the total. California roach were present in all except one of the pools surveyed while Sacramento sucker were found in eight of the fourteen pools. Sacramento pikeminnow and rainbow trout were each present in four of the pools, prickly sculpin were in two pools, and largemouth bass and sunfishes were each present in one of the fourteen pools.

Pool P-1

This Alameda Creek pool was approximately three-feet deep at its deepest point, in the middle of the channel approximately one third way through the pool. Forty percent of the surface was shaded. California roach (all juvenile with the exception of a single adult) accounted for 53 percent of the 521 fishes observed. This pool had the second lowest number of roach and total fish when compared with the other pools (Figure 7-4, Appendix C). The remaining fishes observed were juvenile Sacramento sucker, accounting for the largest number of that species.

Table 7-1. *Snorkel survey station descriptions for 2005.*

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.	8/9/05	09:25	19.1 °C	19.0 °C
P-2	Rat Pool	In Alameda Creek, ~ 900-feet downstream of the wooden truss bridge in Sunol Regional Park.	8/9/05	10:25	19.9 °C	19.8 °C
P-3	Fence Pool	In Alameda Creek, just downstream of the Sunol Regional Park / SFPUC boundary fence.	8/11/05	12:40	21.8 °C	21.0 °C
P-4	Lunch Pool	In Alameda Creek, ~ 3,000-feet downstream of the Sunol Regional Park / SFPUC boundary fence.	8/11/05	11:05	20.1 °C	19.9 °C
P-5	Sycamore Pool	In Alameda Creek, ~ 4,000-feet downstream of the Sunol Regional Park / SFPUC boundary fence.	8/11/05	10:25	20.4 °C	20.3°C
P-6	S-Bend Pool	In Alameda Creek, ~ 3,000-feet upstream of the Calaveras Road bridge.	8/11/05	13:50	22.7 °C	20.6 °C
P-7	Bathing Pool	In Alameda Creek, ~120-feet upstream of the Calaveras Road bridge.	8/11/05	14:40	27.7°C	19.3°C
P-10	Bass Pool	In Calaveras Creek, ~50-feet upstream of the Alameda Creek / Calaveras Creek Confluence.	8/9/05	14:00	25.6 °C	22.1 °C
P-11	Shade Pool	In Alameda Creek, ~4,500-feet downstream of the Sunol Regional Park / SFPUC boundary fence.	8/9/05	16:10	25.0°C	22.9°C
P-12	Sycamore Camp Pool	In Alameda Creek, ~1,000-feet upstream of the Camp Ohlone southern boundary.	8/9/05	12:00	19.7 °C	17.9 °C
P-13	Butterfly Pool	In Arroyo Hondo, ~800-feet upstream of the USGS gauging station.	8/10/05	13:05	22.0 °C	20.7 °C
P-14	USGS Gauge Pool	In Arroyo Hondo, just upstream of the USGS gauging station.	8/10/05	12:05	19.8 °C	19.4 °C
P-15	Raccoon Pool	In Arroyo Hondo, ~800-feet downstream of the USGS gauging station.	8/10/05	10:30	19.7 °C	19.5°C
P-16	Campfire Pool	In Arroyo Hondo, ~1600 feet upstream of the USGS gauging station.	8/10/05	14:15	21.7°C	19.5°C

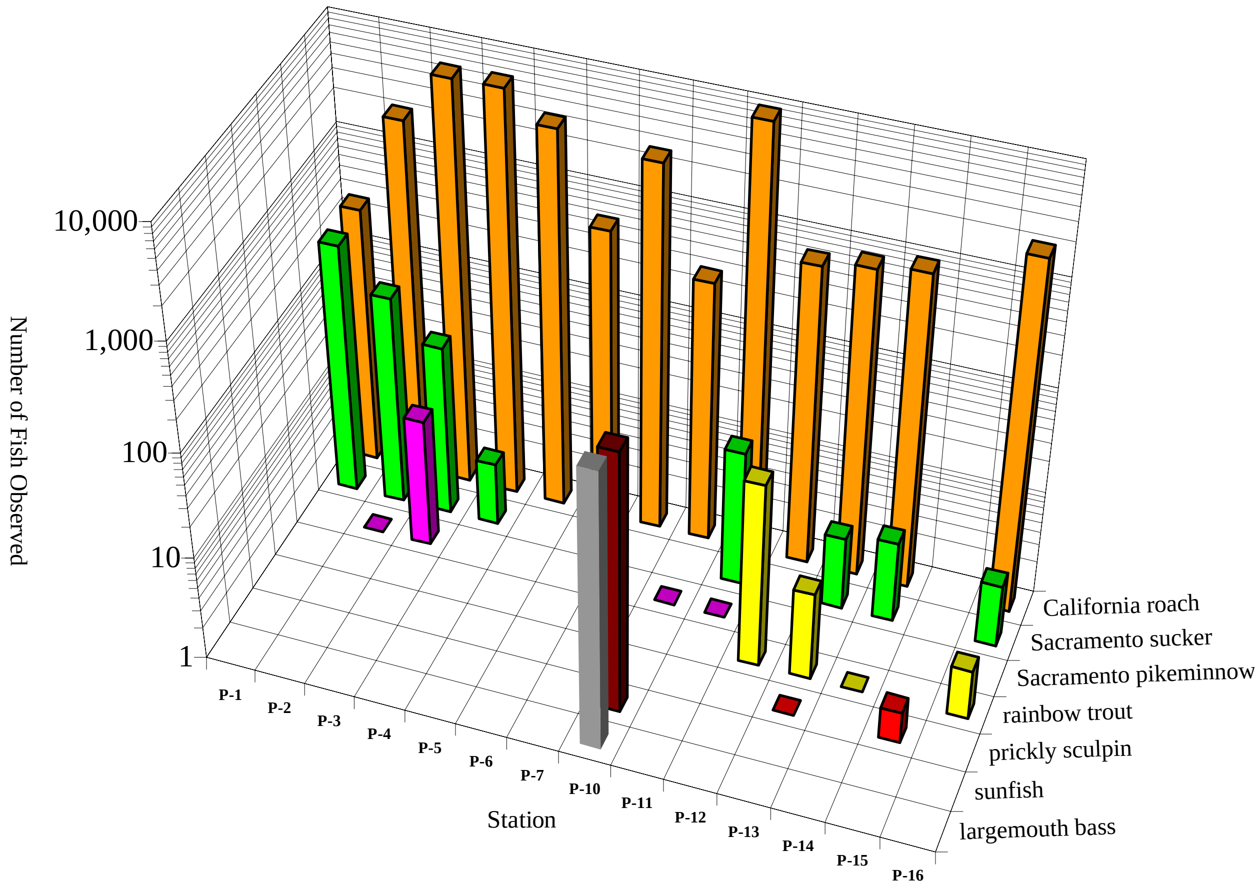


Figure 7-4. *Number of fishes observed by pool during snorkel surveys for 2005.*

Pool P-2.

The maximum depth of this Alameda Creek pool was four and a half feet deep and was located near the right bank, approximately half way through the pool. A point bar bisected the downstream half of the pool. Riparian vegetation shaded approximately 95 percent of the surface during the survey. California roach (six percent adults) accounted for 96 percent of the 2,291 fishes counted. Several Sacramento sucker (no adults) and a single adult Sacramento pikeminnow comprised the remaining four percent of fishes observed. This pool contained the second greatest number of Sacramento sucker.

Pool P-3

This Alameda Creek pool contained many large boulders. The deepest section, at just over four-feet deep, was two thirds of the way downstream, adjacent to a large boulder on the left bank. This pool had one of the highest counts of California roach at 6,235 (three percent adults), which accounted for 99 percent of the fishes observed in the pool. Sacramento pikeminnow and Sacramento sucker combined for the remaining one percent. There were four adult pikeminnow and no adult sucker.

Pool P-4

Located well into the Alameda Creek warm water study reach, this pool was deepest near the steep left bank, about three quarters of the way downstream, at four-feet deep. Thirty percent of the surface was shaded during the survey. As with pool P-3, this pool had extremely high numbers of California roach (two percent adults), accounting for almost 100 percent of the 6,395 fishes observed. Juvenile Sacramento sucker accounted for the remaining fishes observed here.

Pool P-5

This Alameda Creek pool was deepest halfway through, near the steep left bank, which encompassed the majority of riparian cover. Fifty percent of the surface was shaded at the time the survey was conducted. California roach (four percent adults) accounted for all of the 3,560 fish observed.

Pool P-6

Pool P-6 was highly turbid in comparison to the other pools, and underwater lights had to be used for observing fishes beneath undercut banks and cover. This pool had the third lowest number of fishes observed when compared to all other sites surveyed, with all of the 565 fish being juvenile roach. Forty percent of the surface was shaded. The deepest point was located one third of the way downstream, adjacent to a large boulder on the right bank.

Pool P-7

This downstream-most pool in Alameda Creek contained dense mats of algae throughout the lower half, both on and below the water's surface. The deepest point of the pool was just upstream of a fallen tree trunk approximately one quarter of the way downstream. Fifteen percent of the pool's surface was shaded. California roach (one percent adult) were the only species observed.

Pool P-10

This Calaveras Creek pool was approximately seven-feet deep at its deepest point, which was located upstream of the SFPUC/Sunol Regional Park boundary fence, on the right side next to a large boulder. Riparian vegetation along each bank was relatively thick, and 50 percent of the surface was shaded during the survey. It should be noted that the majority of the site was overgrown by extensive beds of macrophytes and surface mats of algae. This, coupled with high turbidity, made observations difficult and the counts likely underestimate relative abundances. This was the only pool in which largemouth bass and sunfishes were found and they comprised the largest portion of observed fishes at 42 and 29 percent, respectively. Seven percent of the bass and 94 percent of the sunfishes were adults. California roach (two percent adults) comprised 29 percent of observed fishes. A single adult Sacramento pikeminnow was also observed.

Pool P-11

This was the longest Alameda Creek pool snorkeled and it had the highest number of observed fishes, almost all being California roach (three percent adult). Juvenile Sacramento sucker and a single adult Sacramento pikeminnow comprised the remainder. One hundred percent of the pool was shaded and the deepest point was one quarter the way downstream of three large boulders that demarcated the end of the pool.

Pool P-12

This pool is the located furthest upstream of all the Alameda Creek sites and a large downed sycamore lies directly over it. This pool was characterized as a log enhanced scour pool and the primary area of refuge was in the water beneath the log, perpendicular to flow. The route the snorkelers took followed the length of the log, with two people upstream and one downstream of the log, and then turned approximately 90 degrees into the flow and upstream to the end of the pool. The downstream snorkeler swam under the base of the log and continued along the left bank. Underwater lights were used to illuminate areas of refuge, however, relative abundances were likely underestimated due to the complex root mass at the base of the log. Twenty five percent of the surface was shaded. Although 92 percent of fishes were California roach (ten percent adult) the pool contained the largest number of observed rainbow trout in comparison to all of the other pools, (eight percent adults). The deepest point was at the base of the log, on the left bank, at five and a half feet deep.

Pool 13

The deepest point of this Arroyo Hondo pool was 4.7-feet and was located adjacent to a large boulder on the right bank, one quarter through the pool. This pool provided fishes with ample cover in the form of rocks, undercut banks and overhanging vegetation. A dense riparian canopy shaded fifty percent of the surface during the survey. California roach (eight percent adults) accounted for 97 percent of the 848 fishes observed, with five juvenile Sacramento sucker, one prickly sculpin and seven juvenile rainbow trout combining to make up the remainder.

Pool P-14

Located just upstream of a USGS gauging station (11173200), this Arroyo Hondo pool was approximately 5.4-feet deep, mid-pool, near the left bank. A dense riparian canopy shaded twenty-five percent of the surface. California roach (14 percent adults) accounted for 99 percent of the 982 fishes observed. Six adult Sacramento sucker were observed along with a single adult rainbow trout to account for the remaining one percent.

Pool P-15

Pool P-15 is located approximately 800-feet downstream of the Marsh Road bridge on Arroyo Hondo. The fewest number of fishes were observed here. Its deepest point, at 3.6-feet, was located midstream, approximately halfway through the pool, just downstream of a large boulder. Forty percent of the pool was shaded. Two prickly sculpin were the only fish observed here.

Pool P-16

Pool P-16 was snorkeled for the first time this year and was the largest and deepest of the Arroyo Hondo pools surveyed. It is located approximately 800-feet upstream of pool P-13. It was 7.5-feet at its deepest point, located center-stream approximately two-thirds the way downstream from the top of the pool. Dense riparian canopy and overhanging vegetation shaded 70 percent of the surface. California roach (11 percent adults) accounted for almost 100 percent of the 2,137 fishes observed. Four adult Sacramento sucker, along with two adult and one juvenile rainbow trout, accounted for the remainder.

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 25, 2005 in Alameda, Calaveras, La Costa and Indian creeks and in Arroyo Hondo (Figure 8-1, Table 8-1). Distinct habitat types (pools, riffles, runs, glides, etc.) at each station were surveyed independently of one another. Not all stations had equal representation of each habitat type. Some habitat types changed from what was surveyed in previous years due to water condition variability.

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 Natural Resource Division 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

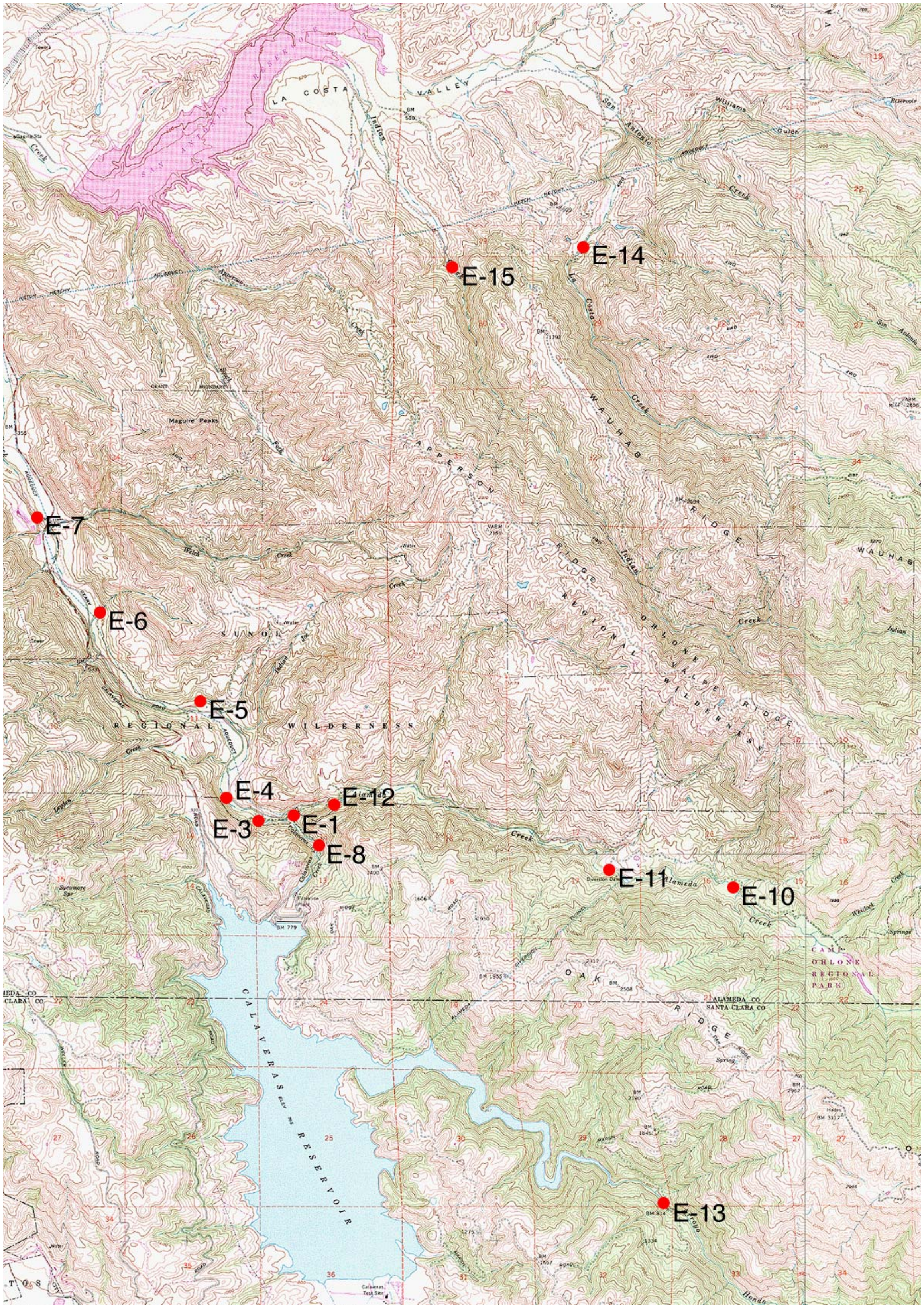


Figure 8-1. *Alameda, Calaveras, La Costa and Indian creeks and Arroyo Hondo 2005 electrofishing survey stations.*

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 2005.*

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 = Glide/Low Gradient Riffle 3 = Glide
E-5	In Alameda Creek, upstream of the Sunol Regional Park / SFPUC boundary fence, near the interpretive center in the Park.	1 = Pool
E-6	In Alameda Creek, at the downstream most Calaveras pipeline crossing.	1 = Run 2 = Low Gradient Riffle 4 = Run/Glide
E-7	In Alameda Creek, downstream of the Calaveras Road bridge, near the Sunol Valley Water Treatment Plant.	1 = Pool 2 = Low Gradient Riffle/Run 3 = Run
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 = Glide 2 = Run 3 = Pool
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/Run 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 = Run/Glide 2 = Low Gradient Riffle
E-15	In Indian Creek, upstream of where the canyon becomes relatively narrow and steep.	1 = Isolated Pool 2 = Isolated Pool 3 = Pool 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 91-feet long, with an average width and depth of 16.1-feet and 1.3-feet, respectively. The maximum depth, located at the upstream end of the pool, was 4.5-feet. The dominant substrate types were gravel and cobble, with some sand along the left side of the pool and several large boulders and bedrock to the right. There was 45-feet of undercut bank and 10-feet of overhanging vegetation, mostly along the right side of the reach. The riparian vegetation was relatively heavy. Shading during the survey ranged from 50 to 100 percent.

Electrofishing station E-3 consisted of two habitat types: a glide and a low gradient riffle. The glide was 77.5-feet long, with an average width and depth of 20.3-feet and 0.7-feet, respectively. The maximum depth of the glide, located in the middle of the channel about midway through the section, was 1.4-feet. The majority of the substrate in the glide was cobble, rubble and gravel, and cover was provided by boulders and about 50-feet of overhanging vegetation along both the left and right banks. Ninety-five percent of the glide was shaded at the start of the survey, dropping to 50 percent by the finish. The riffle was 64.5-feet long, with an average width and depth of 9.9-feet and 0.4-feet, respectively. A maximum depth of 0.5-feet was found two locations along the left side of the channel. The majority of the riffle's substrate was made up of cobble and gravel, with some rubble. Several boulders and about 40-feet of overhanging vegetation provided cover in the riffle. Thirty to 80 percent of the riffle was shaded during the survey.

Electrofishing station E-4 (Figure 8-2) consisted of three habitat types: a glide, a glide flowing into a low gradient riffle, and a second glide. The first glide was 41-feet long, with an average width and depth of 12.3-feet and 0.4-feet, respectively. The dominant substrates in the glide were cobble, boulder and gravel. Cover was provided by the boulders and 40-feet of overhanging vegetation. Approximately 70 percent of the glide was shaded at the start of the survey, increasing to 90 percent by the end of the fourth pass. The glide/riffle was 76-feet long, with an average width and depth of 14.6-feet and 0.3-feet, respectively. The dominant substrates in the riffle portion 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 second glide was 63-feet long, with an average width and depth of 13.3-feet and 0.4-feet, respectively. The dominant substrates in the glide were gravel and rubble, while several boulders and tules along the right bank provided cover. Shading ranged from 50 to 80 percent during the survey.

Electrofishing station E-5 consisted of a single habitat type: a pool. The pool was extremely long, with the lower section too deep to be effectively sampled with electrofishing gear. Consequently, only the upper 74-feet, with an average width and depth of 21.1-feet and 1.5-feet, respectively, were sampled. A maximum depth of 3.0-feet was found on the upstream end of the pool on the right side of the stream. The dominant substrates were gravel and cobble. Some boulders, about 20-feet of undercut bank with submerged tree roots, and 50-feet of overhanging vegetation provided cover. Ninety percent of the pool was shaded at the start of the survey, dropping to about 60 percent by the time it was completed.

Electrofishing station E-6, which in the past has consisted of four habitat types, was divided into three reaches this year: a run, a low gradient riffle and a run flowing into a glide. The run was 75-feet long, with an average width and depth of 16.5-feet and 1.0-feet, respectively. The deepest point of the run was 2.5-feet and located on the right side of the channel toward the upstream end of the habitat. The dominant substrate in the run was cobble, with some rubble, gravel and a few boulders. Thirty-feet of undercut bank and three-feet of overhanging vegetation provided cover. One hundred to seventy percent of the run was shaded during the survey. The low gradient riffle was 202-feet long, with an average width and depth of 15.4-feet and 0.3-feet, respectively. The maximum depth was 0.5-feet, located on the right side of the channel at the downstream end. The dominant substrate in the riffle was cobble, with some rubble mixed in. Other than a few boulders, there was little cover in the riffle. Ninety percent of the riffle was shaded at the start of the survey, dropping to 20 percent by the time it was completed. The run/glide complex was 151-feet long, with an average width and depth of 21.2-feet and 1.2-feet, respectively. The deepest portion of this section was 3.2-feet, located to the left side of the channel in the glide portion. Cobble was the dominant substrate. Boulders, 40-feet of undercut bank, 10-feet of overhanging vegetation and a single instream log provided cover. Shading ranged from 70 to 100 percent during the survey.

Figure 8-2. *SFPUC biologists electrofishing at Station 4 in Alameda Creek.*

Electrofishing station E-7 consisted of three habitat types: a pool, a run flowing into a low gradient riffle and a run. The pool was 85-feet long, with an average width and depth of 19.6-feet and 2.7-feet, respectively. The deepest part of the pool was 4.4-feet, and was located on the left side of the stream about mid-way through the section. The dominant substrates in the pool were cobble and gravel, followed by silt and sand. Cover in the pool was provided by 40-feet of undercut bank in the form of a huge sycamore root mass and 50-feet of overhanging vegetation. Shading in the pool ranged from one hundred percent at the start of the survey to ninety percent when completed. The riffle/run complex was 105-feet long, with an average width and depth of 16.7-feet and 0.5-feet, respectively. The deepest part of the section, located at the middle of the run portion, was 1.3-feet. The dominant substrate in this riffle/run was cobble, followed by sand. Cover in the section consisted of 10-feet of overhanging vegetation and several instream logs. Ninety to one hundred percent of the riffle/run was shaded during the survey. The run was 130-feet long, with an average width and depth of 18.3-feet and 0.4-feet, respectively. The dominant substrate was gravel, although there4 was a large amount of detritus covering the bottom. Fifty-feet of overhanging vegetation provided cover. Seventy to 90 percent of the section 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 43.5-feet long, with an average width and depth of 15.2-feet and 1.6-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 50-feet of overhanging vegetation provided additional cover. Shading in pool 1 through most of the day was 100 percent. Isolated pool 2 was 21-feet long, with an average width and depth of 10.3-feet and 1.7-feet, respectively. A maximum depth of 2.5-feet was located to the left of the pool. The dominant substrate in pool 2 was boulders that provided the only cover. Shading in pool 2 was about 80 percent during the survey.

Electrofishing station E-10 consisted of three habitat types: a glide, a run and a pool. The glide was 88.5-feet long, with an average width and depth of 16.4-feet and 0.5-feet, respectively. The deepest part of the glide, located about mid-channel at the downstream end of the reach, was 1.9-feet. The dominant substrates were a combination of boulders, rubble, cobble and gravel. The only cover available consisted of eight-feet of undercut bank and ten-feet of overhanging vegetation. Seventy percent of the section was shaded at the start of the survey, increasing to 90 percent by the finish. The run, which was broken into several steps, combined for a length of 90-feet, with an average width and depth of 10.4-feet and 0.5-feet, respectively. The deepest part of the reach, located on the left side of the channel at the downstream end, was 0.9-feet. The dominant substrate was boulders, followed by a combination of rubble, gravel, cobble and sand. Other than the abundance of boulders, there was only five-feet each of undercut bank, overhanging vegetation an instream logs providing cover. Shading in the run ranged from 90 to 100 percent throughout the survey. The pool was 47.5-feet long, with an average width and depth of 12.6-feet and 1.1-feet, respectively. The deepest point, located on the left side just over halfway through the pool, was 2.9-feet. Boulders dominated the pool, followed by near-equal amounts of rubble, cobble, gravel, sand and silt. Twenty-feet of undercut bank and five-feet of overhanging vegetation provided cover. Shading during the survey began at 90 percent, increasing to 100 by the end.

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 32-feet long, with an average width and depth of 13.8-feet and 1.8-feet, respectively. The maximum depth of the pool, located near the middle of the channel toward the upstream end, was 3.1-feet. The majority of the substrate in the pool was bedrock, while numerous large boulders provided cover. Ninety to 100 percent of the pool was shaded during the survey. The riffle was 32-feet long, with an average width and depth of 10.5-feet and 0.4-feet, respectively. The majority of the riffle's substrates were a mix of boulder, gravel and rubble. 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 flowing into a short run and a low gradient riffle. The step pools/run and connecting water combined for a total length of 93.5-feet, with an average width and depth of 9.5-feet and 1.0-feet, respectively. The maximum depths of the reach, located in the upstream most pool, was 2.9-feet. The majority of the substrates in the pools were boulder and rubble, which provided the only cover in the pools. Dense riparian canopy shaded 100 percent of the section during the survey. The riffle was 30-feet long, with an average width and depth of 6.4-feet and 0.4-feet, respectively. A maximum depth of 1.1-feet was found mid-channel, at the downstream end of the section. The majority of the riffle's substrates were boulders and rubble, followed by cobble and gravel. The boulders and a few scattered clumps of bunchgrass provided cover. The riffle was 100 percent shaded during the survey.

Electrofishing station E-13 consisted of two habitat types: a glide and a low gradient riffle. The glide was 94-feet long, with an average width and depth of 23.5-feet and 1.1-feet, respectively. The maximum depth of the glide, located just off the left bank about two-thirds of the way downstream, was 2.3-feet. Most of the glide's substrate was gravel, rubble and cobble. Some boulders and 30-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 30 percent shade at the start the survey. The low gradient riffle was 84-feet long, with an average width and depth of 24.5-feet and 0.5-feet, respectively. The majority of the riffle's substrate was rubble and cobble, with a small amount of gravel. Numerous scattered boulders provided the only cover in the riffle. About ninety percent of the section was shaded during the survey.

Electrofishing station E-14 consisted of two habitat types: a run flowing into a glide and a low gradient riffle. The run/glide complex was 61-feet long, with an average width and depth of 10.2-feet and 0.6-feet, respectively. The maximum depth of the section, located along the left side of the channel at the upstream end of the glide, was 1.3-feet. The majority of the run/glide substrate was rubble, gravel and cobble, while several boulders, three-feet of undercut bank and three-feet of overhanging vegetation provided cover. The dense riparian canopy over this reach of the creek resulted in 60 to 80 percent shading during the survey. The low gradient riffle was 51-feet long, with an average width and depth of 6.4-feet and

0.3-feet, respectively. The majority of the riffle's substrate was rubble, followed by equal amounts of boulder, cobble and gravel. The boulders, five-feet of undercut bank and the root-ball of a fallen tree provided cover. Eighty to 100 percent of the section was shaded during the survey.

Electrofishing station E-15 consisted of four habitat types: each a pool or series of isolated step pools. The most downstream pool (isolated pool 1) was 11-feet long, with an average width and depth of 10.0-feet and 0.8-feet, respectively. The deepest part of this pool, located on the left side of the channel halfway through the pool, was 1.0-feet. The dominant substrates in isolated pool 1 were gravel, rubble and cobble, with several boulders providing cover. Shading in isolated pool 1 through the day was constant at 100 percent. The next pool upstream (isolated pool 2) combined for a total length of 13.5-feet, with an average width and depth of 5.0-feet and 0.8-feet, respectively. A maximum depth of one-foot was located just off the right bank, about mid-way through the larger of the two pool series. The dominant substrates in isolated pool 2 were gravel, rubble and cobble, with numerous boulders providing cover. Shading in isolated pool 2 was 100 percent throughout the survey. Moving further upstream, Pool 3 was 20.0-feet long, with an average width and depth of 6.0-feet and 0.9-feet, respectively. The maximum depth of Pool 3, located just off the left bank at the upstream end of the section, was 1.7-feet. Boulders and bedrock created the majority of Pool 3, while small amounts of rubble and gravel were scattered throughout. The boulders provided the only cover in the section. The relatively steep canyon banks and associated dense riparian canopy shaded 100 percent of the section during the survey. The upstream most pool (Pool 4) was 20-feet long, with an average width and depth of 8.5-feet and 1.9-feet, respectively. The deepest part of Pool 4, located on the left side of the stream at the upstream end, was 2.9-feet. Most of the substrate of Pool 4 was gravel, with a very large boulder at the upstream end providing cover. One hundred percent of Pool 4 was shaded during the survey.

Species Composition

A total of eight species were collected from the 13 stations and 30 habitats sampled during the 2005 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 Sacramento sucker (five percent of total), rainbow trout (three percent of total), Sacramento pikeminnow (two percent of total), Pacific lamprey (one percent of total) and prickly sculpin, largemouth bass and bluegill (less than one percent of total each). The number of species found in any single habitat type ranged from one 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.

Five species were collected from electrofishing station E-1 (Figure 8-3). Population estimates (Appendix D) indicate that California roach dominated (204 fish), followed by Sacramento sucker (11 fish), Sacramento pikeminnow (three fish) and rainbow trout and prickly sculpin (one fish each).

Five species were collected from the glide at station E-3 (Figure 8-3). Population estimates (Appendix D) indicate that California roach dominated (514 fish), followed by Sacramento sucker (57 fish), Sacramento pikeminnow (28 fish), Pacific lamprey ammocetes (14 fish) and prickly sculpin (three fish). Five species were also found in the low gradient riffle at station E-3 (Figure 8-3). Population estimates (Appendix D) indicate that there were 180 California roach, 13 Sacramento sucker, six prickly sculpin and one each of rainbow trout and Sacramento pikeminnow.

There were only three species collected from the first glide sampled at station E-4 (Figure 8-3). Population estimates (Appendix D) indicate that California roach dominated (102 fish), followed by Sacramento sucker (28 fish) and Sacramento pikeminnow (six fish). Five species were collected from the glide/low gradient riffle complex at station E-4 (Figure 8-3). Population estimates (Appendix D) indicate that there were 250 California roach, 32 Sacramento sucker, 14 Sacramento pikeminnow, one Pacific lamprey ammocete and one largemouth bass. The same species that were collected from the glide/riffle, with the exception of the bass, were collected from the second glide at station E-4 (Figure 8-3). Population estimates (Appendix D) indicate that California roach once again dominated (68 fish), followed by Sacramento sucker (28 fish), Pacific lamprey (17 fish) and Sacramento pikeminnow (four fish). In comparison to all other stations and habitat types sampled, this glide had the second largest number of Pacific lamprey ammocetes (21 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.

Five species were collected from the pool at electrofishing station E-5 (Figure 8-3). Population estimates (Appendix D) indicate that there were 713 California roach, 16 Sacramento sucker, 13 Sacramento pikeminnow, 12 Pacific lamprey ammocetes and seven largemouth bass. This pool had the greatest number of largemouth bass when compared to other habitats that produced that species.

There were four species collected from the run at station E-6 (Figure 8-3). Population estimates (Appendix D) indicated that California roach dominated in the run (525 fish), followed by Sacramento sucker (25 fish), Sacramento pikeminnow (14 fish) and Pacific lamprey (two fish). The low gradient riffle at station E-6 also had four species, in the same order of abundance (Figure 8-3). Population estimates (Appendix D) indicate that there were 2,301 California roach, 134 Sacramento sucker, ten Sacramento pikeminnow and two Pacific lampreys. This pool had the largest number of roach, accounting for 28 percent of the total collected during the 2005 survey. The run/glide complex at station E-6 (Figure 8-3) had four species. Population estimates (Appendix D) indicated that California roach dominated (1,423 fish), followed by Sacramento pikeminnow (114 fish), Sacramento sucker (60 fish) and Pacific lamprey ammocetes (21 fish). In comparison to all other stations and habitat types sampled, this complex had the greatest number of lamprey (27 percent of the total). The run/glide also had the second largest number of roach, accounting for 17 percent of the total collected from all stations combined.

Five species were collected from the pool at station E-7 (Figure 8-3). Population estimates (Appendix D) indicate that California roach dominated (293 fish), followed by Pacific lamprey (eight fish), Sacramento sucker (five fish), Sacramento pikeminnow (two fish) and largemouth bass (one fish). There were three species found in the run/low gradient riffle complex at station E-7 (Figure 8-3). Population estimates (Appendix D) indicate that there were 279 California roach, three Sacramento sucker and two Pacific lampreys. The run at station E-7 had only two species (Figure 8-3), with population estimates (Appendix D) indicating that there were 739 California roach and 42 Sacramento sucker.

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 46 California roach, six Sacramento sucker and a single bluegill. This was the only station and habitat that bluegill were collected from. California roach (six fish) and Sacramento sucker (one fish) were the only species collected (Figure 8-3) from the upstream isolated pool (isolated pool 2).

There were two species collected from each of the habitat types sampled at station E-10 (Figure 8-3). Population estimates (Appendix D) indicate that California roach dominated in all three (323 fish in the glide, 81 in the run and 18 in the pool). Twenty, 16 and 13 rainbow trout were also collected from the glide, run and pool, respectively.

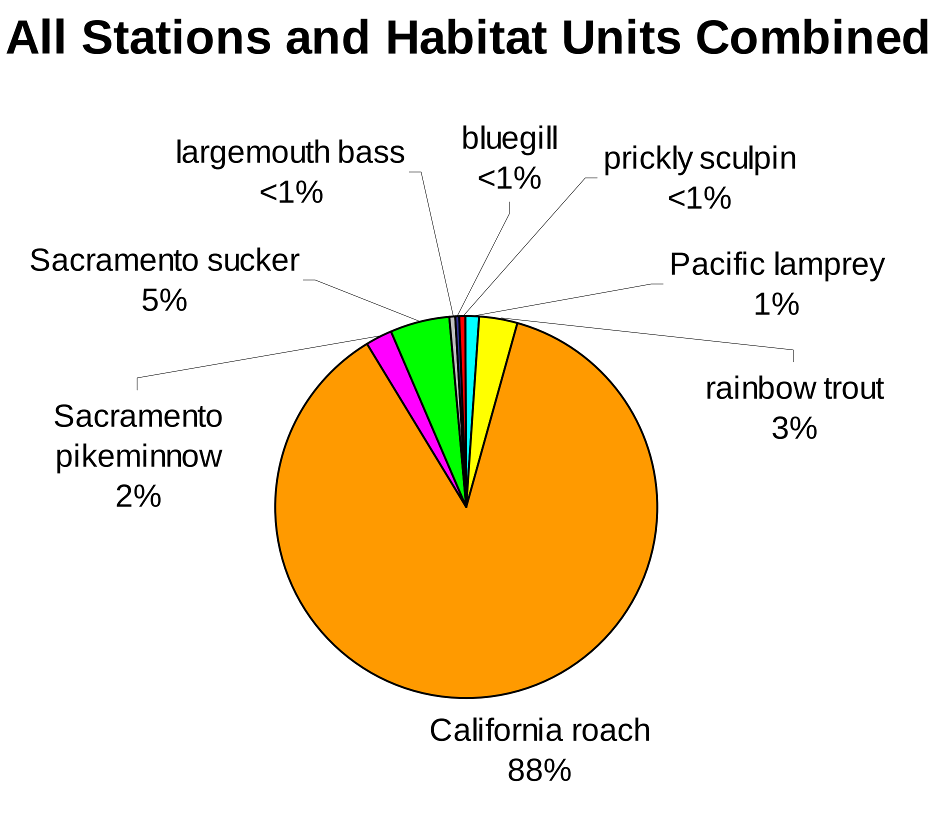


Figure 8-3. *Percent occurrence of each species by station and habitat type, based on population estimates for the autumn 2005 electrofishing surveys.*

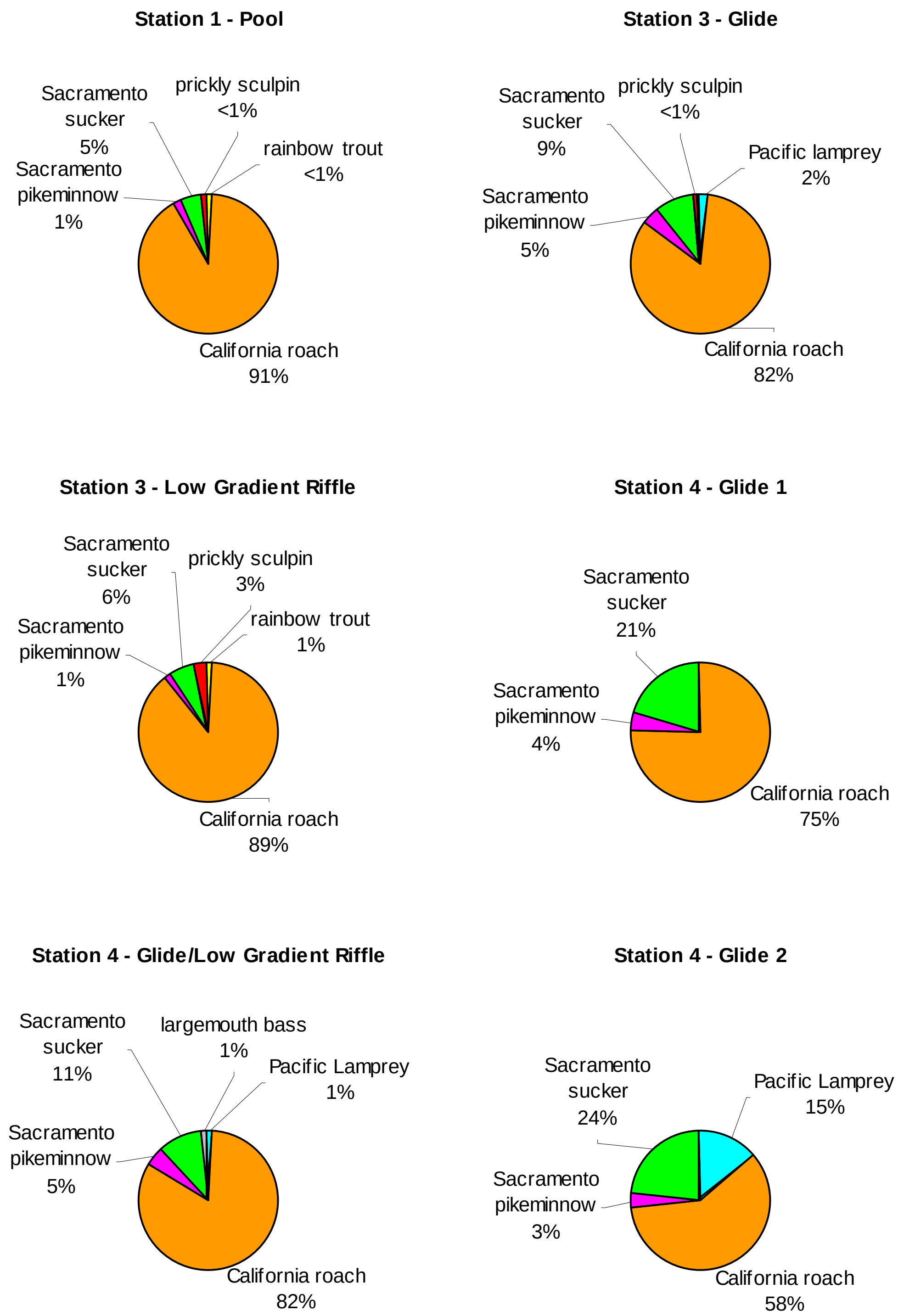
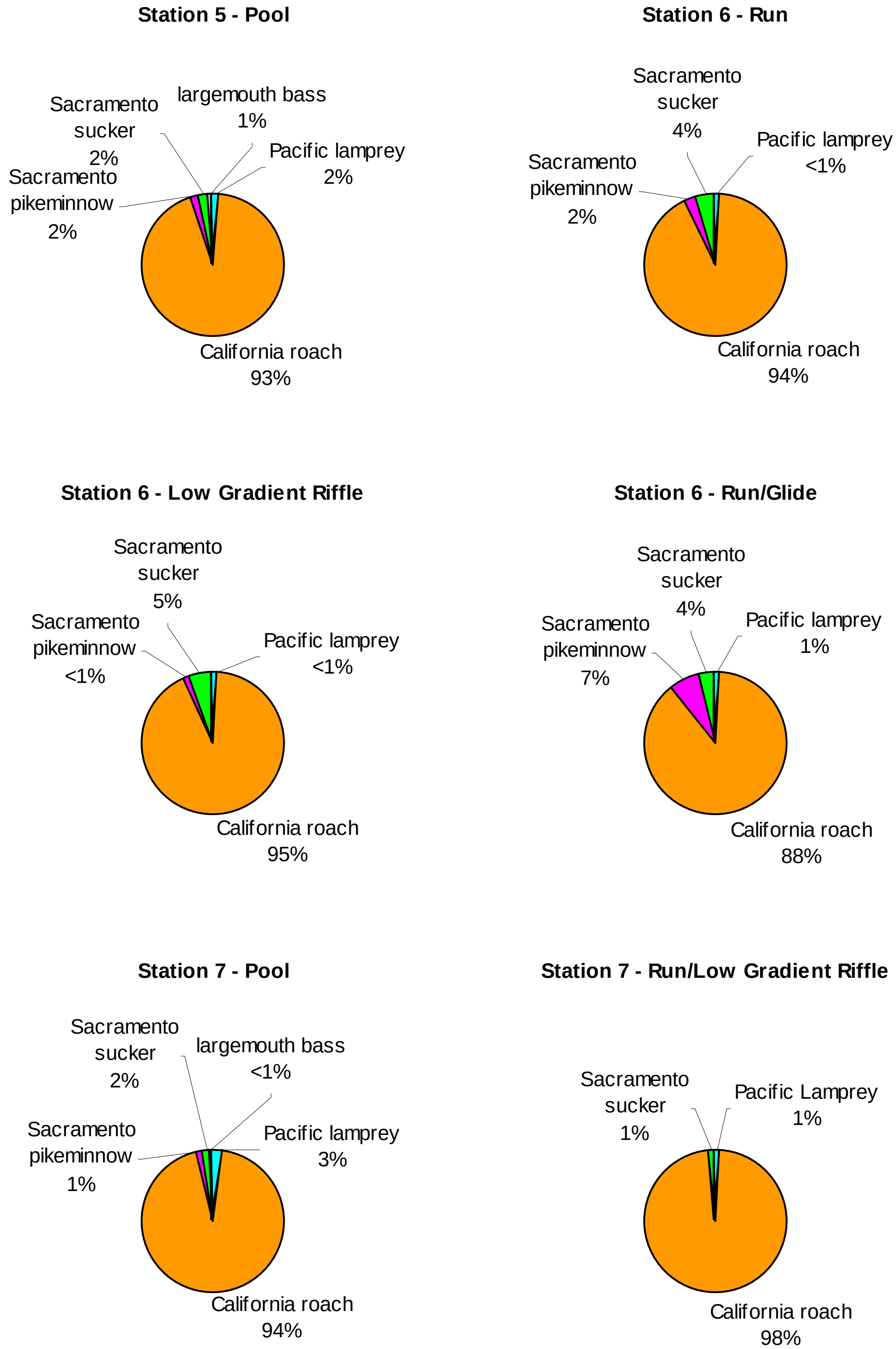


Figure 8-3 continued.



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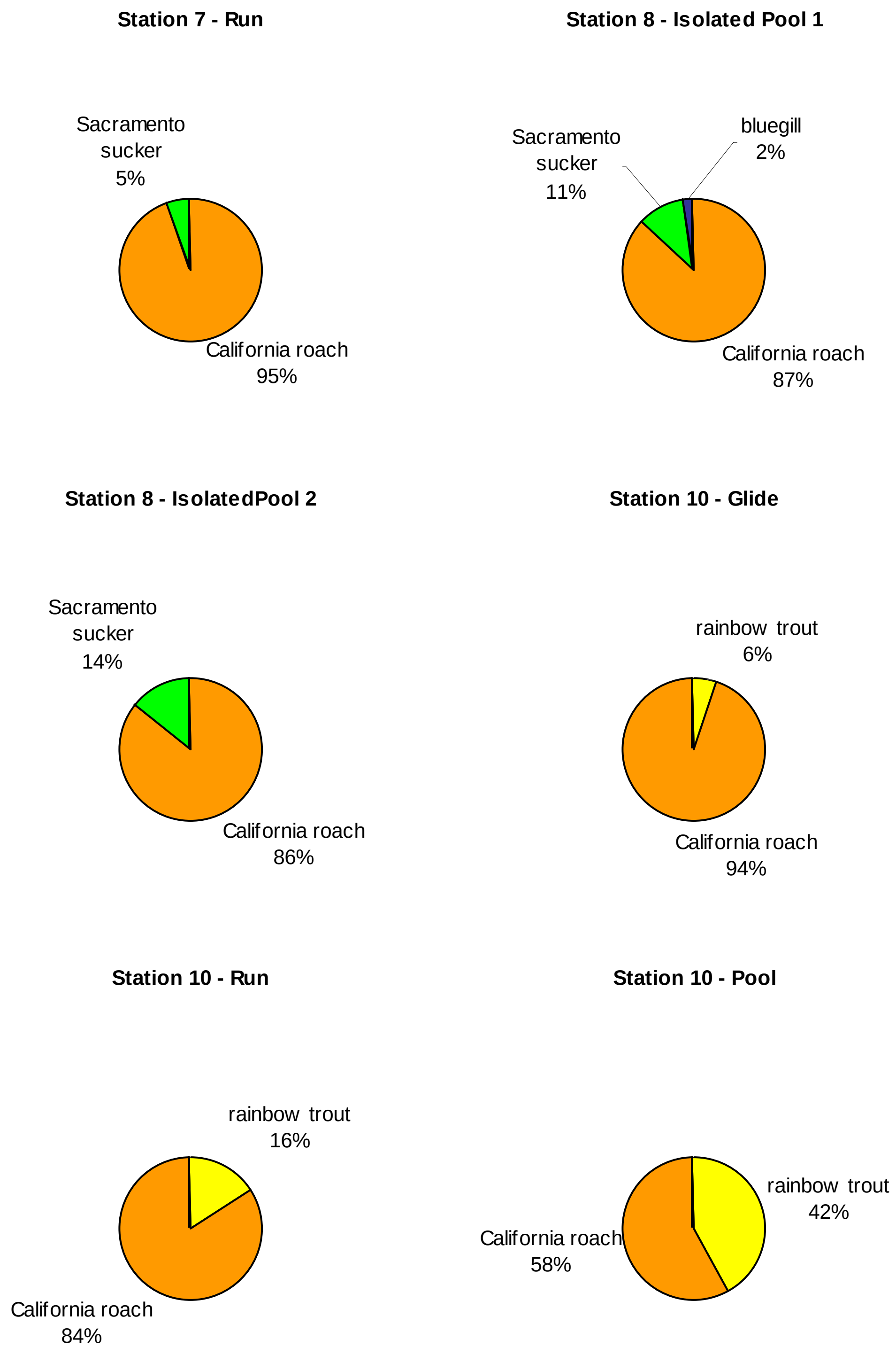

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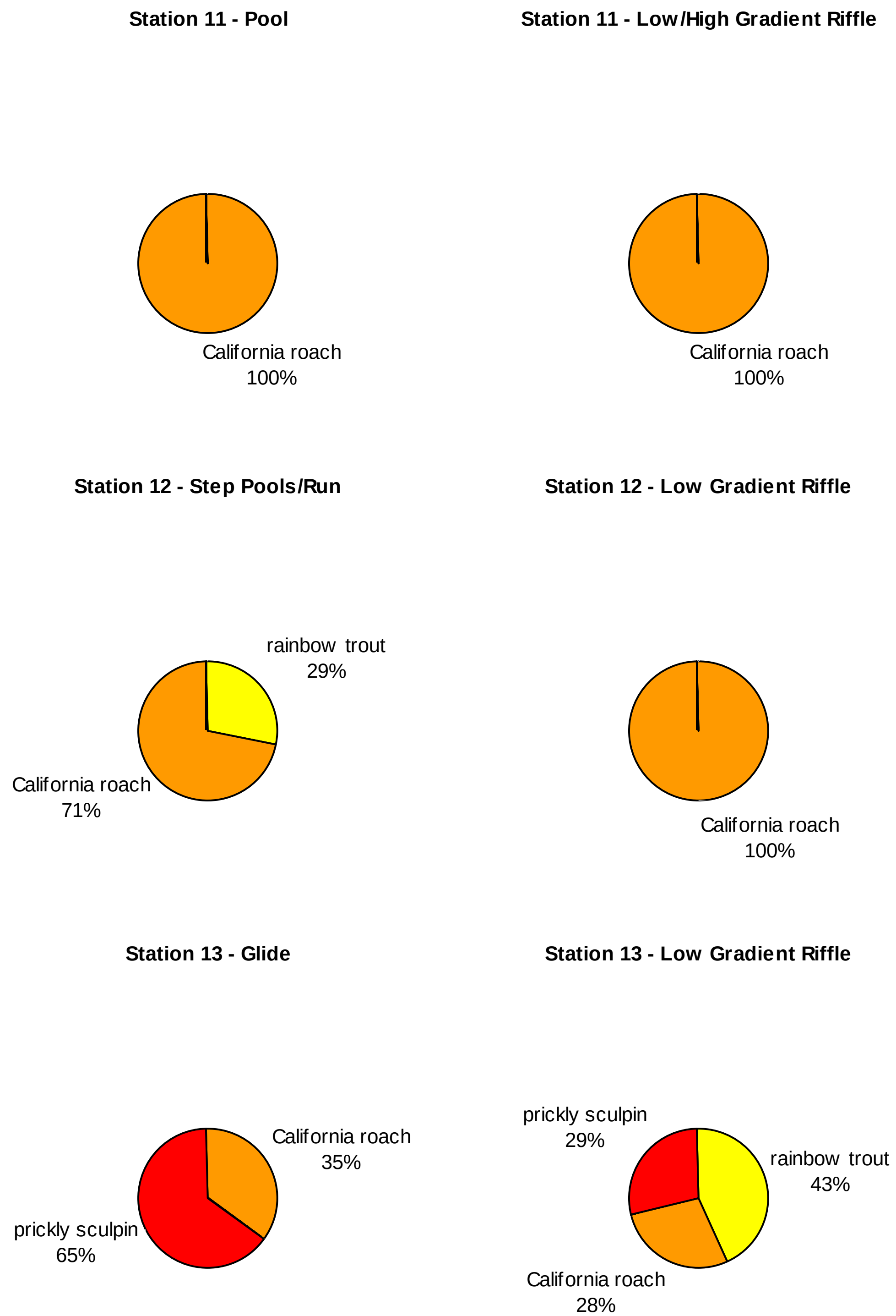


Figure 8-3 continued.

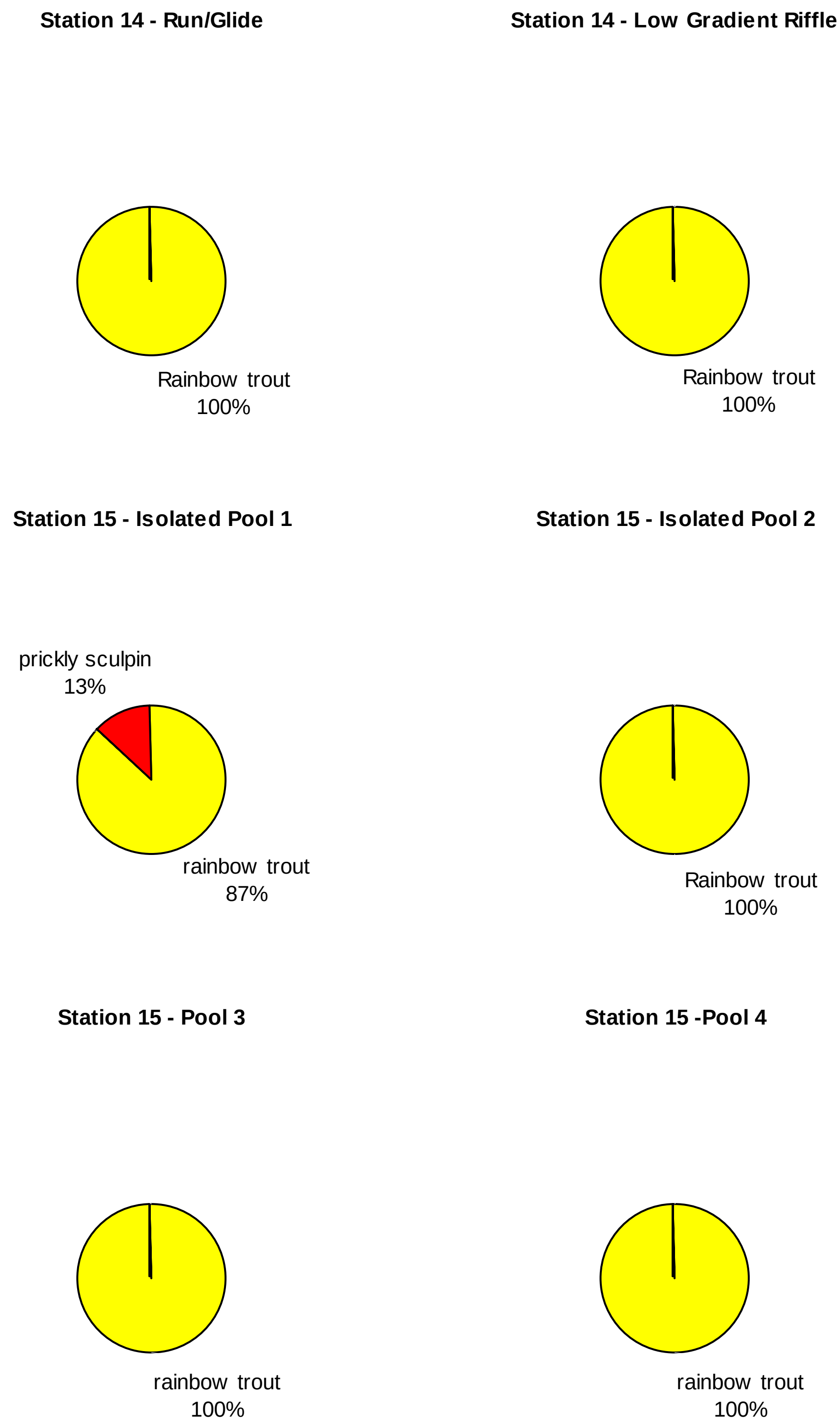


Figure 8-3 continued.

Only California roach was collected from the pool and low/high gradient riffle complex at station E-11 (Figure 8-3). Population estimates (Appendix D) indicate that there were 15 roach in the pool and three in the riffle.

Two species were collected from the step pool/run complex at station E-12 (Figure 8-3). Population estimates (Appendix D) indicate that California roach again dominated (15 fish), followed by rainbow trout (six fish). Only two California roach were collected from the low gradient riffle at station E-12 (Figure 8-3).

Two species were collected from the glide at station E-13 (Figure 8-3). Population estimates (Appendix D) indicate that prickly sculpin dominated (26 fish), followed by California roach (14 fish). In comparison to other stations and habitats with sculpin, the glide had the greatest number of pricklys collected, accounting for 46 percent of the total. There were three species collected from the low gradient riffle at station E-13 (Figure 8-3). Population estimates (Appendix D) indicate that there were 28 rainbow trout, 19 prickly sculpin and 18 California roach. This was the only California roach-containing station (both habitats) in which the roach did not dominate.

Rainbow trout was the only species collected from the two habitats sampled at station E-14 (Figure 8-3). A population estimate (Appendix D) indicated that there were 108 rainbow trout in the run/glide complex. This habitat, when compared to other trout-containing habitats, had the largest number of rainbows, accounting for 35 percent of the total collected from all stations. A population estimate (Appendix D) for the low gradient riffle fish indicates that there were 65 rainbow trout, although it should be noted that the estimate was based on a non-descending removal pattern that may not be reliable.

Two species were collected from the downstream pool (isolated pool 1) at station E-15 (Figure 8-3). Population estimates (Appendix D) indicate that there were 13 rainbow trout and two prickly sculpin. Rainbow trout was the only species found in the remaining three pools at station E-15. Population estimates (Appendix D) indicate that there were eight trout in isolated pool 2, ten trout in pool 3 and 15 rainbow trout in pool 4.

Species Distribution

The distributions of the eight 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 the majority, however, there was no obvious correlation between the number of fish and either location or habitat type. Note that the descriptions below are discussed only in terms of location and habitat, and that it is likely that relationships to other variables play key roles in the distributions patterns observed. Although entire habitat types were sampled in most cases, population estimates are not standardized to the area of each habitat unit.

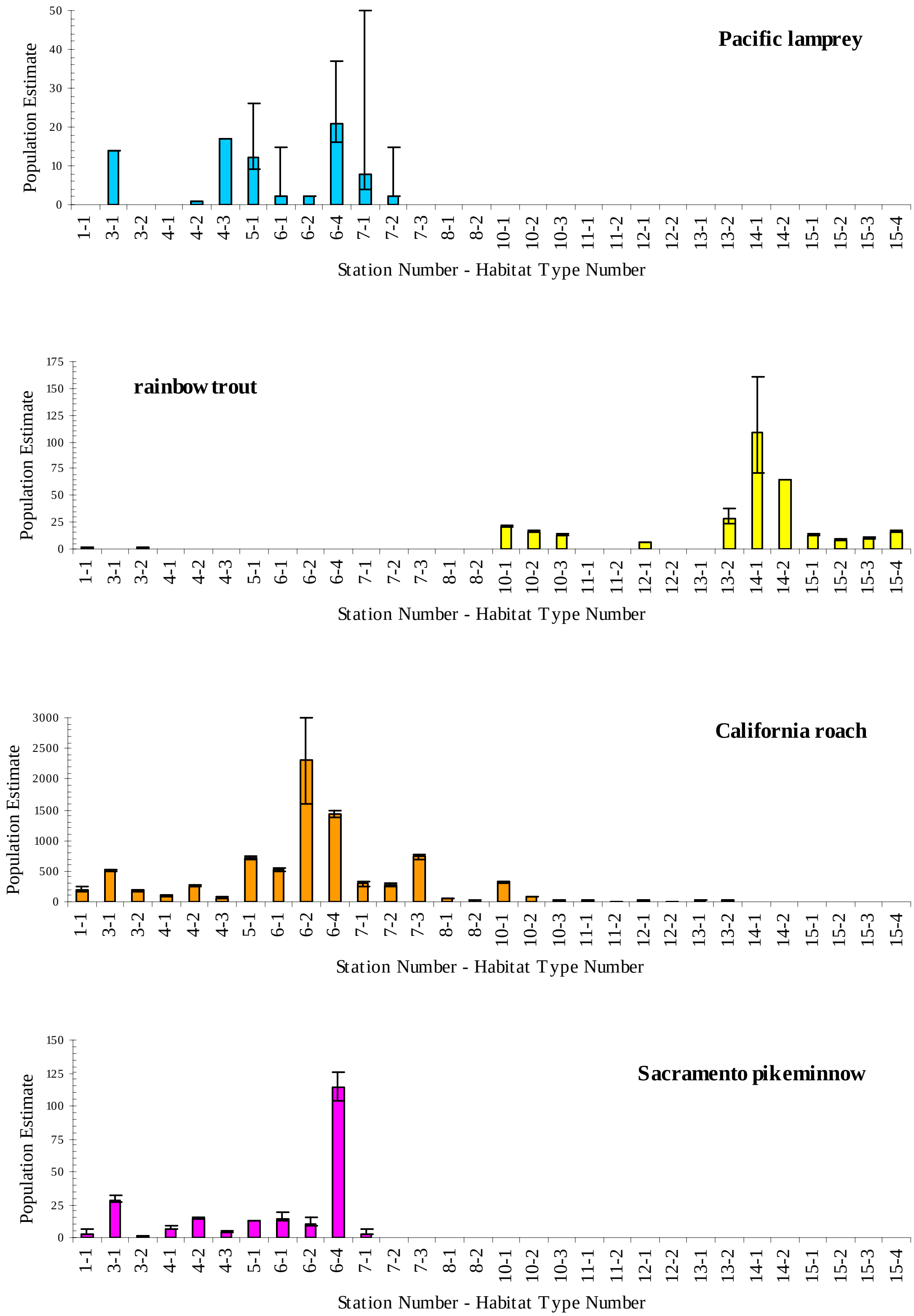
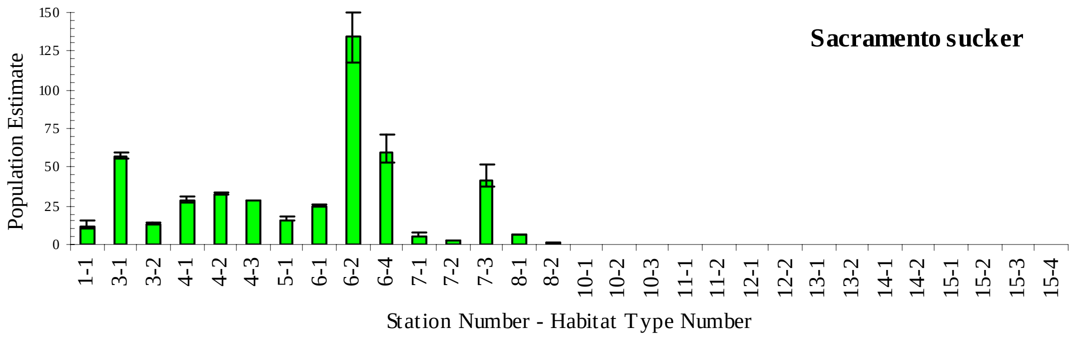
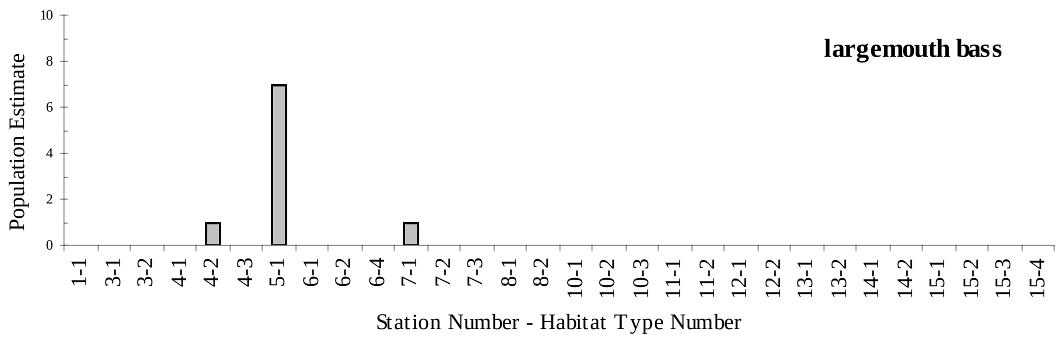
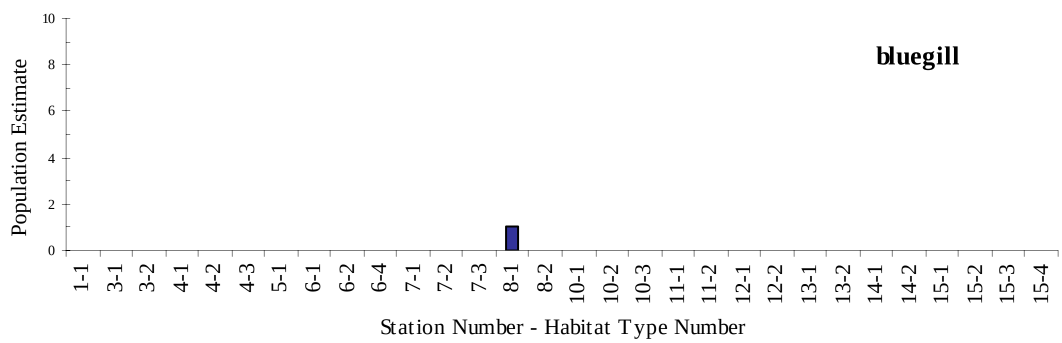


Figure 8-4. *Population estimates and 95 percent confidence intervals for each species by station and habitat type for the autumn 2005 electrofishing surveys.*







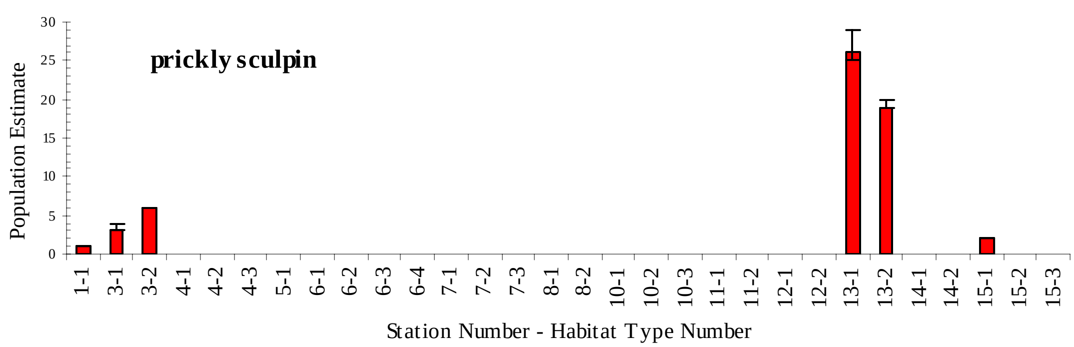


Figure 8-4 continued.

Pacific Lamprey

With the exception of a low gradient riffle at station E-3, a glide at station E-4 and the run at station E-7, 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, slower 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 seven species collected, the distribution pattern of rainbow trout was the most specific to station location (Figure 8-4). Other than a single trout collected in Alameda Creek just downstream of its confluence with Calaveras Creek, one hundred percent of the trout found in Alameda Creek were upstream of the confluence. It should also be noted that in the Alameda Creek stations that had rainbow trout, abundance were noticeably lower downstream of the Diversion Dam in comparison to those upstream of the structure. 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.

California Roach

California roach were the most widespread species, being caught from 24 of the 30 habitats sampled (Figure 8-4). Roach were most abundant in the low gradient riffle and the run/glide complex at electrofishing station E-6. In general, roach were most abundant in Alameda Creek downstream of the Little Yosemite area. They were also relatively abundant in Alameda Creek upstream of the Diversion Dam. Upstream of the two SFPUC East Bay reservoirs, California roach were present in low numbers in Arroyo Hondo, but 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 abundances of Sacramento pikeminnow in Alameda Creek were generally higher in relatively deep, slow water pool and glide habitats, and were especially concentrated in the glide portion of the complex sampled at station E-6.

Sacramento Sucker

Sacramento sucker were caught at every station and habitat sampled in Alameda Creek downstream of Little Yosemite and in Calaveras Creek (Figure 8-4). Suckers were absent from all other areas sampled. The abundances of Sacramento sucker did not appear to be correlated with habitat type, with suckers collected in relatively large numbers from both fast and slow moving water-type areas. It is expected that a more detailed analysis, looking at the abundances of individual life stages, may reveal discernable distribution patterns.

Largemouth Bass

Largemouth bass were only found in the glide portion of the glide/low gradient riffle complex surveyed at Alameda Creek station 4 and in pools at Alameda Creek stations 5 and 7. Largemouths are known to reside in a large, deep pool at the downstream end of Calaveras Creek, and have occasionally been collected in Alameda Creek at station 4, but this is the first time they have been encountered at the downstream most Alameda Creek stations.

Bluegill

Only one bluegill was collected during the electrofishing survey, in the downstream most pool of two similar habitats sampled in Calaveras Creek. The single bluegill collected was an adult fish.

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 Alameda Creek in the vicinity of its confluence with Calaveras Creek and from one pool in Indian Creek. Sculpin were not collected from any of the other stations. It is not practical to establish a correlation between prickly sculpin abundance and habitat type because Cottids are not, in practice, efficiently captured with electrofishing gear.

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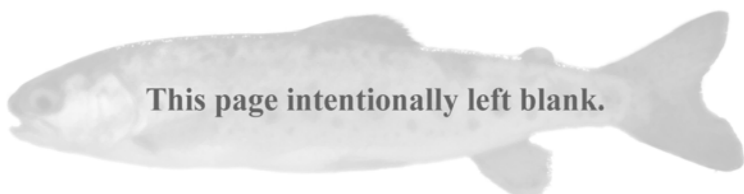
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10.0 Acknowledgments

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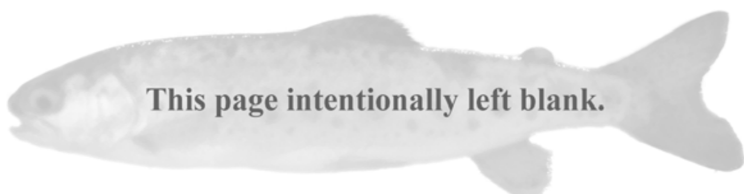
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11.0 Appendices

Appendix A – Target Flow Criteria

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

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

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

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

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

Appendix B – Calaveras Reservoir Water Quality Data

Date	Depth Ft.	Temp °C	pH -log H+	Cond uS/cm	TDS mg/L	DO mg/L	ORP mV	Turb NTU	Alk mg/L	Hard mg/L	Color clr unts	NH3N mg/L	NO3-N mg/L	PO4-P mg/L	Total-P mg/L	Cl- mg/l	TOC mg/L	Fe mg/L	Mn mg/L
1/4/05	0	9.89	7.72	268.3	172	11	358	9.99	105	116		0.06	0.01	0.03	0.04	10	4.2	0.43	0.08
	10	9.82	7.69	265.9	170	10.8	359												
	20	9.68	7.68	261.7	168	10.6	358	15.2	104	114		0.08	0.02	0.04	0.05	10			
	30	9.67	7.65	259.8	166	10.6	358												
	40	9.59	7.59	251.1	161	10.7	359	16.5	102	112		0.07	0.09	0.03	0.04	9	4.4	0.8	0.09
	50	9.49	7.58	225.9	145	10.7	359												
	60	9.45	7.57	203.9	131	10.4	359	91.8	87	94				0.03	0.1	7			
	70	9.39	7.55	195.5	125	10.6	360												
	80	9.32	7.55	175.9	113	10.3	361	219	81	87				0.04	0.14	7			
	90	9.3	7.57	168.1	108	10	362												
	94	9.3	7.62	167.7	107	10.1	362	260	78	79				0.03	0.2	7	6.7	7.25	0.13
1/26/05	0	9.21	7.71	231	148	10.7	372	10.6											
	10	9.12	7.68	230.6	148	10.6	373												
	20	8.97	7.68	229.7	147	10.6	372	10.5											
	30	8.94	7.68	230.1	147	10.6	372												
	40	8.87	7.67	229.4	147	10.3	371	11.3											
	50	8.79	7.65	228.9	147	10.3	371												
	60	8.78	7.65	228.1	146	10.2	371	12.6											
	70	8.76	7.64	228.1	146	10.3	371												
	80	8.75	7.64	227.4	146	10.2	371	14.1											
	90	8.74	7.64	227.2	145	10.2	371												
	100	8.74	7.64	227.1	145	10.1	369												
	102	8.74	7.64	227.5	146	9.93	365	14											
2/8/05	0	10.79	8.1	247.2	158	10.9	427	3.94	91	100	44	0.03	0.04	0.02	0.04	10	4.7	0.13	0.02
	10	10.49	8.05	247	158	10.7	428												
	20	9.49	8.01	246.1	158	9.7	429	5.11	93	104	57	0.02	0.1	0.02	0.03	10			
	30	9.31	7.96	245.4	157	9.6	425												
	40	9.26	7.93	246.1	158	9.53	423	6.9	94	103	65	0.02	0.11	0.04	0.04	9			
	50	9.24	7.91	246.2	158	9.33	422												
	60	9.19	7.9	245.6	157	9.29	421	7.22	94	102	69	0.02	0.11	0.04	0.04	10	4.6	0.34	0.03
	70	9.17	7.88	245.2	157	9.01	422												
	80	9.14	7.87	245.6	157	8.93	424	7.86	94	105	71	0.03	0.11	0.02	0.02	9			
	90	9.12	7.85	246.3	158	8.78	425												
	100	9.14	7.81	252.5	162	8.12	426	8.61	91	101	80	0.05	0.14	0.02	0.03	9	4.4	0.3	0.09
	101	9.14	7.8	254.7	163	7.81	426												
2/25/05	0	12.22	7.84	231.2	148	10	401	4.93											
	10	11.27	7.83	230	147	9.82	402												
	20	10.79	7.82	231.7	148	9.58	401	6.04											
	30	10.55	7.8	234.4	150	9.47	397												
	40	10.28	7.76	245.9	157	9.01	397	5.03											
	50	9.98	7.76	245	157	8.79	396												
	60	9.77	7.73	246.2	158	8.51	395	5.03											
	70	9.38	7.71	247	158	8.01	394												
	80	9.27	7.7	246.8	158	8.04	393	4.88											
	90	9.27	7.68	247.1	158	7.86	392												
	100	9.25	7.67	247	158	7.59	391	5.54											
	108	9.27	7.62	249.8	160	7.27	387	8.02											
3/8/05	0	15.61	7.95	232.5	149	9.67	467	1.87	82	90	30	0.04	0.07	0.01	0.03	10	4.6	0.1	0.01
	5	14.58	7.95	231.4	148	9.61	469												
	10	12.48	7.92	229.2	147	9.59	470												
	20	11.18	7.8	227	145	9.18	471	3.8	83	92	46	0.04	0.07	0.01	0.02	10			
	30	10.72	7.73	231.7	148	8.87	472												
	40	10.44	7.7	235.7	151	8.66	470	4.08	86	95	45	0.04	0.07	0.02	0.02	9			
	50	10.14	7.66	241.6	155	8.3	469												
	60	9.88	7.61	246.5	158	8.04	467	4.41	90	100	43	0.06	0.09	0.02	0.05	10	4.6	0.22	0.01
	70	9.74	7.59	247.1	158	7.69	465												
	80	9.66	7.57	248	159	7.55	463	3.61	89	101	39	0.04	0.08	0.02	0.03	10			
	90	9.61	7.56	248.3	159	7.28	459												
	100	9.55	7.53	249.4	160	6.97	458	3.74	89	97	47	0.05	0.06	0.03	0.03	9			
	109	9.53	7.52	249.6	160	6.7	453	3.58	90	100	50	0.08	0.01	0.02	0.03	9	4.4	0.19	0.07

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
3/25/05	0	13.19	7.91	218.3	140	9.49	399	2.27											
	10	12.94	7.88	217.4	139	9.32	400												
	20	12.78	7.84	216.9	139	9.17	401	4.11											
	30	12.24	7.74	219.2	140	8.53	402												
	40	11.11	7.63	220.1	141	7.86	404	2.82											
	50	10.21	7.56	222.7	143	7.44	405												
	60	10.04	7.54	223.8	143	7.17	406	3.75											
	70	9.86	7.49	226.2	145	6.6	407												
	80	9.81	7.46	227.3	145	6.31	408	4.73											
	90	9.79	7.45	227.5	146	5.95	408												
	100	9.79	7.43	227.6	146	5.73	410	4.94											
	102	9.8	7.44	227.7	146	5.62	410												
4/6/05	0	16	8.16	214.8	138	11.5	455	2.64	88	87	35	0.02	0.01	0.02	0.03	9	4.3	0.1	0.01
	10	14.8	8.16	214.1	137	11.1	456												
	20	14.14	8.12	213.5	137	10.7	457	2.13	86	91	31	0.01	<0.01	<0.01	0.02	10			
	30	12.84	7.81	212.7	136	9.55	458												
	40	11.12	7.58	206.2	132	8.37	458	6.96	84	90	52	0.02	<0.01	0.02	0.04	9			
	50	10.7	7.51	208.6	134	7.14	457												
	60	10.28	7.43	215.2	138	6.76	456	7.63	85	90	67	0.01	0.06	0.02	0.04	11	4.5	0.22	0.02
	70	10.14	7.4	217.8	139	6.39	454												
	80	10.08	7.39	219.1	140	6.04	451	7.32	86	93	67	0.02	0.04	0.02	0.05	10			
	90	10.06	7.38	219.4	140	5.87	446												
	100	10.06	7.38	219.9	141	5.18	436	5.96	87	97	70	0.04	0.12	0.02	0.04	10	4.4	0.23	0.05
4/11/05	0	15.02	8.13	231	402	8.74	148												
	10	14.48	8.09	231	403	8.61	148												
	20	14.21	8.02	231	402	8.47	148												
	30	13.94	7.87	231	402	8.04	148												
	40	11.57	7.59	226	404	7.01	144												
	50	10.87	7.49	227	404	6.22	146												
	60	10.54	7.46	231	403	5.78	148												
	70	10.36	7.43	235	403	5.42	150												
	80	10.33	7.43	236	401	5.34	151												
	90	10.28	7.42	237	400	5.09	151												
	100	10.26	7.42	237	399	5.02	152												
	104	10.26	7.43	237	401	5.08	152												
4/27/08	0	17.31	8.4	228.3	146	10.7	453	1.19	89	99	15	0.01	<0.01	0.02	0.02	9	4.2	0.02	0.01
	10	17.17	8.42	227.8	146	10.5	457												
	20	15.83	8.08	230.9	148	9.48	459	1.35	92	97	19	0.03	0.02	0.02	0.02	9			
	30	12.52	7.72	221.8	142	8.07	460												
	40	11.42	7.55	218.5	140	6.98	461	3.48	88	94	31	0.03	0.04	0.02	0.02	10			
	50	10.98	7.51	217.5	139	6.61	460												
	60	10.84	7.46	218.9	140	5.97	459	4.02	86	95	35	0.03	0.05	0.02	0.02	9	4.2	0.05	0.02
	70	10.66	7.42	219.6	141	5.28	457												
	80	10.5	7.4	220.3	141	4.95	455	5.44	88	95	47	0.02	0.1	0.02	0.03	11			
	90	10.46	7.38	220.8	141	4.59	450												
	96	10.43	7.35	222.4	142	3.43	444	5.68	85	98	56	0.04	0.12	0.03	0.03	10	4.5	0.12	0.08
5/18/05	0	19.33	8.56	247.4	158	10.6	416	1.19	93	96	17	0.01	<0.01	0.01	0.04	7	3.7	0.03	0.02
	10	19.34	8.57	246.3	158	10.3	418												
	20	19.33	8.57	245.8	157	10.3	421	1.28	96	101	19	0.01	<0.01	0.01	0.05	7			
	28	19.28	8.55	245.3	157	10.1	423												
	30	16.28	7.97	248.7	159	8.22	426												
	40	11.75	7.66	225.6	144	5.65	427	2.1	87	96	29	0.01	0.09	0.02	0.07	7			
	50	11.14	7.53	224.1	143	4.59	427												
	60	10.92	7.44	224.1	143	3.95	426	3.01	87	95	31	0.02	0.13	0.03	0.06	7	4.2	0.08	0.03
	70	10.71	7.39	224.1	143	3.41	424												
	80	10.66	7.35	224.5	144	2.74	424	3.51	88	95	40	0.02	0.17	0.03	0.08	7			
	90	10.64	7.33	225.2	144	2.13	377	4.58	89	98	48	0.05	0.21	0.07	0.07	7	4.3	0.09	0.16
5/26/05	0	22.96	8.59	251.3	161	9.89	443	0.92											0.01
	10	22.82	8.58	249.9	160	9.93	444												
	20	17.72	8.12	246.9	1589	9.12	448	1.16											
	30	13.62	7.66	229.9	147	6.19	451												
	40	11.79	7.48	223.8	143	4.5	451	2.22											

Date	Depth	Temp	pH	Cond	TDS	DO	ORP	Turb	Alk	Hard	Color	NH3N	NO3-N	PO4-P	Total-P	Cl-	TOC	Fe	Mn
	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
5/26/05	50	11.24	7.42	222.8	143	3.92	447												
	60	10.93	7.36	222.8	143	2.94	443	3.14											0.038
	70	10.77	7.32	222.9	143	2.26	443												
	80	10.73	7.29	223	143	1.88	443	4.21											
	88	10.71	7.27	224.2	144	1.05	441	4.59											0.178
6/2/05	0	22.5	8.54	254.9	163	9.73	444	0.7											<0.01
	10	21.85	8.54	252.4	161	9.96	444												
	18	21.34	8.5	250.7	161	9.34	444												
	20	16.55	7.88	243.7	156	7.54	448	0.78											
	25	14.73	7.64	233.7	150	6.11	450												
	30	13.84	7.54	229.9	147	5.6	451												
	40	12.44	7.46	224.4	144	4.8	452	2.26											
	50	11.63	7.38	222.1	142	3.95	452												
	60	11.07	7.28	221.8	142	2.6	450	3.65											0.07
	70	10.83	7.24	221.6	142	1.73	449												
	80	10.79	7.22	221.7	142	1.39	448	4.26											
	89	10.77	7.2	222.8	143	0.72	447	6.14											0.41
6/27/06	0	22.04	8.56	267	171	7.79	344	0.7	99	114	10	0.03	<0.01	<0.01	0.04	8	3.5	0.13	0.03
	10	21.69	8.54	267	171	7.8	341												
	20	21.57	8.5	266	170	7.63	339	0.73	97	113	10	0.04	0.02	<0.01	0.05	8			
	30	14.44	7.18	239	153	2.84	350												
	40	11.92	7.07	232	148	1.82	347	0.4	86	99	18	0.03	0.1	0.04	0.05	7			
	50	11.53	7.04	231	148	1.52	345												
	60	11.25	7.03	231	148	1.09	342	0.4	84	98	20	0.09	0.11	0.09	0.1	7	4	0.11	0.06
	70	11.08	7.02	231	148	0.58	337												
	79	11.02	7.05	232	149	0.29	334	1.8	86	98	20	0.05	0.17	0.1	0.11	7	4.1	0.27	0.3
7/20/05	0	26.75	8.45	255.1	163	7.95	417	0.7											
	10	26.42	8.51	254.2	163	7.93	416												
	20	24.91	8.49	251.8	161	7.86	417	0.75											
	25	22.17	8.16	250.8	161	6.26	419												
	30	17.07	7.93	230.9	148	2.89	423												
	40	12.71	7.8	220.9	141	1.02	426	1.32											
	50	11.8	7.63	217.2	139	0.58	426												
	60	11.43	7.58	215.5	138	0.28	426	1.54											
	70	11.19	7.51	217.1	139	0.14	427												
	80	11.14	7.45	218.6	140	0.1	425	0.97											
	89	11.11	7.41	233.7	150	0.08	412	1											
8/2/05	0	25.52	8.71	274.5	176	8.78	450	0.65	100	113	12	0.03	<0.01	<0.01	0.01	13	NA	0.03	0.01
	10	25.35	8.71	274.5	176	8.57	450												
	20	24.36	8.64	272.9	175	8.05	453	0.73	104	114	14	0.02	0.01	<0.01	0.01	14	NA		
	29	22.09	7.74	263.2	163	4.55	456												
	30	18.5	7.42	252.8	162	2.71	456												
	35	14.11	7.21	237.5	152	0.64	458												
	40	12.86	7.16	234.4	150	0.4	459	0.85	93	100	12	0.01	0.01	<0.01	0.01	11	NA		
	50	11.85	7.11	232.5	149	0.11	459												
	60	11.52	7.11	232.6	149	0.05	459	0.93	87	99	20	0.01	0.16	0.03	0.03	11	NA	0.09	0.05
	70	11.19	7.14	234.7	150	0.04	430												
	80	11.14	7.18	236	151	0.02	372	0.67	92	101	24	0.19	0.14	0.1	0.1	11	NA		
	88	11.13	7.23	238.2	153	0.03	332	0.91	93	99	23	0.25	0.16	0.12	0.12	11	NA	0.24	0.79
8/12/05	0	25.29	8.75	271.5	174	8.67	403												
	10	25.1	8.75	271	174	8.23	404												
	20	25.03	8.74	270.6	173	8	404												
	25	23.63	8.47	269	172	6.6	408												
	27.5	22.07	8.1	261.8	168	3.59	414												
	30	17.89	7.99	250.3	160	1.56	419												
	40	12.65	7.99	231.9	148	0.16	424												
	50	11.93	7.99	230.1	147	0.09	425												
	60	11.65	7.99	229.4	147	0.06	424												
	70	11.25	8.62	231	148	0.01	385												
	80	11.17	8.55	231.9	148	0	390												
	88	11.15	8.6	233.4	149	0.02	387												

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
8/24/05	0	23.93	8.5	270	173	8.01	253	0.87	103	117	9	<0.01	0.04	0.05	0.08	8	3.5	0.05	0.04
	10	23.82	8.49	272	174	7.76	249												
	20	23.42	8.38	272	174	7.49	243	1.21	104	118	12	<0.01	0.04	0.03	0.09	8			
	30	21.08	7.53	263	168	4.13	239												
	40	13.13	7.26	232	149	0.49	230	1.46	93	102	24	<0.01	0.04	0.05	0.05	8			
	50	11.98	7.27	231	148	0.47	224												
	60	11.65	7.29	232	149	0.28	212	0.94	92	102	30	0.1	0.06	0.06	0.11	8	3.9	0.09	0.21
	70	11.32	7.3	233	149	0.34	209												
	80	11.28	7.32	235	150	0.33	193	5.44	92	103	115	0.08	0.2	0.21	0.23	8			
	89	11.26	7.33	237	152	0.35	179	6.76	91	103	96	0.12	0.23	0.22	0.27	8	4.4	0.75	1.1
7/20/05	0	26.75	8.45	255.1	163	7.95	417	0.7											
	10	26.42	8.51	254.2	163	7.93	416												
	20	24.91	8.49	251.8	161	7.86	417	0.75											
	25	22.17	8.16	250.8	161	6.26	419												
	30	17.07	7.93	230.9	148	2.89	423												
	40	12.71	7.8	220.9	141	1.02	426	1.32											
	50	11.8	7.63	217.2	139	0.58	426												
	60	11.43	7.58	215.5	138	0.28	426	1.54											
	70	11.19	7.51	217.1	139	0.14	427												
	80	11.14	7.45	218.6	140	0.1	425	0.97											
	89	11.11	7.41	233.7	150	0.08	412	1											
8/2/05	0	25.52	8.71	274.5	176	8.78	450	0.65	100	113	12	0.03	<0.01	<0.01	0.01	13	NA	0.03	0.01
	10	25.35	8.71	274.5	176	8.57	450												
	20	24.36	8.64	272.9	175	8.05	453	0.73	104	114	14	0.02	0.01	<0.01	0.01	14	NA		
	29	22.09	7.74	263.2	163	4.55	456												
	30	18.5	7.42	252.8	162	2.71	456												
	35	14.11	7.21	237.5	152	0.64	458												
	40	12.86	7.16	234.4	150	0.4	459	0.85	93	100	12	0.01	0.01	<0.01	0.01	11	NA		
	50	11.85	7.11	232.5	149	0.11	459												
	60	11.52	7.11	232.6	149	0.05	459	0.93	87	99	20	0.01	0.16	0.03	0.03	11	NA	0.09	0.05
	70	11.19	7.14	234.7	150	0.04	430												
	80	11.14	7.18	236	151	0.02	372	0.67	92	101	24	0.19	0.14	0.1	0.1	11	NA		
	88	11.13	7.23	238.2	153	0.03	332	0.91	93	99	23	0.25	0.16	0.12	0.12	11	NA	0.24	0.79
8/12/05	0	25.29	8.75	271.5	174	8.67	403												
	10	25.1	8.75	271	174	8.23	404												
	20	25.03	8.74	270.6	173	8	404												
	25	23.63	8.47	269	172	6.6	408												
	27.5	22.07	8.1	261.8	168	3.59	414												
	30	17.89	7.99	250.3	160	1.56	419												
	40	12.65	7.99	231.9	148	0.16	424												
	50	11.93	7.99	230.1	147	0.09	425												
	60	11.65	7.99	229.4	147	0.06	424												
	70	11.25	8.62	231	148	0.01	385												
	80	11.17	8.55	231.9	148	0	390												
	88	11.15	8.6	233.4	149	0.02	387												
8/24/05	0	23.93	8.5	270	173	8.01	253	0.87	103	117	9	0.04	<0.01	0.05	0.08	8	3.5	0.05	0.04
	10	23.82	8.49	272	174	7.76	249												
	20	23.42	8.38	272	174	7.49	243	1.21	104	118	12	0.04	<0.01	0.03	0.09	8			
	30	21.08	7.53	263	168	4.13	239												
	40	13.13	7.26	232	149	0.49	230	1.46	93	102	24	0.04	<0.01	0.05	0.05	8			
	50	11.98	7.27	231	148	0.47	224												
	60	11.65	7.29	232	149	0.28	212	0.94	92	102	30	0.06	0.1	0.06	0.11	8	3.9	0.09	0.21
	70	11.32	7.3	233	149	0.34	209												
	80	11.28	7.32	235	150	0.33	193	5.44	92	103	115	0.2	0.08	0.21	0.23	8			
	89	11.26	7.33	237	152	0.35	179	6.76	91	103	96	0.23	0.12	0.22	0.27	8	4.4	0.75	1.1
9/1/05	0	22.8	8.37	298	0.19	8.31	349												
	10	22.8	8.36	298	0.19	8.17	347												
	20	22.8	8.33	287	0.19	8.1	346												
	30	19.9	7.26	281	0.18	2.96	348												
	40	13.1	6.93	255	0.16	0.2	351												
	50	11.9	6.9	253	0.16	0.19	350												
	60	11.7	6.89	252	0.16	0.23	357												

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
9/1/05	70	11.6	6.88	253	0.16	0.26	364												
	80	11.4	6.89	254	0.16	0.25	365												
	88	11.3	6.9	255	0.16	0.25	374												
9/7/05	0	22.81	8.3	301	192	8.49	388												
	10	22.69	8.29	301	192	8.44	388												
	20	22.61	8.27	301	193	8.49	389												
	25	22.47	8.22	301	192	8.03	391												
	27.5	22.08	7.97	299	191	7.01	395												
	30	20.76	7.45	291	185	3.69	403												
	40	13.9	6.95	260	166	0.22	411												
	50	12.07	6.89	255	163	0.36	411												
	60	11.74	6.87	256	164	0.17	411												
	70	11.61	6.85	255	163	0.22	411												
	80	11.53	6.91	256	164	0.18	394												
	88	11.44	6.91	259	166	0.14	387												
9/26/05	0	20.88	8.5	301	192	8.73	369	2.4	103	117	18	0.03	<0.01	0.04	0.05	8	3.8	0.09	0.02
	10	20.09	8.4	300	192	8.23	369												
	20	19.99	8.38	300	192	8.18	365	1.1	104	118	15	0.04	<0.01	0.05	0.07	8			
	30	19.88	8.36	300	192	8.04	362												
	35	16.61	7.15	273	175	0.79	368												
	40	12.74	6.99	258	165	1.03	370	1.3	90	100	39	0.12	0.06	0.13	0.17	7			
	50	12.16	6.96	257	164	2.94	369												
	60	12.06	6.96	257	164	3.58	366	1.8	90	101	47	0.08	0.11	0.16	0.16	7	4.1	0.09	0.21
	70	11.99	6.95	257	164	1.93	364												
	80	11.96	6.94	257	164	1.82	358	1.9	90	102	47	0.06	0.1	0.14	0.16	7			
	88	11.93	6.92	258	165	1.14	360	3.2	90	103	69	0.09	0.12	0.14	0.16	7	4.1	0.08	0.4
9/29/05	0	21.07	8.7	270.1	173	7.8	388	1.4											
	7.33	20.91	8.71	270.4	173	6.93	388												
	14.66	20.3	8.71	270.3	173	7.32	388												
	21.99	20.19	8.71	269.7	173	7.76	388	1.8											
	29.25	20.05	8.69	270	173	7.56	390												
	32.91	17.65	7.7	254.8	163	2.48	396												
	36.58	16.27	7.46	243.6	156	0.46	396	1.1											
	43.91	12.73	7.34	230.8	148	1.14	396												
	51.24	12.24	7.3	229.5	147	1.52	395												
	58.71	12.13	7.29	229.4	147	2.41	394	1.4											
	65.9	12.07	7.3	228.9	147	1.51	394												
	73.3	12.04	7.29	229.6	147	1.82	394												
	80.63	12.01	7.29	229.5	147	1.62	394	2											
	88.03	11.98	7.28	230.4	148	0.98	392	2.8											
10/3/05	0	20.55	8.46	336	215	8.08	453												
	10	20.38	8.45	301	193	7.96	453												
	20	20.29	8.42	302	193	7.79	452												
	30	19.59	7.99	300	192	6.32	452												
	40	13.23	6.94	264	169	3.61	459												
	50	12.4	6.89	262	168	2.25	458												
	60	12.26	6.88	263	168	3.82	457												
	70	12.18	6.88	262	168	2.69	453												
	80	12.13	6.87	262	167	1.78	451												
	84	12.06	6.9	268	171	1.14	453												
10/6/05	0	19.94	8.24	271	173	7.81	451												
	10	19.59	8.22	299	192	7.79	448												
	20	19.38	8.19	299	191	7.47	445												
	30	19.3	8.14	298	191	7.38	444												
	40	13.19	6.91	260	166	2.29	452												
	50	12.54	6.89	258	165	4.6	448												
	60	12.4	6.89	257	164	3.48	444												
	70	12.33	6.88	257	164	3.79	440												
	80	12.27	6.9	257	165	3.09	438												
	88	12.27	6.93	258	165	1.95	406												
10/13/05	0	19.7	8.35	272	174	7.7	311	0.75											
	10	19.2	8.32	273	175	7.6	311												

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
10/13/05	20	19.1	8.22	273	175	7.4	311	0.65											
	30	18.5	7.74	272	174	6.1	314												
	40	13.5	7.22	238	152	3.6	322	0.8											
	50	12.9	7.2	236	151	5.5	323												
	60	12.7	7.19	235	151	5	321	1.2											
	70	12.7	7.21	235	151	5.2	304												
	80	12.6	7.21	235	150	4.9	300	3.8											
	88	12.5	7.23	235	150	3.6	290	6.6											
11/9/05	0	16.18	7.84	220.3	141	10.2	465												
	10	15.92	7.81	219.7	141	10.2	465												
	20	15.86	7.8	219.5	141	9.8	465												
	30	15.84	7.79	219.9	141	9.54	465												
	40	14.56	7.24	203.9	131	10.3	471												
	50	13.92	7.12	199	127	9.65	470												
	60	13.72	7.05	197.5	126	10.9	468												
	70	13.64	7.03	197.7	127	10.3	468												
	80	13.61	7.02	197.7	127	9.58	468												
	86	13.53	7	200.3	128	8.03	439												
12/6/05	0	12.82	8.05	216.4	139	10.9	455	5.26	96	116	33	<0.01	<0.01	0.01	0.02	10	4	0.18	0.06
	10	12.73	8.04	216.7	139	10.9	456												
	20	12.6	7.99	216.7	139	10.5	458	5.79	97	114	34	0.02	<0.01	0.01	0.02	10			
	30	12.56	7.97	216.5	139	10.2	459												
	40	12.56	7.98	216.6	139	10.1	460	5.55	98	116	41	0.01	<0.01	<0.01	0.02	11			
	50	12.52	7.97	216.8	139	10.1	460												
	60	12.5	7.98	216.5	139	9.89	461	6.58	98	116	44	0.02	<0.01	0.01	0.02	10	3.9	0.21	0.07
	70	12.51	7.98	217	139	10.1	461												
	80	12.47	7.97	217.4	139	10.2	463												
	85	12.46	7.96	217.5	139	10.2	454	6.5	97	115	47	0.01	<0.01	0.01	0.02	11	4	0.23	0.07

Appendix C – Snorkel Survey Data

Species (adults)	Number of Fish Observed														
	Pool Number														
	P-1	P-2	P-3	P-4	P-5	P-6	P7	P-10	P-11	P-12	P-13	P-14	P-15	P-16	Total
rainbow trout	0	0	0	0	0	0	0	0	0	5	0	1	0	2	8
Sacramento sucker	0	0	0	0	0	0	0	0	0	0	0	6	0	4	10
Sacramento pikeminnow	0	1	4	0	0	0	0	1	1	0	0	0	0	0	7
California roach	1	125	185	151	150	0	30	5	261	70	65	140	0	230	1,413
prickly sculpin	0	0	0	0	0	0	0	0	0	0	1	0	2	0	3
largemouth bass	0	0	0	0	0	0	0	33	0	0	0	0	0	0	33
unidentified sunfish	0	0	0	0	0	0	0	290	0	0	0	0	0	0	290
Total	1	126	189	151	150	0	30	329	262	75	66	147	2	236	1,764

Species (juveniles)	Number of Fish Observed														
	Pool Number														
	P-1	P-2	P-3	P-4	P-5	P-6	P7	P-10	P-11	P-12	P-13	P-14	P-15	P-16	Total
rainbow trout	0	0	0	0	0	0	0	0	0	54	7	0	0	1	62
Sacramento sucker	245	100	43	4	0	0	0	0	20	0	5	0	0	0	417
Sacramento pikeminnow	0	0	13	0	0	0	0	0	0	0	0	0	0	0	13
California roach	275	2,065	6,050	6,240	3,410	565	2,785	300	9,450	630	770	835	0	1,900	35,275
prickly sculpin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
largemouth bass	0	0	0	0	0	0	0	413	0	0	0	0	0	0	413
unidentified sunfish	0	0	0	0	0	0	0	20	0	0	0	0	0	0	20
Total	520	2,165	6,106	6,244	3,410	565	2,785	733	9,470	684	782	835	0	1,901	36,200

Appendix D – Electrofishing Survey Catch Summary and Population Estimates

Alameda Creek Watershed catch summary for the autumn, 2005 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		9			1	11	9	2	2	- -	16	4	2			
rainbow trout	1		1							- -						
California roach	166	500	177	88	230	68	673	472	1,004	- -	1,239	237	228	640	43	5
Sacramento pikeminnow	3	27	1	6	14	4	13	13	9	- -	104	2				
Sacramento sucker	10	56	13	27	32	28	16	25	118	- -	53	5	3	37	6	1
largemouth bass					1		7			- -		1				
bluegill										- -					1	
prickly sculpin	1	3	6							- -						
Total	181	595	198	121	278	111	718	512	1,133	- -	1,412	249	233	677	50	6

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																56
rainbow trout	20	16	13			6			24	71	43	13	8	10	15	241
California roach	296	79	18	15	2	13	2	14	18							6,227
Sacramento pikeminnow																196
Sacramento sucker																430
largemouth bass																9
bluegill																1
prickly sculpin								25	19			2				56
Total	316	95	31	15	2	19	2	39	61	71	43	15	8	10	15	7,216

** Site 6-3 was incorporated into Sites 6-2 and 6-4 this year due to stream morphological changes.*

Alameda Creek Watershed population estimates for the autumn, 2005 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		14			1	17	12	2	2	- -	21	8	2			
rainbow trout	1		1							- -						
California roach	204	514	180	102	250	68	713	525	2,301	- -	1,423	293	279	739	46	6
Sacramento pikeminnow	3	28	1	6	14	4	13	14	10	- -	114	2				
Sacramento sucker	11	57	13	28	32	28	16	25	134	- -	60	5	3	42	6	1
largemouth bass					1		7			- -		1				
bluegill										- -					1	
prickly sculpin	1	3	6							- -						
Total	220	616	201	136	298	117	761	566	2,447	- -	1,618	309	284	781	53	7

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																79
rainbow trout	20	16	13			6			28	108	65	13	8	10	15	304
California roach	323	81	18	15	3	15	2	14	18							8,132
Sacramento pikeminnow																209
Sacramento sucker																461
largemouth bass																9
bluegill																1
prickly sculpin								26	19			2				57
Total	343	97	31	15	3	21	2	40	65	108	65	15	8	10	15	9,252

** Site 6-3 was incorporated into Sites 6-2 and 6-4 this year due to stream morphological changes.*

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

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		*/**	16.116	0.709	2.434			*/**		*/**	1.437	2.516	0.367			*/**
3-1	***		5.044	1.996	1.650			0.266	***		1.081	0.449	2.389			0.509
3-2		*/**	2.360	*/**	0.331			0.142		*/**	0.245	*/**	0.927			0.205
4-1			8.106	1.355	1.659						2.716	1.848	5.545			
4-2	*		7.949	1.017	1.025	*/**			*		3.409	6.501	3.878	*/**		
4-3	***		1.062	0.205	0.438				***		1.700	0.343	1.684			
5-1	6.452		9.910	0.187	1.087	**			0.970		2.022	4.743	0.680	**		
6-1	1.038		13.907	2.156	0.725				5.786		0.891	1.902	0.788			
6-2	**		352.65	2.704	8.286				**		28.577	3.105	1.684			
6-3^																
6-4	7.626		28.692	5.953	5.684				1.307		2.154	0.124	0.138			
7-1	17.588		19.815	0.384	1.189	*			1.244		0.117	0.929	7.923	*		
7-2	1.038		18.372		**				2.786		6.844		**			
7-3			21.459		4.943						0.417		2.621			
8-1			3.105		**		*/**				0.101		**		*/**	
8-2			3.572		*/**						1.651		*/**			
10-1		0.735	9.334							1.205	0.867					
10-2		0.410	2.145							1.373	0.560					
10-3		0.331	0.976							0.927	0.610					
11-1			0.595								0.147					
11-2			***								***					
12-1		0.051	3.472							0.220	1.251					
12-2			**								**					
13-1			1.006					1.640			4.896					1.001
13-2		4.859	1.153					0.620		1.770	2.692					0.134
14-1		26.781								0.135						
14-2		***								***						
15-1		0.298						**		0.023						**
15-2		1.056								2.671						
15-3		0.346								0.038						
15-4		0.917								0.435						

^ Site 6-3 was incorporated into Sites 6-2 and 6-4 this year due to stream morphological changes.
* 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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