Alameda Creek
Aquatic Resource Monitoring Report
2007

SFPUC
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NATURAL RESOURCES DIVISION

Alameda Creek
Aquatic Resource Monitoring Report
2007

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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 expects to 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, while at the same time affording a reliable drinking water supply, prior to the replacement of Calaveras Dam.

The National Oceanographic and Atmospheric Administration's 1997 listing of Central California Coast steelhead as threatened was also not considered in the drafting of the MOU, although under its terms the 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 both the Calaveras Dam Replacement Project and a 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 2012.

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 tenth year of pre-water release monitoring (January, 2007 through December, 2007). 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 incorporates the findings of the sixth year of the additional monitoring. Also included this year, for the first time, are Alameda Creek water temperature monitoring data through the Niles Canyon and flood control reaches.

Peak flows in Alameda and Calaveras creeks and Arroyo Hondo occurred between January and early March, when seasonal storms resulted in typical fluctuations in the amount of water moving through stream channels. The greatest maximum daily mean flow in 2007 in the upper watershed (upstream of Alameda Creek's confluence with Arroyo de la Laguna) was recorded in Arroyo Hondo. Average annual daily mean flows were also greatest in the Arroyo Hondo. Average annual flows in Calaveras and San Antonio creeks, downstream of Calaveras and Turner dams, respectively, were drastically lower that those measured at all other sites within the Alameda Creek watershed. Flows in Niles Canyon, on the other hand, were considerably higher.

Water storage volumes in Calaveras Reservoir never dropped below the 30,000 acre-feet minimum storage criteria defined in the MOU. Reservoir volumes also remained below the DSOD imposed maximum, due mainly to relatively few winter and spring storms and February increases in demand.

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 or above saturation throughout most of the water column for the entire year thanks to the operation of a hypolimnetic oxygenation system (HOS). The pH ranged from a low of 6.4 in both mid-July and November to a high of 8.7 in mid-June and early August. The highest turbidities in Calaveras Reservoir were measured in early March, with a high of 22 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 for the second consecutive year, never exceeding 0.18 mg/L. Plankton concentrations in Calaveras Reservoir reached nuisance levels on only one occasion in 2007, but the blue-green algae bloom was short lived and there were consequently no treatment applications.

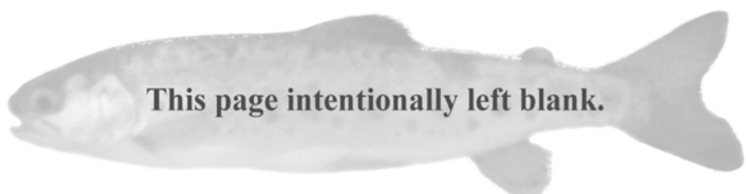
Stream water temperatures were highly variable, both temporally and spatially. Water temperatures in Alameda Creek in the lower study reach were generally higher than temperatures in the upper study reach throughout the year. The highest water temperatures at all stations in both reaches occurred from early July through early September. Following those months the temperatures in both study reaches gradually decreased over the remainder of the year, with the lowest temperatures measured from mid- to late December. The stations in Calaveras Creek had the least amount of mean daily water temperature variability, while the Alameda Creek stations below the confluence of Alameda and Calaveras creeks and near the "W" tree upstream of Little Yosemite had the highest variability's. A single Arroyo Hondo pool with temperature sensors at both the surface and bottom showed signs of stratification, with waters near the bottom showing virtually no variability. In comparison to the MOU reaches discussed above, the Niles Canyon and flood control channel stations, monitored for the first time this year, had both the highest average water temperatures and some of the greatest daily temperature fluctuations.

Turbidity and pH in Alameda, Calaveras, La Costa and Indian creeks and Arroyo Hondo, measured during electrofishing surveys, were all within the tolerance limits of rainbow trout and native, warm water fishes. Dissolved oxygen concentrations at the Calaveras Creek sites, some of the downstream-most Alameda Creek sites, and the Indian Creek sites, were low enough to stress fishes, with the concentration in one pool in Calaveras Creek low enough to exclude all but the most tolerant fishes.

Ten rainbow trout redds (four in the MOU reach and six upstream of the Alameda Creek Diversion Dam) were observed during seven days of Alameda Creek spawning surveys. All of the redds were found following significant storm events, toward the base of the resulting hydrograph's receding limb, with nine of the ten recorded during the February 21, 2007 survey.

Resident rainbow trout were not observed in Calaveras Creek just upstream of Alameda Creek during snorkel surveys, while they were found at only a single Alameda Creek site downstream of its confluence with Calaveras Creek. They were, however, encountered at each of the Arroyo Hondo sites. There were also six other species of fishes observed in the thirteen pools surveyed. California roach were the most abundant species, while roach and Sacramento sucker were the most widely distributed. Largemouth bass and sunfishes, the only non-native fishes observed, were found in Calaveras Creek and several pools in Alameda Creek downstream of its confluence with Calaveras Creek.

Twenty-eight habitat units (riffles, runs, glides, and shallow pools) from thirteen stations were sampled using electrofishing gear. A total of eight species of fishes were collected, including, in descending abundances, California roach, rainbow trout, Sacramento sucker, Sacramento pikeminnow, prickly sculpin, Pacific lamprey ammocetes, largemouth bass and Western mosquitofish. The highest density of rainbow trout within Alameda Creek was found upstream of Calaveras Creek at the Little Yosemite step pool site. Resident rainbow trout were collected at only two sites (but not all habitat types) in Alameda Creek downstream of its confluence with Calaveras Creek, with abundances relatively low at each. A single trout was collected from Alameda Creek upstream of the Diversion Dam, while none were found at the site just below the structure. Rainbow trout were not collected in Calaveras Creek, but were found in La Costa Creek, Indian Creek and Arroyo Hondo. While California roach were found just about everywhere, with the exception of La Costa and Indian creeks, lamprey ammocetes, Sacramento sucker and largemouth bass were restricted to Alameda Creek downstream of the Little Yosemite area and Calaveras Creek.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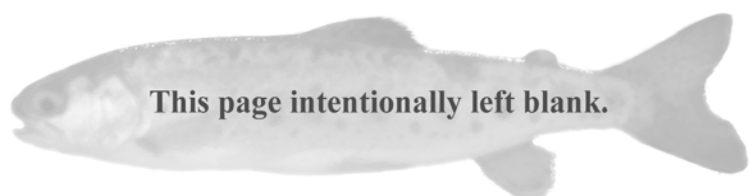
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1.0 Introduction

Storage of water at Calaveras Reservoir on Calaveras Creek, a tributary to Alameda Creek, first occurred in 1916 (Hagar, et al., 1993) by Spring Valley Water Company (SVWC). Calaveras 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 included in the original plans for Calaveras Dam, to secure storage of runoff from the upper Alameda Creek Watershed in Calaveras Reservoir.

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.

Figure 1-1. *Lower Arroyo Hondo.*

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 the water stored in Calaveras Reservoir is derived from the Arroyo Hondo drainage (Figure 1-1), but with the completion of the Diversion Dam and Tunnel in 1931, the SFPUC began acquiring a significant volume of water from Alameda Creek several miles upstream of its confluence with Calaveras Creek (EDAW, 1998). Flows from upper Calaveras Creek and other small tributaries also contribute to the reservoir.

Prior to 1934, the SFPUC released water from Calaveras Reservoir into Calaveras and Alameda creeks, recapturing it at the Sunol Infiltration Gallery (Bookman-Edmonston, 1995). Since 1934, however, water management by the SFPUC within the Alameda Creek Watershed has led to diminished streamflows in Calaveras Creek below Calaveras Dam, Alameda Creek downstream its confluence with Calaveras Creek, and to a lesser extent below the Diversion Dam. Most of the flows in Alameda Creek today, during normal rainfall years, come from leakage through Calaveras and the Diversion dams, groundwater seepage through geologic formations and runoff from the lower, drier portion of the watershed.

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 aspects 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 resident 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 extirpating established fish populations, the Alameda Creek Water Resources Study proposed a flow management plan that would create suitable habitat in the upper portion of the reach for cold water species, while maintaining existing 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 both the degree of improvement of habitat conditions for cold water fishes and maintenance of habitat for warm water fishes.

The MOU requires that the SFPUC establish 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 2007 pre-water release monitoring program. It has been supplemented with additional monitoring to provide a more comprehensive watershed-based 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 through the upper reaches varying from between one to five percent. 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.

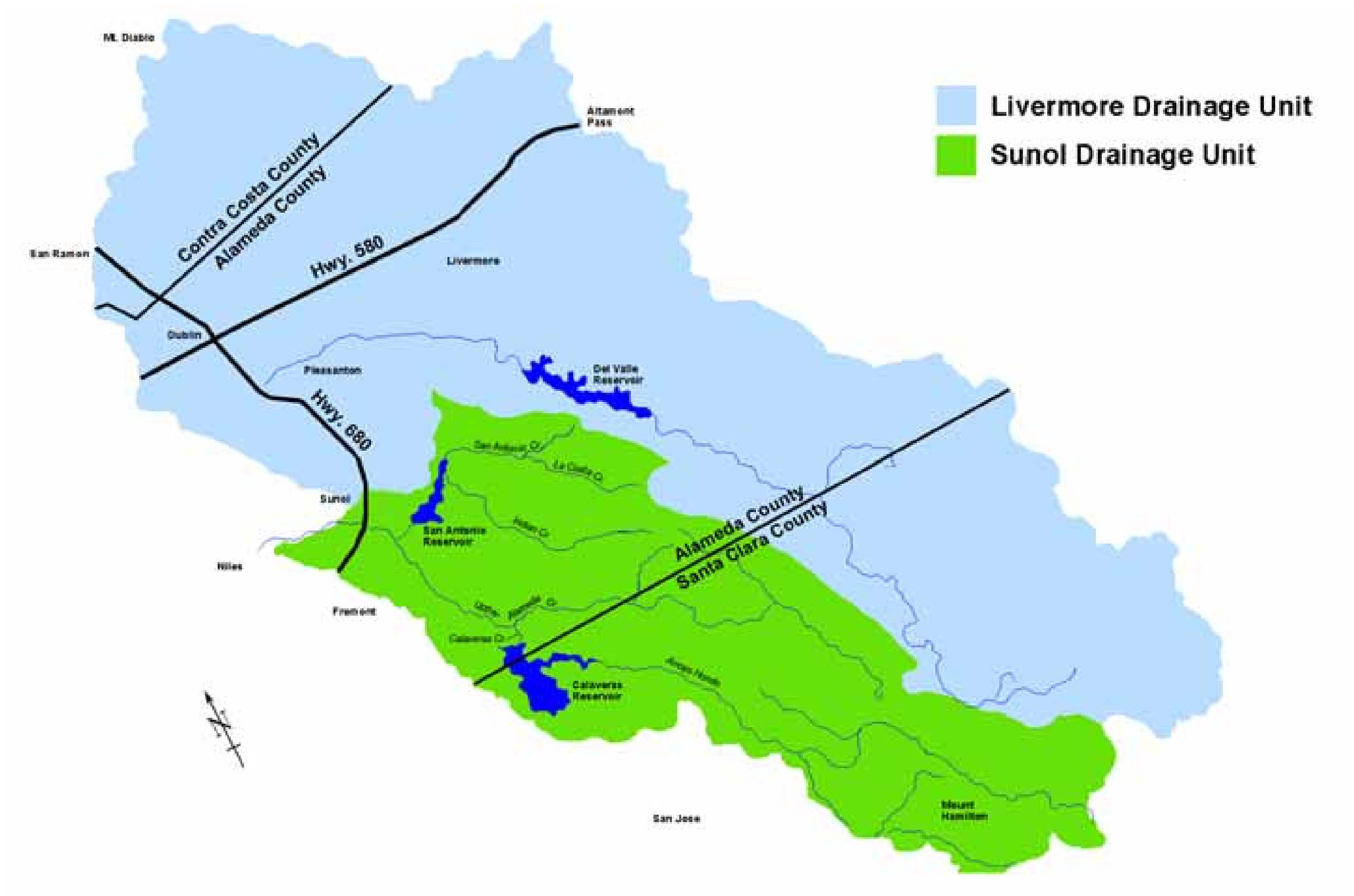


Figure 2-1. *Alameda Creek watershed.*

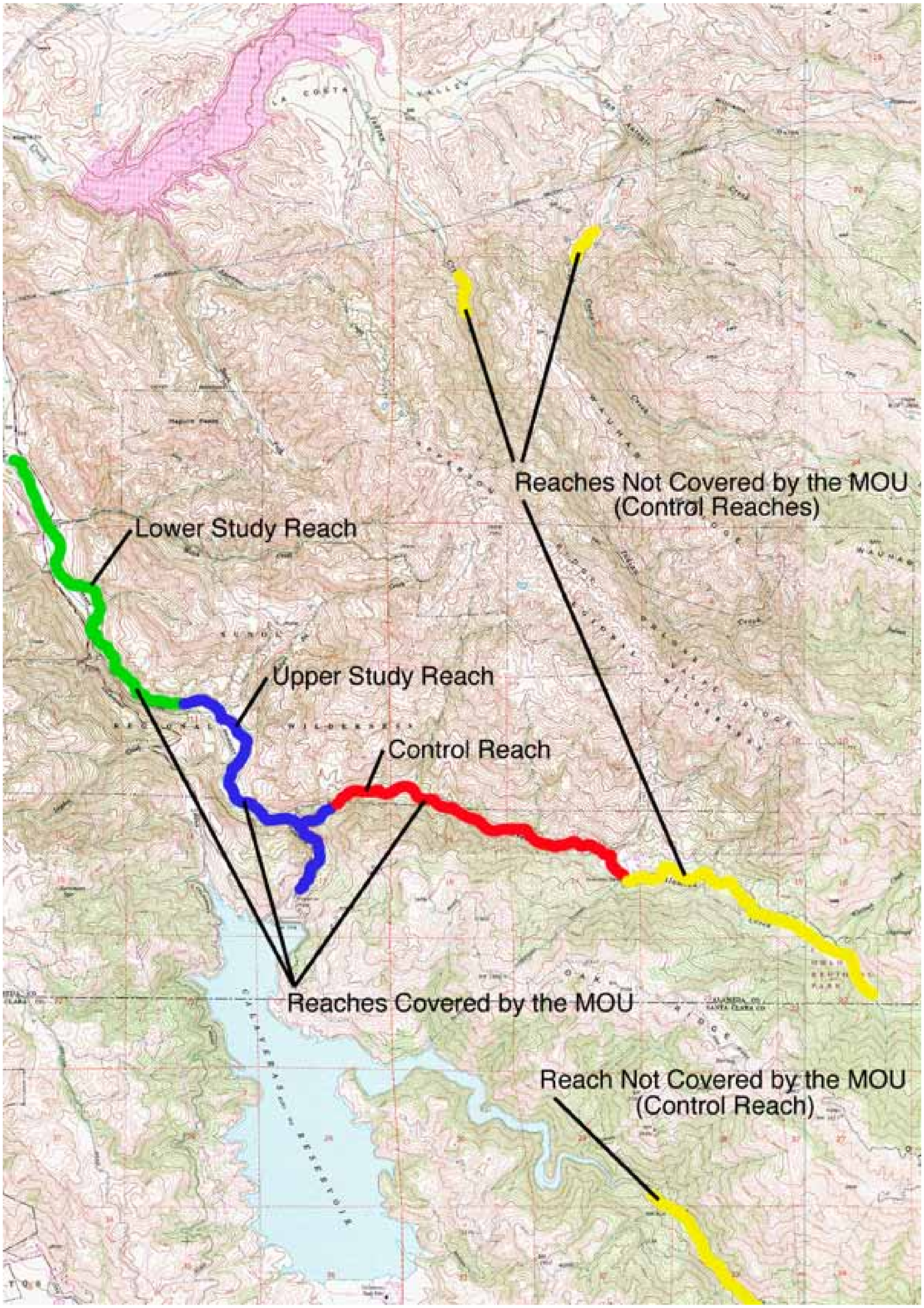
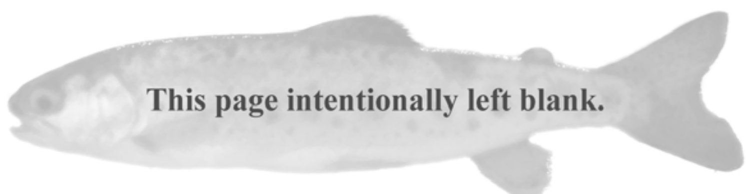


Figure 2-2. *Alameda and Calaveras creek reaches covered by the MOU between the SFPUC and CDFG, plus additional reaches added to the monitoring program to take a watershed approach to restoration.*

The MOU (CDFG, 1997) between CDFG and SFPUC 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 include waters in Alameda Creek upstream of the Diversion Dam and waters in a small portion of La Costa Creek upstream of San Antonio Reservoir. The program was expanded again in 2003, adding waters in parts of Indian Creek upstream of San Antonio Reservoir and Arroyo Hondo upstream of Calaveras Reservoir. Temperature monitoring was increased even further in 2007 to include Alameda Creek through Niles Canyon and the flood control channel. Water temperature monitoring duration was also modified in 2007 to encompass the entire calendar year.

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 originally proposed water recapture facility in Alameda Creek, near the Sunol Valley Water Treatment Plant. Although the third reach covered by the MOU, from the base of Little Yosemite upstream to the Alameda Creek Diversion Dam, is partially regulated by diversions when the Diversion Dam is in operation, it will not be influenced by water releases from Calaveras Reservoir and is considered a control reach where cold water fishes are known to be present under existing conditions.

The reaches in Alameda Creek upstream of the Alameda Creek Diversion Dam and downstream of Sunol valley to San Francisco Bay, 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, some with known populations of resident rainbow trout and some without, are not expected to be influenced by water releases from Calaveras Reservoir and are considered supplementary reference reaches. The conditions at these reference reaches (including but not limited to water quality, fish community structure and fish population densities), which are assumed to be favorable to the survival of warm and cold water fishes, will be compared to the conditions found in the reaches of Alameda Creek influenced by water releases to assess project success.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3.0 Streamflows

3.1 Background

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

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

3.2 Procedure

An initial component of the project is to assess the existing flow rates in upper Alameda Creek so that there are data available to compare to the minimum flow requirements in the 1997 MOU. Daily mean flow data from seven USGS streamflow gauges are included in the report (Table 3-1, and Figure 3-1). The 2007 report has been expanded to include the San Antonio Creek and the Alameda Creek near Niles gauges. Provisional and approved daily mean streamflow values, in cubic-feet per second (cfs), were downloaded from the United States Geological Survey (USGS) website for streamflow data; http://waterdata.usgs.gov/nwis/sw.

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 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.
USGS 11179000	37° 35.23′ N 121° 57.58′ W	Alameda Creek near Niles in Niles Canyon.
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 11174000	37° 34.65′ N 121° 51.40′ W	San Antonio Creek below Turner Dam.

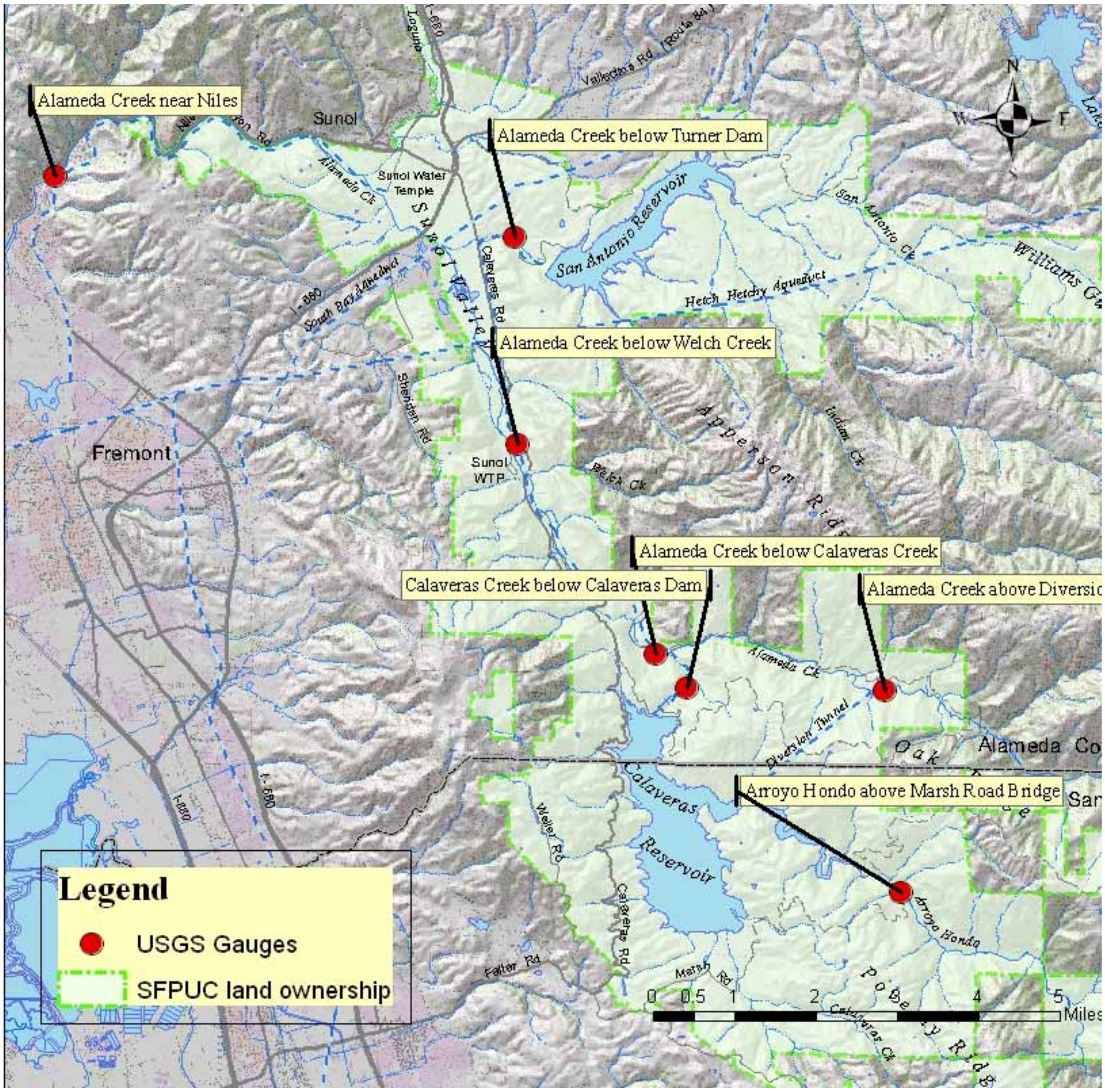


Figure 3-1. *United States Geological Survey streamflow gauging stations in the Alameda Creek Watershed.*

Streamflows throughout the Alameda Creek Watershed were consistently lower during 2007 than the median values observed in the watershed over the recent period of record (10 years). Streamflows dropped to less than recordable levels for periods of time at two of four Alameda Creek gauges and at the San Antonio and Calaveras creek gauges. All seven gauges reported maximum annual flows on February 26 or 27, 2007.

3.3 Results

3.3.1 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. Daily flows averaged 5.9 cfs, ranging from no recordable flow during most of August and September, 2007, to 330 cfs on February 26, 2007 (Figure 3-2).

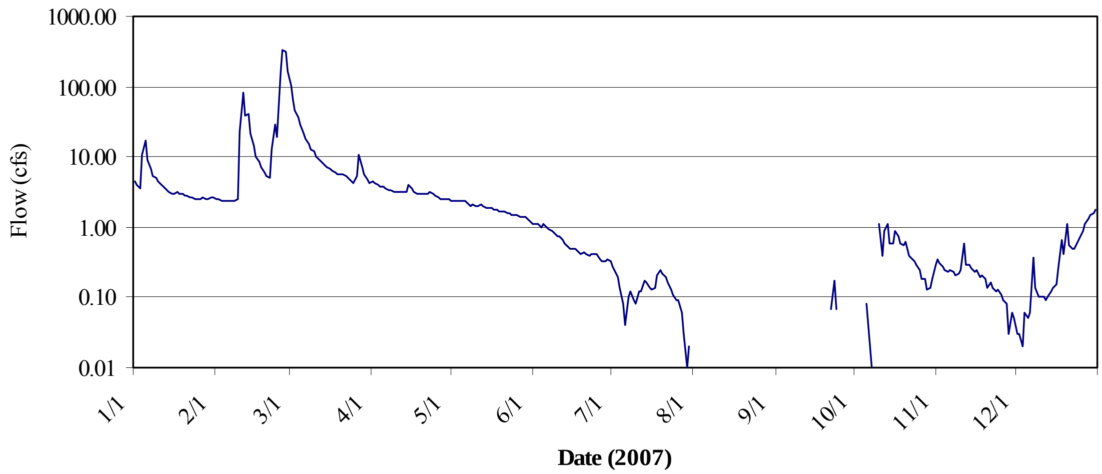


Figure 3-2. Daily mean streamflows recorded at USGS station 11172945, located in upper Alameda Creek above the Alameda Creek Diversion Dam, for 2007.

3.3.2 USGS 11173510 Streamflows

The USGS streamflow gauge located in Alameda Creek in Sunol Regional Park is a low-flow gauge only, calibrated for flows of up to 200 cfs. Daily flows exceeded 200 cfs on two days, with a peak of 451 cfs on February 26, 2007. Daily flows averaged 6.4 cfs. A minimum flow of 0.08 cfs was recorded on November 7, 2007 (Figure 3-3).

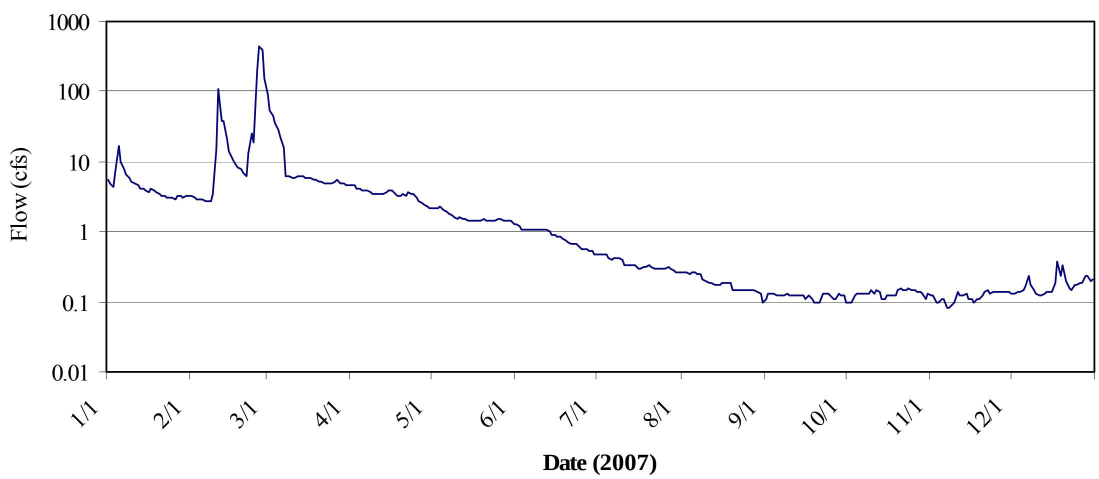


Figure 3-3. *Daily mean streamflows recorded at USGS station 11173510, located in upper Alameda Creek in Sunol Regional Park, for 2007.*

3.3.3 USGS 11173575 Streamflows

The average daily flow at the streamflow gauge located in Alameda Creek downstream of its confluence with Welch Creek, near the Sunol Valley Water Treatment Plant, was 7.0 cfs, with an annual maximum of 445 cfs recorded on February 27, 2007. There were no recordable flows between August 30 and September 8, 2007 (Figure 3-4).

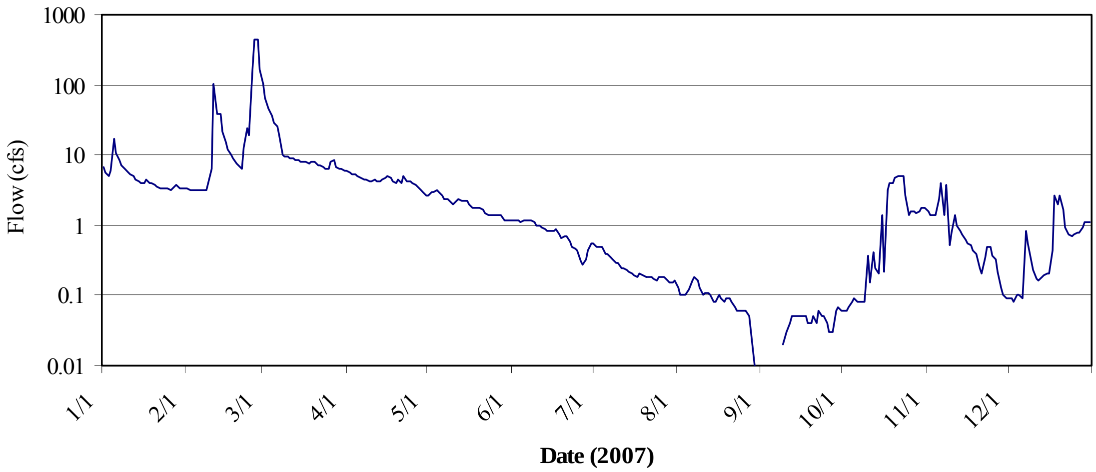


Figure 3-4. *Daily mean streamflows recorded at USGS station 11173575, located downstream of the confluence of Alameda and Welch creeks, for 2007.*

3.3.4 USGS 11179000 Streamflows

An average daily flow of 59.0 cfs was recorded at the streamflow gauge located in Alameda Creek in Niles Canyon near Niles, CA. Daily flows ranged from 15 cfs on August 29, 2007 to 1,220 cfs on February 27, 2007 (Figure 3-5).

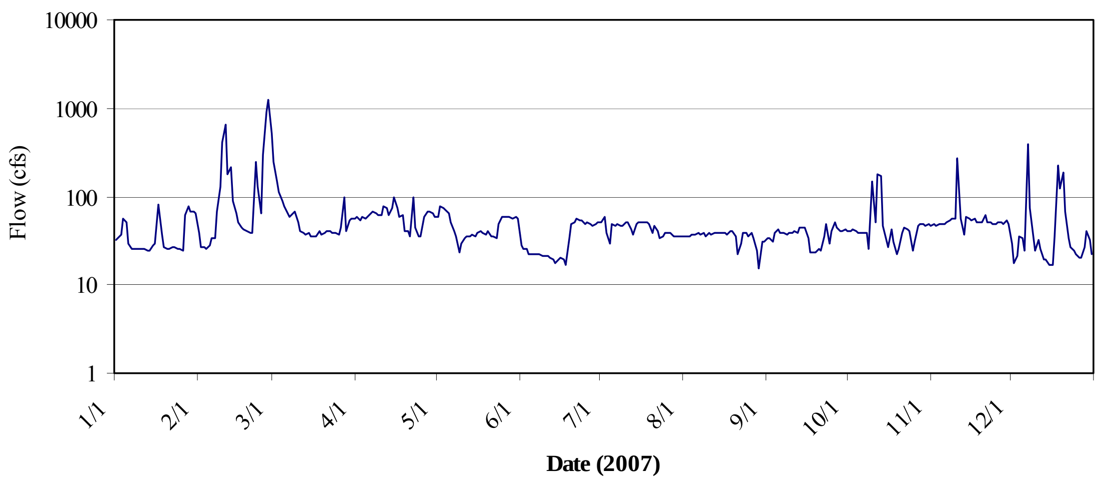


Figure 3-5. *Daily mean streamflows recorded at USGS station 11179000, located in Alameda Creek in Niles Canyon near Niles, CA, for 2007.*

3.3.5 USGS 11173200 Streamflows

Located in Arroyo Hondo upstream of the Marsh Road Bridge, this streamflow gauge collected data for the entire year. Measurements averaged 10.5 cfs, with a minimum daily mean flow of 0.14 cfs recorded on September 6, 2007 and maximum daily mean flow of 614 cfs recorded on February 27, 2007 (Figure 3-6).

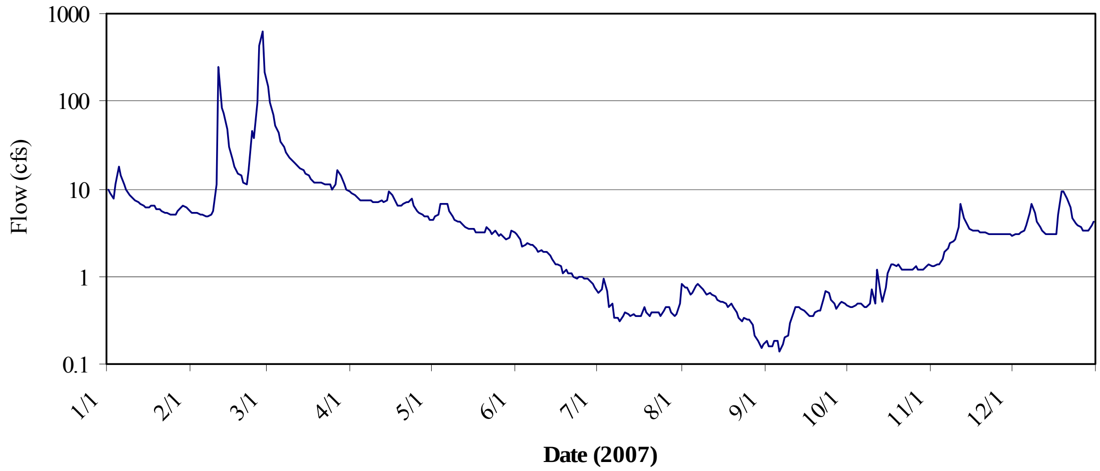


Figure 3-6. *Daily mean streamflows recorded at USGS station 11173200, located in Arroyo Hondo at the Marsh Road Bridge, for 2007.*

3.3.6 USGS 11173500 Streamflows

Located in Calaveras Creek at the second weir downstream of Calaveras Dam, this streamflow gauge collected data throughout the year. No water was released from Calaveras Dam during 2007. Flows averaged 0.04 cfs and ranged from 0.01 cfs in June, 2007 to 0.17 cfs on February 26, 2007 (Figure 3-7).

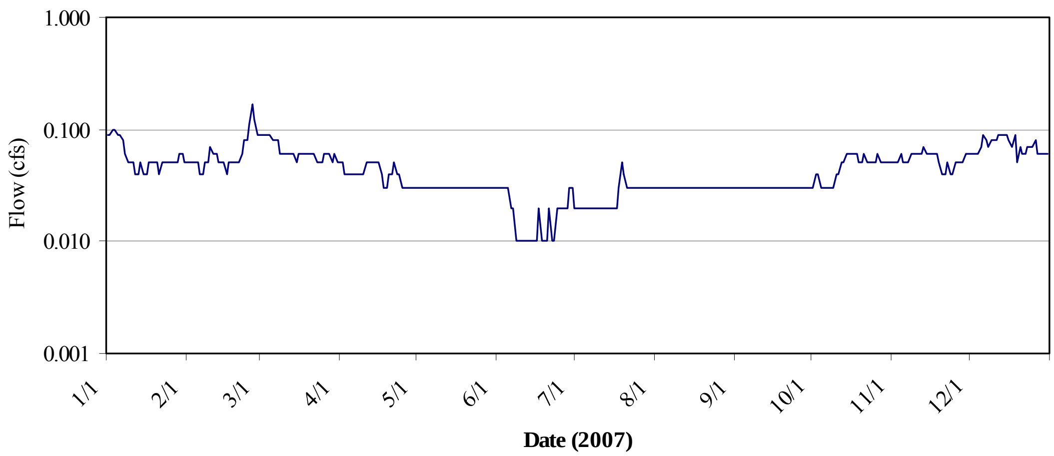


Figure 3-7. *Daily mean streamflows recorded at USGS station 11173500, located in Calaveras Creek below Calaveras Dam, for 2007.*

3.3.7 USGS 11174000 Streamflows

An annual average flow of 0.09 cfs was recorded at the streamflow gauge located in San Antonio Creek 0.6 miles downstream of Turner Dam at San Antonio Reservoir. A maximum daily mean flow of 1.1 cfs was measured on February 27, 2007. There were no recordable flows during the majority of the period between July 5 and September 23, 2007 (Figure 3-8).

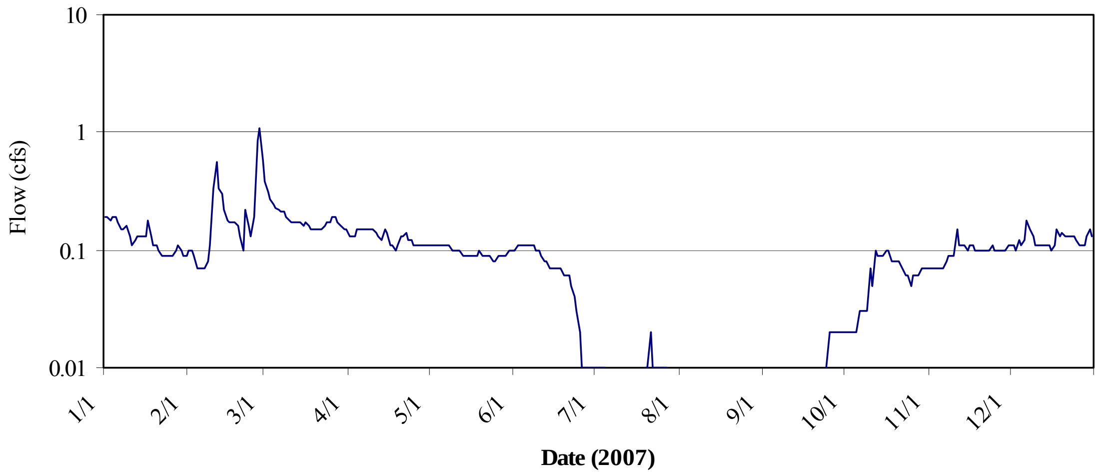


Figure 3-8. *Daily mean streamflows recorded at USGS station 11174000, located in San Antonio Creek 0.6 miles downstream of Turner Dam, during 2007.*

4.0 Calaveras Reservoir Conditions

4.1 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 depth-related variability's of some water quality parameters occurring in stratified reservoirs, the quality of release water has the potential to 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 and therefore available to supplement stream flows. Historical data show that this requirement can be met by maintaining a minimum storage volume of 30,000 acre-feet from July through October. In 2003, however, the Department of Water Resources' Division of Safety of Dams (DSOD) issued a final opinion that placed a maximum storage restriction of approximately 38,000 acre-feet on Calaveras Reservoir (DSOD, 2003). 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, 2007) (Table 4-1). During the summer of 2005, in efforts to improve reservoir water quality, the SFPUC had a hypolimnetic oxygenation system (HOS) installed in Calaveras Reservoir (SFPUC, 2006). This is the second year of operation of the HOS and the quality of water available for release now meets all applicable objectives of the Basin Plan.

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
3 month average	≥ 80% of DO saturation value
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 San Francisco Bay
** specific to Alameda Creek Watershed above Niles

4.2 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. Data are presented in acre-feet in this report. Natural Resources and Lands Management Division biologists monitor Calaveras Reservoir water quality conditions approximately twice monthly (Appendix B). Sampling includes measurements taken at ten-foot intervals using a Hydrolab® multi-parameter probe that records *in-situ* water quality conditions including temperature, conductivity, pH, dissolved oxygen (DO) and oxidation-reduction potential. In addition, 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 and 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 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. Samples are collected and analyzed for copper only when the reservoir is treated with copper sulfate (to control noxious algae blooms). Additional samples for copper may also be collected for special studies and regulatory compliance.

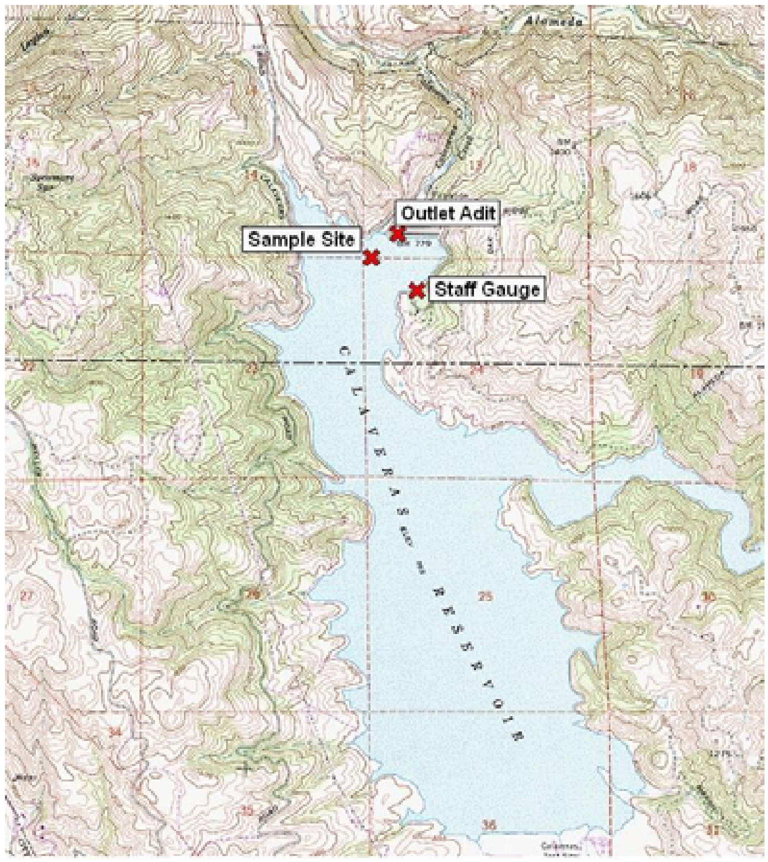


Figure 4-1. *Map of Calaveras Reservoir.*

4.3 Results

4.3.1 Water Storage

Calaveras Reservoir was operated to comply with both the DSOD restriction and the requirement to maintain the recommended 30,000 acre-feet of storage throughout 2007 (Figure 4-2). Due to the lack of major storm events, and the SFPUC's need to provide additional drinking water during a scheduled Hetch Hetchy supply shutdown, that objectives were met for the entire year.

Reservoir storage started to decrease in February due to increased demands at the Sunol Valley Water Treatment Plant. In late February, however, several storms produced enough rainfall to result in a peak annual inflow from Arroyo Hondo of 1,680 cfs. The flow in Arroyo Hondo had dropped to below 20 cfs by April, and continued decreasing until seasonal rains returned in October. Reservoir storage also declined slowly during this six month period, but stayed within the range required to maintain the cold water pool below the thermocline.

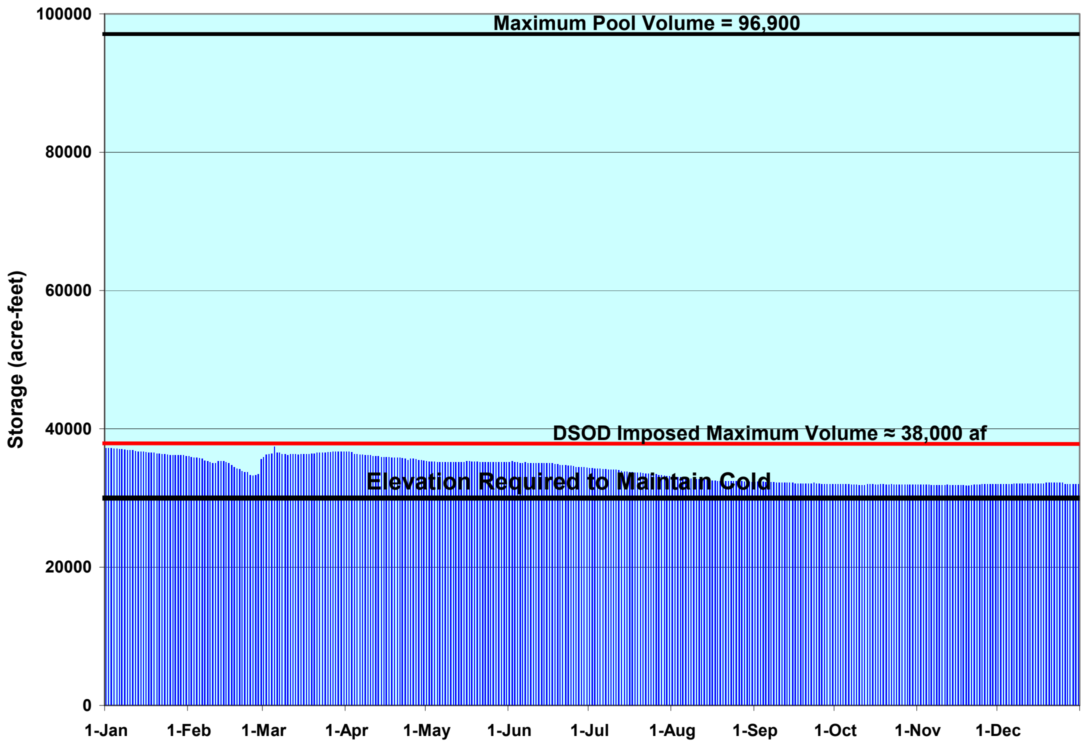


Figure 4-2. *Calaveras Reservoir daily storage 2007*

4.3.2 Water Quality

Temperature

The onset of thermal stratification at Calaveras Reservoir in 2007 was earlier than in 2006. In 2007 the reservoir remained stratified to some degree from mid-March through late November. The thermocline formed at about 20-feet below the surface at the beginning of the process, and gradually lowered to around 40-feet as the summer progressed into autumn. The maximum and minimum reservoir water temperatures recorded were 24.4°C on August 8 and 7.9°C on February 2, 2007, respectively. Both the high and the low temperatures were cooler than those recorded during the previous year.

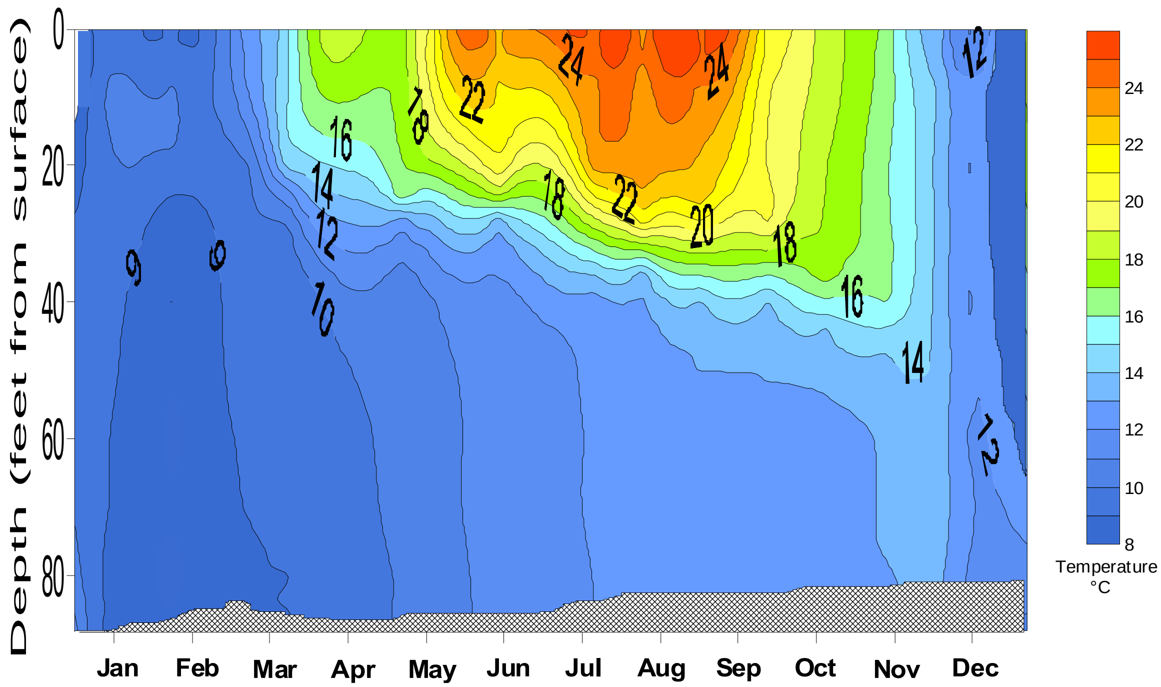


Figure 4-3. *Calaveras Reservoir water temperature profile for 2007.*

Dissolved Oxygen

Dissolved oxygen concentrations in Calaveras Reservoir remained at or above Basin Plan objectives throughout most of 2007 (Figure 4-4). Oxygen concentrations near the bottom fell below the Basin Plan "cold water" target of 7.0 mg/L for a short period in April. At that time, the hypolimnetic oxygenation system was brought into operation and concentrations increased quickly. Dissolved oxygen levels started falling again in September due to reduced oxygen flow to the diffusers. The decrease in flow was necessitated when trucks were required to cease delivery of oxygen to the storage tank on top of the dam. Ultimately, the system had to be shut down. The HOS disruption resulted in reservoir dissolved oxygen concentrations falling to below Basin Plan levels, but only for a short time prior to the annual turnover that "re-oxygenated" waters through natural processes. The highest DO concentration recorded in 2007 was 15.9 mg/L on August 6 and the lowest was 3.5 mg/L on October 15.

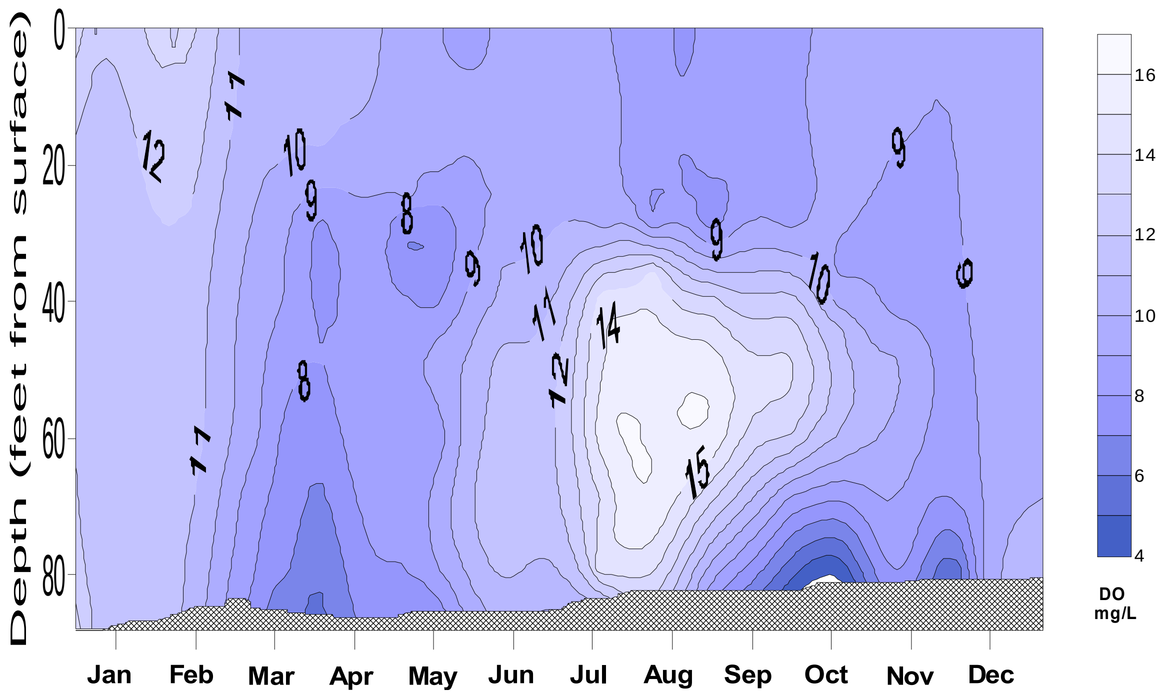


Figure 4-4. *Calaveras Reservoir dissolved oxygen profile for 2007.*

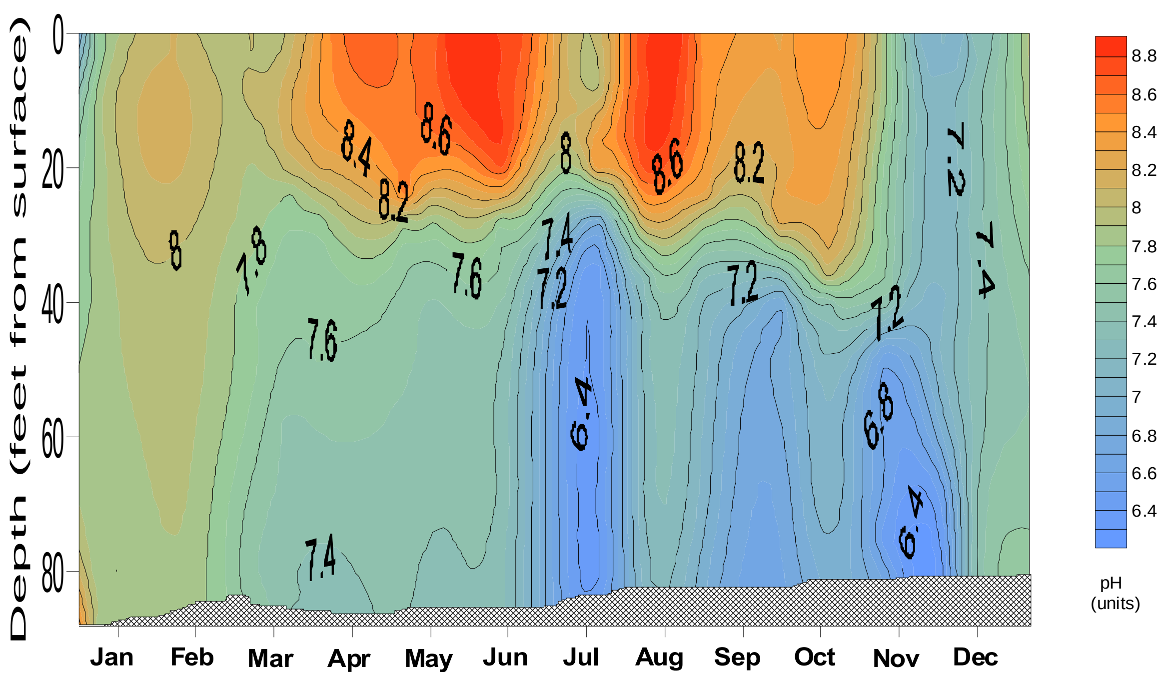


Figure 4-5. *Calaveras Reservoir pH profile for 2007*

<u>*pH*</u>

Calaveras Reservoir pH values ranged from 6.37 near the bottom on July 19 to 8.74 near the surface on August 6, 2007 (Figure 4-5). The low value is slightly below the lowest recorded the previous year, while the high value is identical to that of 2006. Lower pH values near the bottom of the reservoir are usually associated with biological respiration, which increases the available carbon dioxide. This affects the equilibrium reactions occurring and allows the formation of carbonic acid, which consequently lowers the pH. The process of photosynthesis consumes carbon dioxide near the surface affectively raising pH, with the process intensifying during algae blooms. As in past years, the higher pH waters near the surface mix with deeper waters during and after the reservoir turnover process resulting in a more-or-less orthograde (straight line) condition. This year's post-turnover pH of 7.4 was slightly lower than the pH following the 2006 turnover.

<u>Turbidity</u>

Turbidity in Calaveras Reservoir is affected by a combination of storm runoff, plankton and, before the HOS was installed, anoxia. As in previous years, the first

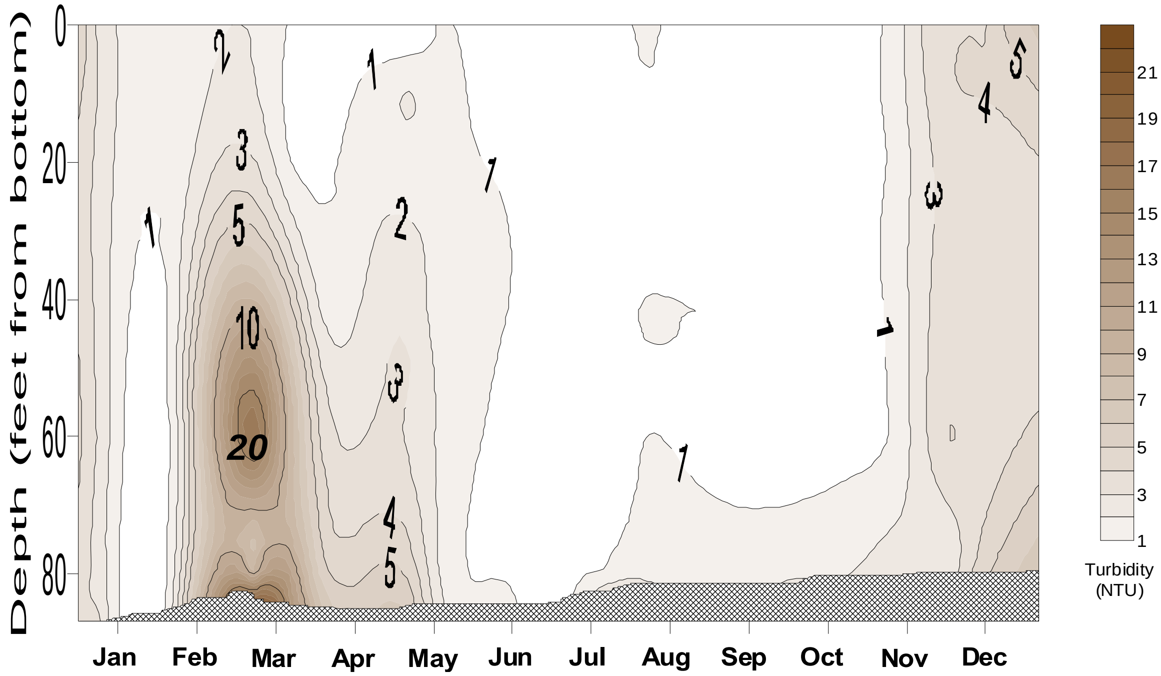


Figure 4-6. *Calaveras Reservoir turbidity profile for 2007.*

significant rains of the season drove turbidity up as the inflow cut through the alluvial flat where Arroyo Hondo meets the reservoir (Figure 4-6). The first and only significant rainfall events this year occurred in February. There was very little precipitation for the remainder of the winter and spring. During this relatively dry period the reservoir entered a settling pattern as suspended sediments slowly sank to the bottom. Turbidities remained very low until October when they was affected by the return of rain coupled with the annual "turnover." The highest annual turbidity, measured on March 6, 2007, was 22 NTU. The lowest turbidity was measured on May 7 at 0.7 NTU.

Ammonia

Ammonia concentrations in 2007 (Figure 4-7) were lower than many of the years previously monitored. While speculations about why is beyond the scope of this report it is probable that the HOS is at least partly responsible for the change.

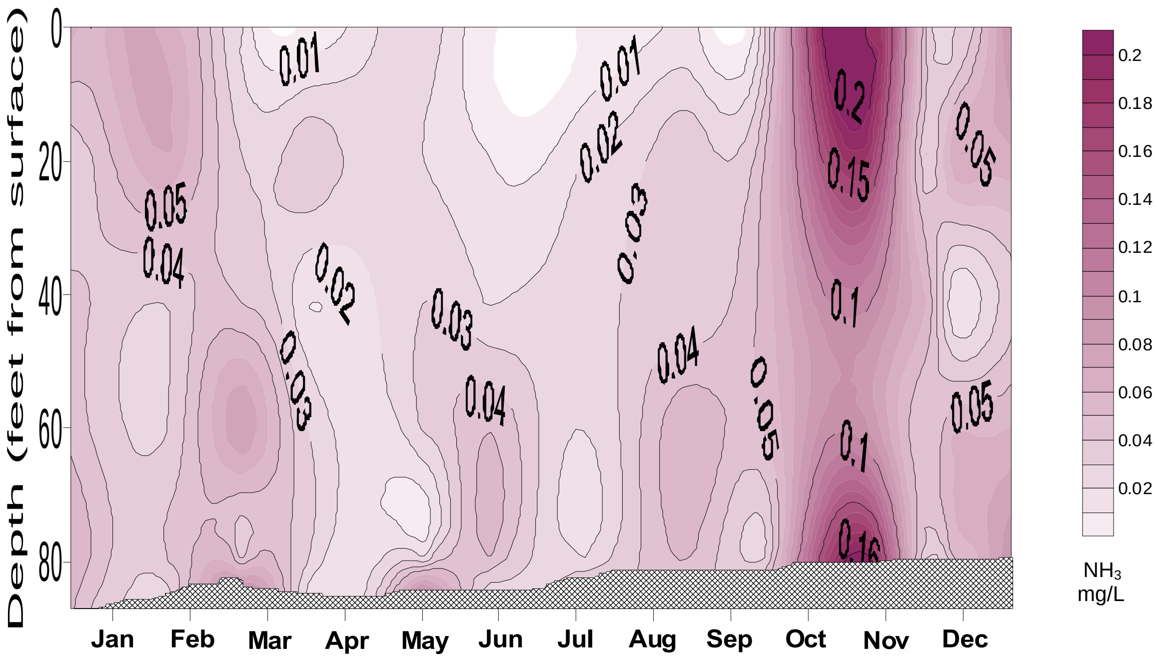


Figure 4-7. *Calaveras Reservoir ammonia (NH_3-N) concentration for 2007.*

The addition of oxygen to the hypolimnion has virtually eliminated the highly reducing environment that used to form in the anoxic water. This, in part, explains the decreased concentrations that are evident near the bottom. The premature shutdown of the HOS this year may have contributed to the increased concentration of ammonia evident in November. Regardless of the reason for the increase, concentrations remained well below the level recommended in the Basin Plan. The lowest concentration in 2007 occurred multiple times, falling below the detection limits of the analytical equipment. The highest concentration of 0.20 mg/L was experienced near the surface on November 5, 2007.

Plankton

Calaveras Reservoir plankton counts in 2007 were relatively low throughout most of the year. In January and February *Mougeotia* reached concentrations of 10 million cells per cubic meter. In October and November *Aphanizomenon*, a problem blue-green algae, reached 32 and 73 million cells per cubic meter, respectively. The bloom was short lived and no treatment was necessary.

Hydrogen Sulfide

Hydrogen sulfide can form in the hypolimnion during periods of severe anoxia. Due to the operation of the hypolimnetic oxygenation system, no hydrogen sulfide odors were detected during 2007 sampling trips.

Copper

Copper was not applied to Calaveras Reservoir in 2007. Copper analyses were, however, conducted for regulatory purposes. A single sample collected on July 10, with a concentration of 4.58 *u*g/L, was well below the Basin Plan objective.

5.0 Stream Water Quality

5.1 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. Apparent reductions in stream flow, channel widening and the loss of riparian vegetation in several areas may 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. *Upgraded temperature recording equipment deployed in 2007.*

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.

5.2 Procedure

Water temperature loggers (Onset, Optic StowAway®, Hobo® H8 and Hobo® Pro V2 temperature recorders; Figure 5-1) were deployed in a variety of protective cases, including PVC and steel pipes, pipe insulation as padding, and proprietary protective sensor sleeves, attached by means of swaged stainless steel cabling to a variety of rebar, stakes, and existing structures as anchors. A typical deployment is pictured in Figure 5-2. Sensor locations are concealed on public lands to prevent tampering or vandalism.

The array of temperature loggers used in monitoring water quality within the study area has gradually expanded from just five locations from Calaveras Creek downstream through Sunol Regional Park in 1998 to 24 locations from near the upstream limits of SFPUC property in tributaries to San Antonio and Calaveras Reservoirs downstream to near San Francisco Bay. Six additional sensor locations were added in the Niles Canyon and flood control reaches of Alameda Creek and at the downstream extent of Arroyo Hondo at Calaveras reservoir. The monitoring period was expanded from only summer and fall months to year-round deployment starting in April 2007. Instruments were launched to record at 30-minute intervals and installed at the 24 locations in Alameda, Calaveras, La Costa and Indian Creeks and Arroyo Hondo between April 9 and 19, 2007 (Table 5-1, Figure 5-3). Water temperature loggers were upgraded from a combination of Optic Stowaway® and Hobo® H8 temperature recorders deployed in April to Hobo® Pro V2 recorders at all locations in late July and early August. Data was downloaded bi-monthly, accomplished without interruption to monitoring by the use of an optic data shuttle (Figure 5-1). The accelerated download frequency allowed for periodic adjustments to sensor position in changing seasonal flow conditions and battery level monitoring. In anticipation of exposure to damaging winter flows, the deployments were ‘hardened’ with more robust anchoring and protective cases during final fall downloads.

Figure 5-2. *Scott Chenue, NRLMD Biologist III, delploying temperature sensor in Alameda Creek.*

Four air temperature/relative humidity loggers (Onset, Hobo® Pro Series Recorders), set to record at 30-minute intervals, were installed at sites near Arroyo Hondo and Alameda, Indian, and La Costa Creeks between April 10 and 13, 2007 (Table 5-1). Loggers were mounted to secure, shaded structures (posts, trees, etc.) near the creeks. All temperature/relative humidity loggers were maintained for continuous year-round deployment.

Instantaneous water temperature, turbidity, pH, conductivity and dissolved oxygen concentrations were measured in each of the electrofishing habitat units (Figure 8-1) during the 2007 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.

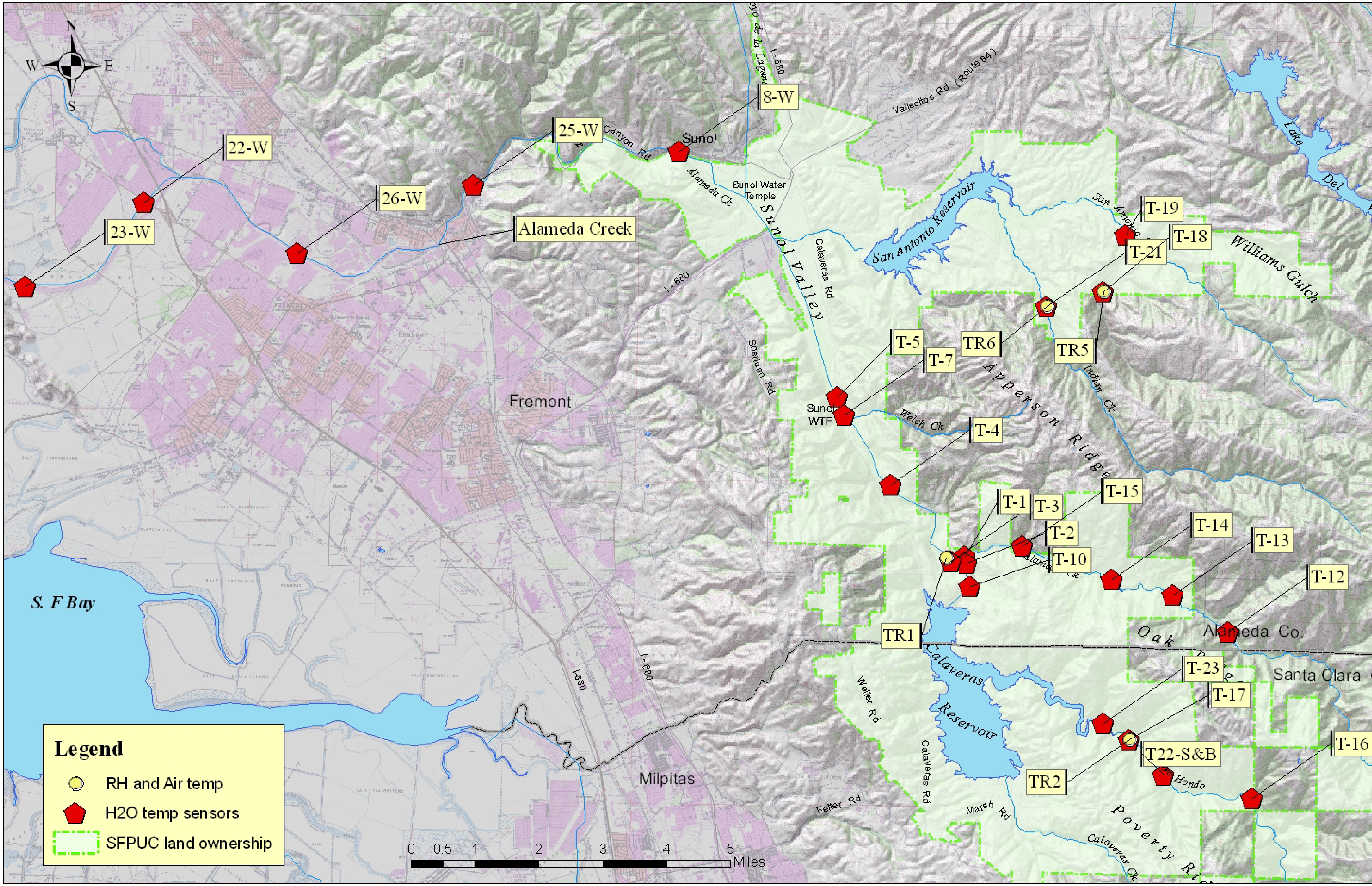


Figure 5-3. Remote temperature recording locations in 2007.

Table 5-1. *Remote temperature recording locations for 2007.*

Station	Deployed	Recorded thru	Coordinates		Location	Site Description
Temperature Sensors						
T-1	4/9/2007	12/31/2007	37° 30.26´ N	121° 49.18´ W	In Alameda Creek, about 650-feet upstream of the Alameda Creek / Calaveras Creek confluence.	Under a large boulder on the right bank of the stream, in the shade, with flowing water.
T-2	4/9/2007	12/31/2007	37° 30.16´ N	121° 49.16´ W	In Calaveras Creek, about 500-feet upstream of the Alameda Creek / Calaveras Creek confluence.	Staked behind large boulder midstream, where flow enters large creek confluence pool.
T-3	4/9/2007	12/31/2007	37° 30.19´ N	121° 49.42´ W	In Alameda Creek, about 500-feet downstream of the Alameda Creek / Calaveras Creek confluence.	Under a large boulder in the middle of the stream, in the shade, with flowing water.
T-4	4/9/2007	12/31/2007	37° 31.11´ N	121° 50.60´ W	In Alameda Creek, about 1,200-feet downstream of the Sunol Regional Park / SFPUC boundary.	Staked on downstream side of large left bank dead tree.
T-5	4/17/2007	12/31/2007	37° 32.40´ N	121° 51.41´ W	In Alameda Creek, about 250-feet upstream of the Sunol Valley Water Treatment Plant bridge.	Hanging from a root-ball on the right stream bank, in the shade, with flowing water.
T-7	4/12/2007	12/31/2007	37° 32.16´ N	121° 51.28´ W	In Alameda Creek, downstream of Welsh Creek.	Attached to a root-ball on the left stream bank, at the bottom of a pool, in the shade, with little flow.
T-10	4/12/2007	12/31/2007	37° 29.87´ N	121° 49.05´ W	In Calaveras Creek, at second weir downstream from Calaveras Dam.	Attached to a rock, in the middle of the channel, just to the right of the opening in the concrete weir.
T-12	4/9/2007	11/16/2007	37°29.28´ N	121°44.67´ W	In Alameda Creek near Camp Ohlone.	Attached to root-ball in left bank of root-ball scour pool near cabin.
T-13	4/9/2007	12/31/2007	37°29.77´ N	121°45.62´ W	In Alameda Creek upstream from Diversion Dam.	Attached to boulder in mid-channel small boulder scour.
T-14	4/9/2007	12/31/2007	37° 29.97´ N	121° 46.67´ N	In Alameda Creek downstream of Diversion Dam.	Attached to stake upstream of large left bank boulder, in deepest part of boulder scour pool.
T-16	4/10/2007	12/31/2007	37°27.02´ N	121°44.21´ W	Arroyo Honda about ½ mile upstream from slide.	Attached to medium sized rock among boulders in middle of channel.
T-15	4/9/2007	12/31/2007	37°30.41´ N	121°48.21´ W	In Alameda Creek near 'W' tree.	Attached to right bank sycamore scour pool root-ball.
T-17	4/10/2007	12/31/2007	37°27.79´ N	121°46.33´ W	Arroyo Hondo about 150' downstream of USGS station (Marsh Rd. bridge)	Attached to root-ball on left bank near trapping site.
T-18	4/12/2007	12/31/2007	37°33.89´ N	121°46.88´ W	La Costa Creek 100' below private property line.	Attached to root-ball in small pool on left bank.
T-19	4/12/2007	12/31/2007	37°34.57´ N	121°46.51´ W	La Costa Creek 400' upstream from confluence with San Antonio Creek.	Attached to stake in left bedrock bank of boulder scour pool.
T-21	4/12/2007	12/31/2007	37°33.67´ N	121°47.85´ W	Indian Creek upstream of where it crosses over Coast Tunnel.	Attached to stake in right bank of shallow bedrock scour pool.
T-22S	4/10/2007	12/31/2007	37°27.317' N	121°45.731' W	Arroyo Hondo about ½ mile upstream from Marsh Rd. bridge.	Attached to small alder on left bedrock bank, deployed with float on surface of pool.
T-22B	4/10/2007	10/29/2007	37°27.317' N	121°45.731' W	Arroyo Hondo about ½ mile upstream from Marsh Rd. bridge.	Attached to small alder on left bedrock bank, deployed on bottom of pool.
T-23	4/10/2007	12/31/2007	37°28.01' N	121°46.79' W	Arroyo Hondo at historic Calaveras Reservoir high water mark.	Attached to right bank willow tree roots.
8-W	4/13/2007	12/31/2007	37°35.71' N	121°54.18' W	Alameda Creek between train bridge tressel abutments downstream of former Sunol Dam site.	Attached to willow roots on right bank, directly across from upstream edge of downstream abutment.
22-W	4/16/2007	12/31/2007	37°34.82' N	121°03.19' W	Alameda Creek ~100yds downstream of the Alvarado/Fremont Blvd bridge.	Attached to stake and anchor in small right bank corner pool among cattails and bullrush.
23-W	4/16/2007	11/7/2007	37°33.73' N	121°05.33' W	Alameda Creek in tidal area near Coyote Hills Regional Park.	Staked in right tidal channel bank, directly across flats from picnic area 1.2 miles from stables.
25-W	4/13/2007	12/31/2007	37°35.21' N	121°57.69' W	Alameda Creek in Niles Canyon USGS gauge concrete apron pool.	Attached to USGS staff gauge steel pipe on right bank, just upstream from concrete apron.
26-W	4/16/2007	12/31/2007	37°34.25' N	121°00.69' W	Alameda Creek upstream of Isherwood Way bridge.	Attached to stake in right bank, ~200' upstream of restrooms on right bank trail.
Temperature & Relative Humidity Sensors						
TR-1	4/13/2007	12/31/2007	37° 30.23´ N	121° 49.51´ W	Adjacent to Alameda Creek, in the Sunol Regional Park, at USGS streamflow station 11173510.	Attached to a staff gauge, on the right side of the stream, in the shade.
TR-2	4/10/2007	12/31/2007	37°27.79´ N	121°46.33´ W	Arroyo Hondo about 150' downstream of USGS station (Marsh Rd. bridge)	Attached to alder tree on left bank of creek near trapping site.
TR-5	4/12/2007	12/31/2007	37°33.89´ N	121°46.88´ W	La Costa Creek 100' below private property line.	Attached to laurel tree on left bank.
TR-6	4/12/2007	12/31/2007	37°33.67´ N	121°47.84´W	Indian Creek upstream of where it crosses over Coast Tunnel.	Attached to alder tree on right bank of creek upstream of temperature sensor.

5.3 Water Temperature

Temperature sensors were deployed during the 2007 season with more robust anchoring hardware to protect the equipment from winter storm conditions during their first year-round deployment. Despite these efforts, three sensors were lost due to flashy winter storms in early 2008 (losing some periods of fall 2007 data still contained in the sensors). Sensors were lost at T12 sometime following the November 16, 2007 download, at T22B after the October 30, 2007 download, and at 23W after downloading on November 7, 2007. Otherwise data sensors collected continuous data following their deployments on April 9, 2007 through April 19th, 2007. Periods of temperature data collected during periods without surface flow were omitted from the record (appearing blank on the figures presented in this chapter) at sensor sites T4, T12, T13, and T15.

Graphical analyses of the sites showed the same general trends with the warmest temperatures occurring from early July to mid-September, tapering off to the coolest temperatures at the end of the year (Figure 5-4).

The lowest maximum temperature of 18.1°C was recorded at T22B, at the bottom of a deep pool in Arroyo Hondo (Table 5-2, Figure 5-21). This station also had the lowest average daily temperature fluctuation of only 0.6°C, providing the most consistently cool temperatures in the study area. The coldest average daily temperature of 13.1°C was recorded at station T21 in Indian Creek (Table 5-2, Figure 5-20). The coldest instantaneous temperature of 1.9°C recorded in the study area was at station T4 (Table 5-2, Figure 5-8).

The warmest waters by daily average in the study area were at the five stations added in the lower Alameda Creek reach between the town of Sunol and San Francisco Bay (Table 5-2, Figures 5-24 to 5-28). Stations 8W, 22W, 23W, 25W, and 26W had the highest daily average temperatures ranging from 17.8 to 19.7°C, while the daily average temperatures at the remaining stations upstream in the watershed all ranged between 13.1 and 16.8°C. The highest maximum temperature recorded at any station (31.9°C) was at 26W upstream of the Isherwood Way Bridge (Table 5-2, Figure 5-28). This station also recorded the highest average daily temperature fluctuation of any site at 5.8°C. The Indian Creek station T21 measured the highest single day temperature fluctuation of 14.8°C (Table 5-2, Figure 5-20).

Table 5.2 *Daily water temperature (°C) statistics for 2007.*

	Water Temperature			Daily Water Temperature Fluctuation		
Station	**Average**	**Maximum**	**Minimum**	**Average**	**Maximum**	**Minimum**
T-1	15.1	23.3	5.4	3.0	5.6	0.4
T-2	15.0	22.2	4.9	1.3	2.7	0.1
T-3	16.8	29.3	4.2	4.7	7.8	1.0
T-4	14.4	23.9	1.9	2.9	7.7	0.5
T-5	15.7	22.9	6.6	2.6	7.3	0.6
T-7	15.5	23.0	8.0	2.0	8.0	0.1
T-10	14.4	20.7	5.5	0.9	2.1	0.3
T-12	13.7	20.3	10.1	2.7	5.6	0.7
T-13	13.8	23.0	5.4	2.3	6.0	0.4
T-14	15.1	22.8	5.0	1.9	4.9	0.2
T-15	14.8	20.8	9.9	4.6	8.5	1.4
T-16	16.0	23.5	8.4	3.1	5.7	0.6
T-17	15.4	25.4	6.7	3.7	7.4	0.6
T-18	13.3	25.4	3.4	3.3	7.5	0.7
T-19	14.7	23.7	4.1	2.8	7.1	0.4
T-21	13.1	29.0	4.9	2.4	14.8	0.4
T-22S	15.2	24.3	7.8	2.4	6.3	0.3
T-22B	15.1	18.1	10.7	0.6	2.5	0.1
T23	14.2	24.7	5.9	3.1	10.6	0.6
8W	17.8	29.1	5.8	4.3	9.2	0.5
22W	18.6	28.3	7.1	3.7	8.1	0.8
23W	19.7	27.5	12.7	2.2	7.8	0.0
25W	17.7	27.9	6.0	3.3	6.9	0.4
26W	19.3	31.9	5.3	5.8	12.4	0.9

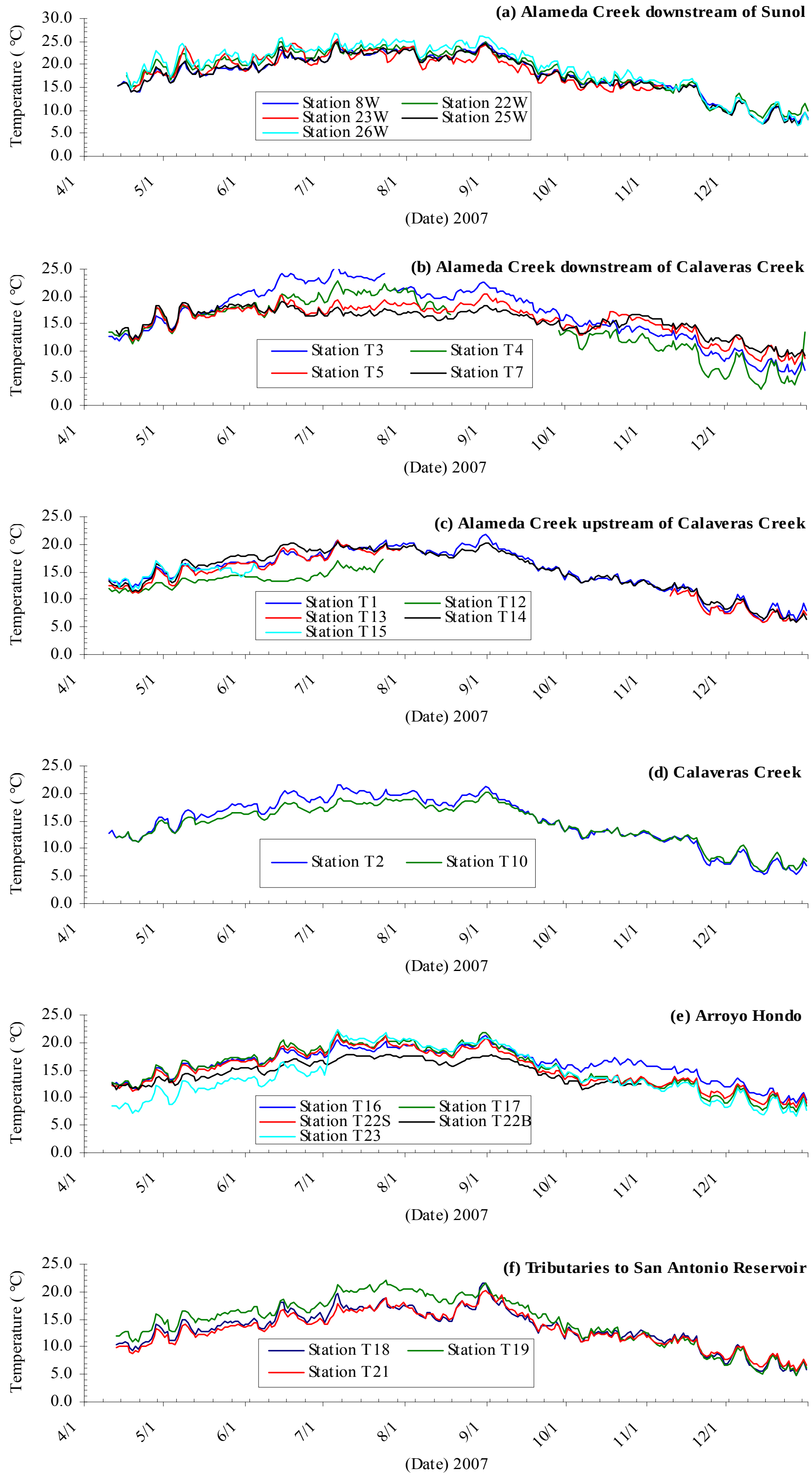


Figure 5-4. *2007 Daily mean water temperatures at the monitoring stations in Alameda, Calaveras, La Costa and Indian creeks and Arroyo Hondo.*

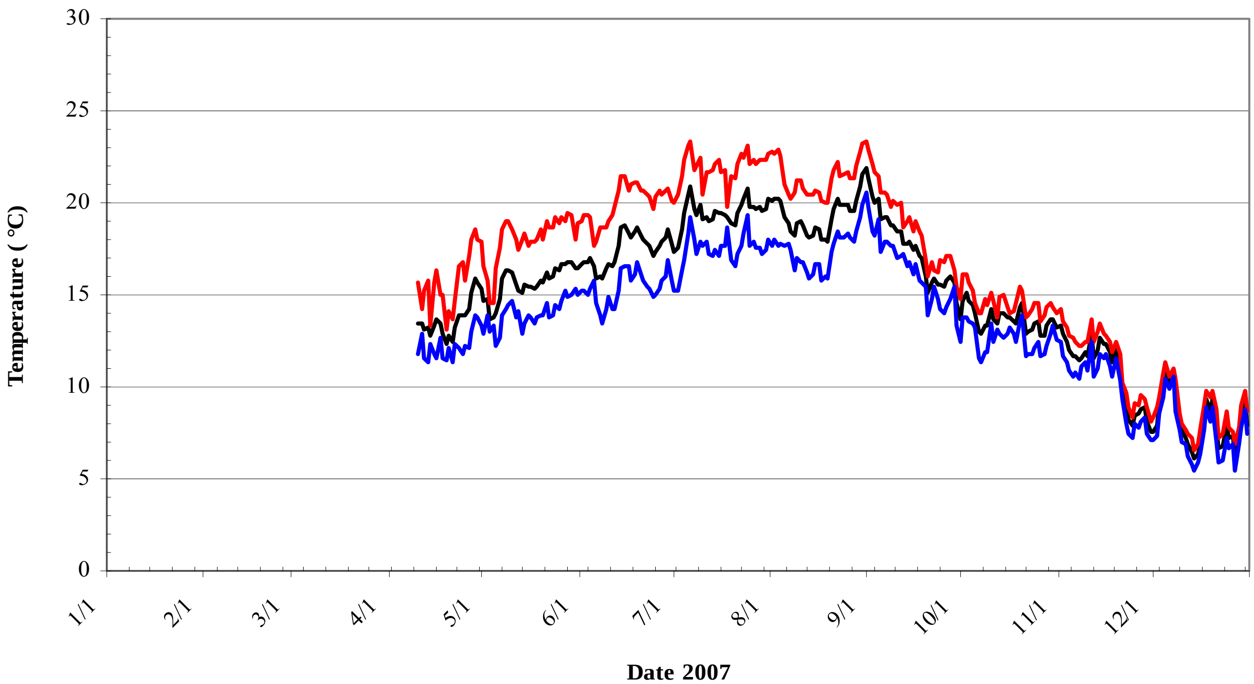


Figure 5-5. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-1 in Alameda Creek.*

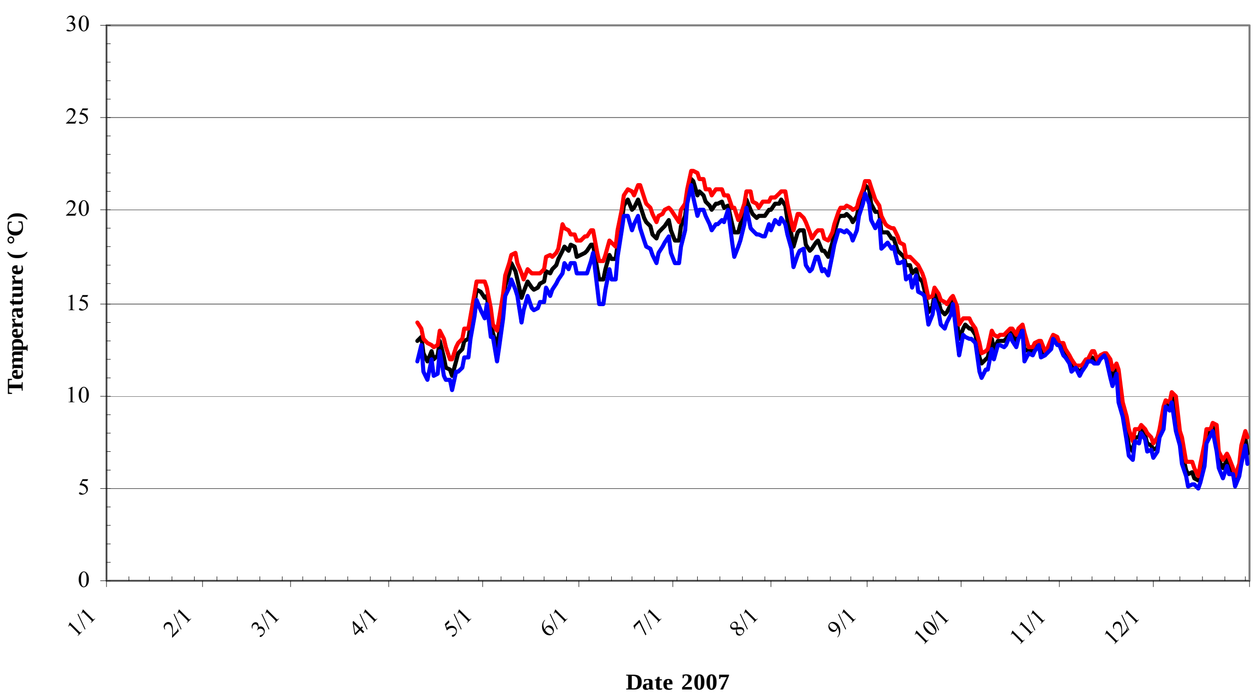


Figure 5-6. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-2 in Calaveras Creek.*

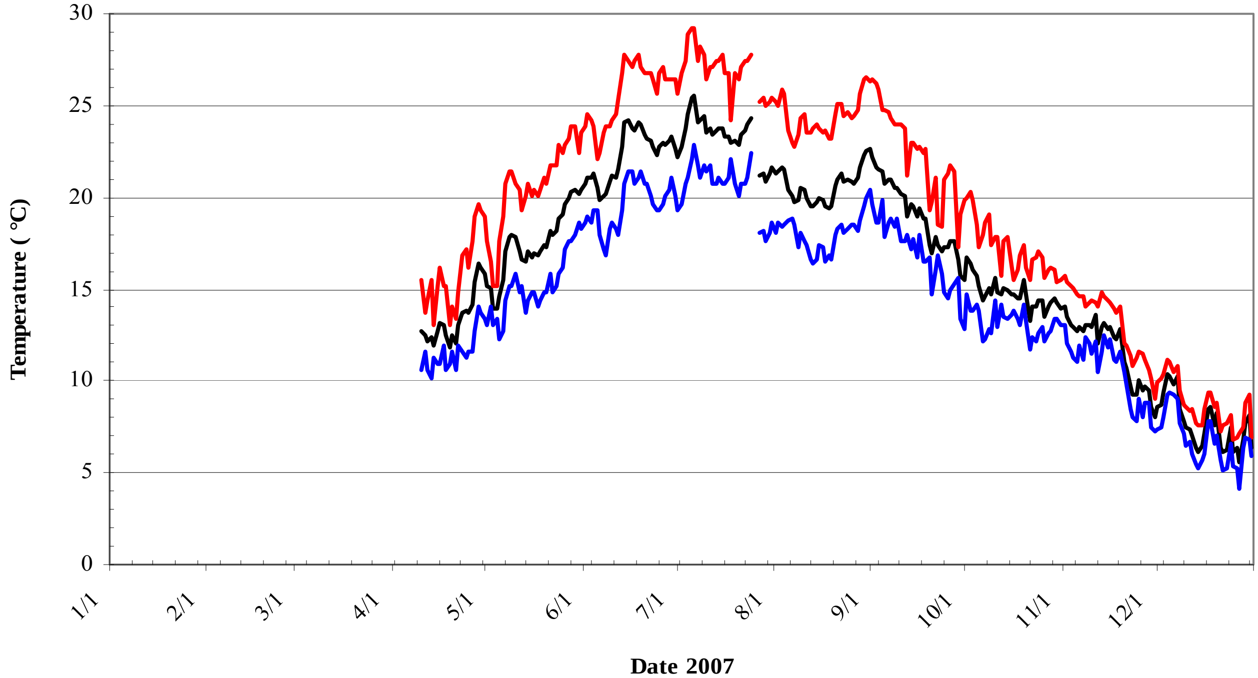


Figure 5-7. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-3 in Alameda Creek.*

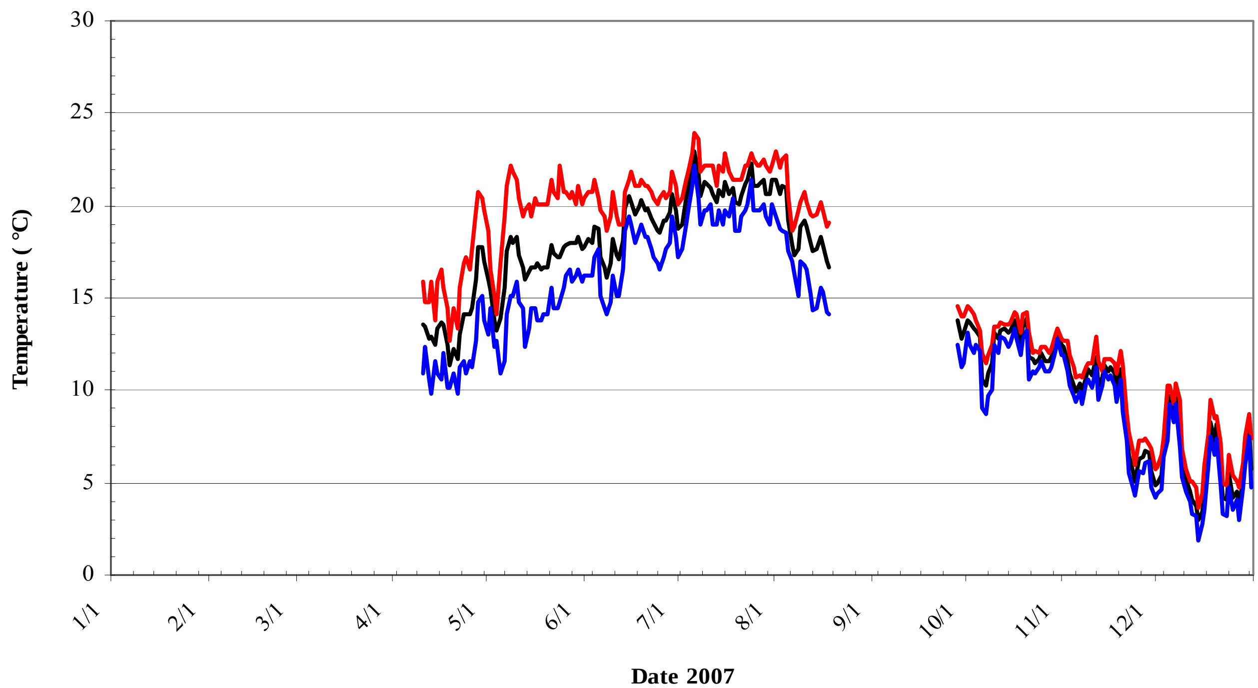


Figure 5-8. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-4 in Alameda Creek.*

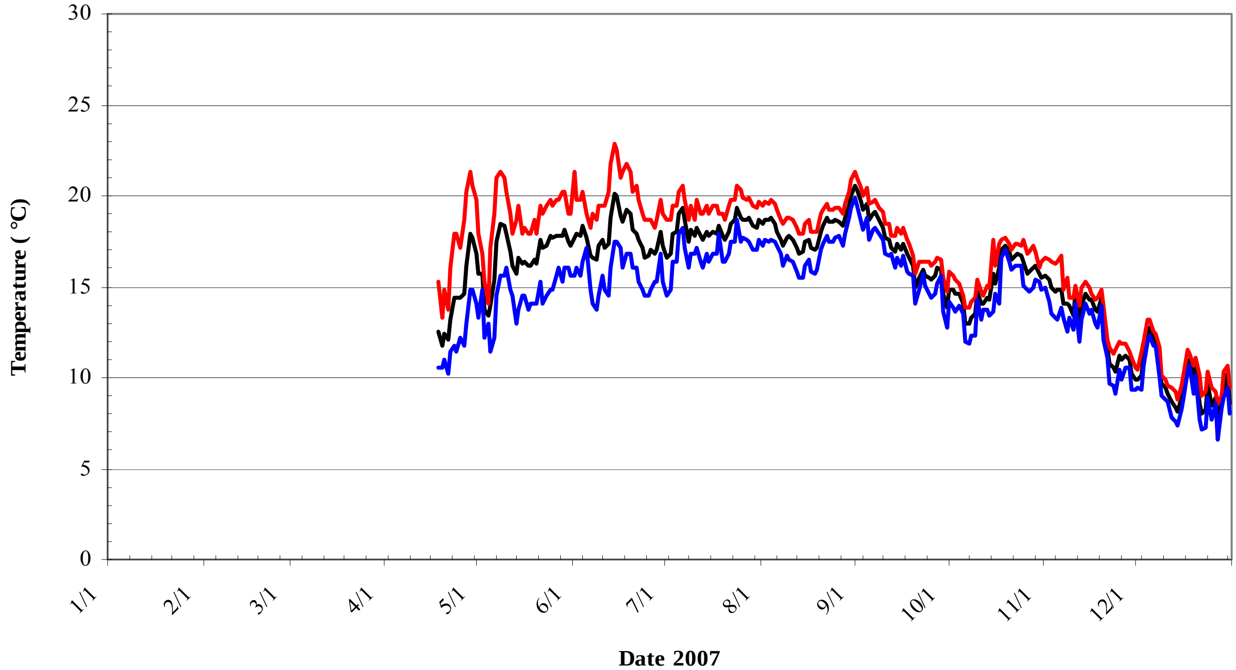


Figure 5-9. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-5 in Alameda Creek.*

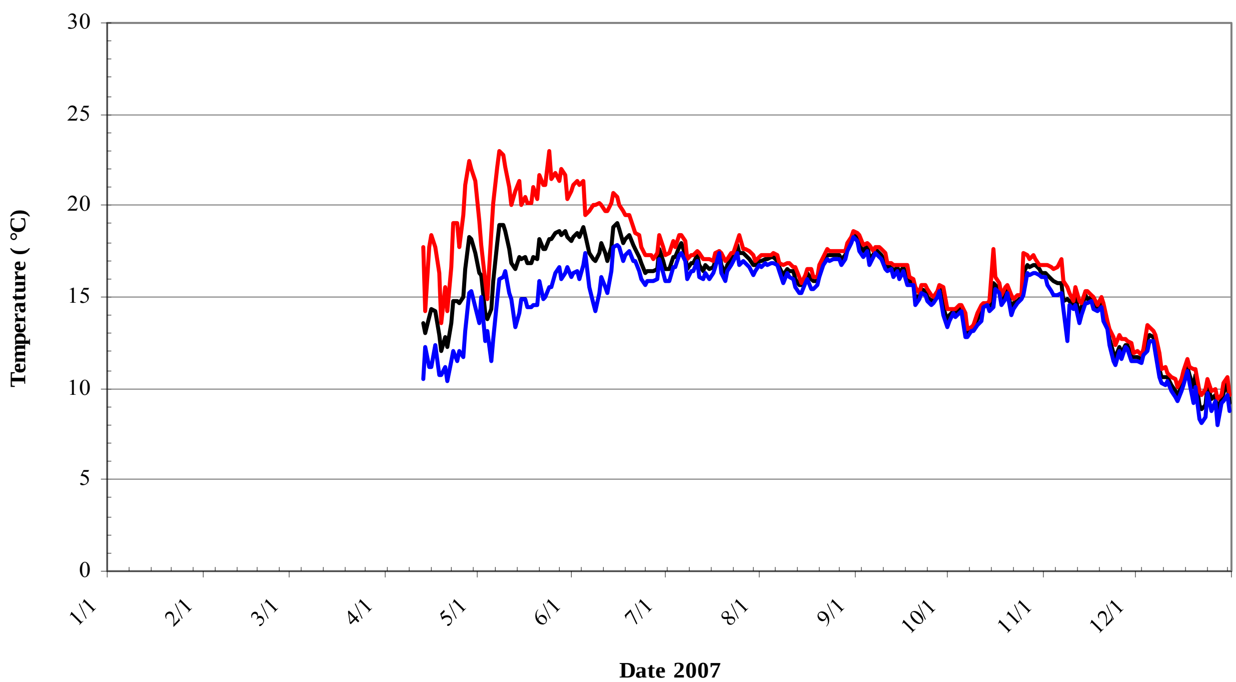


Figure 5-10. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-7 in Alameda Creek.*

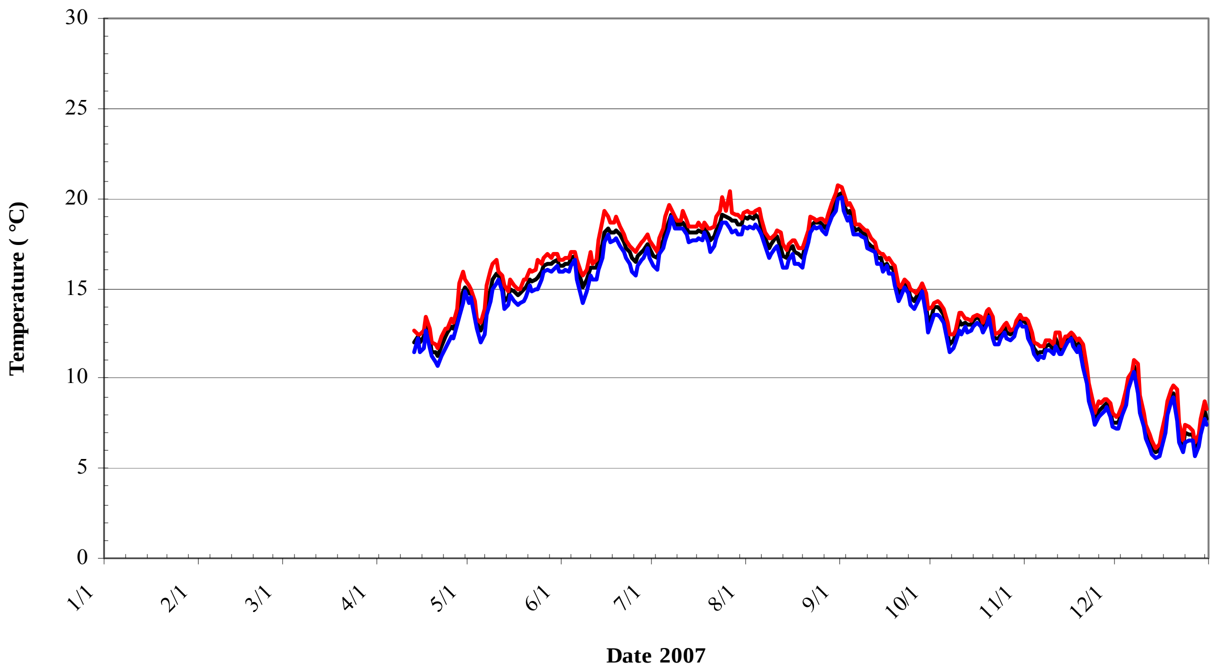


Figure 5-11. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-10 in Calaveras Creek.*

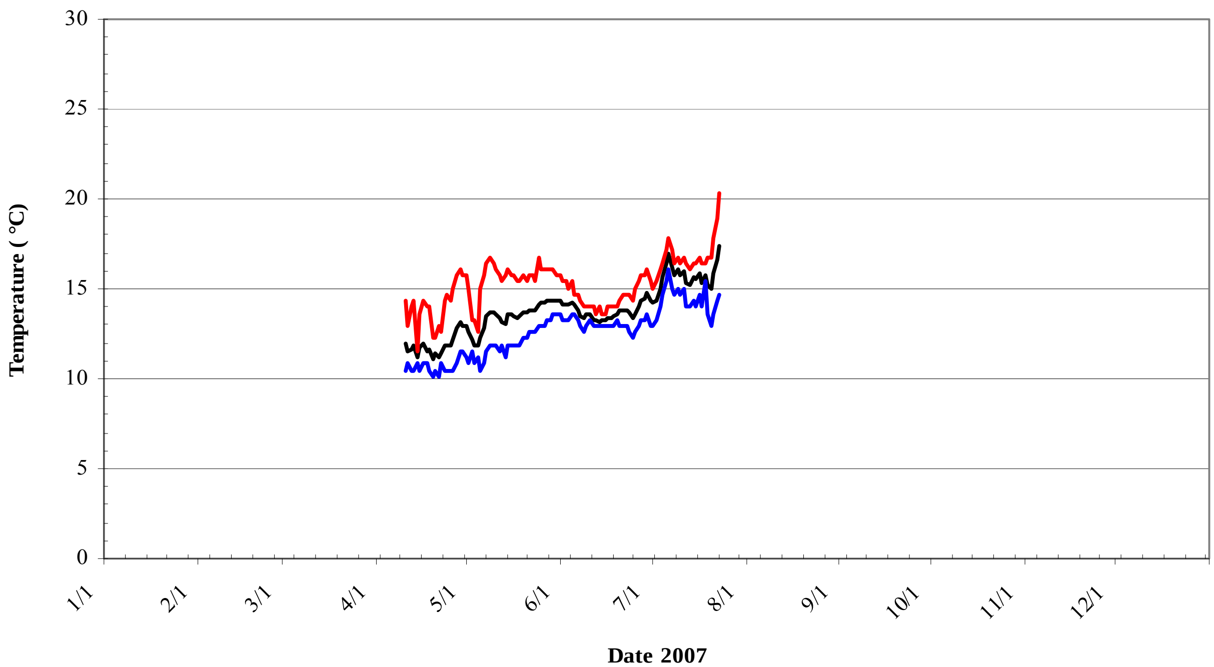


Figure 5-12. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-12 in Alameda Creek.*

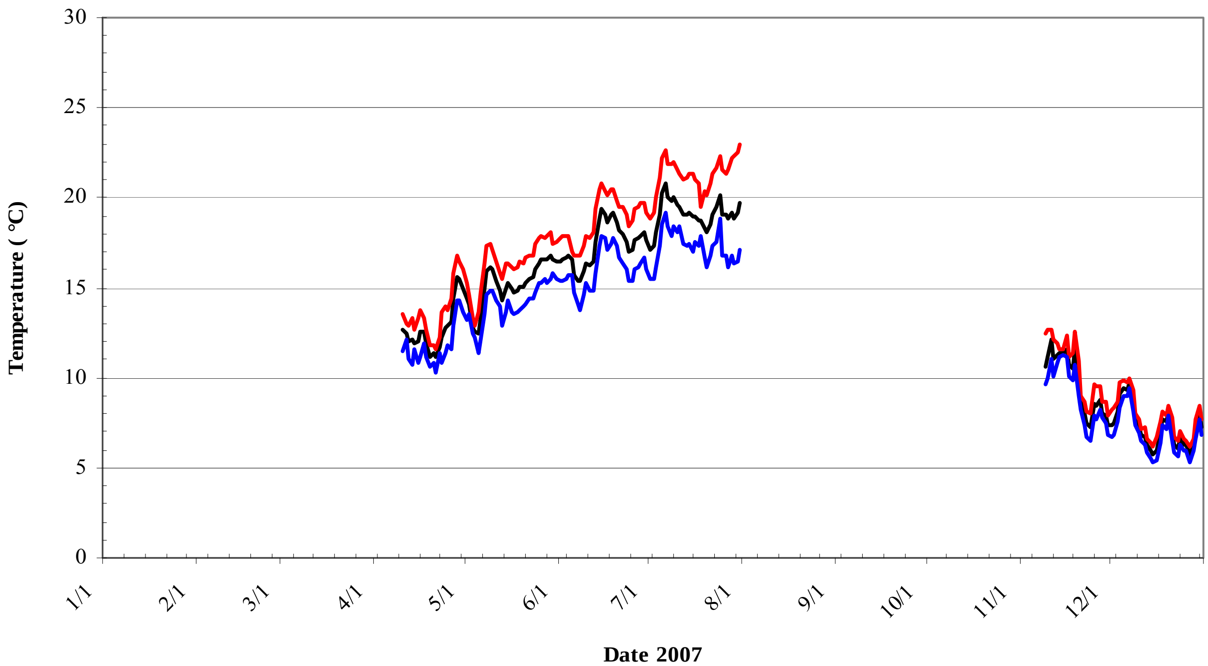


Figure 5-13. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-13 in Alameda Creek.*

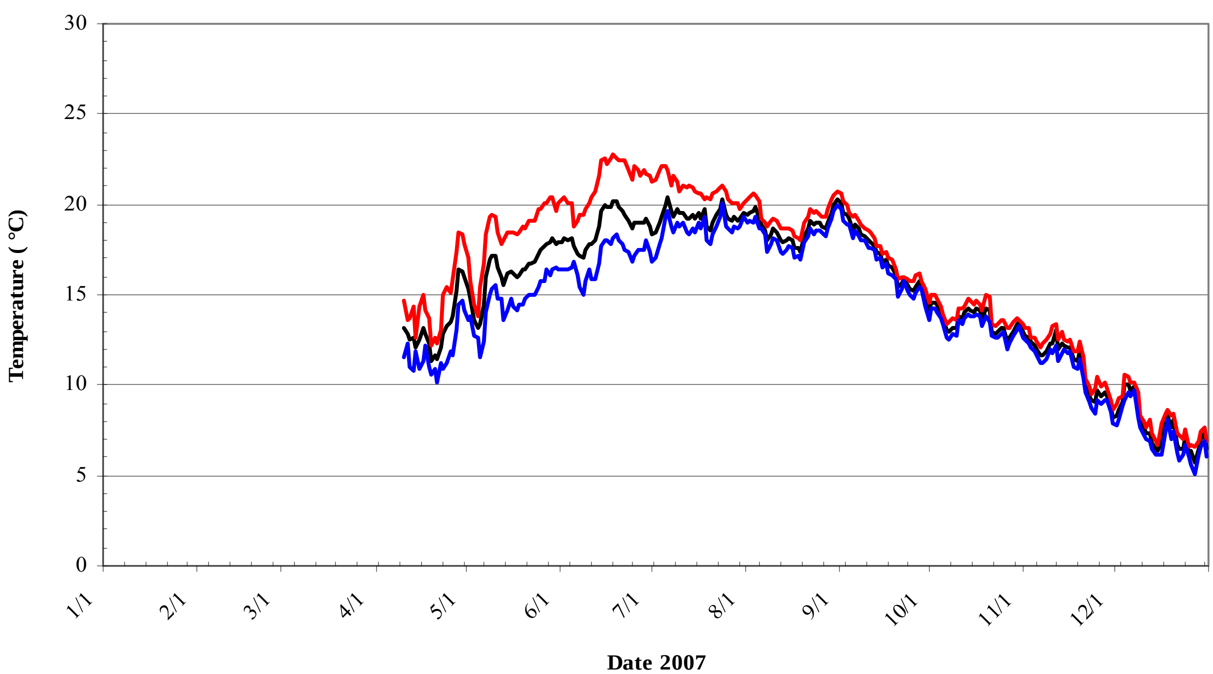


Figure 5-14. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-14 in Alameda Creek.*

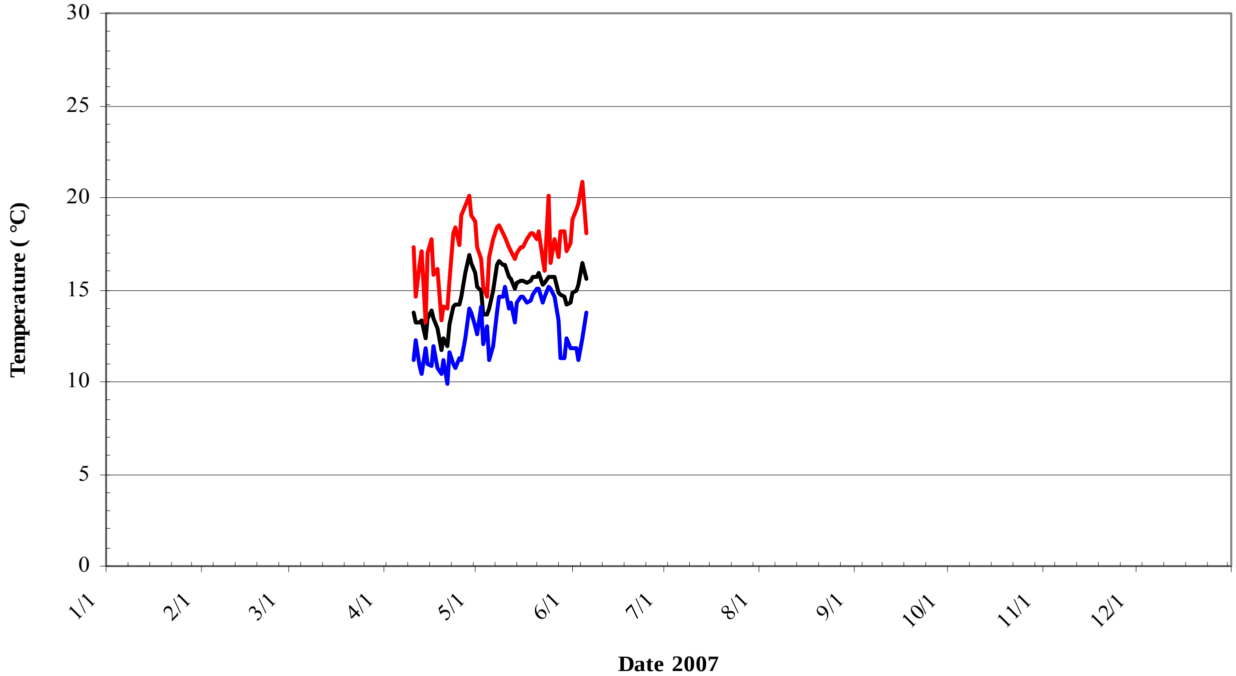


Figure 5-15. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-15 in Alameda Creek.*

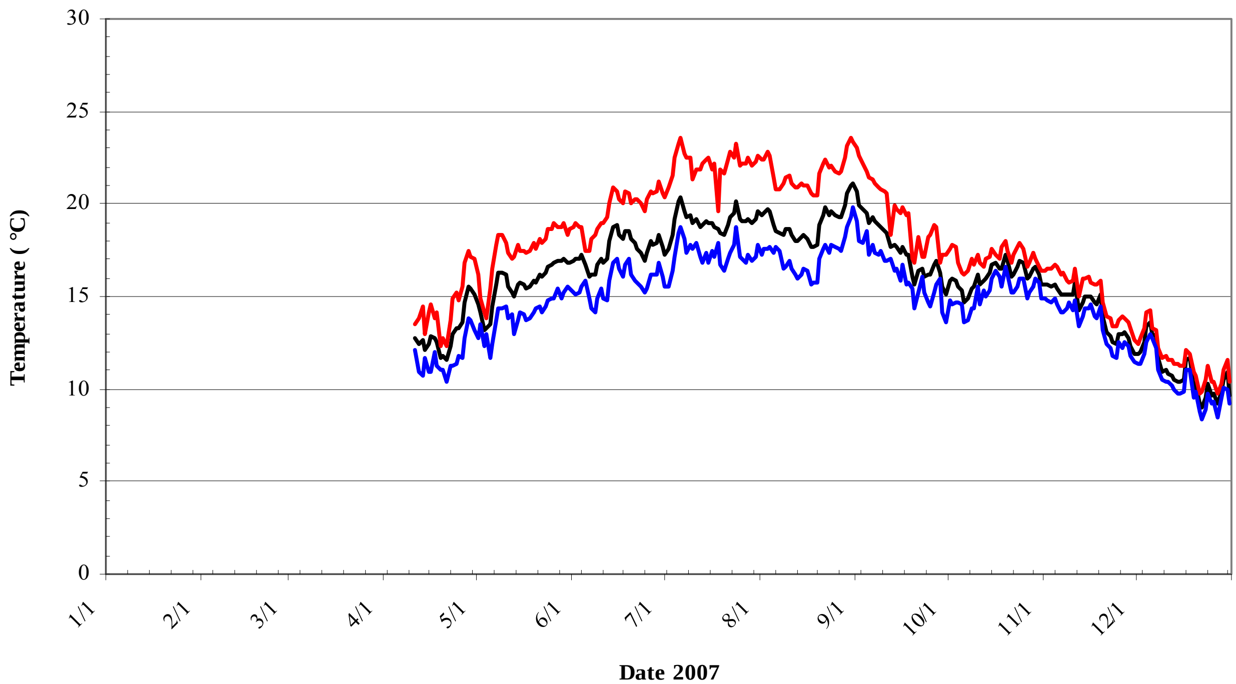


Figure 5-16. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-16 in Arroyo Hondo.*

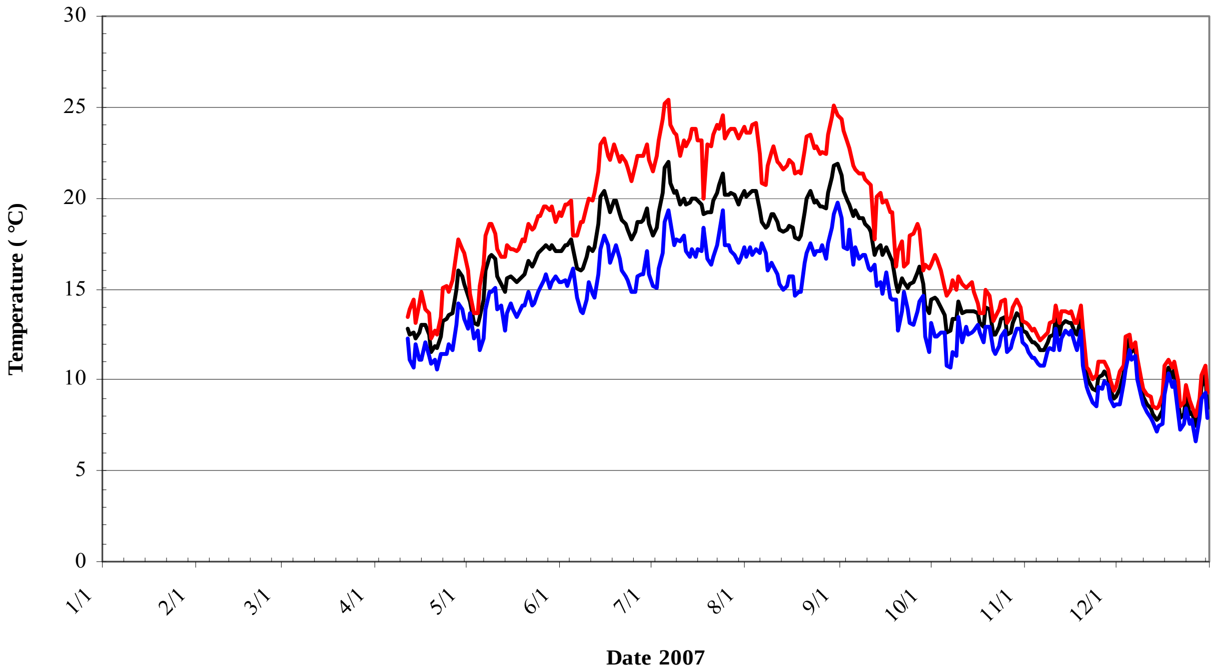


Figure 5-17. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-17 in Arroyo Hondo.*

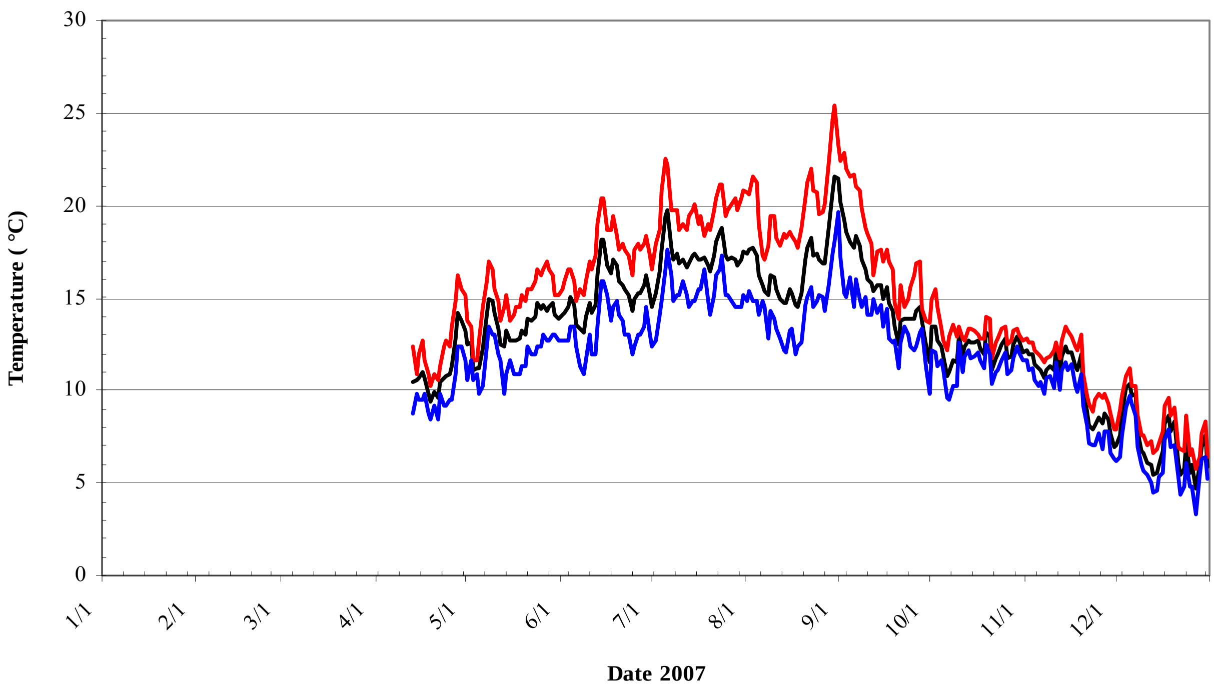


Figure 5-18. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-18 in La Costa Creek.*

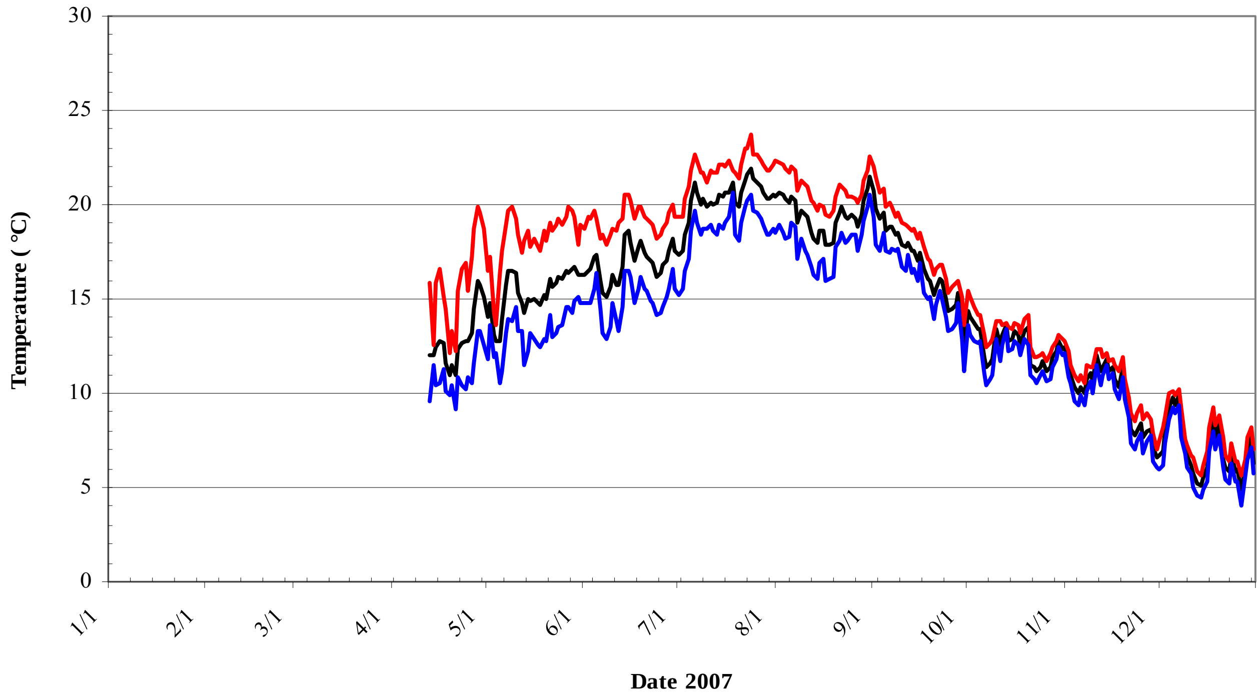


Figure 5-19. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-19 in La Costa Creek.*

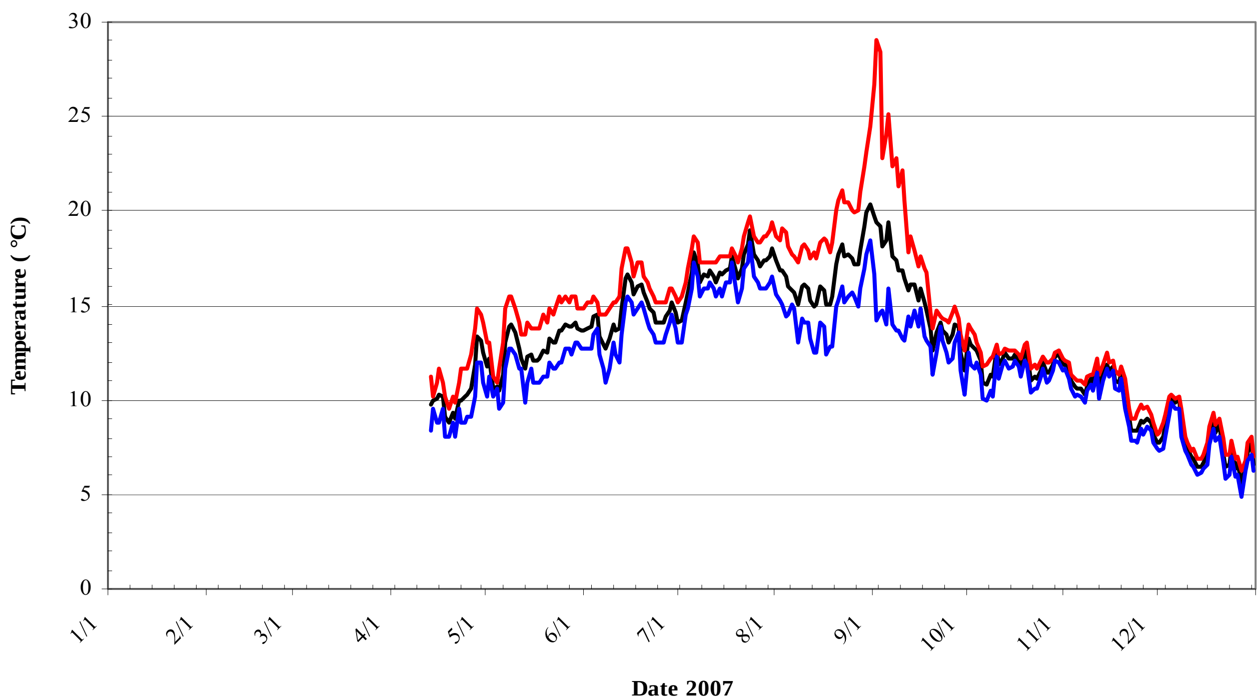


Figure 5-20. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-21 in Indian Creek.*

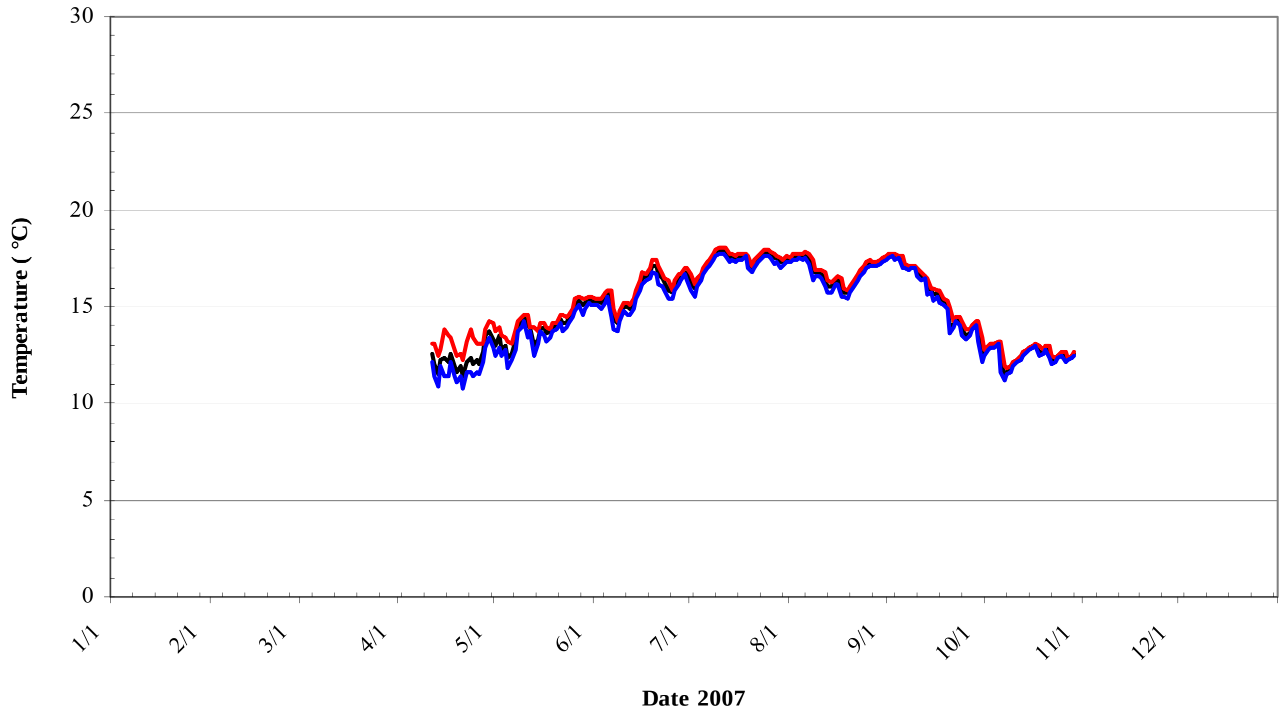


Figure 5-21. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-22B in Arroyo Hondo.*

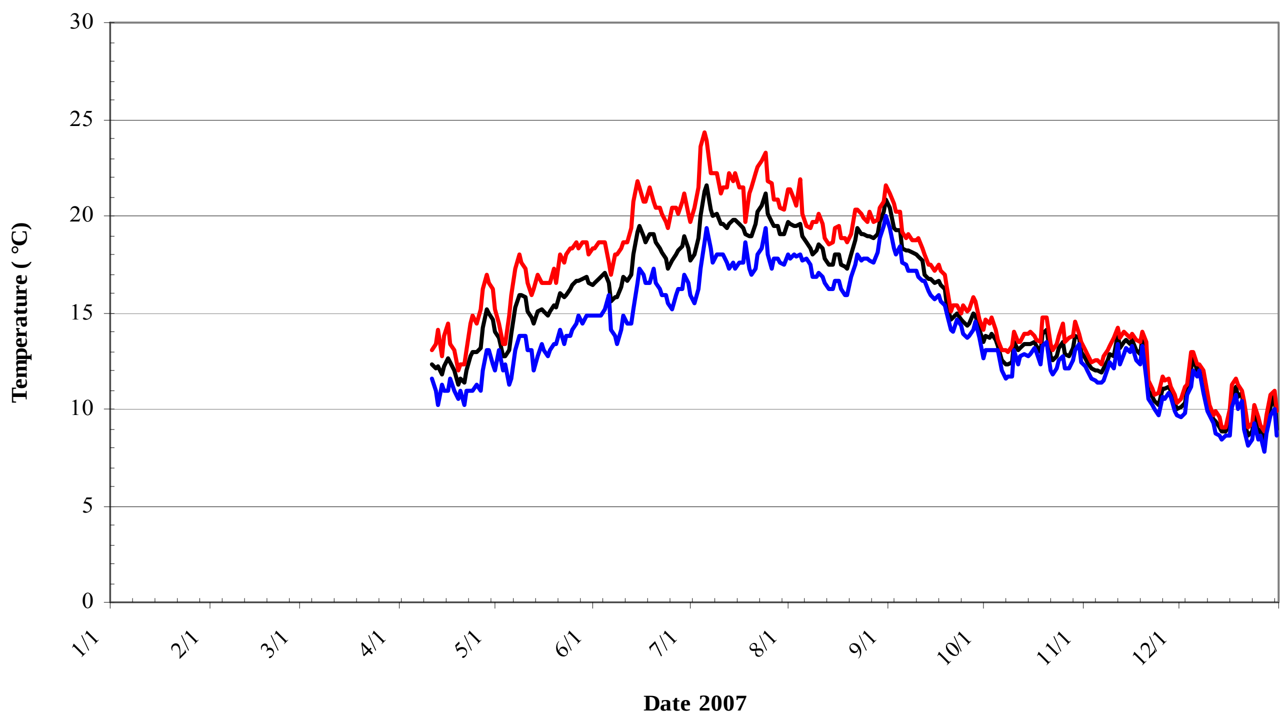


Figure 5-22. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-22S in Arroyo Hondo.*

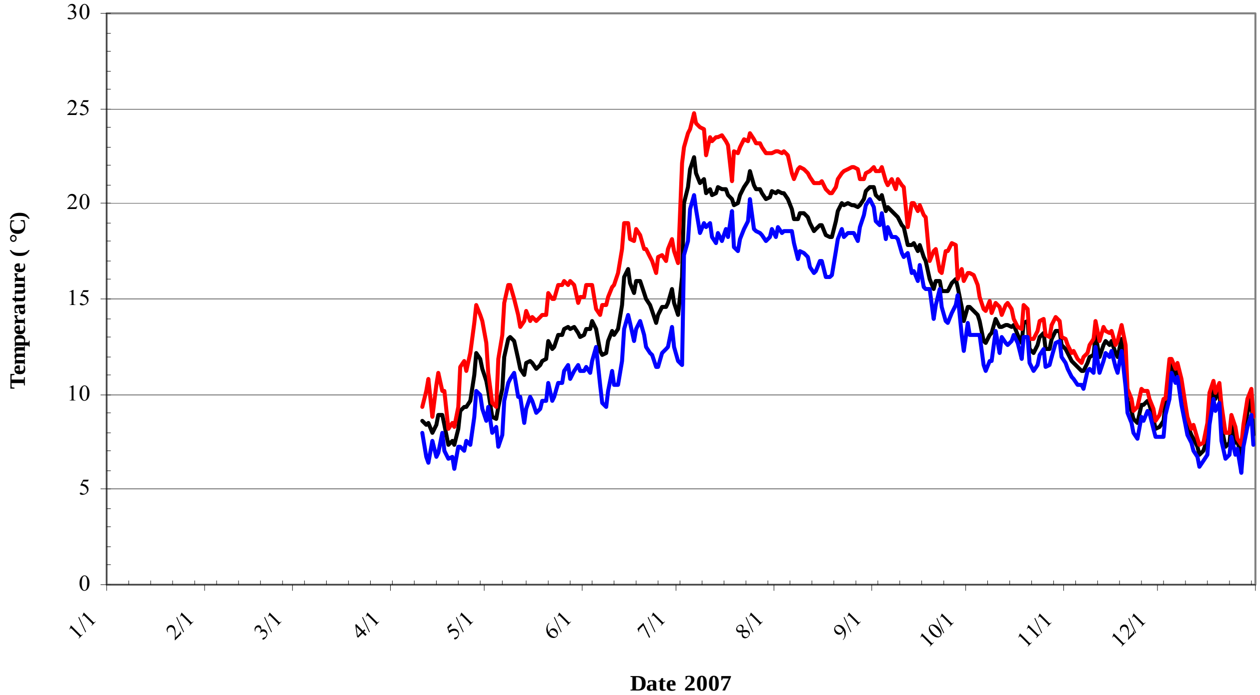


Figure 5-23. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station T-23 in Arroyo Hondo.*

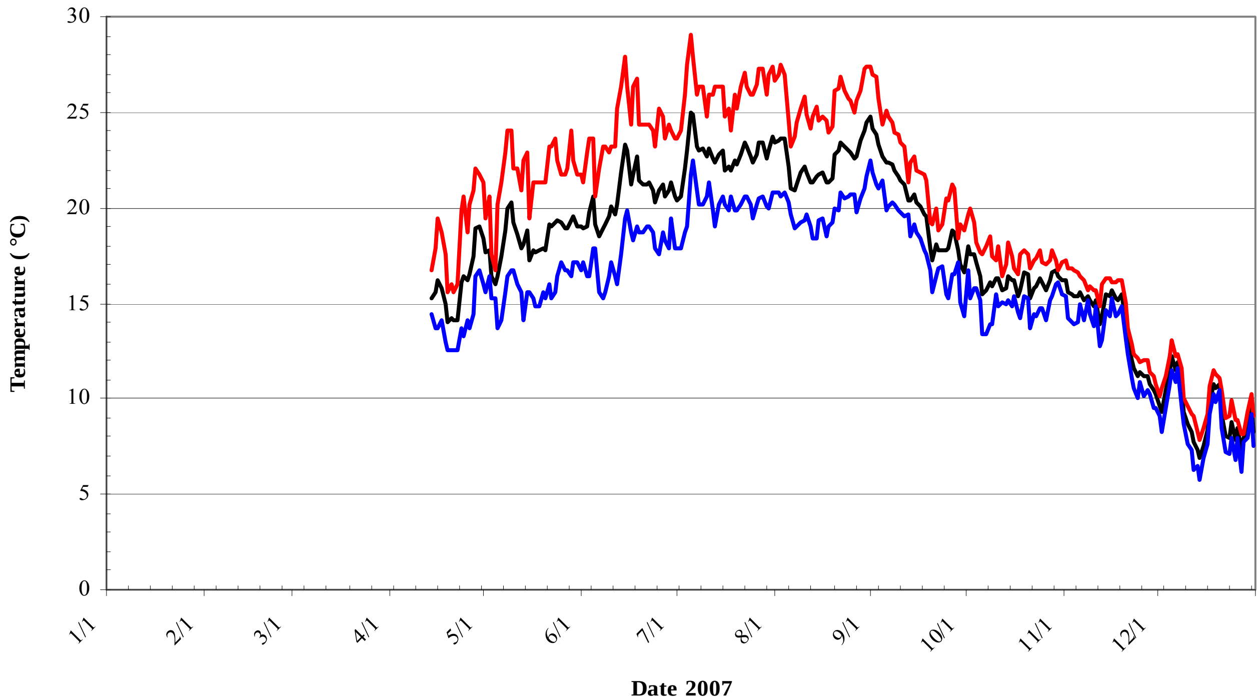


Figure 5-24. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station 8W in Alameda Creek.*

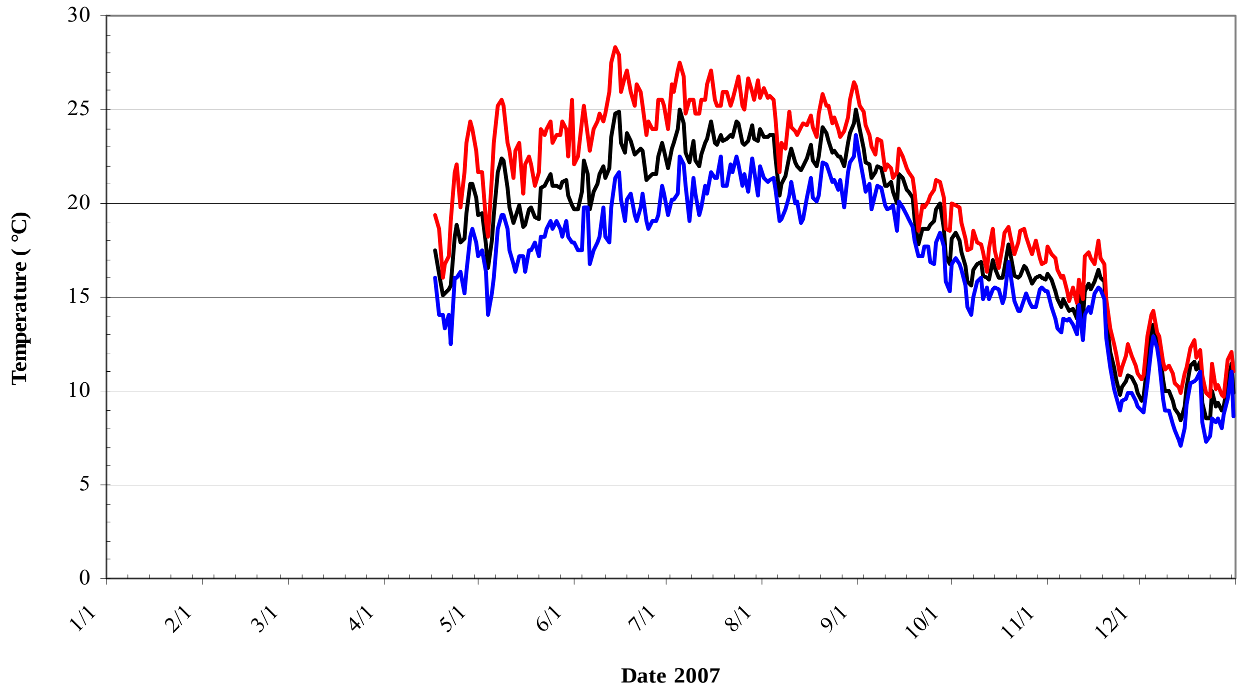


Figure 5-25. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station 22W in Alameda Creek.*

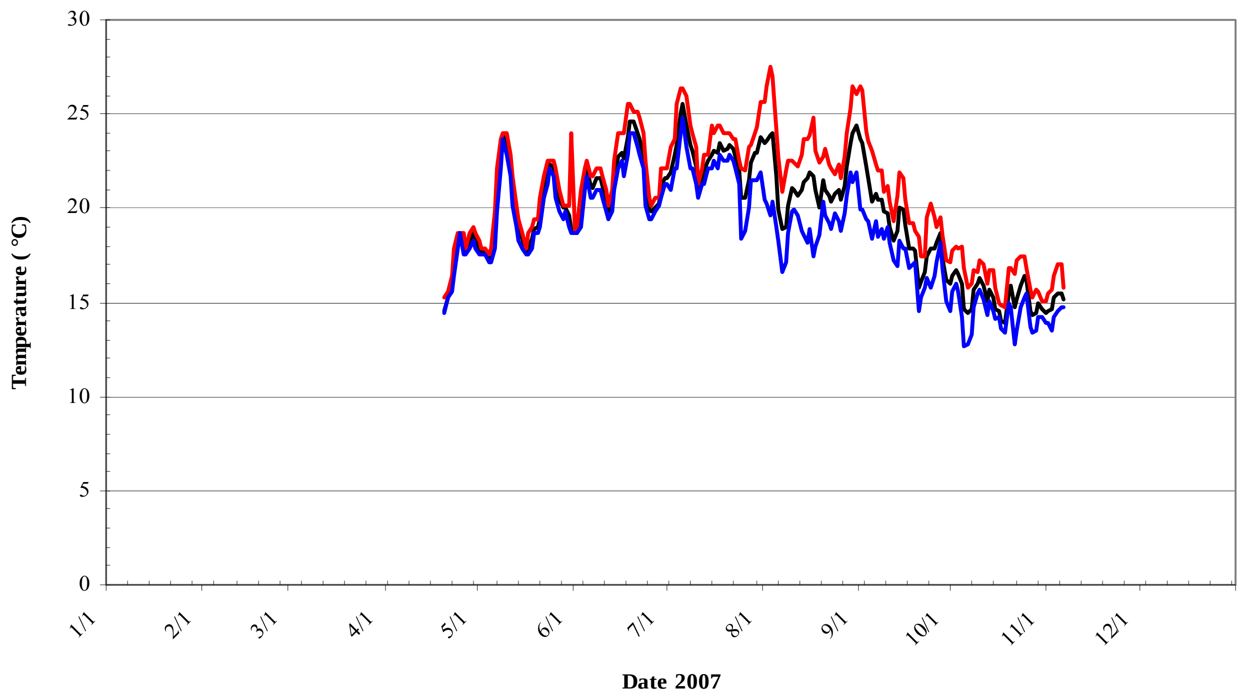


Figure 5-26. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station 23W in Alameda Creek.*

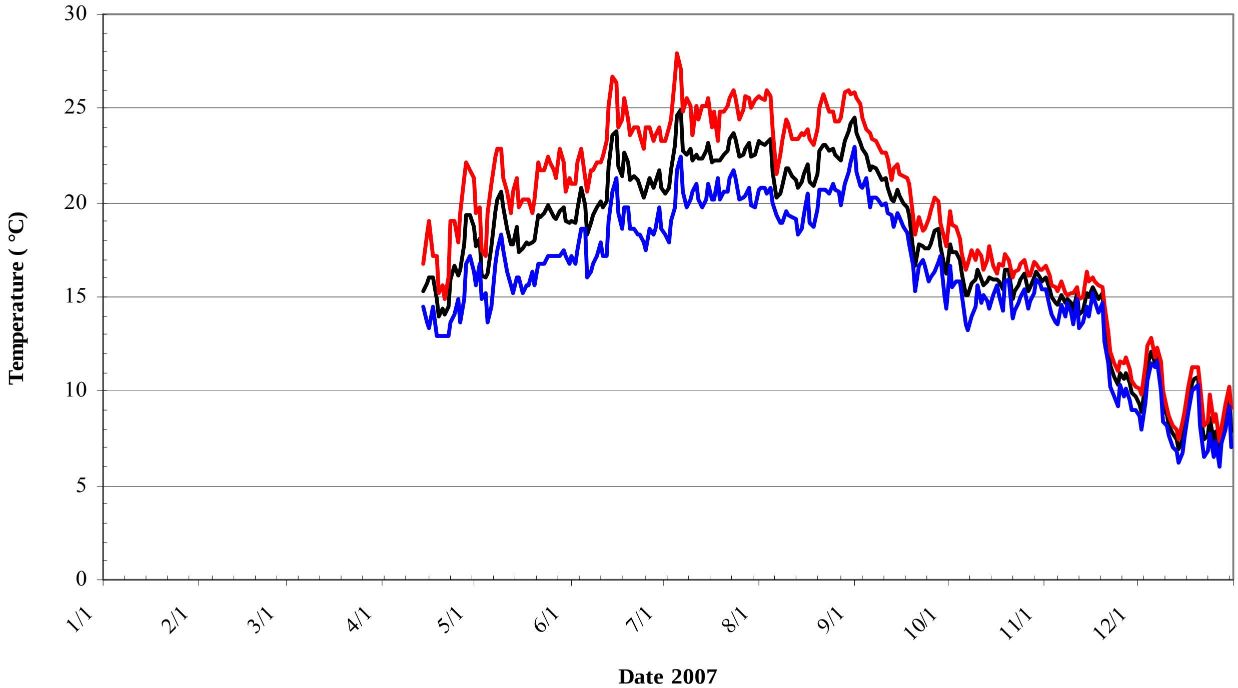


Figure 5-27. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station 25W in Alameda Creek.*

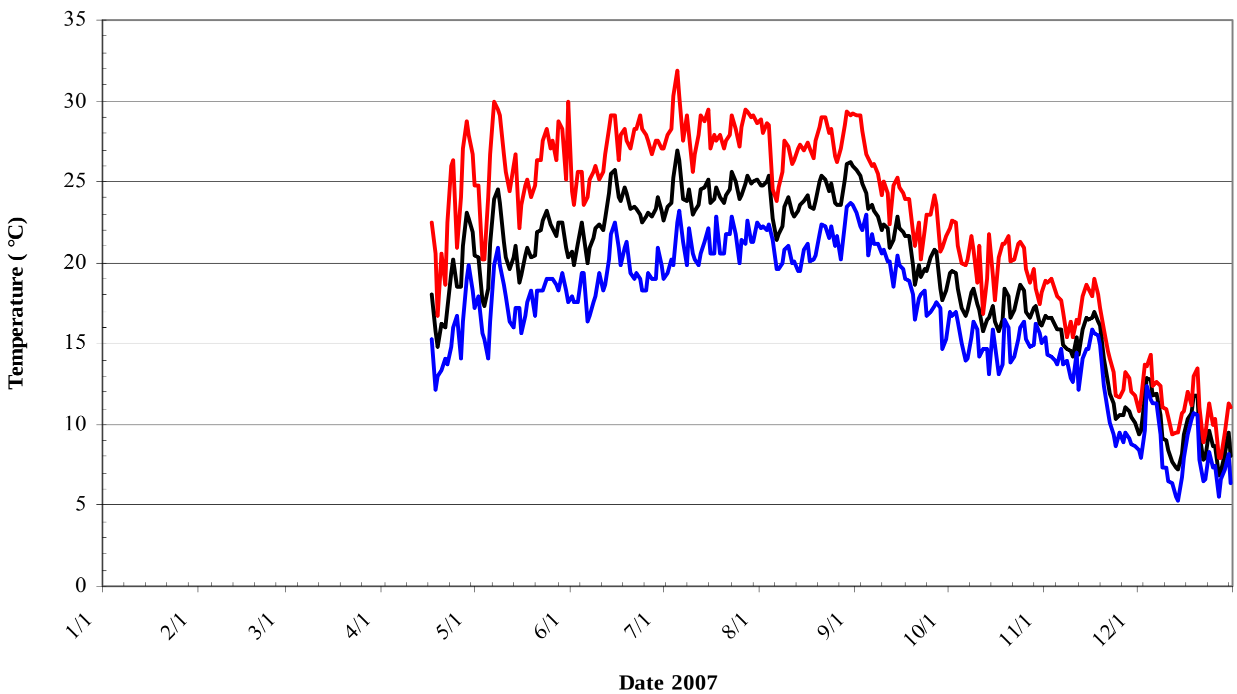


Figure 5-28. *Daily mean (black), maximum (red) and minimum (blue) water temperatures at Station 26W in Alameda Creek.*

5.4 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.

Air temperatures at Stations TR-1, TR-2, TR-5, and TR-6, all reached peaks in late June through early September and gradually decreased through the remainder of 2007. Daily averages temperatures were similar at TR-2 in Arroyo Hondo, TR-5 in La Costa Creek, and TR-6 in Indian Creek, ranging from 14.2°C to 14.4°C (Table 5-3, Figures 5-31, -33, and -34). Average temperatures were slightly higher on Alameda Creek in Sunol Regional Park at 15.0°C (Table 5-3, Figure 5-29). Instantaneous air temperatures ranged from -2.9°C at TR-1 on Alameda Creek to 37.9°C on Alameda and Indian Creeks (Table 5-3, Figures 5-29 and 5-34).

Average daily air temperature fluctuations ranged from 10.9°C at La Costa Creek to 14.1°C at Alameda Creek (Table 5-3, Figures 5-29 and 5-33). The lowest daily temperature fluctuation of 2.1°C and the highest daily temperature fluctuation of 24.2°C both occurred on Indian Creek (Table 5-3, Figure 5-34). .

Relative humidity values were not available at La Costa Creek due to a malfunctioning sensor at that station. The remaining stations at Arroyo Hondo, Indian Creek, and Alameda Creek were similar with the lowest values recorded during June through October and higher values recorded in the spring, and winter months (Figures 5-30, -32, and -35). Relative humidity recordings at all stations include values greater than 100%, which are likely associated with rain events. The highest average daily relative humidity was 72.6% at TR-1 in Alameda Creek; the lowest daily average relative humidity was 63.4% at TR-2 in Arroyo Hondo (Table 5-4, Figures 5-30 and 5-32. Minimum daily relative humidity ranged from –1.6% at TR-6 in Indian Creek to 7.2% at TR-1 in Alameda Creek (Table 5-4, Figures 5-30 and 5-35).

Daily fluctuations of relative humidity ranged from 0% at all stations to a high of 90.9% at TR-2 (Table 5-4, Figures 5-30, -32, and -35). Average daily fluctuations ranged from 50.7% at TR-6 to 57.9% at TR-1 (Table 5-4, Figures 5-30 and 5-35).

Table 5-3. *Daily air temperature (° C) statistics for 2007.*

Station	Air Temperature			Daily Fluctuation		
	Average	Maximum	Minimum	Average	Maximum	Minimum
TR-1	15.0	37.9	-2.9	14.4	24.1	2.9
TR-2	14.4	35.3	-2.0	11.9	21.3	3.2
TR-5	14.3	34.4	-1.5	10.9	20.2	2.1
TR-6	14.2	37.9	-0.6	11.5	24.2	2.1

Table 5-4. *Daily relative humidity (%) statistics for 2007.*

Station	Relative Humidity			Daily Fluctuation		
	Average	Maximum	Minimum	Average	Maximum	Minimum
TR-1	72.6	104.0	7.2	57.9	89.8	0
TR-2	63.4	103.7	4.5	54.4	90.9	0
TR-5*	-	-	-	-	-	-
TR-6	65.6	103.9	-1.6	50.7	87.7	0

**Relative Humidity data not available due to sensor malfunction*

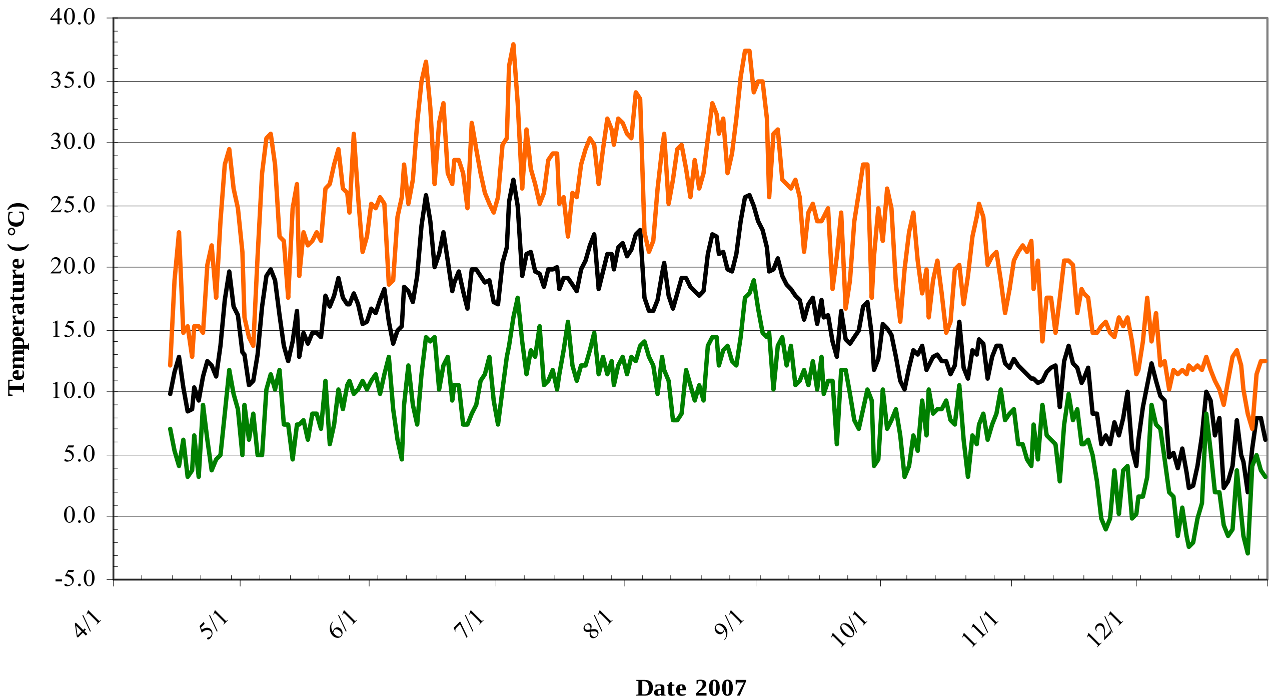


Figure 5-29. *Daily mean (black), maximum (orange) and minimum (green) air temperatures at Station TR-1 near Alameda Creek.*

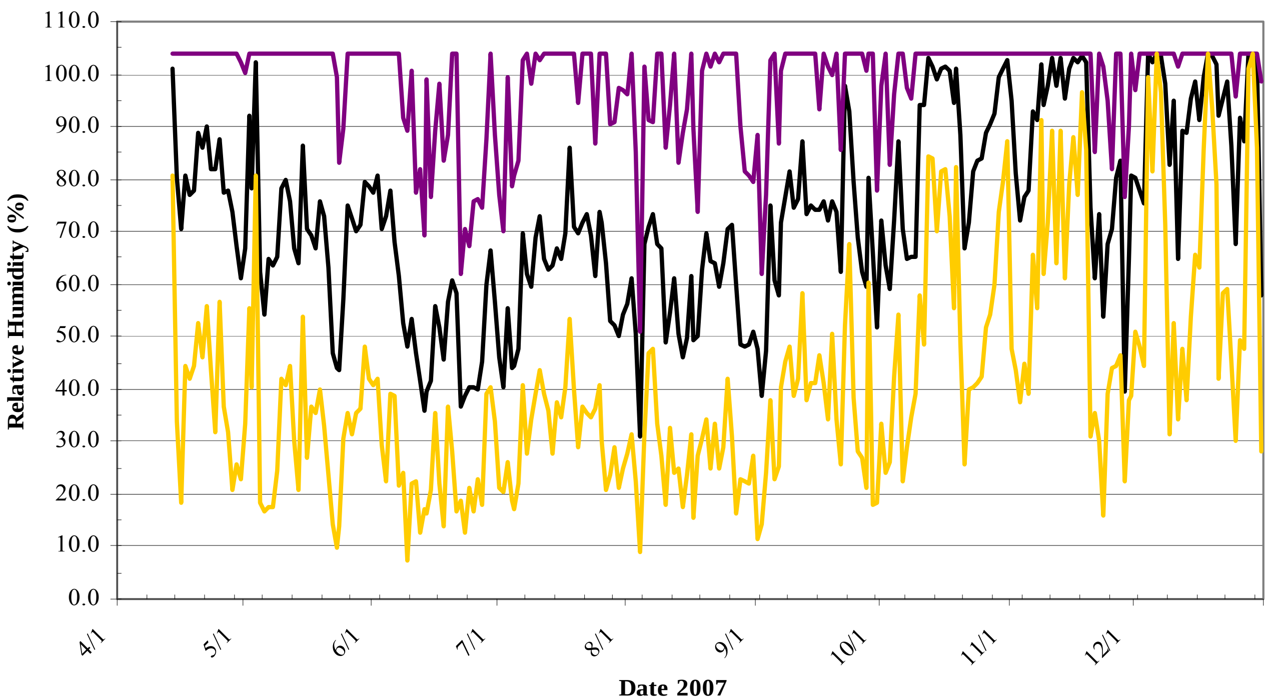


Figure 5-30. *Daily mean (black), maximum (purple) and minimum (gold) relative humidities at Station TR-1 near Alameda Creek.*

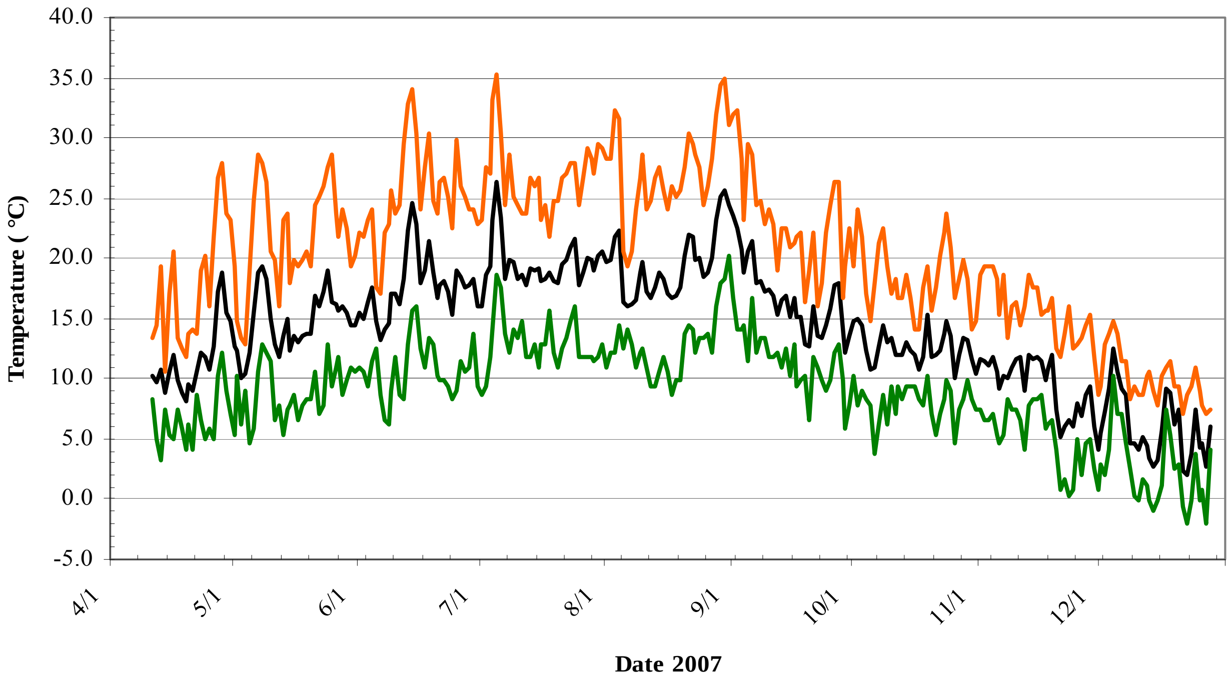


Figure 5-31. *Daily mean (black), maximum (orange) and minimum (green) air temperatures at Station TR-2 near Arroyo Hondo.*

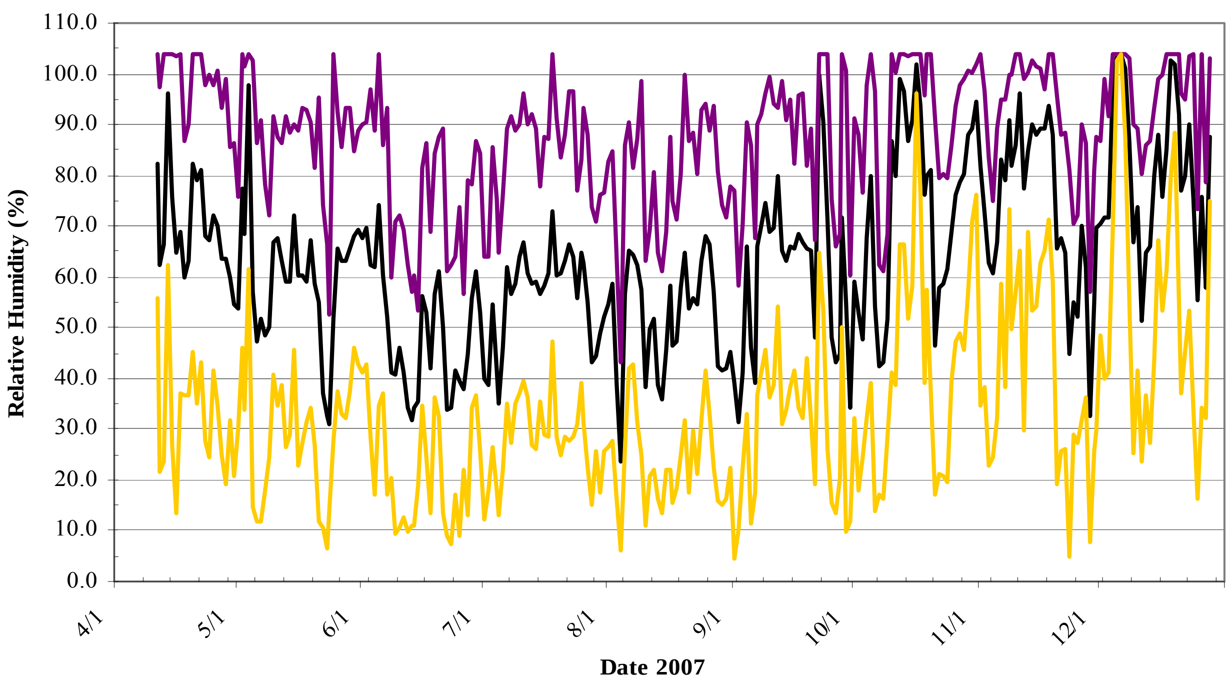


Figure 5-32. *Daily mean (black), maximum (purple) and minimum (gold) relative humidities at Station TR-2 near Arroyo Hondo.*

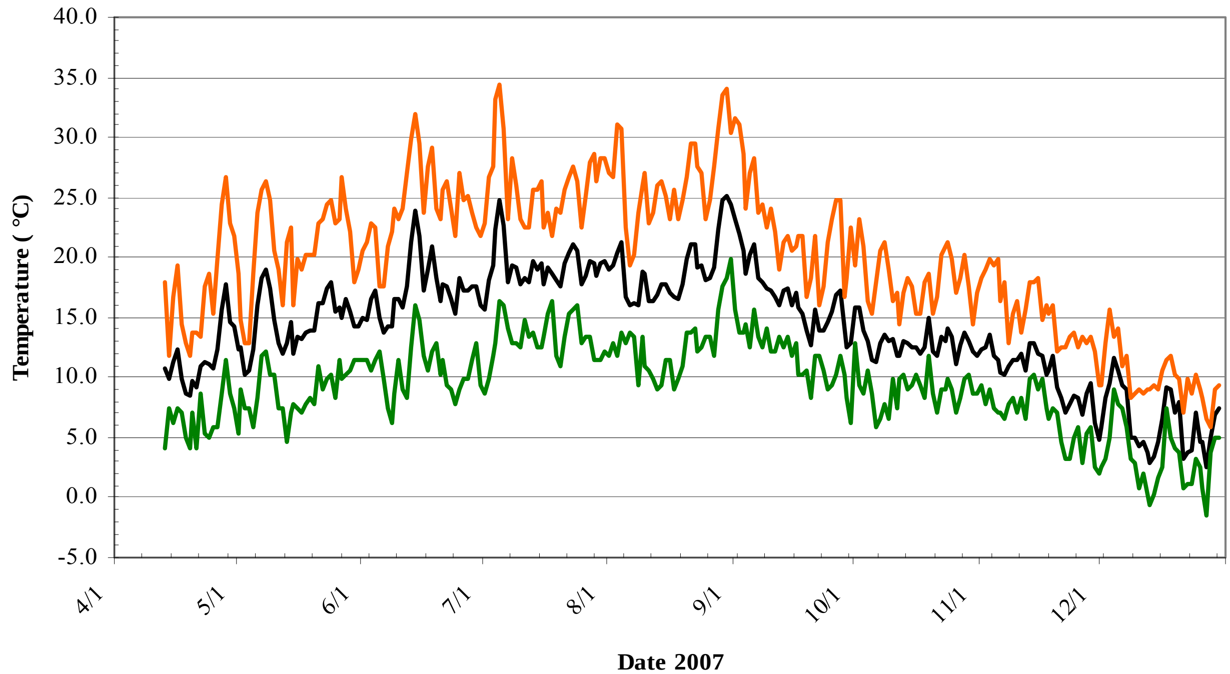


Figure 5-33. *Daily mean (black), maximum (orange) and minimum (green) air temperatures at Station TR-5 near La Costa Creek.*

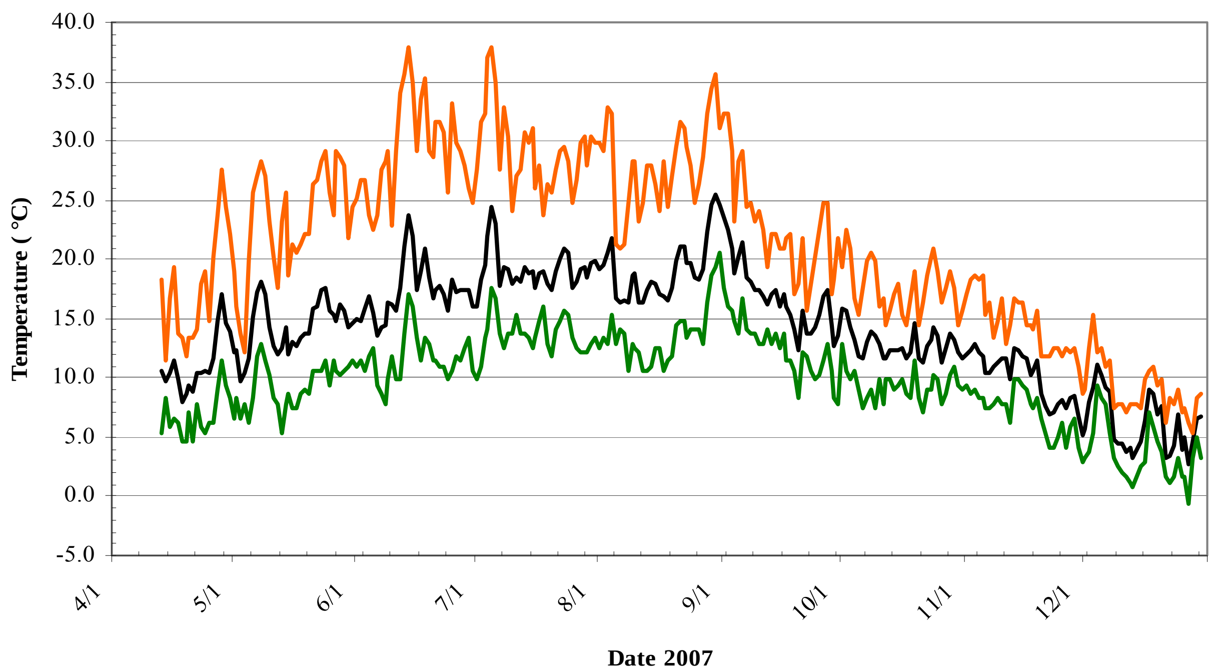


Figure 5-34. *Daily mean (black), maximum (orange) and minimum (green) air temperatures at Station TR-6 near Indian Creek.*

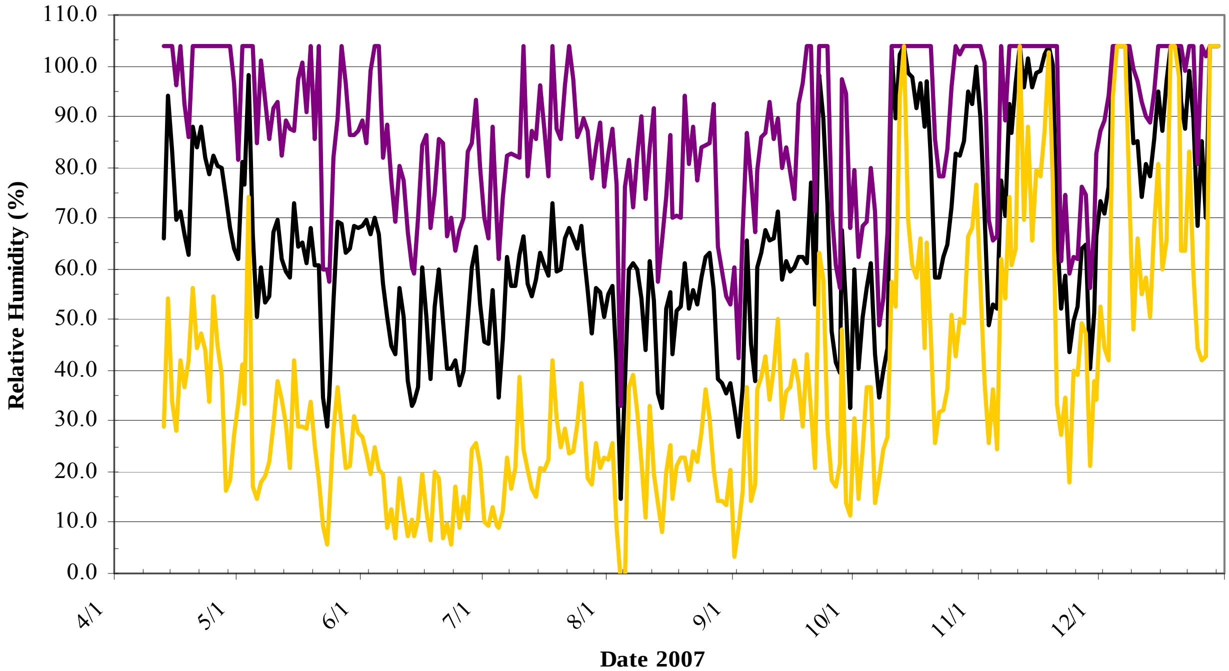


Figure 5-35. *Daily mean (black), maximum (purple) and minimum (gold) relative humidities at Station TR-6 near Indian Creek.*

5.5 Electrofishing Water Quality Measurements

During the 2007 electrofishing survey, discrete water quality monitoring was conducted in 28 electrofishing habitat units within Alameda, Calaveras, La Costa and Indian Creeks and Arroyo Hondo (Table 5-5, Figure 8-1).

Turbidity and dissolved oxygen measurements were not available at some sites due to intermittently malfunctioning water quality instruments. Available turbidity readings ranged from 0.1 NTU to 4.9 NTU, with only station 5 exceeding 1.0 NTU. Survey pH readings ranged from pH 7.61 to pH 8.35. The only site measured to have a dissolved oxygen concentration less than 4.0 mg/L was one of the pools in Calaveras Creek (0.9 mg/L at site 8-2). Conductivity readings ranged from 483 $\mu S/cm^2$ to 1403 $\mu S/cm^2$, with the highest measurements in two pools in Calaveras Creek downstream of Calaveras Dam (sites 8-1 and 8-2), and the lowest in Arroyo Hondo glide and run sites near the Marsh Road Bridge (sites 13-1 and 13-2).

Table 5-5. *Alameda Creek water quality measurements for the 2007 electrofishing survey. See Section 8 for details about site locations and habitat descriptions.*

	Sites-Habitats in Alameda Creek Below Confluence with Calaveras Creek											
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	0923	0927	0920	0925	0930	1221	0928	0922	0935	0859	0905	0912
Temperature (°C)	12.7	15.0	13.2	13.2	13.1	14.0	13.1	10.0	11.8	13.5	13.8	13.8
Turbidity (NTU)	0.9	0.6	0.5	0.6	0.5	4.9	0.7	0.3	1.0	0.8	0.9	0.9
pH	8.13	8.15	8.03	8.02	8.01	8.12	7.59	7.75	7.76	7.69	7.73	7.7
Dissolved Oxygen (mg/L)	*	*	7.2	6.7	6.7	*	4.9	8.0	5.9	*	*	*
Conductivity (µS/cm)	828	829	949	963	968	798	666	636	633	519	521	526

	Sites-Habitats in Alameda and Calaveras Creeks Above Confluence									
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	1324	0936	1008	1144	1145	1156	0932	0937	0859	0905
Temperature (°C)	13.1	14.1	15.3	13.9	13.9	13.7	14.2	14.2	13.5	13.8
Turbidity (NTU)	0.3	1.0	1.0	0.6	0.7	0.4	1.0	1.0	0.8	0.9
pH	8.35	7.84	7.61	7.94	7.78	7.93	8.01	7.99	7.69	7.73
Dissolved Oxygen (mg/L)	*	4.5	0.9	9.5	7.7	7.3	10.6	8.0	8.0	8.2
Conductivity (µS/cm)	503	1395	1403	509	509	506	597	598	519	521

	Sites-Habitats in Arroyo Hondo, La Costa and Indian Creeks						
Water Quality Parameter	13-1	13-2	14-1	14-2	15-1	15-2	**Mean All Sites**
Time Measured	0950	1316	0935	0932	1425	1427	--
Temperature (°C)	12.9	14.4	10.8	11.1	11.3	12.6	13.2
Turbidity (NTU)	0.92	0.79	*	*	0.10	0.6	0.9
pH	8.17	8.05	7.8	7.9	7.7	7.7	7.9
Dissolved Oxygen (mg/L)	*	*	6.3	6.0	5.3	5.9	6.7
Conductivity (µS/cm)	483	484	598	600	952	950	713

** Measurements not taken due to probe malfunction.*

6.0 Spawning Survey

6.1 Background

6.1.1 Survey Goal

Water releases and improved water quality in the cold water reach of the study area are intended to provide conditions suitable for resident 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 program is designed to identify rainbow trout spawning activities occurring in upper Alameda Creek under existing pre-release conditions.

6.1.2 Rainbow Trout Life History

Rainbow trout are by definition a cold water fish, with optimal growth occurring in waters with temperatures between 15º and 18ºC. Trout typically disperse from areas of high density to areas of low density during their first year of life. Once juveniles begin to establish territories and home ranges, usually during their second year of life, their movements are reduced. Adult fish are more sedentary, making only short feeding excursions within their home range (Behnke, 1992). Spawning can occur from late December through June, with the actual time varying and dependant on temperature and flow regimes (Moyle, 2002). Trout spawn in locations where the streambed is composed of gravelly substrate, including riffles and pool tail-outs. Female trout construct redds (Figure 6-1) and, depending upon body size and origin, deposit 200 to 12,000 eggs (Moyle, 2002). Rainbow trout measuring less than 30 cm total length typically produce less than 1,000 eggs per year (Behnke, 1992). In three to four weeks the eggs hatch (at 10-15°C), and the larval trout spend another two to three weeks under the cover of the gravel before emerging as young-of-year (YOY) fry. The first year to two years of life are spent in cool, clear, riffle-dominated stream reaches where there is ample cover from riparian vegetation and undercut banks (Moyle, 2002). Growth rates are highly variable and dependent upon a variety of factors, including temperature, food abundance (of both aquatic and terrestrial origin) and flow (Moyle, 2002). As juveniles age they begin moving to slower waters, only moving briefly to fast waters to forage (Behnke, 1992).

Figure 6-1. *Female rainbow trout constructing a redd.*

6.2 Procedure

6.2.1 Survey Area

Two portions of upper Alameda Creek were selected for spawning surveys. The downstream area, which includes portions of both the upper study reach and control reach covered by the MOU, consists of a 2.7-mile stretch within the boundaries of Sunol Regional Park. This portion starts below the park interpretive center and ends at the "W" tree in Sunol Regional Park (Figure 6-2). The upstream area consists of a readily accessible 1.9-mile stretch just upstream of the area covered by the MOU. This portion, that is considered an additional control reach, starts on SFPUC property approximately 0.6 miles upstream of the Alameda Creek Diversion Dam and ends in Sunol Regional Park near Camp Ohlone (Figure 6-2). This upstream area includes topographic and stream morphologic features that are comparable to the MOU reach, with both areas having exceptional spawning and rearing habitat.

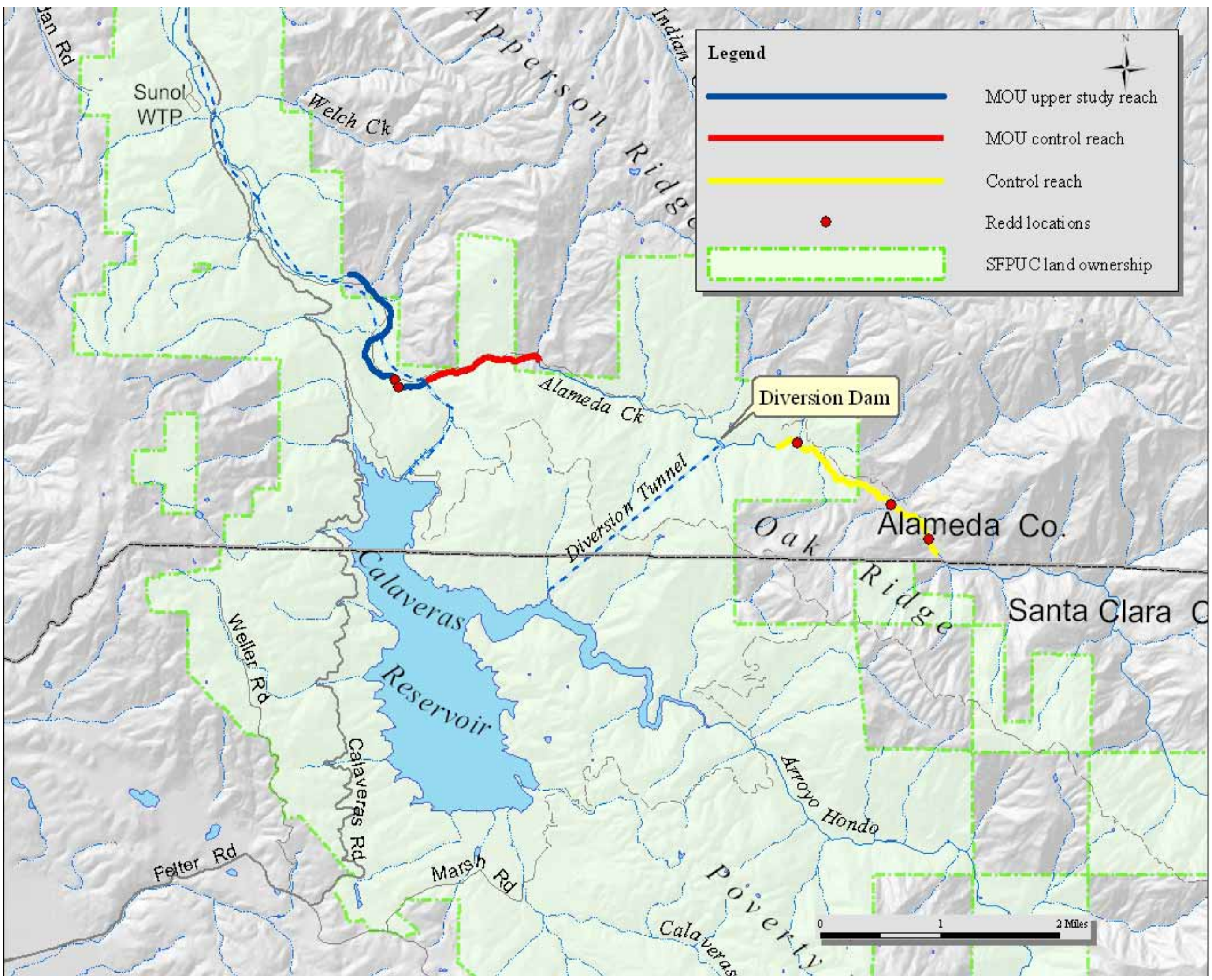


Figure 6-2. *Survey reaches including the control area not covered by the MOU.*

6.2.2 Methods

Each stream reach was surveyed a total of six times, biweekly, from February 7 through April 17, 2007. With the exception of the first survey, both reach surveys were conducted on the same day. Stream reaches were surveyed from the downstream end to the upstream end with one biologist on each bank. Surveyors avoided walking in the creek whenever possible. Each biologist wore a hat with visor and a pair of polarized sunglasses to optimize their ability to view trout, redds and diggings. Recorded observations included any sightings of adult rainbow trout, young-of-the-year (YOY), redds and diggings. Observed redds were marked by hanging red flagging on adjacent vegetation, and documented by recording GPS coordinates. Each flag was labeled with the date, a unique redd number, redd dimensions and redd position with respect to the channel (i.e. mid-channel, left or right bank, etc). The time of the sighting was also noted. In addition to actual redds, the GPS coordinates of suspected test redds and diggings were recorded. Noting GPS coordinates, time observed and the type of habitat that the fish were using documented all rainbow trout adult and YOY observations. Fish observed, but not positively identified as rainbow trout, were not included in counts. Air and water temperature were measured at the beginning and end of each stream reach surveyed.

6.3 Results

6.3.1 Trout and Redd Observations

A total of 13 rainbow trout and four trout redds were noted from the MOU reach, while a total of 67 rainbow trout, six trout redds and five diggings were noted from the control reach (Table 6-1). It is likely that some rainbow trout went undetected during each spawning survey, especially within the pool habitats of the MOU reach, considering the variety of cover available for fish to hide in.

<u>February 7, 2007</u>

This MOU reach survey began at 8:35 a.m. and was completed at 11:35 a.m. Two adult rainbow trout were noted and no redds were observed. Water and air temperatures ranged from 10.0º and 10.0ºC, respectively, at the start of the day to 12.0º and 16.0ºC, respectively, at the end of the day. Although weather conditions consisted of overcast skies with light rain, water visibility remained clear throughout the survey. The mean daily flow was 2.8 cubic-feet-per-second (cfs).

<u>February 8, 2007</u>

This control reach survey began at 8:40 a.m. and was completed at 12:35 p.m. Twenty adult rainbow trout and one digging were noted. No trout redds were observed. Survey conditions and water and air temperatures remained unchanged from the previous day’s survey. The mean daily flow was 2.3 cfs. Cattle were noted in the creek at one location.

<u>February 21, 2007</u>

The second MOU reach survey began at 7:40 a.m. and was completed at 10:50 a.m. Three adult rainbow trout and four trout redds were observed. Three of the observed redds were located within the same creek cross section. Two adult trout observed were on one of the three redds (Figure 6-2). Water and air temperatures ranged from 9.5º and 11.0ºC, respectively, at the start of the survey to 12.5º and 17.0ºC, respectively, at the end of the survey. Weather conditions consisted of patchy sunshine, with water visibility clear throughout the survey. The mean daily flow was 6.3 cfs. Twelve cows were noted on the bank of the creek at one location.

The second control reach survey began at 12:35 p.m. and was completed at 3:10 p.m. Twenty-three adult rainbow trout and five trout redds were observed. Two of the adult trout observed were on a single redd. Weather and water conditions were similar to those encountered during the earlier MOU reach survey. Water and air temperatures ranged from 11.0º and 16.0ºC, respectively, at the start of the survey to 11.5º and 17.0ºC, respectively, at the end of the survey. The mean daily flow was 5.0 cfs. A number of cattle were noted to be in the creek at one location.

<u>March 7, 2007</u>

The MOU reach survey began at 7:40 a.m. and was completed at 10:25 a.m. One adult rainbow trout and no trout redds were observed. Water and air temperatures ranged from 11.0º and 14.5ºC, respectively, at the start of the survey to 12.0º and 16.5ºC, respectively, at the end of the survey. Weather conditions ranged from overcast to sunny with water visibility remaining clear throughout the survey. The mean daily flow was 16.0 cfs.

The control reach survey began at 12:15 p.m. and was completed at 2:50 p.m. Five rainbow trout and one trout redd were observed. Three of these trout were observed on redds. Survey conditions remained unchanged from the MOU reach. Water and air temperatures ranged from 13.0º and 17.0ºC, respectively, at the start of the survey to 13.0º and 22.0ºC, respectively, at the end of the survey. The mean daily flow was 18.0 cfs.

<u>March 23, 2007</u>

The survey of the MOU reach began at 7:55 a.m. and was completed at 10:30 a.m. One adult rainbow trout and no trout redds were observed. Water and air temperatures ranged from 10.0º and 12.0ºC, respectively, at the start of the survey to 12.0º and 16.0ºC, respectively, at the end of the survey. Weather conditions were sunny and water visibility clear throughout the survey. The mean daily flow was 5.0 cfs. Cattle were observed in the creek at two locations.

The survey of the control reach began at 12:05 p.m. and was completed at 2:20 p.m. Eleven rainbow trout and four diggings were observed. Survey conditions remained unchanged from the MOU reach. Water and air temperatures ranged from 13.0º and 24.0ºC, respectively, at the start of the survey to 14.5º and 25.0ºC, respectively, at the end of the survey. The mean daily flow was 4.9 cfs. Cattle were observed in the creek at one location.

<u>April 5, 2007</u>

The MOU reach survey began at 8:15 a.m. and was completed at 10:35 a.m. No rainbow trout and no trout redds were observed. Water and air temperatures ranged from 13.0º and 15.0ºC, respectively, at the start of the survey to 14.0º and 19.0ºC, respectively, at the end of the survey. Weather conditions were overcast and water visibility was clear throughout the survey. The mean daily flow was 3.9 cfs.

The control reach survey began at 12:05 p.m. and was completed at 2:35 p.m. Two rainbow trout and no trout redds were observed. Weather conditions consisted of high, patchy clouds with water visibility remaining clear throughout the survey. Water and air temperatures ranged from 14.0º and 15.0ºC, respectively, at the start of the survey to 14.5º and 19.0ºC, respectively, at the end of the survey. The mean daily flow was 3.7 cfs.

April 17, 2007

The final MOU reach survey began at 8:35 a.m. and was completed at 11:45 a.m. Six rainbow trout (five of them YOY at the same location) were noted, while no trout redds were observed. Water and air temperatures ranged from 12.0º and 13.0ºC, respectively, at the start of the survey to 15.5º and 17.0ºC, respectively, at the end of the survey. Weather conditions ranged from patchy fog to sunny and water visibility was clear throughout the survey. The mean daily flow was 3.5 cfs.

The final control reach survey began at 1:20 p.m. and was completed at 3:35 p.m. Six rainbow trout (all YOY) were noted and no trout redds were observed. Weather conditions consisted of patchy sunshine with clear water visibilities throughout the survey. Water and air temperatures, measured only at the end of the survey, were 13.5º and 16.5ºC, respectively. The mean daily flow was 3.1 cfs.

Table 6-1. *Observations from the 2007 Alameda Creek spawning survey.*

Survey Date	MOU reach			Diversion Dam Reach		
	Rainbow trout	Redds	Diggings	Rainbow trout	Redds	Diggings
7-Feb-07	2	0	0	-	-	-
8-Feb-07	-	-	-	20	0	1
21-Feb-07	3	4	0	23	5	0
7-Mar-07	1	0	0	5	1	0
23-Mar-07	1	0	0	11	0	4
5-Apr-07	0	0	0	2	0	0
17-Apr-07	6	0	0	6	0	0
Totals	13	4	0	67	6	5

6.3.2 Flow and Spawning Activity Relationships

The only major storm events that affected Alameda Creek stream flows during the 2007 spawning survey period occurred in February. A series of storms between February 9 and 13, 2007 increased mean daily flows, peaking them at 107 cfs at the USGS gage just below the confluence of Alameda and Calaveras creeks (11173510) on February 11. Mean daily flow at the same station dropped back down to a low of 6.3 cfs on February 22, before another series of storms between February 22 and 28, 2007 drove them back up to a maximum of 451 cfs on February 26. While the total number of redds observed during the 2007 surveys was relatively low, they were all found at the base of the receding limb of the two storm events (Figure 6-3).

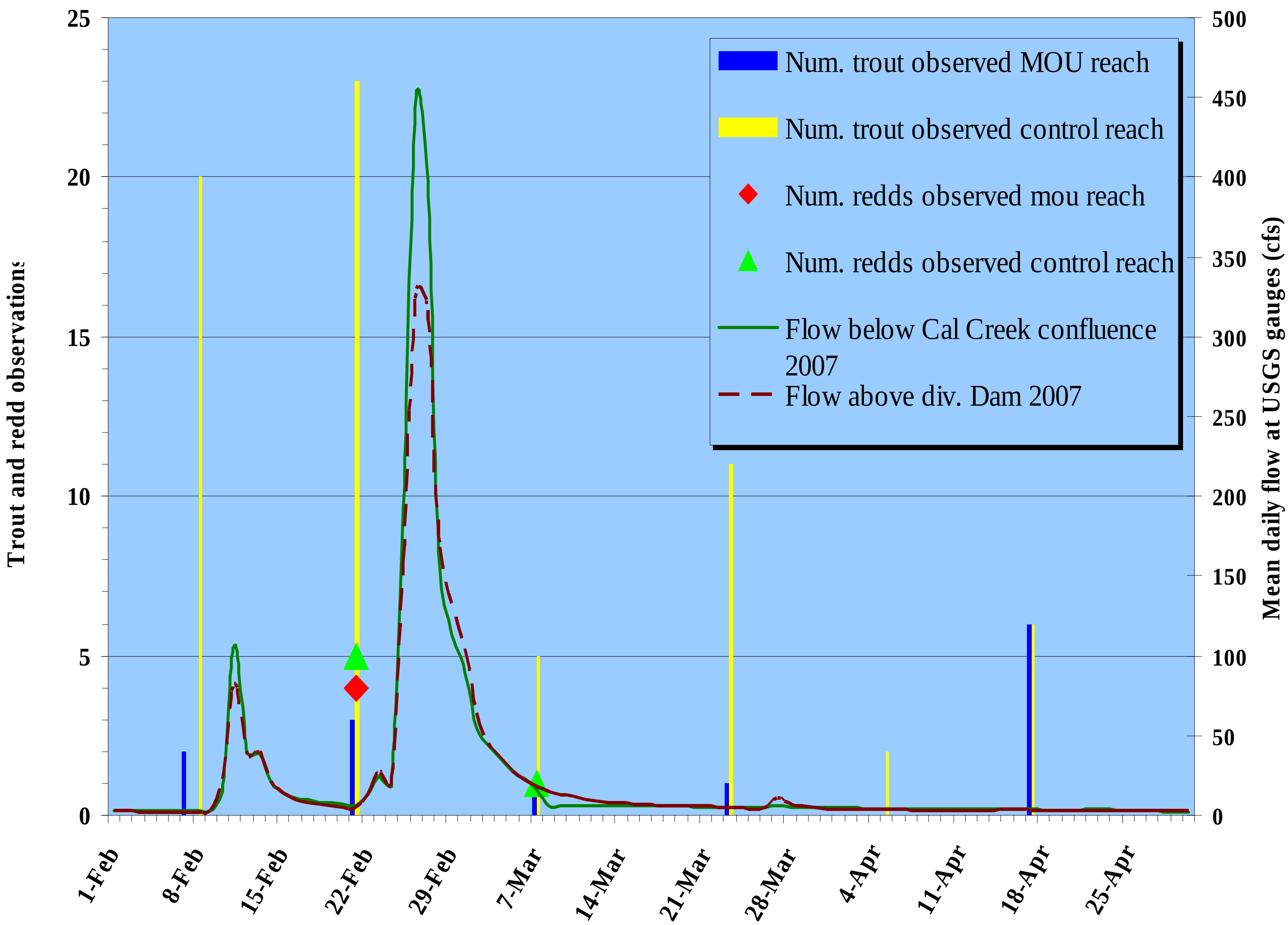


Figure 6-3. *Rainbow trout and redd observations, and Alameda Creek flows, for the 2007 spawning season.*

7.0 Snorkel Survey

7.1 Background

There are deep pools along Alameda and Calaveras creeks and Arroyo Hondo that may be important to sustaining populations of rainbow trout and native, warm water fishes (Figure 7-1). These pools can provide cool-water refugia, especially during summer and early fall when temperatures are at their highest and flows at their lowest. This component of the study is designed to evaluate the extent to which pools in these three streams provide suitable habitat to fishes. A series of selected pools have been routinely monitored and the data will help to understand the effect of water releases on pool habitat for rainbow trout and native warm water fish species.

Figure 7-1. *Snorkelers in a pool in Arroyo Hondo.*

7.2 Procedure

Snorkel surveys are a cost-effective means of sampling deeper pools where electrofishing does not work well. For the purposes of this study, pools were typically defined as instream bodies of water with an average depth of greater than or equal to four-feet. While some pool locations may not meet these depth criteria during dry water years, they are not excluded from the study. Thirteen pools were snorkeled on August 8, 9 and 14, 2007 in Alameda and Calaveras creeks and Arroyo Hondo (Figure 7-2, Table 7-1). Fourteen sites were selected, but due to a low water year one of the sample sites had dried completely and no alternate pool was selected. Upon arrival at each pool, a 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. Some pool locations included starting points with depths too shallow to begin the survey with masks submerged. At these locations, prior to lowering themselves into the pool to begin counting, the snorkel team would walk in a line herding any observed fish into the survey area. The snorkelers moved slowly upstream as a group, identifying species by size class, and counting fishes only as they were encountered passing between biologists or between a biologist and the bank (Figure 7-3).

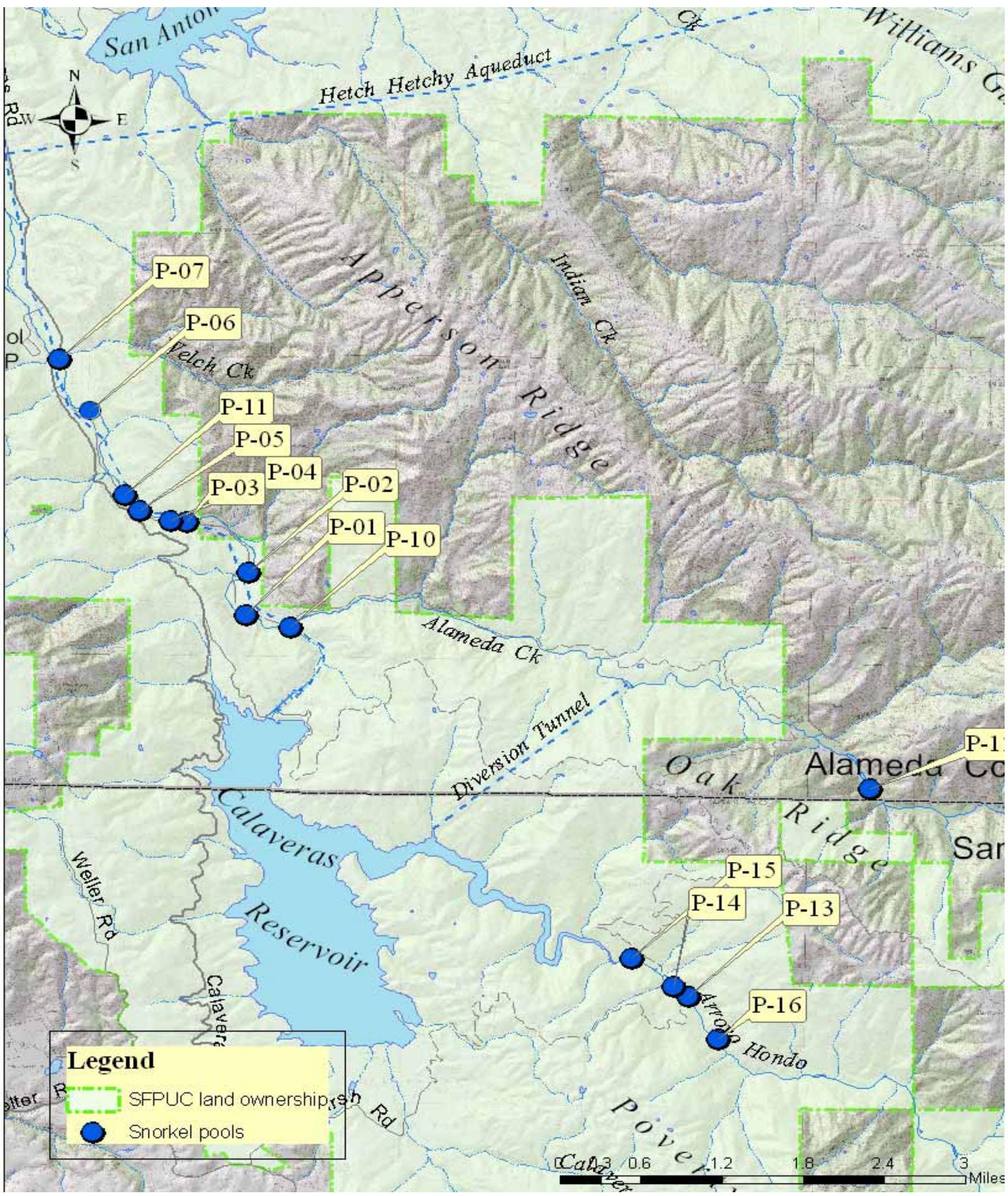


Figure 7-2. *Snorkel survey sites in Alameda and Calaveras creeks and Arroyo Hondo.*

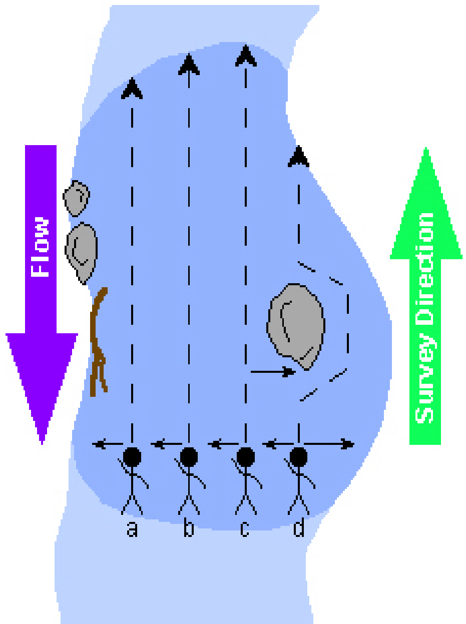


Figure 7-3. *Typical snorkel survey strategy. Snorkelers count fish in the direction the arrows indicate, from their arm to the bank or to the snorkeler next to them.*

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 either hiding or difficult to see. This included undercut banks, 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.

7.3 Species Composition

A total of seven species of fishes were observed in thirteen pools during the 2007 snorkel survey (Figure 7-4). California roach was the most abundant species, accounting for almost 94 percent of all fishes observed, followed by Sacramento pikeminnow (2.2 percent of total), largemouth bass and sunfishes (2.2 percent of total), Sacramento sucker (1.8 percent of total), rainbow trout (0.22 percent of total) and prickly sculpin (0.07 percent of the total). California roach were present in all except one of the 13 pools surveyed while Sacramento sucker were found in ten of the 13 pools. Sacramento pikeminnow were observed in seven of the pools and rainbow trout and prickly sculpin were each present in five of the pools. Largemouth bass were found in four and sunfishes in one of the 13 pools.

7.3.1 Pool P-1

This Alameda Creek pool was 2.2-feet at its deepest point, near the right bank, roughly one third through the pool. Approximately thirty-five percent of the surface was shaded. This pool accounted for three percent of the total number of fishes observed in the survey (Figure 7-4, Appendix C) and the only observation of rainbow trout within the Alameda Creek sites. California roach (85 percent adult) accounted for 93 percent of the 457 fishes observed. Fifteen largemouth bass (one adult) were observed and comprised just over three percent of the pool total. The remaining fishes observed were Sacramento pikeminnow, comprising three percent of the pool total, two adult rainbow trout and one juvenile Sacramento sucker.

Table 7-1. *Snorkel survey station descriptions for 2007.*

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.	8/8/07	11:10	17.5 °C	17.3 °C
P-2	Rat Pool	In Alameda Creek, ~ 900-feet downstream of the wooden truss bridge in Sunol Regional Park.	8/8/07	09:55	17.0 °C	17.0 °C
P-3	Fence Pool	In Alameda Creek, just downstream of the Sunol Regional Park / SFPUC boundary fence.	8/9/07	13:15	21.3 °C	19.5 °C
P-4	Lunch Pool	In Alameda Creek, ~ 3,000-feet downstream of the Sunol Regional Park / SFPUC boundary fence.	8/9/07	14:20	20.0 °C	19.5 °C
P-5	Sycamore Pool	In Alameda Creek, ~ 4,000-feet downstream of the Sunol Regional Park / SFPUC boundary fence.	8/9/07	14:10	20.1 °C	19.2°C
P-6	S-Bend Pool	In Alameda Creek, ~ 3,000-feet upstream of the Calaveras Road bridge.	8/9/07	09:30	19.0 °C	18.8 °C
P-7	Bathing Pool	In Alameda Creek, ~120-feet upstream of the Calaveras Road bridge.	8/9/07	10:45	21.0°C	20.3°C
P-10	Bass Pool	In Calaveras Creek, ~50-feet upstream of the Alameda Creek / Calaveras Creek Confluence.	8/8/07	12:00	21.9 °C	18.0 °C
P-11	Shade Pool	In Alameda Creek, ~4,500-feet downstream of the Sunol Regional Park / SFPUC boundary fence.	8/8/07	13:00	19.6°C	19.5°C
P-12	Sycamore Camp Pool	In Alameda Creek, ~1,000-feet upstream of the Camp Ohlone southern boundary.	8/8/07	N/A	N/A	N/A
P-13	Butterfly Pool	In Arroyo Hondo, ~800-feet upstream of the USGS gauging station.	8/14/07	13:35	17.8 °C	17.0 °C
P-14	USGS Gauge Pool	In Arroyo Hondo, just upstream of the USGS gauging station.	8/14/07	12:30	18.0 °C	16.7 °C
P-15	Raccoon Pool	In Arroyo Hondo, ~800-feet downstream of the USGS gauging station.	8/14/07	10:30	18.7 °C	16.7°C
P-16	Campfire Pool	In Arroyo Hondo, ~1600 feet upstream of the USGS gauging station.	8/14/07	14:50	16.9°C	15.8°C

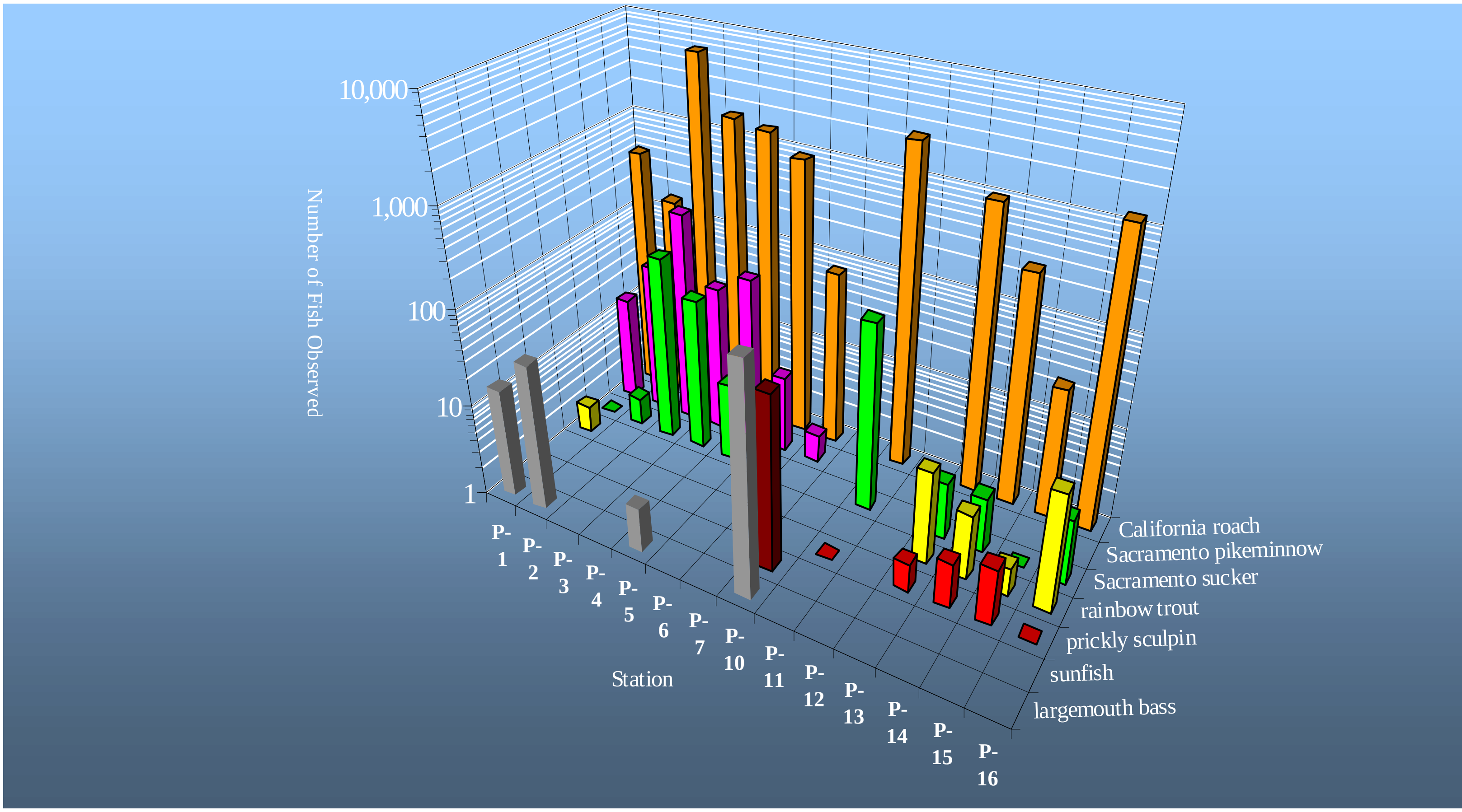


Figure 7-4. *Number of fishes observed by pool during snorkel surveys for 2007.*

7.3.2 Pool P-2.

The maximum depth of this Alameda Creek pool was five-feet, found at two points; both near the right bank, approximately halfway through the pool, near the right bank adjacent to bedrock. Riparian vegetation shaded approximately 95 percent of the surface. A small man-made boulder dam lay across the main channel, adjacent to a gravel bar just downstream of the starting point. California roach (67 percent adults) accounted for 65 percent of the 234 fishes counted. Sacramento pikeminnow accounted for 18 percent of the pool total and the third highest count in the survey. Largemouth bass (five percent adult) comprised nearly 16 percent of the pool total and the second highest count in the survey. Two Sacramento sucker, one adult and one juvenile, were observed.

7.3.3 Pool P-3

This Alameda Creek pool had the highest fish count of the survey. It contained many large boulders and the deepest section, at 3.5-feet, was located on the right margin of mid-channel one third of the way through the pool, behind a large boulder. California roach (12 percent adults) accounted for 95 percent of the 6,377 fishes observed and was the largest count for that species in the survey. Sacramento pikeminnow (highest count of the survey) and Sacramento sucker (second highest count of the survey) accounted for the remainder at three and two percent, respectively. Nineteen pikeminnow and three suckers were adults, with many of them the largest observed in any pool. Twenty percent of the pool was shaded.

7.3.4 Pool P-4

Located downstream of Sunol Regional Park, within the Alameda Creek warm water study reach, this pool was bisected at the upstream end by a large gravel bar. The deepest point was located in the thalweg of the left channel, approximately one quarter downstream of the end point, at three-feet. Twenty percent of the surface was shaded. This pool had the third highest total fish count in the survey. California roach (27 percent adults) accounted for 95 percent of the 1,746 fishes observed. Sacramento Sucker (no adults) accounted for three percent of the total and Sacramento pikeminnow the remaining two percent. Roach and sucker counts were the third highest in the survey.

7.3.5 Pool P-5

Thick algal matting covered nearly 25 percent of this shallow Alameda Creek pool. The deepest point was 2.5-feet and was located approximately halfway through the pool, on the left bank. Eighty-five percent of the surface was shaded. California roach (seven percent adults) accounted for 95 percent of the 1,517 fishes observed. This was the fourth highest total count of the pools surveyed. This pool contained the second highest number of Sacramento pikeminnow, representing four percent of the total pool count. The remaining one percent consisted of Sacramento sucker and largemouth bass.

7.3.6 Pool P-6

Pool P-6 was slightly turbid in comparison to the other pools. Seventy percent of the surface was shaded. The deepest point was four-feet and located mid-pool, adjacent to a large boulder on the right bank. California roach (five percent adult) comprised 99 percent of the 937 total fishes observed in the pool. Adult Sacramento pikeminnow accounted for the remaining one percent.

7.3.7 Pool P-7

The downstream-most pool in Alameda Creek had the highest turbidity reading of all pools and was isolated from surrounding surface flows. The absence of riparian vegetation and copious amounts of manure suggested the frequent presence of cattle. This pool had the second lowest observed total count in the survey, along with a relatively low dissolved oxygen concentration of 5 milligrams per liter. The deepest point of three-feet was located mid-channel, approximately halfway through the pool. Ninety percent of the surface was shaded. California roach accounted for 98 percent of the 82 fishes observed. Adult Sacramento pikeminnow accounted for the remaining two percent. Visibility was poor and it is likely that some fishes were not observed.

7.3.8 Pool P-10

This Calaveras Creek pool was the largest surveyed, with a total length of approximately 470-feet and an average width of 50-feet. The deepest point of eight-feet was located mid-channel upstream of the SFPUC/Sunol Regional Park boundary fence, next to a large boulder. Riparian vegetation along each bank was relatively thick, and approximately ten percent of the surface was shaded. It should be noted that the majority of the pool was chocked by extensive macrophyte beds and covered by algal mats. The vegetation, coupled with high turbidity and visibilities of one- to three-feet, made observations difficult and the counts likely underestimate relative abundances. This pool also had the lowest measured dissolved oxygen concentration at 4.7 milligrams per liter. Largemouth bass and sunfishes combined for 100 percent of the 323 observed fishes, at 78 and 22 percent, respectively. Ten percent of the bass and 29 percent of the sunfishes were adults. Large numbers of unidentified larval fishes were noted sheltering in the dense beds of macrophytes and were not included in the final count.

7.3.9 Pool P-11

This was the longest Alameda Creek pool snorkeled and had the second highest number of observed fishes at 2,546 of which 96 percent were California roach (23 percent adult). Sacramento sucker (no adults) and a single prickly sculpin combined for the remaining four percent. Seventy-five percent of the pool was shaded. The deepest spots of 1.5-feet were located at two locations; along the steep left bank, two thirds downstream of the end of the pool, and on the right bank, just downstream of the end of the pool.

7.3.10 Pool P-12

This pool, located furthest upstream of all the Alameda Creek sites with a large downed sycamore lying directly over the channel, was dry. The morphology of the streambed at this site has changed dramatically since the previous survey, with a large gravel bar forming and filling in the pool beneath the fallen tree. The main channel has been redirected to the left of the base of the fallen tree where it is eroding the relatively steep bank.

7.3.11 Pool P-13

This Arroyo Hondo pool, located approximately 800-feet upstream of USGS gauging station 11173200, contained the second highest number of observed rainbow trout in the survey. The deepest point was 5.4-feet and located on the left bank, one quarter of the way upstream from the starting point. This pool provides fishes with ample cover in the form of rocks, undercut bank and overhanging vegetation. A dense riparian canopy shaded 50 percent of the surface. California roach (ten percent adults) accounted for 98 percent of the 1,016 total fishes observed. Ten rainbow trout (eight adults), four adult Sacramento sucker and two prickly sculpin accounted for the remaining two percent.

7.3.12 Pool P-14

Located just upstream of USGS gauging station 11173200, this Arroyo Hondo pool was approximately 9-feet deep, mid-pool, near the left bank. A dense riparian canopy shaded 30 percent of the surface. California roach (43 percent adults) accounted for 96 percent of the 292 fishes observed. Five adult rainbow trout, four adult Sacramento sucker and three prickly sculpin accounted for the remaining four percent.

7.3.13 Pool P-15

Pool P-15 is located roughly 800-feet downstream of the Marsh Road Bridge on Arroyo Hondo. The fewest number of fishes were observed here. Its deepest point (3.8-feet) was located midstream, approximately halfway through the pool, just downstream of a large boulder. Forty percent of the pool was shaded by a dense riparian canopy. Twenty-five adult California roach accounted for 78 percent of the 32 fishes observed. Two adult rainbow trout, three prickly sculpin and one juvenile Sacramento sucker accounted for the remainder.

7.3.14 Pool P-16

At 288-feet, site P-16 was the longest of the Arroyo Hondo pools snorkeled and contained the greatest number of rainbow trout observed in the survey. It is located approximately 800-feet upstream of pool P-13. Its deepest point, at 9.5-feet, was located in the scoured mid-channel approximately halfway through the pool. The surface was 85 percent shaded by a dense riparian canopy and overhanging vegetation. California roach (32 percent adults) accounted for 98 percent of the 1,264 fishes observed. Eighteen rainbow trout (17 adult), five adult Sacramento sucker and one prickly sculpin accounted for the remaining two percent. With less than ideal visibility conditions, due mostly to shading and turbidity, it is likely that the observed number of adult rainbow trout underestimates the true number present.

8.0 Electrofishing Survey

8.1 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 achieved. Additionally, fishes from other parts of the watershed, where existing conditions are expected 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.

8.2 Procedure

Electrofishing surveys took place at 13 stations between October 9 and October 22, 2007, in Alameda, Calaveras, La Costa and Indian creeks and in Arroyo Hondo (Figure 8-1, Table 8-1). A total of 28 distinct habitat types (pools, riffles, runs, glides, etc.) at the stations 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.

Habitat types were isolated with 3/8-inch mesh block-nets upon arrival at each sampling station. 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 Resources and Lands Management 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

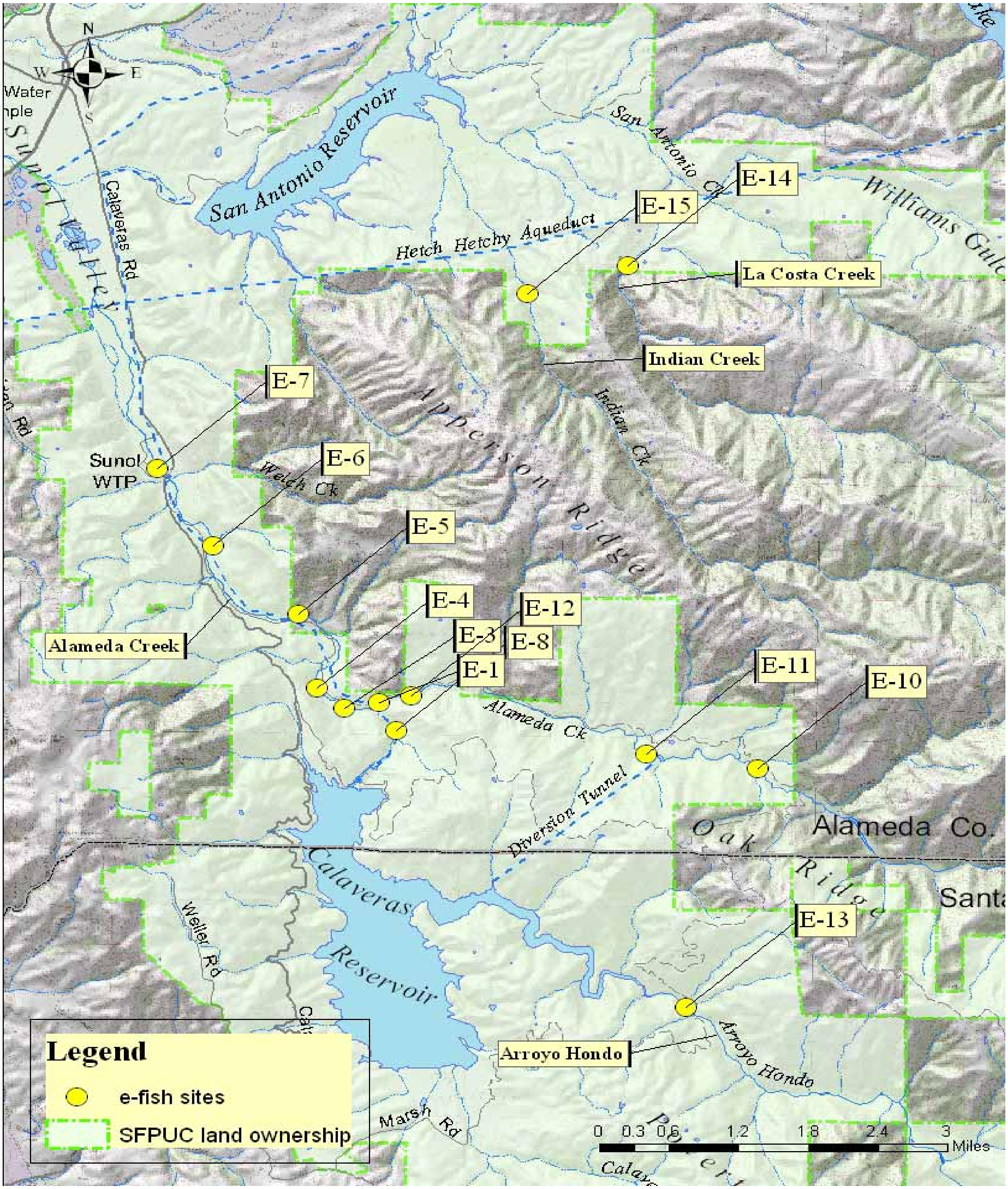


Figure 8-1. *Alameda, Calaveras, La Costa and Indian creeks and Arroyo Hondo 2007 electrofishing survey stations.*

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 2007.*

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/Chute 3 = Run/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 = Pool
E-7	In Alameda Creek, downstream of the Calaveras Road bridge, near the Sunol Valley Water Treatment Plant.	1 = Pool 2 = Run/Low Gradient Riffle 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 = Run 2 = Low Gradient Riffle 3 = Pool
E-11	In Alameda Creek, downstream of the Alameda Creek Diversion Dam.	1 = High Gradient Riffle 2 = Pool
E-12	In Alameda Creek, in and toward the top of Little Yosemite.	1 = Step Pools 2 = High Gradient Riffle
E-13	In Arroyo Hondo, between the USGS gauging station and just downstream of the Marsh Road bridge.	1 = Glide 2 = Low/High Gradient Riffle
E-14	In La Costa Creek, at the boundary between SFPUC property and private property.	1 = Shallow Pool 2 = Run/Riffle
E-15	In Indian Creek, upstream of where the canyon becomes relatively narrow and steep.	1,2,3 = Step Pool Complex 4 = Isolated 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 resident 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.

8.3 Station Descriptions

Electrofishing station E-1 consisted of a single habitat type: a pool. The pool was 80-feet long, with an average width and depth of 14.2-feet and 1.8-feet, respectively. The maximum depth, located at the upstream end of the pool, was 4.7-feet. The dominant substrate types were gravel, sand, and cobble, with some bedrock and boulders on either side of the pool. There were 20-feet of undercut bank and 15-feet of overhanging vegetation, mostly along the left side of the reach. Shading during the survey ranged from 60 to 90 percent.

Electrofishing station E-3 (Figure 8-2) consisted of two habitat types: a glide and a low gradient riffle. The glide was 85.0-feet long, with an average width and depth of 11.5-feet and 0.6-feet, respectively. The maximum depth of the glide, located in the middle of the channel in the upstream third of the section, was 1.5-feet. The majority of the substrate in the glide was sand, gravel, and cobble, and cover was provided by boulders and about 50-feet of overhanging vegetation along both the left and right banks. Ninety percent of the habitat was shaded throughout the survey. The low gradient riffle was 75.0-feet long, with an average width and depth of 8.9- and 0.3-feet, respectively. The majority of the substrate was gravel and cobble. Cover was provided by 25-feet of overhanging vegetation. Eighty to ninety percent of the riffle was shaded during cloudy survey conditions.

Figure 8-2. *SFPUC biologists electrofishing at Alameda Creek Station E-3 in Sunol Regional Park.*

Electrofishing station E-4 consisted of three habitat types: a glide, a glide flowing into a chute, and a run flowing into a glide. The first glide was 60-feet long, with an average width and depth of 12.3-feet and 0.5-feet, respectively, and a deepest point of 1.1-feet at the upstream end near the right bank. The dominant substrates in the glide were cobble and boulder. Cover was provided by the boulders and 65-feet of overhanging vegetation. The entire survey was overcast at all three habitats. The glide/chute was 110-feet long, with an average width and depth of 14.7-feet and 0.4-feet, respectively, and a deepest point of 0.7-feet. The dominant substrates in the riffle portion were cobble and rubble. Some cover in the riffle was provided by 65-feet of overhanging vegetation. The run/glide was 95-feet long, with an average width and depth of 16.2-feet and 1.1-feet, respectively. The dominant substrates in the glide were cobble, gravel and rubble, while several boulders and tules along either bank (130-feet of overhanging vegetation) provided cover. The deepest point in the run of 2.0-feet was found midstream at the upstream end of the habitat.

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 69-feet, with an average width and depth of 20.7-feet and 1.1-feet, respectively, were sampled. A maximum depth of 2.7-feet was found on the upstream end of the pool on the right side of the channel. The dominant substrates were gravel and cobble. Some boulders, about 20-feet of undercut bank with submerged tree roots, and 15-feet of overhanging vegetation provided cover. The pool was overcast during the survey.

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 (Figure 8-3) and a pool. The glide habitat at E-6 was not sampled due to stream morphological changes. The run was 65-feet long, with an average width and depth of 14.6-feet and 0.8-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 substrates in the run were cobble, gravel and rubble with a few boulders. Fifteen feet of undercut bank without any overhanging vegetation provided cover. Ninety to 100 percent of the run was shaded during the survey. The low gradient riffle was 152-feet long, with an average width and depth of 9.4-feet and 0.2-feet, respectively. The maximum depth was 0.6-feet, located mid-stream at the downstream end. The dominant substrate in the riffle was cobble and rubble with some gravel mixed in. Much of the habitat area was completely covered with floating algae, making fish observations and collection very difficult. Twenty to 90 percent of the riffle was shaded during the survey. The pool was 131-feet long, with an average width and depth of 22.5-feet and 0.8-feet, respectively. The deepest portion of this section was 2.9-feet, located to the left side of the channel in the middle reach of the pool. Cobble with rubble and gravel were the dominant substrates. Boulders, 20-feet of undercut bank, 5-feet of

Figure 8-3. *Floating algae chokes the surface of a low gradient riffle at Station E-6.*

overhanging vegetation and a single instream log provided cover. Shading ranged from 50 percent to overcast during the survey.

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 80-feet long, with an average width and depth of 19.4-feet and 1.2-feet, respectively. The deepest part of the pool was 4.0-feet, and was located beneath a fallen tree on the left side of the stream about mid-way through the section. The dominant substrates in the pool were cobble, gravel and sand, followed by silt and rubble. Cover in the pool was provided by 30-feet of undercut bank in the form of a large sycamore root mass and 6-feet of overhanging vegetation. Shading in the pool ranged from 60 to 80 percent during the survey. The riffle/run complex was 92-feet long, with an average width and depth of 12.3-feet and 0.5-feet, respectively. The deepest part of the section, located at the middle of the run portion, was 1.2-feet. The dominant substrate in this riffle/run was gravel, followed by cobble and sand. Cover in the section consisted of 2-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 153-feet long, with an average width and depth of 13.2-feet and 0.4-feet, respectively, and a deepest point of 1.0-feet located mid-channel near the upstream end of the habitat. The dominant substrates were cobble, sand, and gravel. Thirty-feet of overhanging vegetation provided cover. Eighty to one hundred 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 downstream pool (pool 1) was 44-feet long, with an average width and depth of 13.3-feet and 1.6-feet, respectively. The deepest part of pool 1, located at the right side of its upstream end, was 3.0-feet. The dominant substrate in pool 1 was boulder, and about 60-feet of overhanging vegetation provided additional cover. Shading in pool 1 during the survey ranged from 70 to 90 percent. Isolated pool 2 was 22-feet long, with an average width and depth of 6.6-feet and 1.9-feet, respectively. A maximum depth of 2.8-feet was located to the right of the pool. The dominant substrate in pool 2 was boulder that provided the only cover. Shading in pool 2 ranged from 90 to 100 percent during the survey.

Electrofishing station E-10 consisted of three habitat types: a run, a riffle, and a pool. The run was 42.5-feet long, with an average width and depth of 8.6-feet and 0.5-feet, respectively. The deepest part of the run, located right of mid-channel at the downstream end of the reach, was 1.1-feet. The dominant substrates were a combination of boulder, rubble, and gravel. Boulders provided the only cover available. All three habitats were overcast during the survey. The low gradient riffle was wetted for a length of only 8.6-feet with another 70-feet of dry creek bed normally surveyed during wetter conditions. The average width and depth were 9.3-feet and 0.3-feet, respectively. A maximum depth of 0.4-feet was found in the remnant riffle. The dominant substrate was boulder and rubble. Boulders provided the only cover in the stream reach. The pool was 42-feet long, with an average width and depth of 7.5-feet and 0.8-feet, respectively. The deepest point, located on the left side just over halfway through the pool, was 2.0-feet. Boulders dominated the pool, followed by rubble, cobble, and gravel. Boulders were the only form of cover.

Electrofishing station E-11 consisted of two habitat types: a high gradient riffle and a pool. The riffle was 21-feet long, with an average width and depth of 7.0-feet and 0.3-feet, respectively. The maximum depth of the riffle, located in the middle of channel near the middle of the reach, was 0.7-feet. The majority of the substrate in the riffle was gravel and cobble, while numerous large boulders provided cover. The riffle was overcast during the survey. The pool was 49-feet long, with an average width and depth of 12.3-feet and 0.9-feet, respectively. The pool substrates were an even mix of boulder, rubble, cobble and gravel. There was no other cover in the pool. The pool was overcast during the survey.

Electrofishing station E-12 consisted of two habitat types: a series of step pools and a high gradient riffle. The step pool complex combined for a total length of 95-feet, with an average width and depth of 10.8-feet and 0.4-feet, respectively. The maximum depth of the reach, located in the upstream most pool, was 2.8-feet. The majority of the substrates in the pools were boulder, cobble, and gravel. Three-feet of overhanging vegetation provided some additional cover in the pools. The pool and riffle were both overcast during the survey. The riffle was 28-feet long, with an average width and depth of 4.0-feet and 0.2-feet, respectively. Maximum depth of 0.5-feet was found mid-channel, at the downstream end of the section. The majority of the riffle's substrates were cobble followed by even amounts of boulder, rubble and gravel. The boulders and 4-feet of overhanging vegetation provided cover.

Electrofishing station E-13 consisted of two habitat types: a glide and a variable gradient riffle. The glide was 104-feet long, with an average width and depth of 21.6-feet and 0.9-feet, respectively. The maximum depth of the glide, located midstream about two-thirds of the way downstream, was 1.7-feet. Most of the glide's substrate was rubble, cobble and gravel. Some boulders and 40-feet of overhanging vegetation along the left bank provided cover. Although the riparian vegetation along this portion of creek is dense, the bed load from a large drainage entering the stream from the right has made this section relatively open, providing only 20 percent shade at the start the survey, becoming overcast by the end of the survey. The 70-foot long riffle complex contained 30-feet of high gradient and 40-feet of low gradient area, with an overall average width and depth of 21.8-feet and 0.2-feet, respectively, and a deepest point 0.5-feet. The majority of the riffle's substrates were rubble and cobble, with lesser amounts of boulder and gravel. Numerous scattered boulders provided the only cover in the riffle. The riffle ranged from 20 percent shading to overcast during the survey.

Electrofishing station E-14 consisted of two habitat types: a shallow pool and a run flowing into a riffle. The shallow pool was 52-feet long, with an average width and depth of 10.5-feet and 0.4-feet, respectively. The maximum depth of the section, located left of center channel in the upstream third of the pool, was 1.1-feet. The majority of the substrate was cobble, gravel and silt, while several boulders provided cover. The dense riparian canopy over this reach of the creek resulted in 90 to 95 percent shading during the survey. The run/riffle was 56-feet long, with an average width and depth of 8.4-feet and 0.5-feet, respectively. The maximum run/riffle depth was 1.2-feet near the upstream right bank. The majority of the section's substrate was cobble, rubble, and silt. Some boulders provided the only cover. Seventy to eighty percent of the section was shaded during the survey.

Electrofishing station E-15 (Figure 8-2) consisted of two habitat types: one a step-pool complex and the other an isolated pool. Due to current flow conditions, the step pool complex (15-1,2,3) was comprised of the three isolated pools formerly sampled as discrete stations 15-1, 15-2, and 15-3. This pool complex combined in length to 74.0-feet in four discrete step-pools, with an average width and depth of 7.0-feet and 0.9-feet, respectively. The deepest point within these pools was 1.5-feet. The dominant substrates in the pool complex were cobble, gravel and sand, with several boulders and 6-feet of undercut bank providing cover. Shading in the pools through the day was constant at 100 percent. The upstream isolated pool had a total length of 15-feet, with an average width and depth of 9.0-feet and 1.5-feet, respectively. A maximum depth of 2.5-feet was located just off the right bank, near the pool's upstream end. The dominant substrate in the pool was gravel, with lesser equal amounts of cobble and sand. Cover in the pool was provided by 6-feet of undercut bank. The pool was shaded 100 percent of the time during the survey.

8.4 Species Composition

A total of eight species were collected from the 13 stations and 28 habitats sampled during the 2007 electrofishing survey (Figure 8-4). Population estimates of each species were calculated from multiple-pass fish collection data at all sites with the Microfish 3.0 statistical software package. According to population estimates, California roach dominated the catches, accounting for 84 percent of all fishes collected, followed by rainbow trout (five percent of total), Sacramento sucker (four percent of total), Sacramento pikeminnow (three percent of total), prickly sculpin (two percent of total) and Pacific lamprey (one percent of total), and largemouth bass and Western mosquitofish (less than one percent of total each). The number of species found in any single habitat type ranged from zero to seven. Appendix D includes a summary of the number of fishes caught and population estimates for each species by station and habitat type. Appendix E presents error and goodness of fit statistics for the population estimates.

Four species were collected from electrofishing station E-1 (Figure 8-4). Population estimates (Appendix D) indicate that California roach dominated (148 fish), followed by Sacramento sucker (23 fish), prickly sculpin (10 fish), and Sacramento pikeminnow (five fish).

Seven species were collected from the glide at station E-3 (Figure 8-4). Population estimates (Appendix D) indicate that California roach dominated (257 fish), followed by Pacific lamprey ammocetes (12 fish), Sacramento sucker and Sacramento pikeminnow (4 fish each), largemouth bass (three fish), prickly sculpin and rainbow trout (two fish each). Only two species were found in the low gradient riffle at station E-3 (Figure 8-4). Population estimates (Appendix D) indicate that there were 42 California roach and five rainbow trout.

There were three species collected from the glide sampled at station E-4 (Figure 8-4). Population estimates (Appendix D) indicate that California roach dominated (36 fish), followed by Sacramento sucker (2 fish) and largemouth bass (one fish). Five species were collected from the glide/chute at station E-4 (Figure 8-4).

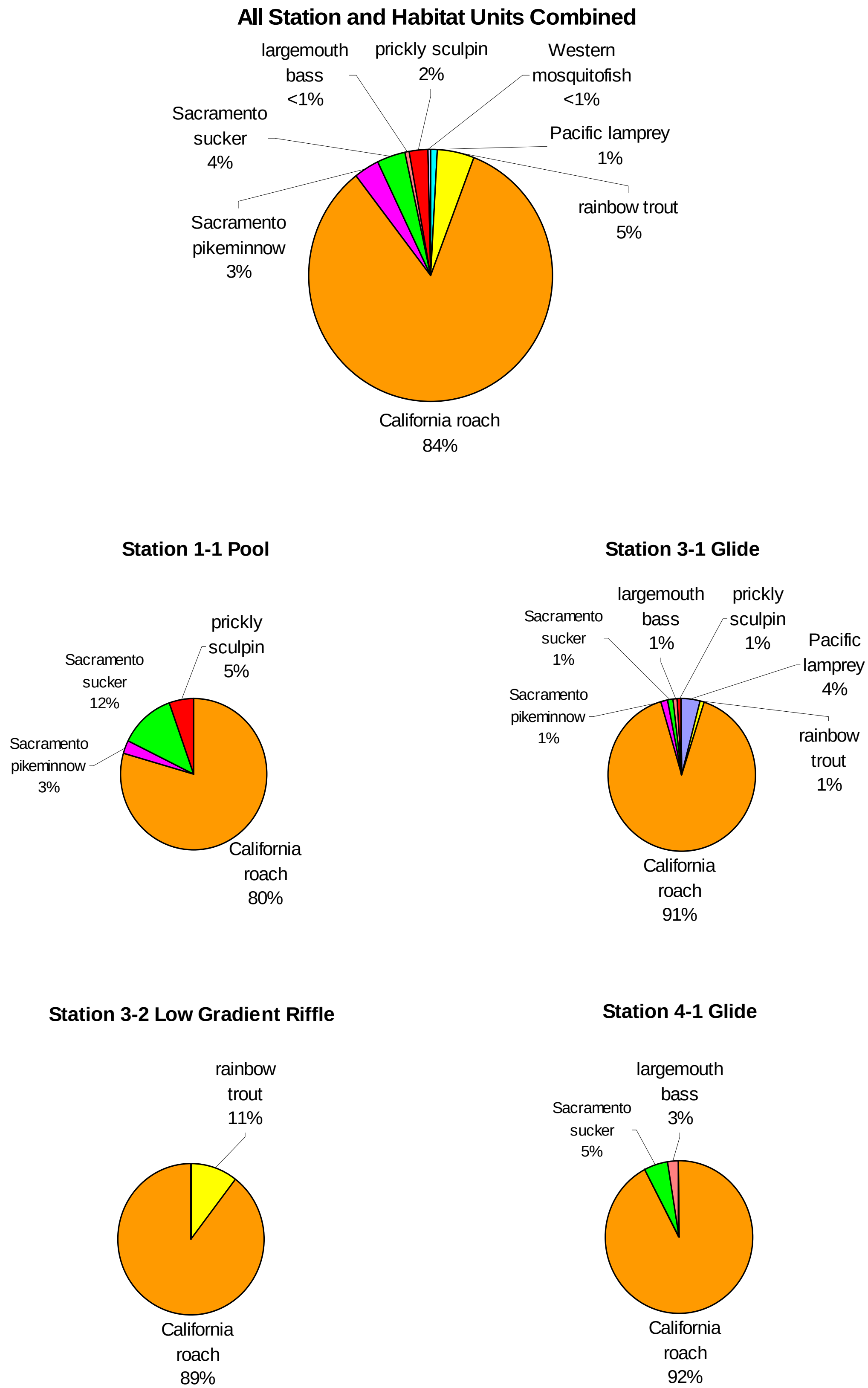
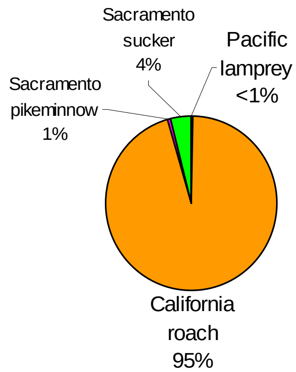


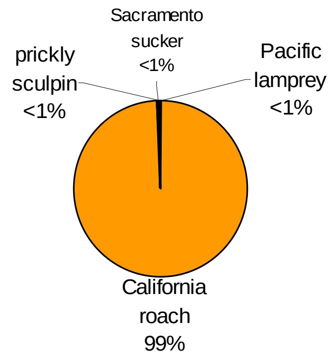
Figure 8-4. *Percent occurrence of each species by station and habitat type, based on population estimates for the autumn 2007 electrofishing surveys.*

Figure 8-4 continued.

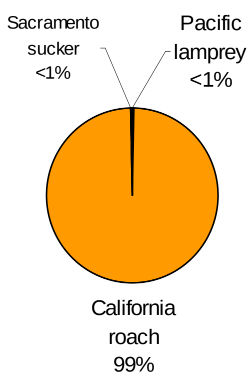
Station 7-1 Pool



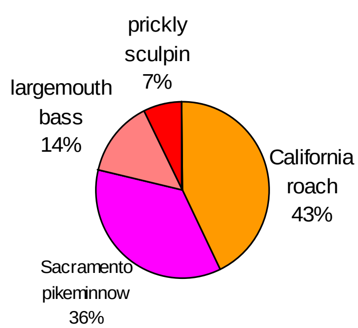
Station 7-2 Run/Riffle



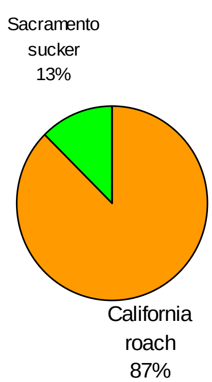
Station 7-3 Run



Station 8-1 Pool



Station 8-2 Pool



Station 10-1 Run

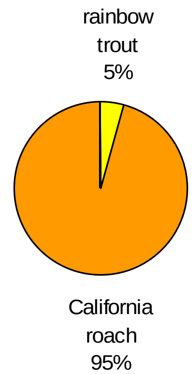
No fish caught

Figure 8-4 continued.

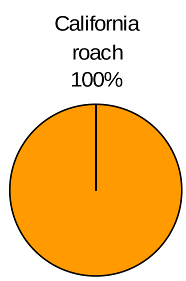
Station 10-2 Run/Riffle Complex

No fish caught

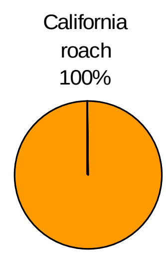
Station 10-3 Pool



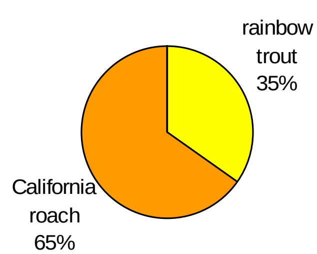
Station11-1 High Gradient Riffle



Station 11-2 Pool



Station 12-1 Step Pools



Station 12-2 Riffle

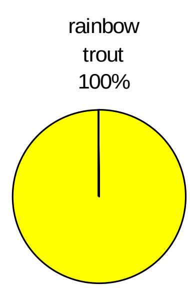


Figure 8-4 continued.

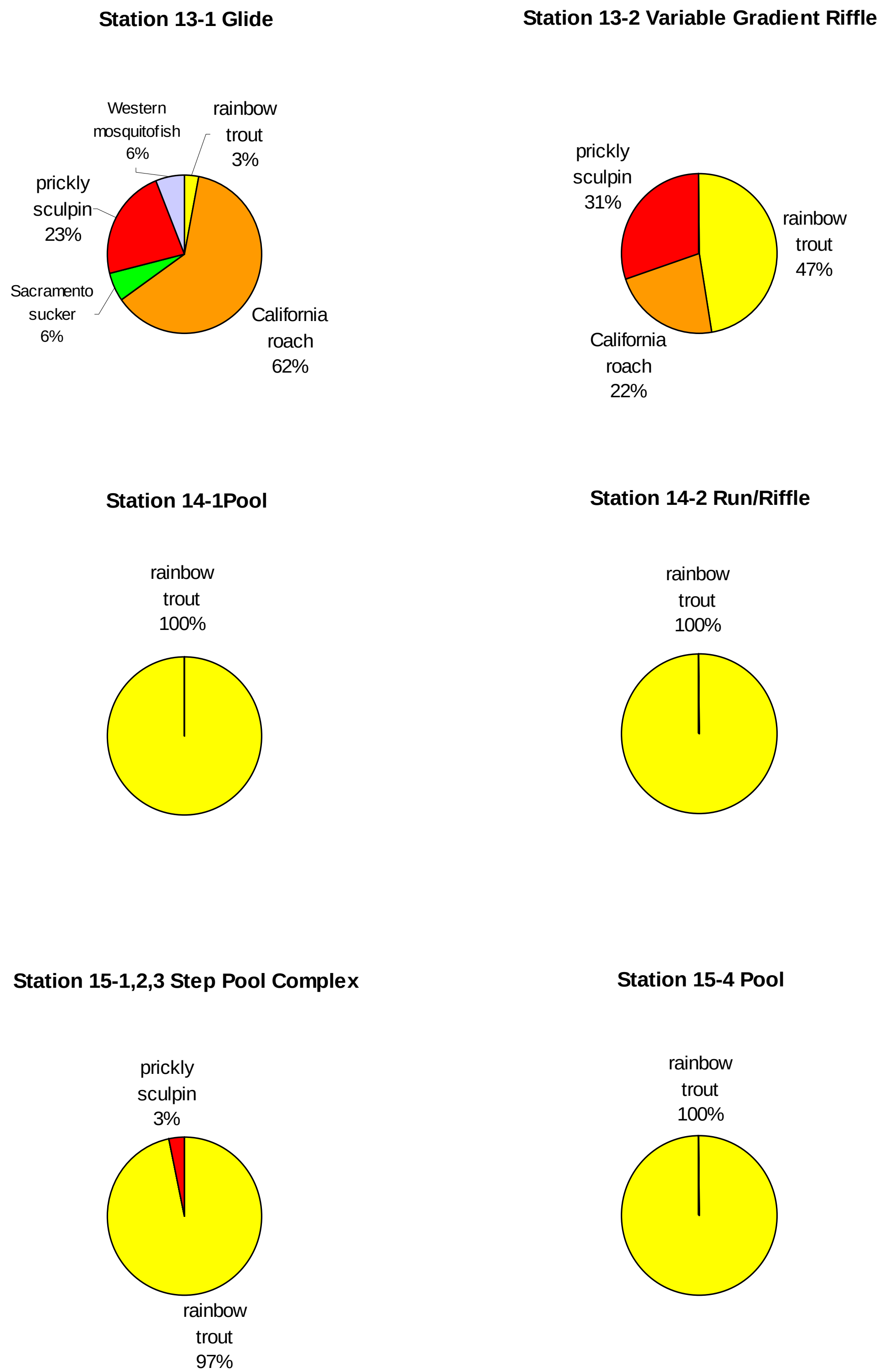


Figure 8-4 continued.

Population estimates (Appendix D) indicate that there were 32 California roach, three Pacific Lamprey, two largemouth bass, and one each of rainbow trout and prickly sculpin. It should be noted, however, that lamprey estimates were based on a non-descending removal pattern and should not be considered reliable. The lamprey estimate was reset to 1.5 times the total catch. Five species were collected at the station E-4 run/glide (Figure 8-4). Population estimates (Appendix D) indicate that Sacramento sucker and largemouth bass dominated with 15 and 14 fish respectively, followed by six fish each of Pacific lamprey and prickly sculpin, and two Sacramento pikeminnow.

Five species were collected from the pool at electrofishing station E-5 (Figure 8-4). Population estimates (Appendix D) indicate that there were 265 California roach, 19 Sacramento sucker, 15 Sacramento pikeminnow, five prickly sculpin, and one Pacific lamprey.

There were three species collected from the run at station E-6 (Figure 8-4). Population estimates (Appendix D) indicated that California roach dominated in the run (215 fish), followed by Sacramento sucker (16 fish) and Sacramento pikeminnow (11 fish). The low gradient riffle at station E-6 had only three species (Figure 8-4). Population estimates (Appendix D) indicate that there were 63 California roach, two Sacramento pikeminnow, and one Pacific lamprey. The pool at station E-6 (Figure 8-4) had four species. Population estimates (Appendix D) indicated that California roach dominated (628 fish), followed by Sacramento pikeminnow (93 fish), Sacramento sucker (47 fish) and Pacific lamprey ammocetes (three fish).

Four species were collected from the pool at station E-7 (Figure 8-4). Population estimates (Appendix D) indicate that California roach dominated (380 fish), followed by Sacramento sucker (15 fish), Sacramento pikeminnow (three fish), and prickly sculpin (one fish). There were also four species found in the run/low gradient riffle complex at station E-7 (Figure 8-4). Population estimates (Appendix D) indicate that there were 307 California roach, and just one each of Sacramento sucker, prickly sculpin and Pacific lamprey. The run at station E-7 had three species (Figure 8-4), with population estimates (Appendix D) indicating that there were 786 California roach, three Pacific lamprey ammocetes and two Sacramento sucker.

Four species were collected from the downstream isolated pool (pool 1) at station E-8 (Figure 8-4). Population estimates (Appendix D) indicate that the pool had six California roach, five Sacramento pikeminnow, two largemouth bass, and one prickly sculpin. California roach (14 fish) and Sacramento sucker (two fish) were the only species collected (Figure 8-4) from the upstream isolated pool (pool 2).

There were no fish collected from either the run or run/riffle complex habitat types sampled at station E-10 (Figure 8-4). These two habitats were noticeably dryer than in preceding survey years, with much of the usual habitat area dewatered. Two species were collected from the pool with population estimates (Appendix D) of only 21 California roach and one rainbow trout.

California roach was the only species collected from either the pool or high gradient riffle at station E-11 (Figure 8-4). Population estimates (Appendix D) indicated only three fish at the riffle and 82 fish and the pool.

Two species were collected from the step pool/run complex at station E-12 (Figure 8-4). Population estimates (Appendix D) indicate that California roach again dominated (34 fish), followed by rainbow trout (eighteen fish). Population estimates indicated that only five rainbow trout were present in the riffle at station E-12 (Appendix D).

Five species were collected from the glide at station E-13 (Figure 8-4). Population estimates (Appendix D) indicate that California roach dominated (176 fish), followed by prickly sculpin (65 fish), Sacramento sucker and Western mosquitofish (17 fish each), and rainbow trout (nine fish). Due to a non-descending electrofishing removal pattern, the population of the unusual species Western mosquitofish was estimated at 1.5 times the total catch and should not be considered reliable. There were three species collected from the variable gradient riffle at station E-13 (Figure 8-4). Population estimates (Appendix D) indicate that there were 17 rainbow trout, 11 prickly sculpin, and eight California roach in the riffle. In comparison to other stations and habitats, the glide and variable gradient riffle at station E-13 contained 74 percent of all sculpin and the only Western mosquitofish collected during the 2007 survey. This was the first occurrence of mosquitofish at any of the electrofishing stations.

Rainbow trout was the only species collected from the two habitats sampled at station E-14 (Figure 8-4). Population estimates (Appendix D) indicated that there were three rainbow trout in the shallow pool and 101 rainbow trout in the run/riffle. The run/riffle accounted for the highest population of rainbow trout in the survey (47 percent of the rainbow trout collected at all stations).

Two species were collected from the step-pool complex at station E-15 (Figure 8-4). Population estimates (Appendix D) indicate that there were 28 rainbow trout and just one prickly sculpin. Rainbow trout was the only species found in the remaining pool at station E-15. Population estimates (Appendix D) indicate that there were 24 trout in the isolated pool.

8.5 Species Distribution

The distributions of the eight species collected during the electrofishing surveys were highly variable. In some cases the presence of a given species was associated with certain regions within the watershed, 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 distribution patterns observed. Although entire habitat types were sampled in most cases, population estimates are not standardized to the area of each habitat unit.

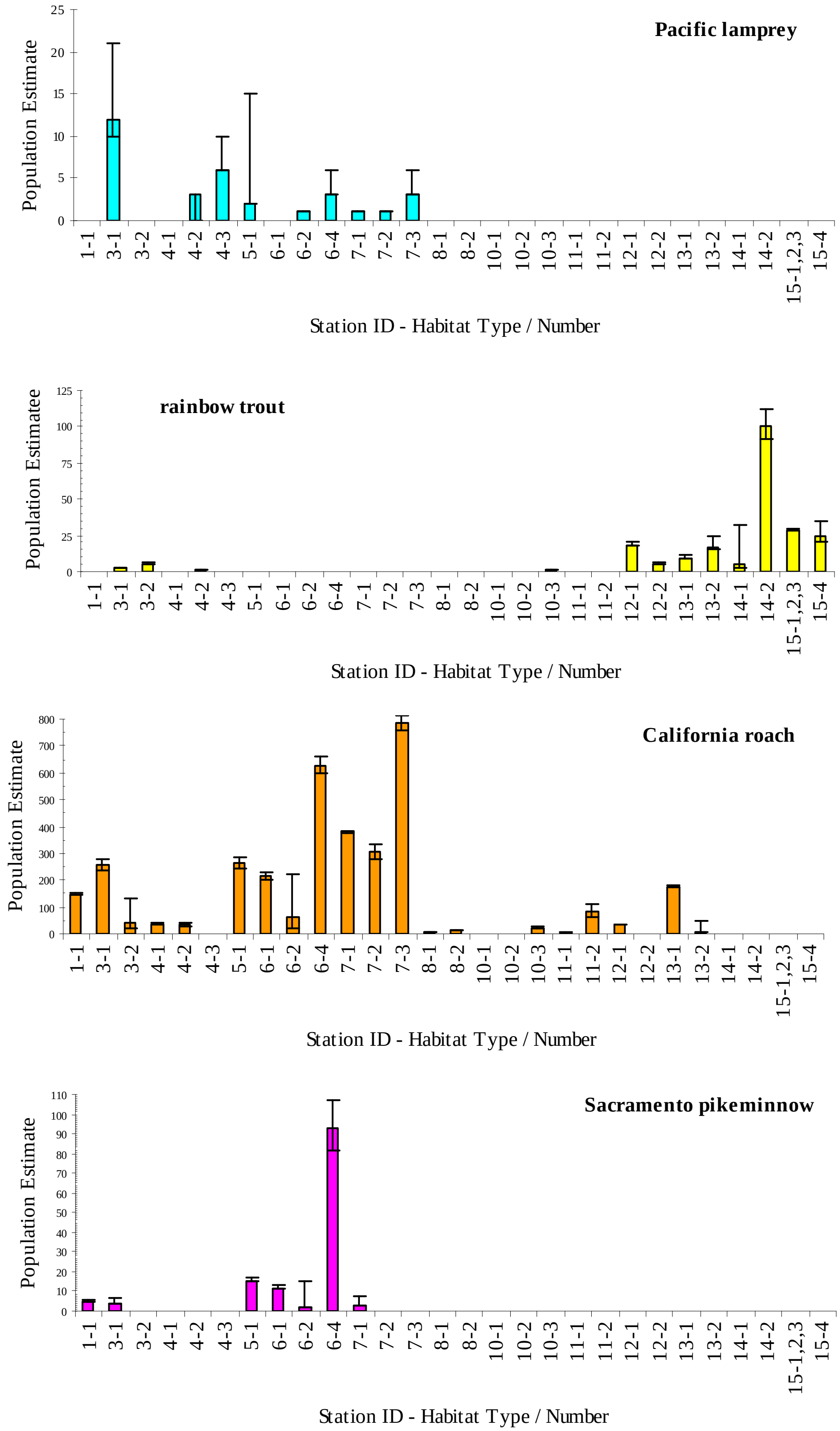


Figure 8-5. Population estimates and 95 percent confidence intervals for each species by station and habitat type for the autumn 2007 electrofishing surveys.

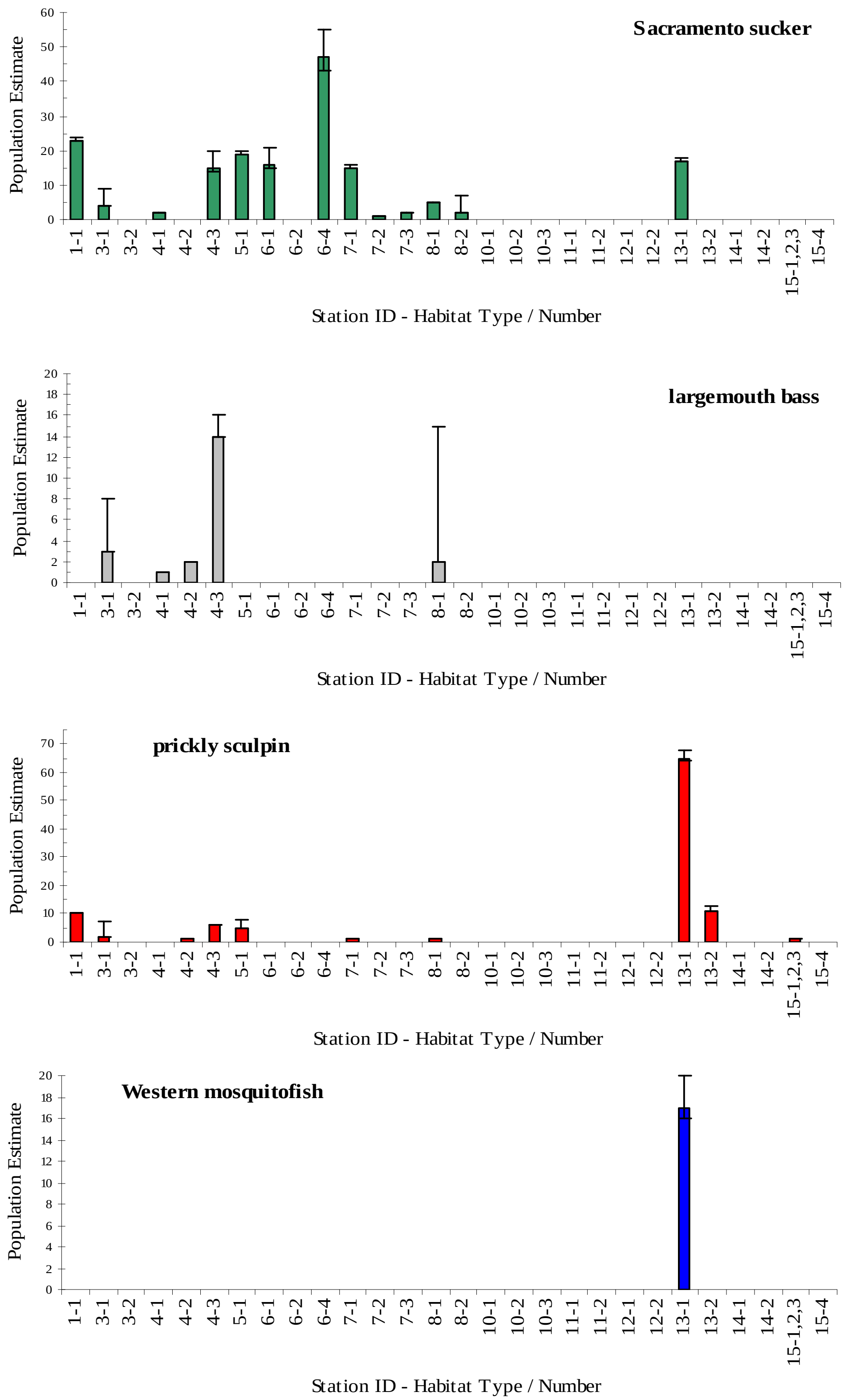


Figure 8-5 continued.

8.5.1 Pacific Lamprey

Pacific lamprey ammocetes were found in 9 of 12 habitats and at all five stations sampled in Alameda Creek downstream of its confluence with Calaveras Creek (Figure 8-5). No lampreys were found in Alameda and Calaveras creeks above their confluence, and none were found in the three creeks upstream of the reservoirs. Ammocete presence at stations below the confluence was not associated with habitat type as they were collected in two of three riffle habitats, three of four run habitats, three of four glide habitats, and all three pools within their range. Due to the nature of electrofishing lamprey ammocetes, where subsequent passes frequently draw greater numbers of fish out of the substrate, population estimate confidence intervals were sometimes very large.

8.5.2 Rainbow Trout

Rainbow trout were collected in two glides and one riffle of the13 habitats sampled downstream of the confluence of Alameda and Calaveras creeks (Figure 8-5). There were no rainbow trout collected in the station just below Little Yosemite, although the station within Little Yosemite did yield trout in relatively moderate abundance. Just one rainbow trout was located at the station just upstream of the Diversion Dam and none were collected from just downstream of the dam. Rainbow trout were collected at each of the six stations in creeks upstream of reservoirs (Indian Creek, La Costa Creek and Arroyo Hondo) and at the highest collected abundances at these stations. There were no trout collected in Calaveras Creek.

Rainbow trout are associated with lower fish diversity in the Alameda Creek watershed. This is a typical pattern often found in high gradient headwater streams throughout the central valley and central coast (Hagar, 2006). Of the 12 habitats where rainbow trout were collected, they were the only species present at four habitats and one of two species at four habitats. They were most often found with California roach. In habitats with trout present, the average number of species collected was 2.8, while an average of 3.3 species were collected in their absence.

8.5.3 California Roach

California roach were the most widespread species, being caught from 20 of the 28 habitats sampled (Figure 8-5). Roach were the dominant species in 19 of the 20 habitats where they were found, outranked only by sculpin and trout at one riffle in Arroyo Hondo. Roach were once again the most abundant in the run at station E-7. In general, roach were most abundant in the pool and run habitats in Alameda Creek downstream of the Little Yosemite area. They were also present in variable numbers in Alameda Creek above Little Yosemite both above and below the Diversion Dam, and in Calaveras Creek. Upstream of the two SFPUC East Bay reservoirs, California roach were present in moderate numbers in Arroyo Hondo, while absent from La Costa and Indian creeks.

8.5.4 Sacramento Pikeminnow

Sacramento pikeminnow were limited to eight of the thirteen habitats in Alameda Creek downstream of Little Yosemite and one in Calaveras Creek (Figure 8-5). The abundances of Sacramento pikeminnow in Alameda Creek were generally higher in pool habitats, and they were found in the highest numbers in the pool habitat at station E-4. Pikeminnow were collected in all five of the pool habitats within their distribution and only two of four runs, one of three glides and one of two riffles within their range.

8.5.5 Sacramento Sucker

Sacramento sucker were the third most abundant species in the survey area after California roach and rainbow trout. They were caught at two of 13 habitats sampled in Alameda Creek downstream of Little Yosemite and in Calaveras Creek (Figure 8-5). With the exception of their presence in the glide at station E-13, suckers were absent from all other areas sampled. The abundances of Sacramento sucker did appear to be correlated with habitat type, with suckers collected in higher numbers from pool habitats.

8.5.6 Largemouth Bass

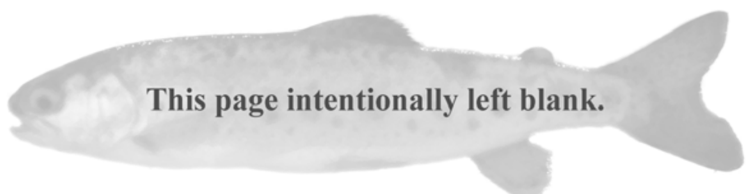
Largemouth bass were found in the lower pool in Calaveras Creek station E-8, and in all four of the glide habitats downstream of the Alameda Creek confluence with Calaveras Creek, at stations E-3 and E-4 (Figure 8-5). The highest abundance of Largemouth bass was collected in the run/glide habitat at station E-4. Largemouths are known to reside in a large, deep pool at the downstream end of Calaveras Creek, and have been collected in Alameda Creek stations to the downstream extent of the study area.

8.5.7 Prickly Sculpin

Prickly sculpin were collected in relatively large numbers from both habitats sampled in Arroyo Hondo (Figure 8-5), while only one sculpin was collected in Indian Creek and none were found in La Costa Creek. Relatively low numbers of sculpin were collected in a variety of habitat types and in seven of 15 habitats sampled in Calaveras Creek and Alameda Creek below the Little Yosemite area. They were not collected from any stations in Alameda Creek upstream of Little Yosemite. 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.

8.5.8 Western mosquitofish

Western mosquitofish were collected for the first time in the monitoring programs at the glide habitat at station E-13 on Arroyo Hondo. Population estimates indicated 17 mosquitofish, 6% of the total population estimate at that habitat. It should be noted that due to a non-descending removal pattern the estimate should not be considered reliable.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10.0 Acknowledgments

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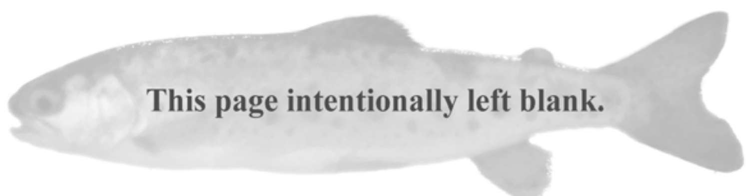
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11.0 Appendices

11.1 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. ”

11.2 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
1/9/07	0	9.74	7.75	268.3	172	12	490	2.58	104	112	27	0.05	0.05	0.01	0.01	14	3.1	0.1	0.07
	10	9.36	7.8	267.7	171	11.9	492												
	20	9.31	7.82	267.1	171	11.6	494	2.78	104	113	28	0.04	0.07	0.01	0.01	12			
	30	9.3	7.82	267.1	171	11.7	495												
	40	9.28	7.82	267.4	171	11.7	496	2.65	103	114	30	0.04	0.06	0.01	0.01	13			
	50	9.28	7.82	266.8	171	11.7	496												
	60	9.27	7.83	267.1	171	11.6	497	2.86	105	114	30	0.04	0.03	0.01	0.01	12	3.1	0.11	0.06
	70	9.28	7.83	267.4	171	11.6	497												
	80	9.26	7.83	267.4	171	11.6	498	2.65	103	113	28	0.05	0.04	0.01	0.02	12			
	87	9.25	7.83	266.9	171	11.6	496	3.17	107	112	32	0.04	0.03	0.02	0.02	12	3.2	0.11	0.11
2/7/07	0	9.86	8.12	275.8	177	12.8	463	1.32	104	115	16	0.06	0.01	<0.01	0.01	14	3.3	0.08	0.05
	10	9.83	8.12	276.1	177	12.8	463												
	20	9.82	8.12	276.2	177	12.7	463	1.35	104	115	16	0.07	0.01	0.01	0.01	12			
	30	8.17	8	273.3	175	12	466												
	40	8.01	7.97	273.4	175	11.8	467	1.49	101	115	14	0.03	0.01	0.01	0.01	13			
	50	7.99	7.94	273.3	175	11.7	468												
	60	7.96	7.93	273.6	175	11.7	468	1.5	106	115	17	0.03	0.03	<0.01	0.01	12	3.2	0.07	0.06
	70	7.94	7.9	273.5	175	11.5	469												
	80	7.95	7.88	274.2	176	11.2	469	2.18	104	114	20	0.04	0.04	0.01	0.01	12			
	85	7.95	7.86	274	175	11.2	433	2.48	104	115	21	0.03	0.01	<0.01	0.01	12	3.5	0.11	0.09
3/6/07	0	12.9	8.02	288	185	10.5	500	1.8	99	113	20	0.02	0.05	0.01	0.01	12	3.3	0.06	0.05
	10	12	8	287	184	10.6	499												
	20	10	7.89	284	182	10.3	500	3	101	111	25	<0.01	0.03	0.02	0.02	11			
	30	9.6	7.84	281	180	10	501												
	40	9.4	7.72	273	175	9.6	501	9.7	99	109	71	0.04	0.01	0.03	0.03	11			
	50	9.2	7.71	263	168	9.4	501												
	60	9.1	7.66	260	167	9.3	502	16.9	95	106	91	0.08	0.04	0.04	0.04	10	4.2	0.74	0.08
	70	8.9	7.56	259	166	8.5	502												
	80	8.8	7.52	259	166	8.1	503	8.8	96	108	67	0.04	0.05	0.02	0.02	10			
	87	8.7	7.51	259	166	8	502	21.8	94	104	115	0.11	0.02	0.03	0.05	10	4.2	0.95	0.18
3/22/07	0	14.83	8.07	293.3	188	10.3	494	0.9											
	10	14.69	8.15	292.7	187	10.2	494												
	20	14.18	8.05	291.1	186	9.91	496	0.9											
	25	11.53	7.78	284.9	182	9.38	499												
	30	9.98	7.69	277	177	9.02	500												
	40	9.36	7.64	269.2	172	8.8	501	5.06											
	50	9.2	7.56	265.3	170	8.34	502												
	60	9.08	7.47	262.3	168	7.55	503	8.38											
	70	9.04	7.45	261.8	168	7.46	503												
	80	8.99	7.41	261	167	6.93	504	10.8											
	87	9	7.39	260.7	167	6.79	504	12.1											
4/4/07	0	17.57	8.36	296.6	190	10.3	488	0.7	99	116	10	0.01	0.01	0.02	0.03	11	3.3	0.02	0.04
	10	16.84	8.37	295.8	190	10.2	490												
	20	14.8	8.19	294	188	9.77	493	0.86	98	116	12	0.04	0.01	0.01	0.02	11			
	30	12.19	7.72	281.4	180	7.96	498												
	40	9.77	7.61	269.9	173	7.82	500	1.84	95	110	20	0.01	0.1	0.01	0.01	11			
	50	9.45	7.58	268.5	172	8.02	500												
	60	9.29	7.49	264.8	170	7.42	501	3.85	91	106	37	0.03	0.01	0.01	0.02	11	3.8	0.15	0.05
	70	9.22	7.43	263.1	168	6.89	501												
	80	9.18	7.37	262.4	168	6.11	502	5.55	90	105	43	0.03	0.06	0.01	0.02	10			
	85	9.17	7.35	262.4	168	5.93	503	6.84	89	103	50	0.02	0.13	0.01	0.01	10	4	0.23	0.12
5/7/07	0	17.55	8.54	301.1	193	9.58	474	0.3											
	10	17.27	8.54	300.6	192	9.5	475	2.2											
	20	16.91	8.52	299.2	191	9.29	476	1.4											
	25	16.81	8.49	299.3	191	9.42	476	1.7											
	30	12.43	7.82	279.3	179	7.04	484	2.3											
	35	10.88	7.61	272.7	175	7.57	485	2.6											
	40	10.55	7.55	271.3	174	8.06	486	2.7											
	50	10.3	7.5	271.2	174	8.6	486	3.1											
	60	10.21	7.46	270.9	173	8.55	487	2.9											
	70	10.14	7.44	270.4	173	8.08	487	3.6											
	80	10.09	7.42	270.8	173	7.98	487	4.7											
	85	10.04	7.4	271	174	7.32	488	5.5											

Date	Depth Ft.	Temp °C	pH -log H+	Cond uS/cm	TDS mg/L	DO mg/L	ORP mV	Turb NTU	Alk mg/L	Hard mg/L	Color clr unts	NH3N mg/L	NO3-N mg/L	PO4-P mg/L	Total-P mg/L	Cl- mg/L	TOC mg/L	Fe mg/L	Mn mg/L
5/17/07	0	20.12	8.62	309.5	198	9.16	434	1.03	106	120	12	0.03	0.01	0.01	0.01	12	3.1	0.04	0.03
	10	20	8.64	308.9	198	9.26	435												
	20	17.81	8.44	303.6	194	9.15	439	1.19	108	120	15	0.02	0.01	0.02	0.02	13			
	25	15.62	8.11	297.9	191	8.56	444												
	30	13.43	7.78	287.2	184	7.36	448												
	35	11.56	7.57	280.2	179	7.48	451												
	40	10.86	7.49	277.5	178	7.9	452	1.45	101	111	16	0.03	0.05	0.03	0.03	12			
	50	10.69	7.44	276.6	177	9.44	452												
	60	10.58	7.41	276.2	177	8.58	453	1.89	101	109	16	0.03	0.11	0.01	0.01	12	3.5	0.07	0.07
	70	10.5	7.39	276	177	9.4	453												
	80	10.43	7.37	276.3	177	8.81	453	2.1	102	109	20	0.02	0.07	0.01	0.02	11			
	85	10.37	7.34	276.7	177	7.84	455	2.45	102	108	21	0.08	0.09	0.02	0.02	12	3.6	0.11	0.1
6/13/07	0	22.49	8.73	310.1	199	9.33	471	0.63	102	117	8	0.01	0	0.01	0.01	15	3.1	0.02	0.03
	10	21.8	8.74	309.1	198	9.17	473												
	20	20.65	8.7	307.2	197	9.28	474	0.94	106	116	10	0.01	0.01	0	0.01	15			
	25	18.43	8.25	303	194	9.03	481												
	30	13.46	7.7	285.3	183	9.24	489												
	35	12.12	7.59	282.3	181	10.2	491												
	40	11.73	7.49	281.7	180	10.1	491	0.95	103	112	15	0.02	0.03	0.01	0.01	16			
	50	11.39	7.37	281	180	11.3	492												
	60	11.3	7.36	280.7	180	11.3	493	0.78	102	112	16	0.05	0.11	0	0	14	3.5	0.02	0.05
	70	11.27	7.35	281	180	11.9	493												
	80	11.18	7.32	281	180	11.1	494	0.84	102	113	18	0.05	0.12	0	0	15			
	85	11.14	7.31	281.6	180	10.4	494	1.27	103	112	19	0.03	0.1	0	0	16	3.4	0.05	0.07
7/19/07	0	24.05	8.06	280.1	179	9.23	204	0.73	105	119	10	0.01	<0.01	<0.01	0.17	10	3.3	0.05	<0.01
	10	23.61	7.96	279.6	179	9.39	211												
	20	23.33	8.32	279.5	179	9.37	194	0.69	104	116	10	0.02	<0.01	0.01	0.09	10			
	30	18.6	6.79	277.3	178	9.48	237												
	40	12.43	6.43	265.3	170	14.6	249	0.6	103	114	13	<0.01	0.06	0.03	0.06	9	3.6	0.05	0.02
	50	12.26	6.41	265.3	170	14.9	249												
	60	12.15	6.37	265.3	170	15.6	249	0.88	103	114	16	0.02	0.07	0.01	0.06	9			
	70	12.09	6.38	265.4	170	14.2	247												
	80	12.04	6.37	265.8	170	14	242	1.01	103	114	17	0.02	0.09	0.03	0.18	9			
	85	11.93	6.43	270.1	173	11.2	231	2.66	102	116	26	0.04	0.09	0.03	0.19	9	3.5	0.11	0.14
8/6/07	0	23.44	8.73	302	193	8.65	464	1.1											
	10	23.45	8.74	301.4	193	8.31	468	0.9											
	20	23.44	8.74	301.4	193	8.6	470	1											
	28	22.85	8.52	302.1	193	7.95	477	0.8											
	30	19.84	7.75	297.5	190	8.09	490	0.9											
	35	13.66	7.38	284.7	182	14.2	497	0.7											
	40	12.89	7.28	285.4	183	14.9	497	1.1											
	50	12.66	7.24	285	182	15.3	497	0.9											
	60	12.55	7.21	285.2	183	15.9	497	1											
	70	12.47	7.2	285.4	183	15.9	497	1.2											
	80	12.4	7.17	286.5	183	14.8	497	1.8											
	82	12.35	7.13	287.7	184	13	480	2.2											
8/28/07	0	24.39	8.45	281.5	180	8.47	458	0.47	107	120	12	0.02	0.01	0.01	0.01	10	3.4	0.05	0.01
	10	23.89	8.45	281.9	180	8.27	460												
	20	22.79	8.39	280.7	180	8.26	464	0.69	105	118	10	0.04	0.01	<0.01	0.01	10			
	25	22.53	8.28	281	180	7.71	466												
	30	20.87	7.85	281	180	7.43	475												
	35	16.05	7.33	269.6	173	11.3	487												
	40	13.91	7.2	268	172	13.4	488	0.93	106	116	14	0.03	0.05	0.01	0.03	9			
	50	12.95	7.13	266.1	170	15.3	487												
	60	12.73	7.09	267.4	171	15.7	487	0.73	105	116	18	0.06	0.04	0.01	0.01	8	3.4	0.05	0.03
	70	12.58	7.04	268.6	172	13.4	487												
	80	12.5	6.95	271.5	174	10.1	488												
	81	12.46	6.93	272.8	175	8.62	479	1.62	106	117	17	0.05	0.06	0.02	0.03	9	3.4	0.09	0.14
9/25/07	0	20.59	8.28	282.1	180	8.71	366	0.67	102	119	10	0.03	<0.01	<0.01	0.03	10	3.7	0.02	<0.01
	10	20.06	8.27	281.5	180	8.71	368												
	20	19.97	8.21	281.7	180	8.52	369	0.73	103	119	12	0.05	<0.01	0.01	0.04	10			
	30	19.92	8.2	281.8	180	8.7	372												
	40	14.03	6.81	273.5	175	12.4	409	0.69	103	118	15	<0.01	<0.01	0.01	0.03	9	3.3	0.03	0.01
	50	13.08	6.83	270.1	173	14	404												
	60	12.78	6.78	270	173	12.9	398	0.47	102	118	14	<0.01	0.1	0.03	0.04	9			
	70	12.59	6.7	271.7	174	9.24	390												
	80	12.51	6.66	274.7	176	5.63	359	1.83	103	115	34	0.03	0.24	0.02	0.04	9			
	82	12.53	6.68	275.4	176	4.98	315	2.24	106	119	44	0.05	0.28	0.03	0.03	9	3.4	0.11	0.24

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
10/15/07	0	18.44	8.4	278.6	178	9.74	378												
	10	18.39	8.41	279.4	179	9.79	377												
	20	18.05	8.33	279.8	179	9.48	380												
	30	17.76	8.23	279.9	179	9.17	383												
	35	17.52	8.04	280.7	180	8.98	388												
	40	15.76	7.41	273.9	175	9.77	418												
	45	13.86	7.25	270.7	173	11.2	420												
	50	13.34	7.17	270	173	11.5	421												
	60	12.72	7.08	270.1	173	10.9	422												
	70	12.59	7.06	272.1	174	8.39	420												
	80	12.48	6.94	276.2	177	4.54	421												
	82	12.47	6.9	276.6	177	3.75	269												
11/5/07	0	16.65	7.9	285	182	NA	322	1.3	107	121	14	0.18	<0.01	0.01	0.02	9	3.4	0.04	0.01
	10	16.52	7.85	284.9	182	NA	324												
	20	16.2	7.79	284.6	182	NA	326	1.2	106	121	14	0.18	0.01	0.01	0.02	9			
	30	16.11	7.76	284.6	182	NA	326												
	40	16.06	7.73	284.7	182	NA	326	1.2	108	119	15	0.1	<0.01	<0.01	0.02	9	3.4	0.05	0.05
	50	13.85	6.74	275.7	176	NA	358												
	60	13.08	6.7	274.3	176	NA	351	1.1	106	119	17	0.09	0.13	0.09	0.11	8			
	70	12.92	6.67	275.2	176	NA	345												
	80	12.75	6.64	277.2	177	NA	338												
	80.5	12.75	6.64	277.7	178	NA	331	2.5	106	123	60	0.2	0.17	0.01	0.05	8	3.4	0.07	0.25
11/7/07	0	17.15	7.78	285.9	183	9.55	279												
	10	16.44	7.76	285.1	182	9.51	280												
	20	16.21	7.54	285.1	182	8.86	285												
	30	16.05	7.42	285.4	183	8.73	286												
	40	15.91	7.2	285.2	182	8.6	291												
	50	13.53	6.48	275.1	176	9.97	311												
	60	13.17	6.46	274.7	176	9.63	305												
	70	12.95	6.43	275.1	176	8.99	291												
	78	12.91	6.43	275.9	177	8.59	275												
11/27/07	0	13.65	7.13	286.5	183	9.17	331	3.27	108	120	31	0.04	0.05	<0.01	0.03	10	3.5	0.21	0.02
	10	13.58	7.12	286.5	183	9.08	331												
	20	13.5	7.13	286.7	184	8.99	330	3.5	108	120	32	0.03	0.05	<0.01	0.06	10			
	30	13.49	7.11	286.6	183	8.94	330												
	40	13.5	7.09	286.4	183	8.88	330	3.55	107	120	25	0.06	0.05	0.02	0.04	10	3.2	0.25	0.04
	50	13.47	7.1	286.8	184	8.76	329												
	60	13.36	6.91	286.2	183	8.58	333	4	106	120	32	0.04	0.07	0.04	0.05	10			
	70	13.25	6.56	282.3	181	8.26	341												
	80	13.06	6.38	279.8	179	6.47	340	2.52	105	120	28	0.03	0.18	0.01	0.08	9			
	81.9	13	6.39	282.8	181	4.43	352	3.18	105	117	55	0.02	0.24	0.01	0.04	9	3.2	0.16	0.28
12/10/07	0	12.11	7.31	287.5	184	9.48	333	3.52	107	122	31	0.03	0.09	0.03	0.06	10	3.9	0.2	0.02
	10	11.98	7.3	287.6	184	9.47	332	3.9	106	122									
	20	11.98	7.3	287.6	184	9.37	331	3.45	106	122	30	0.07	0.05	0.03	0.05	10			
	30	11.96	7.3	287.7	184	9.28	329												
	40	11.96	7.3	287.7	184	9.24	327	3.55	106	121	30	0.01	0.06	0.02	0.04	10	3.4	0.24	0.03
	50	11.95	7.3	287.9	184	9.2	326												
	60	11.94	7.29	287.7	184	9.14	322	3.56	105	121	33	0.06	0.07	0.02	0.07	10			
	70	11.94	7.29	287.6	184	9.09	319												
	80	11.88	7.31	287.7	184	9.12	314	4.47	105	118	40	0.05	0.09	0.01	0.18	10			
	82.3	11.84	7.26	288.2	184	8.85	301	5.03	108	120	40	0.02	0.08	<0.01	0.05	10	3.3	0.31	0.03

11.3 Appendix C – Snorkel Survey Data

Species (adults)	Number of Fish Observed														
	Pool Number														
	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-10	P-11	P-12*	P-13	P-14	P-15	P-16	Total
rainbow trout	2	0	0	0	0	0	0	0	0	- -	8	5	2	17	34
Sacramento sucker	0	1	3	0	5	0	0	0	0	- -	4	4	0	5	22
Sacramento pikeminnow	4	8	19	25	12	7	2	0	0	- -	0	0	0	0	77
California roach	363	102	720	440	103	50	0	0	566	- -	100	120	25	400	2,989
prickly sculpin	0	0	0	0	0	0	0	0	1	- -	2	3	4	1	11
largemouth bass	1	2	0	0	1	0	0	25	0	- -	0	0	0	0	29
sunfish	0	0	0	0	0	0	0	22	0	- -	0	0	0	0	22
Total	370	113	742	465	121	57	2	47	567	- -	114	132	31	423	3,184

** Did not survey this site because the pool was dry.*

Species (juveniles)	Number of Fish Observed														
	Pool Number														
	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-10	P-11	P-12*	P-13	P-14	P-15	P-16	Total
rainbow trout	0	0	0	0	0	0	0	0	0	- -	2	0	0	1	3
Sacramento sucker	1	1	100	46	2	0	0	0	104	- -	0	0	1	0	255
Sacramento pikeminnow	10	35	185	15	52	0	0	0	0	- -	0	0	0	0	297
California roach	62	50	5,350	1,220	1,340	880	80	0	1,875	- -	900	160	0	840	12,757
prickly sculpin	0	0	0	0	0	0	0	0	0	- -	0	0	0	0	0
largemouth bass	14	35	0	0	2	0	0	226	0	- -	0	0	0	0	277
sunfish	0	0	0	0	0	0	0	50	0	- -	0	0	0	0	50
Total	87	121	5,635	1,281	1,396	880	80	276	1,979	- -	902	160	1	841	13,639

** Did not survey this site because the pool was dry.*

11.4 Appendix D – Electrofishing Survey Catch Summary and Population Estimates

Alameda Creek Watershed catch summary for the autumn, 2007 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		10			2	6	2		1		3	1	1	3		
rainbow trout		2	5		1											
California roach	147	230	19	33	28		239	201	24		562	378	266	715	6	14
Sacramento pikeminnow	5	4				2	15	11	2		82	3				
Sacramento sucker	23	4		2		14	19	15			43	15	1	2	5	2
largemouth bass		3		1	2	14									2	
prickly sculpin	10	2			1	6	5						1		1	
Total	185	255	24	36	34	42	280	227	27	*	690	397	269	720	14	16

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**	**15-1,2,3****	**15-4**	**Total**
Pacific lamprey														29
rainbow trout			1			18	5	9	15	3	92	28	20	199
California roach			19	3	62	34		176	4					3,160
Sacramento pikeminnow								17						141
Sacramento sucker														145
largemouth bass														22
prickly sculpin								64	11			1		102
Western mosquitofish								11						11
Total	0	0	20	3	62	52	5	277	30	3	92	0	20	3,809

* Site 6-3 was not electrofished this year due to stream morphological changes.
** Isolated pool sites 15-1, 15-2 and 15-3 were incorporated this year into pool complex site 15-1,2,3 due to stream morphological conditions.

Alameda Creek Watershed population estimates for the autumn, 2007 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		12			3***	6	2		1		3	1	1	3		
rainbow trout		2	5		1											
California roach	148	257	42	36	32		265	215	63		628	380	307	786	6	14
Sacramento pikeminnow	5	4				2	15	11	2		93	3			5	
Sacramento sucker	23	4		2		15	19	16			47	15	1	2		2
largemouth bass		3		1	2	14									2	
prickly sculpin	10	2			1	6	5						1		1	
Total	186	284	47	39	36	43	306	242	66	*	771	399	310	791	14	16

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**	**15-1,2,3****	**15-4**	**Total**
Pacific lamprey														32
rainbow trout			1			18	5	9	17	3	101	28	24	214
California roach			21	3	82	34		176	8					3,503
Sacramento pikeminnow														140
Sacramento sucker								17						163
largemouth bass														22
prickly sculpin								65	11			1		103
Western mosquitofish								17***						17
Total	0	0	22	3	82	52	5	267	36	3	101	29	24	4,194

* Site 6-3 was not electrofished this year due to stream morphological changes.
** Isolated pool sites 15-1, 15-2 and 15-3 were incorporated this year into pool complex site 15-1,2,3 due to stream morphological conditions.
*** Population estimate is based on a non-descending removal pattern, and should not be considered reliable.

11.5 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*	*prickly sculpin*	*Western mosquitofish*	*Pacific lamprey*	*rainbow trout*	*California roach*	*Sacramento pikeminnow*	*Sacramento sucker*	*largemouth bass*	*prickly sculpin*	*Western mosquitofish*
1-1			1.305	0.204	0.672		0.090				20.791	1.407	1.667		0.552	
3-1	4.152	*	10.099	0.969	1.468	1.271	0.384		4.364	*	2.367	0.865	2.071	8.679	0.929	
3-2		0.879	43.885							3.508	14.315					
4-1			3.472		*	*					0.596		*	*		
4-2	**	***	4.588			*	*		**	***	2.717			*	*	
4-3	1.381	*		2.274		1.017	0.000		2.833	*		3.725		1.359	0.000	
5-1	1.050		9.434	0.934	0.269		1.171		3.335		12.155	3.103	0.330		5.012	
6-1			6.258	1.020	2.126						0.040	1.094	5.222			
6-2	***		79.238	1.038					***		1.889	5.786				
6-3[a]																
6-4	0.709		15.751	6.952	3.891				2.516		9.605	2.320	2.207			
7-1	***		1.897	1.271	0.595				***		22.326	1.345	0.147			
7-2	*		13.851		*		*		*		0.806		*		*	
7-3	0.681		15.029		*				1.492		18.438		*			
8-1			0.666		*	1.038	*				0.786		*	2.786	*	
8-2			1.229		0.384						0.879		0.929			
10-1																
10-2																
10-3		*	2.947							*	4.305					
11-1			0.745								0.381					
11-2			14.359								0.087					
12-1		0.809	1.085							4.453	0.700					
12-2		0.787								0.760						
13-1		0.690	0.834		0.531		0.155	**		3.104	8.953		2.138		2.743	**
13-2		3.323	17.588				0.788			0.932	1.244				4.014	
14-1		9.677								2.723						
14-2		5.457								4.142						
15-1,2,3[b]		1.101					*			0.584					*	
15-4		5.260								5.303						

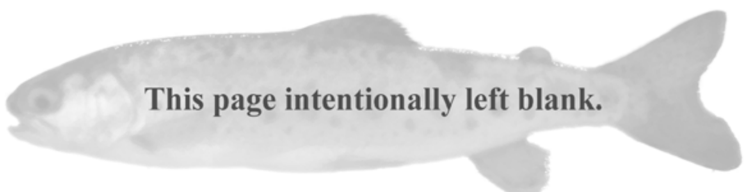
[a] Site 6-3 was not electrofished this year due to stream morphological conditions.

[b] Isolated pool sites 15-1, 15-2 and 15-3 were incorporated this year into pool complex site 15-1,2,3 due to stream morphological conditions.

* No statistics generated because all fish were caught on the first pass.

** Population estimate terminated at five times the total catch and reset to 1.5 times the total catch due to a non-descending removal pattern. Estimate should not be considered reliable.

*** No statistics generated because only one fish was captured in all passes.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San Francisco Public Utilities
Natural Resources Division