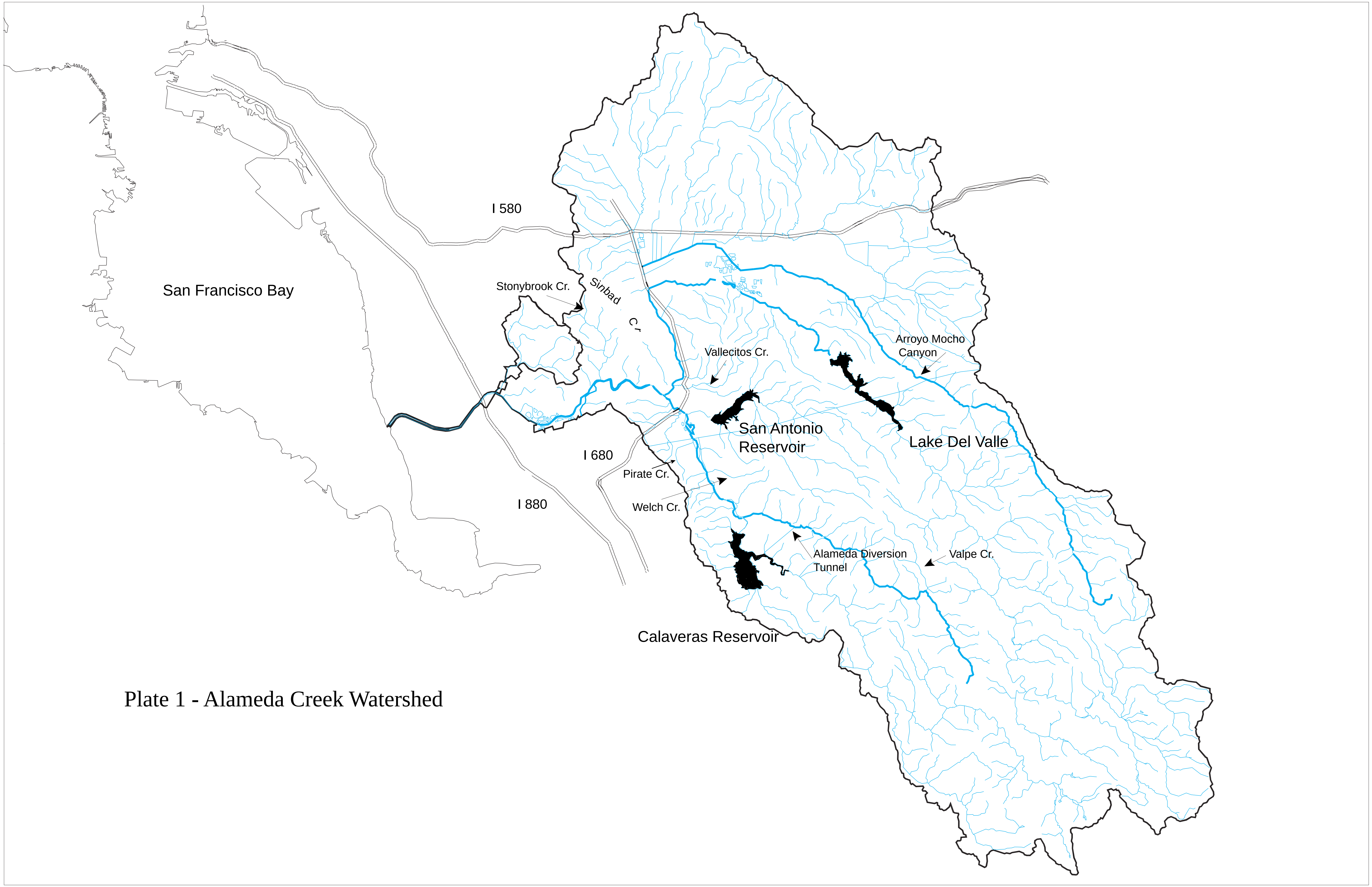

Plate 1 - Alameda Creek Watershed

An Assessment of the Potential for Restoring a Viable Steelhead Trout Population in the Alameda Creek Watershed

prepared for the

Alameda Creek
Fisheries Restoration Workgroup

by

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Executive Summary

Background. Steelhead, the ocean-going form of rainbow trout (*Onchorhynchus mykiss*), used to inhabit the Alameda Creek watershed in significant numbers prior to the construction of dams and other human development of the watershed. The idea of restoring a viable steelhead population to the Creek, which along with their cousins the salmon are a symbol of healthy coastal ecosystems, has been proposed periodically beginning in the 1940s. The recent identification of steelhead from Alameda Creek as genetically asssociated with the Central Coast stock listed as a threatened species pursuant to the Federal Endangered Species Act, and availability of various means of public and private support to fund restoration activities, have combined to focus public attention again on restoration of the population.

The Alameda Creek watershed (Plate 1) is the largest drainage in the South San Francisco Bay region, and includes portions of three counties, a number of cities and unincorporated areas, and various state, regional and local agencies responsible for water supply, flood control, fish and wildlife, and other public duties. In recognition that a feasible restoration program could only be produced by the cooperative efforts of all stakeholders, in early 1999 the Alameda Creek Fisheries Restoration Workgroup (Workgroup) was established. Lead by the efforts of the Alameda County Flood Control and Water Conservation District, the Workgroup benefits from the active participation of Alameda County Water District, the San Francisco Public Utilities Commission, the East Bay Regional Park District, the California Coastal Conservancy, the City of Fremont, the California Department of Fish and Game, the Alameda Creek Alliance (a citizens group), the U.S. Army Corps of Engineers, and the National Marine Fisheries Service.

The first product of the Workgroup is this report, which assesses the potential of restoring the steelhead population in Alameda Creek, identifies actions that must be taken to begin restoration, and highlights remaining scientific and technical uncertainties facing restoration efforts. A key approach taken in the report is to consider how other public uses supported by the watershed, such as municipal water supply, flood control, and recreational fishing, could be impacted by the steelhead restoration. The report is organized by considering the full life cycle of the steelhead - migration of adults into the watershed from the ocean (December - April), spawning and rearing (juveniles spend at least one year in freshwater ecosystems), and migration of young fish back to the ocean (March - June).

Findings. Based upon limited field efforts, a review of available data, and information in the technical literature, the report makes the following findings:

*1. Suitable habitat exists within the Alameda Creek watershed to support spawning and rearing of steelhead***.** The best potential spawning and rearing habitat in the watershed exists in upper Alameda Creek, Niles Canyon and its tributaries, and the Arroyo Mocho canyon south of Livermore. Rearing habitat is limited in most of the areas potentially supporting steelhead by low summer stream flow. Although this has been exacerbated by development, this is a natural condition characteristic of watersheds in central and southern California that support steelhead trout.

2. Genetic testing indicates that a native, locally-adapted steelhead trout stock survives in the watershed, and this stock can be considered part of the Central California stock listed as threatened by the National Marine Fisheries Service pursuant to the Federal Endangered Species Act. Resident trout populations in Stonybrook Creek, in tributaries of Calaveras and San Antonio Reservoirs, in upper Alameda Creek, and possibly in Arroyo Mocho appear to be descended from native steelhead populations isolated behind dams or natural barriers. The adult steelhead recently captured attempting to migrate into the watershed, and the rainbow trout sampled in the upper watershed, appear to be native fish that have their closest genetic associations with other populations within the federally-threatened "Central Coast Evolutionarily Significant Unit" of steelhead. It is likely that these fish are physiologically and behaviorally adapted to this region, making them well-suited to respond to restoration actions.

3. Steelhead are currently prevented from completing their life-history cycle within Alameda Creek due to the presence of an impassable migration barrier near the bottom of the watershed, and are severely limited by several other impassable or partial migration barriers. A flow-control structure (owned by the Alameda County Flood Control District) where the BART and railroad tracks cross Alameda Creek in Fremont ("the BART weir") represents an impassable barrier to adult steelhead, and prevents these fish from completing their life cycle in the Alameda Creek watershed. Inflatable dams in this reach of the watershed (owned and operated by the Alameda County Water District) are impassable barriers to adult steelhead when inflated, but under current operations are deflated with enough frequency to allow at least some adult fish passage into the watershed. The Calaveras and San Antonio, and Alameda Creek Diversion Dams (all owned and operated by the San Francisco Public Utilities Commission) and the Del Valle Dam (owned and operated by the California Department of Water Resources) are all impassable barriers in the upper part of the watershed. A natural gas pipeline (owned and operated by Pacific Gas and Electric Company) that crosses Alameda Creek in the Sunol Valley may also be an impassable barrier to adult steelhead except at the highest of flows. All of these facilities were built in compliance with the environmental regulations and standards in force at the time of their construction.

4. Migration of juvenile steelhead to the ocean may be limited by existing water project operations. This is particularly the case in years with low spring storm activity. Out-migration of juvenile fish is not precluded in all years, however, and this has been especially true during the last decade when there has been higher than average rainfall in May. There are currently significant periods of time under existing operations where it appears that smolts and adults have a reasonable opportunity to migrate downstream to the Bay. Migration of smolts from rearing areas in Arroyo Mocho is influenced by stream flow and groundwater management in the Livermore/Amador Valley area. It may be possible to enhance migration conditions in this and other reaches through pulse flow augmentation following storm events in April and May.

It is concluded from these findings that steelhead could complete their life-cycle in the watershed reaches below the major dams with provision of fish passage at the BART weir and the gas pipeline crossing in Sunol Valley. The viability of a steelhead run made possible by these changes would be greatly enhanced through other passage improvements related to additional structural barriers, operation of inflatable dams, provisions to prevent entrainment of juvenile fish in water diversion structures, and augmentation of stream flows in lower Alameda Creek and lower Arroyo Mocho during peak out-migratory periods.

It should be kept in mind that restoration of a viable steelhead population is contingent upon the interaction of many factors, including climate, water diversion practices, and removal of migration barriers. It is not possible to predict with certainty how steelhead/rainbow trout would respond to all of these factors.

Recommendations. Based on the above findings, this report recommends nine essential restoration actions that must be taken to provide steelhead trout the opportunity to complete their life cycle in the Alameda Creek watershed. The report also identifies five additional restoration actions to increase the likelihood of successful restoration, and seven follow-on technical investigations to reduce technical uncertainties.

Provide passage for fish around the BART weir and other barriers to in-migration of adult steelhead (see Essential Actions 1, 2, 3, 4, 5, 8 and Additional Actions 1, 2, and 3). Passage improvements at several sites (BART weir, inflatable dams, the gas pipeline crossing, Sunol Dam, Stanley Blvd. weir, Livermore National Laboratory pumping facility) are necessary to allow any access to potential habitat in Niles Canyon and its tributaries (~7 miles of potential habitat) and partial access to Alameda Creek and its tributaries up to Little Yosemite (~4 miles of potential habitat) and to Arroyo Mocho (up to 9 miles of potential habitat).

Improve migratory habitat by protection of young steelhead from entrainment in diversion structures, and augmenting spring flows if feasible (see Essential Action 4 and Additional Actions 4 and 5). Improvement of out-migration passage conditions through modification of operations at diversion facilities or by installation of fish screens, bypass channels, or other improvements at existing diversion facilities downstream of Niles Canyon would enhance out-migration success when diversions are operating. The possibility of using Arroyo Mocho rather than Vallecitos Creek to transfer State Water Project water to the ACWD should be investigated as to its predicted impacts on costs, water supply, and water quality. In addition, it is possible that water rights could be obtained through various public and private entities that would provide additional flows in the watershed to assist with out-migration in late Spring months.

Prepare an application to the U.S. Army Corps of Engineers §1135 Program (see Essential Action 6). The Workgroup should endorse the preparation of an application to the U.S. Army Corps of Engineers pursuant the §1135 of the Water Resources Development Act of 1986 for funding to improve upstream passage and reduce downstream entrainment of steelhead in the watershed.

Modification of Recreational Fisheries Management within the Watershed (see Essential Action 7). Stocking of hatchery-raised steelhead in Alameda Creek must be altered to prevent possibility of interbreeding and competition with wild stocks, and to redirect recreational fishing pressure. The planned development of the ACWD quarry lakes as an EBRPD recreational fishing venue can serve as an alternative for recreational fishers in the area, but should be developed to ensure that no fish can escape to the creek itself.

Identify Private and Public Landowners in Spawning and Rearing Habitat (see Essential Action 9). The maintenance or enhancement of spawning and rearing habitat will be most successful if attempted in conjunction with the private and public land owners who are the ultimate stewards of this resource. These individuals and organizations should be identified and contacted in a systematic fashion, possibly with assistance of the Alameda County Resource Conservation District, to inform them regarding the restoration program and encourage their support and participation.

Further Investigations There are several issues that merit further investigation as part of the planning for restoration of steelhead trout in the Alameda Creek watershed. These include (1) a critical passage analysis to allow definition, for each major migratory route, of the minimal flows that provide out-migratory habitat for steelhead in the watershed, (2) a spring smolt survey to verify the existence of steelhead smolts and to identify sites where spawning or rearing habitat might be enhanced, (3) visitation of some areas during wet weather conditions, including barriers that might be only passable under higher flow, (4) a limited survey of the Arroyo Mocho Canyon area to observe any potential migratory barriers and resident rainbow trout populations, (5) examine the potential to “re-operate” or jointly manage the municipal water supply activities of the SFPUC, ACWD, and Zone 7 to improve conditions for fish without adversely affecting municipal water supply (6) developing operational guidelines for minimum flow requirements for steelhead during periods of prolonged drought, and (7) develop guidelines for maximizing fish passage around the upper and lower inflatable dams given the constraints of the municipal water supply needs.

I. Introduction

The Alameda Creek watershed (Plate 1), the largest drainage to southern San Francisco Bay at nearly 700 square miles, once supported viable runs of anadromous fish. Development has greatly altered the watershed, including such changes as the channelization of the lower 12 miles of the creek for flood control, the construction of the San Antonio, Calaveras, and Del Valle Reservoirs for water supply, and the construction of a concrete drop structure to stabilize the channel around a transit overpass. Changes such as these have subsequently made the spawning habitat within the watershed inaccessible for returning anadromous fish.

There have been many observations of anadromous steelhead trout, *Onchorhynchus mykiss*, attempting to migrate up Alameda Creek (Appendix 1). In the late 1990s these fish have been observed in ever-increasing numbers, due possibly to favorable conditions recently for out-migration of smolts or maybe just due to increased observation effort. The presence of these fish has rekindled interest in their restoration by the public, elected officials, and the responsible management agencies, and in 1999 a task force made up of various stakeholders was convened to investigate the possibility of restoring a sustainable population of steelhead to the Alameda Creek watershed. Coincident with this interest is the existence of a federal restoration program administered by the U.S. Army Corps of Engineers that could provide funding for capital improvements as part of the restoration effort.

This report, generated at the request of and in cooperation with the task force, presents an assessment of the feasibility of restoring a viable steelhead run in the watershed. Based on the natural history of the steelhead, the report reviews the available habitat in the watershed for in-migration, spawning, rearing, and out-migration of young and adult fish. The existing beneficial uses of the watershed for water supply, flood control, and recreation are also considered, and conflicts between these uses and a restored anadromous fishery are explored. A set of findings and recommendations are provided that document the existing conditions in the watershed, and describe (1) management actions and structural changes that would be required to restore a viable steelhead population, (2) factors likely to impact the success of restoration, and (3) additional studies that could be conducted to reduce technical uncertainties.

A. Background

The idea of restoring an anadromous fishery to Alameda Creek has been studied periodically since the 1940s, and a 1983 task force determined that the upper reaches of the watershed could support anadromous fish. In 1989, a Technical Advisory Committee of local agency representatives[1] identified several possible alternatives for obtaining varying degrees of restoration for steelhead (Technical Committee, 1989). The Committee was unable to reach consensus on what level of restoration would be appropriate, and no restoration was instigated at the conclusion of the Committee's deliberations.

Several factors can be identified as contributing to the lack of consensus for selecting a restoration alternative, including:

- The technical discussions focused extensively on the difficult task of determining how many steelhead the watershed could be expected to support;

- Estimates of flow releases that were recommended to support varying levels of restoration were not generated with the degree of scientific rigor that was desired by the associated water supply agencies;
- The significant costs for restoration activities were expected to be borne by the participating agencies or from competitive grants;
- There were several technical questions that remained unanswered to the satisfaction of all participants.

Several recent scientific and political developments have combined to bring the issue of steelhead restoration in Alameda Creek back to the forefront once again. Among these are: (1) increased public interest, (2) identification of steelhead as threatened pursuant to the Federal Endangered Species Act, (3) the results of the application of recent advanced techniques in molecular genetics to the analysis of local steelhead populations, and (4) the availability of new sources of funding to support the restoration.

Public Interest. Although anadromous fish have been sighted in the flood control section of Alameda Creek periodically, those numbers have been increasing dramatically in the last few years.[2] Observations have been made by employees of the Alameda County Flood Control and Water Conservation District (ACFCWCD), Alameda County Water District (ACWD), East Bay Regional Park District (EBRPD), National Marine Fisheries Service (NMFS), California Department of Fish and Game (CDF&G), the Alameda Creek Alliance (ACA), and local citizens. These entities have cooperated over the past two winters to transport migrating steelhead above the uppermost barrier in the flood control channel section.

Additionally, in 1998 fifth-grade students from Donlon Elementary School, in cooperation with the Golden West Women’s Flyfishing Foundation, participated in a successful effort to rear steelhead from eggs deposited by steelhead spawning in the lower flood control channel.[3] The hatchlings were later released into Alameda Creek in the Sunol Regional Wilderness area. All of these efforts have combined to bring the visibility of the steelhead in Alameda Creek to a level not seen in a very long time. Recently, newspaper editorials have been prepared supporting the restoration[4], and the Alameda County Board of Supervisors has held hearings on the subject[5].

This increase in public interest is reflected in numerous projects in northern California to restore anadromous fish habitat. Pacific Gas and Electric Co. (PG&E) recently announced plans to remove five power-generating dams from Battle Creek and retrofit three others with fish ladders to benefit salmon and steelhead trout. In 1998, four dams were removed from Butte Creek at a cost of $9.5 million in an effort to restore spring-run Chinook salmon to that stream. Petaluma high school students completed a $500,000 fish ladder on Adobe Creek in 1998 to open three miles of stream habitat to salmon and steelhead. The Santa Clara Valley Water District has undertaken numerous projects recently including removal of fish passage barriers in the Guadalupe River (completed in 1998), construction of a fish ladder at the Alamitos drop structure (completed in November 1999), and planned fish passage facilities at the Blossom Hill drop structure and Masson Dam. These projects are being undertaken to provide access for salmon and steelhead to approximately 19 miles of upstream habitat. A project is underway to improve passage for migrating salmonids in San Geronimo Creek in Marin County, and a coalition of organizations in Contra Costa County have prepared an application to the U.S. Army Corps of Engineers for restoration of anadromous fish habitat in Wildcat Creek.

Threatened status of steelhead. During the last decade scientific analysis has continued to develop a compelling picture of the decline of anadromous fishes of the Pacific (Huntington *et al.*, 1996; Nehlsen, 1997). The status of steelhead trout in California is of particular concern, with virtually all steelhead stocks in California having declined often to record low levels by 1995 (Mills *et al.*, 1997).[6] There has been significant discussion regarding the causes of these declines and how to restore these populations (Lufkin, 1991; Moyle, 1994; Stouder *et al.*, 1997).

The conclusions from the scientific community and the concern of the public led to Central Coast steelhead being listed by NMFS as a threatened species (National Marine Fisheries Service, 1997). As a result of a recently settled lawsuit, NMFS has issued proposed rules (pursuant to §4(d) of the Endangered Species Act) that will clarify what is considered an illegal take of steelhead. These regulations will provide a new legal context to guide the activities of state and local governments in watersheds containing steelhead.

Genetic analysis of Alameda Creek fish. One factor that negatively impacted the ability of the 1987 Technical Advisory Committee to reach consensus on the restoration potential of steelhead was the indeterminate origin of the steelhead present in the watershed. At that time, there was doubt as to whether the observed steelhead were fish native to the stream or were the result of some past stocking of the stream with hatchery-bred fish. If the fish were native or "wild" steelhead, then they represent the product of evolution, and their genetic code is the product of generations of fish interacting with the physical and biological conditions in Central California. They are consequently an irreplaceable resource, and much more effective stock from which to begin a restoration effort than fish derived from hatcheries (Higgins, 1991).

In the last decade, new molecular techniques have been applied in genetics that allow researchers to identify the origins of fish with a much greater level of confidence (Nielsen, 1996). Tissue samples have been collected from steelhead and rainbow trout in the Alameda Creek watershed and from other streams in the area. In 1999, the Alameda Countywide Clean Water Program funded analyses to compare DNA from these samples to DNA extracted from other populations of steelhead/rainbow trout of known origin, including hatchery stocks commonly used for supplementation in streams and reservoirs throughout California (Nielsen and Fountain, 1999). This analysis concluded with a high level of confidence that the Alameda Creek samples are not of hatchery origin, and should in fact be classified as part of the Central California Coast Evolutionarily Significant Unit (ESU).[7]

Availability of §1135 funding. Implementation of §1135 of the Water Resources Development Act of 1986 by the US Army Corps of Engineers has created a potential major source of funding for required restoration actions. This program supports watershed restoration activities in areas deemed to have been impacted by prior Corps activities. The program funds 75% of agreed-upon restoration costs, requiring a 25% share for approved local sponsors. This provides a critical mechanism by which the capital cost of items such as fish passage facilities or diversion screens can be shared.

B. Decision Process for preparation of this report

Given these developments, the Alameda Creek Fisheries Restoration Workgroup (the Workgroup) was formed to consider the restoration of steelhead in Alameda Creek. Lead by the efforts of the ACFCWCD, the Workgroup benefits from the active participation of ACWD, the San Francisco Public Utilities Commission (SFPUC), EBRPD, California Coastal Conservancy, the City of Fremont, CDF&G, the Alameda Creek Alliance, and NMFS.

The initial goal of the Workgroup was to assess fish passage options around an impassable barrier in lower Alameda Creek, but this goal was expanded to determine the required actions necessary to restore a viable steelhead run in Alameda Creek. While there is growing consensus to consider construction of fish passage facilities in the lower watershed, a key first step is to verify that adequate habitat exists in the upper watershed to support a steelhead run prior to investing significant public funds to remove in-migration barriers. With financial sponsorship from the ACFCWCD and the California Coastal Conservancy, the Workgroup hired Applied Marine Sciences, Inc. and Hagar Environmental Science to assess the feasibility of a steelhead restoration effort. The scope of work given these consultants was to:

- Complete a review of the available literature regarding Alameda Creek to identify historic steelhead patterns in the watershed, known areas with spawning and/or rearing potential, known barriers to migration, and areas requiring additional inquiry;
- Meet with managing agencies as necessary to identify existing management procedures and information they would require for making feasibility decisions;
- Based on the results of the above steps and with the participation of Workgroup members, undertake any additional field surveys as necessary to furnish needed information;
- Compile and present the results of the analyses for review by the entire Workgroup.

This report represents the findings of this process. The subsequent sections of the report will provide some background information regarding the watershed and the beneficial uses it supports, review the existing habitat conditions for steelhead, and describe changes in the watershed that are likely needed to re-establish a steelhead run.

II. The Alameda Creek Watershed

The Alameda Creek watershed is a large and diverse natural landscape that supports a variety of beneficial uses through a complex array of municipal and regional institutions with overlapping jurisdictions. This section of the report provides a brief background on the landscape, climate, and hydrology of the Alameda Creek watershed. It also reviews the beneficial uses currently supported, including a summary of the fish resources in the watershed.

A. Landscape, Climate, and Hydrology

The physical environment of the Alameda Creek watershed encompasses a number of different landform types, most notably the flatlands and rolling hills of the Livermore Valley, the increasingly rugged terrain associated with the Niles Canyon and Sunol-Ohlone Regional Wilderness areas, and the lowlands of the Bay coastal plain (Figure 1). Land uses in the region include residential, commercial, light industrial, agricultural, ranch, and parklands. Within the watershed are portions of three counties, a number of cities and unincorporated areas, and different municipal agencies responsible for overseeing the various needs for water supply, flood control, and sewage treatment.

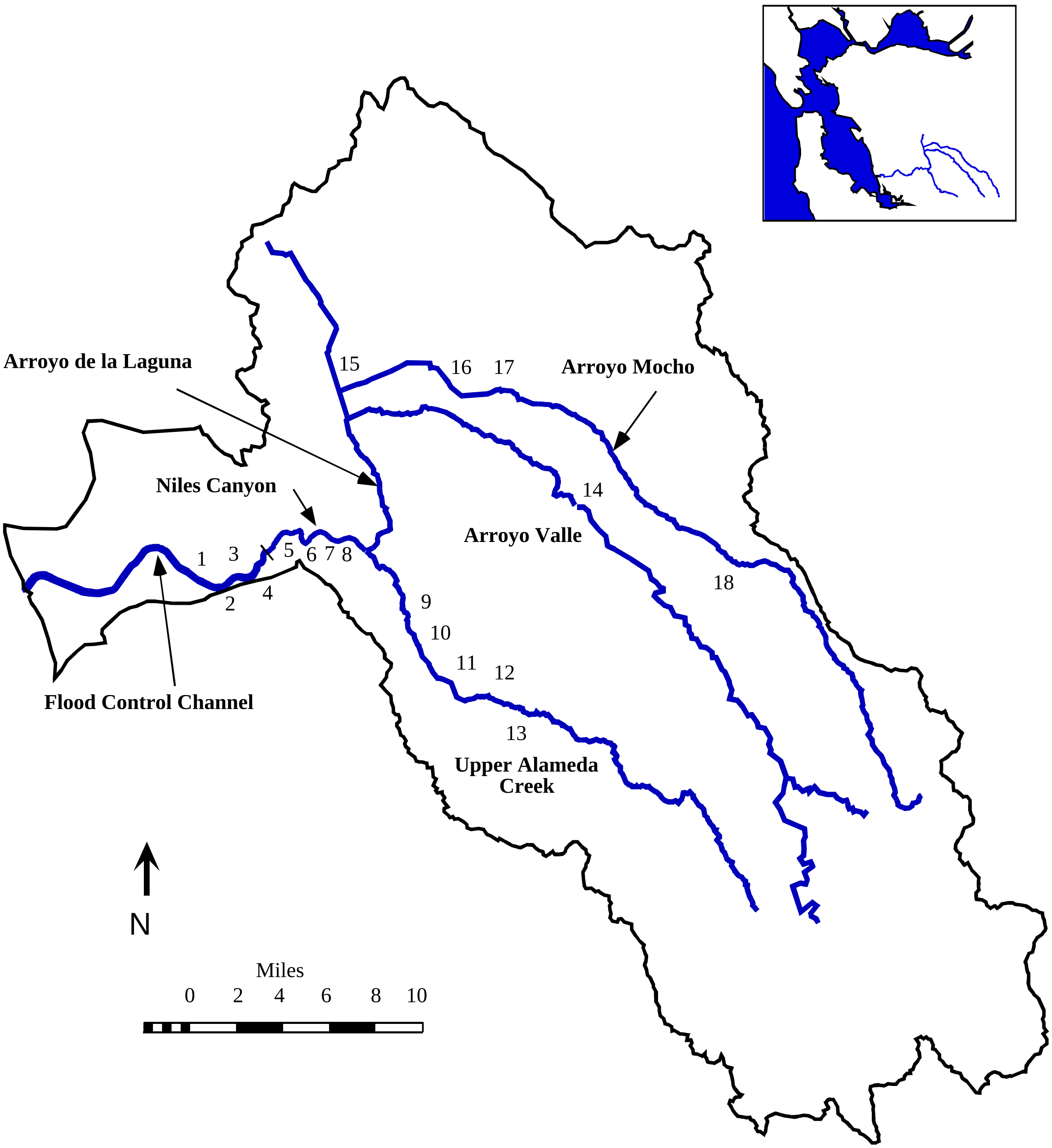


Figure 1 - The Alameda Creek Watershed. The numbers refer to potential barriers to in-migration of anadromous fishes. (See Table 3 for descriptions)

The Alameda Creek watershed comprises two similar yet distinct microclimates separated by the coastal hills in the Niles Canyon area. Both areas experience a relatively mild marine climate, with average daily winter temperatures of 4.5-10°C (40-50˚F) and average summer temperatures of 15.5-21°C (60-70˚F) (Welch *et al.*, 1996). Temperature data also indicate that the eastern section of the watershed typically experiences warmer summer and cooler winter temperatures than the western section.[8] Average annual precipitation ranges from ten to thirty inches, but in most areas will fall in the mid-teens. Precipitation increases eastward from the Bay, with increasing elevation, to a maximum in the coastal hills, then drops rapidly with distance eastward from the hills (Welch *et al.*, 1966).

The Alameda Creek watershed, like others on the central and southern California coast, is subject to periodic droughts. Alameda Creek is usually a perennial stream in the upper parts of the watershed, but in the Sunol Valley a high rate of infiltration will normally result in a dry creek during the summer months. Many of the tributaries that supply flows to the Creek are historically intermittent, and can be isolated from the mainstem beginning in early to mid-summer (Welch *et al.*, 1966). This is especially true of streams, both natural and channelized, draining the Livermore Valley. In addition to fluctuations in streamflows caused by varying levels of surface water runoff, flows in Alameda Creek tributaries also vary greatly with rising and falling water tables in the area.

In addition to alterations caused by development and flood control, the hydrology of the Alameda Creek watershed has been greatly altered by water supply activities. Creek channels are frequently used to move water from one facility to another, and thus a creek reach can have significant flow due to water releases from various facilities. For example, the ACWD purchases water from the State Water Project, and this water is released into Vallecitos Creek in the summer and allowed to flow through Niles Canyon into Fremont, where it is diverted for ground water recharge. Similarly, discharges from quarries in the Pleasanton area provide year-round flow in Arroyo de la Laguna.

B. Beneficial Uses Supported in the Watershed

1. Municipal Water Supply

Three Bay area water supply agencies make use of the Alameda Creek watershed as both a source of local water and as a conduit for delivering that water and additional purchased water to its customers. The agencies are the Alameda County Water District, the San Francisco Public Utilities Commission, and the Zone 7 Water Agency.[9]

Alameda County Water District (ACWD). The ACWD supplies potable water to a population of over 300,000 in the municipalities of Fremont, Union City, and Newark. The ACWD also manages the groundwater recharge for the local aquifer (the Niles Cone), affecting recharge in the stream channel and in quarry lakes located adjacent to the lower stretches of Alameda Creek.

ACWD purchases water from the California Department of Water Resources (DWR) via the South Bay Aqueduct (approximately 55% of their total) and Hetch Hetchy water from SFPUC (approximately 30%); the remaining 15% is generated by local runoff. “Finished” water from

SFPUC is input directly into the potable water system. Unfinished water is either treated to become potable, or diverted into the quarry lakes.

San Francisco Public Utilities Commission (SFPUC). The SFPUC supplies retail water to residents of the City and County of San Francisco. Additionally, the SFPUC sells water wholesale to various water contractors, including agencies in Alameda, Santa Clara, and San Mateo counties. The SFPUC manages some of the most pristine lands within the watershed, including a large portion of land bordering the Sunol-Ohlone Regional Wilderness. The SFPUC operates two reservoirs within the watershed, San Antonio and Calaveras reservoirs. The San Antonio Reservoir, completed in 1965, stores water from the Hetch Hetchy aqueduct that is supplemented by natural streams, while the Calaveras Reservoir, completed in 1925, is fed by both natural streams and a tunnel leading from a dam on upper Alameda Creek known as the Alameda Creek Diversion Dam.

Zone 7 Water Agency (Zone 7). Zone 7 Water Agency, also known as Zone 7 of Alameda County Flood Control and Water Conservation District, is a water wholesaler that provides potable water to, among others, the municipalities of Dublin, Pleasanton, Livermore, and San Ramon. Zone 7 also has responsibility for managing the groundwater recharge for the local aquifer and providing flood control for a 425 square mile area including the cities of Dublin, Pleasanton, and Livermore.

Zone 7 relies mainly on two sources of water for its supply, Feather River water delivered via the State Water Project, and “local water” supplied by precipitation in the Livermore Valley. Zone 7 can then sell treated water to water contractors, sell untreated water primarily to vineyards for irrigation, or recapture the water for groundwater recharge.

Currently water is released by DWR through the South Bay Aqueduct in a number of possible locations into Arroyo Mocho, Arroyo Valle, and Arroyo Las Positas to affect the groundwater recharge. During the dry season, Arroyo Mocho is effectively two distinct segments separated by an approximately 200-yard dry length in the Pleasanton gravel quarry area. Flows in the upper watershed are regulated by DWR releases from the California Aqueduct. Flows below the quarries are supplied by an NPDES-permitted discharge from quarry operators. Zone 7 manages the releases from DWR to maintain the “dry” length, assuring the water purchased from the State is entering the groundwater basin.

In approximately 2005, management of the Pleasanton quarries will begin to revert to Zone 7, with the final quarry expected to be turned over by approximately 2030. Flows from Arroyo Mocho and Arroyo Valle are planned to be diverted into these quarries for groundwater recharge, much as in the manner the ACWD employs. This will involve the construction of some type of diversion structure in the Arroyo Mocho channel near the quarries. Additionally, flows currently output to the Arroyo by the quarry operators will cease.

2. Flood Control

The Alameda Creek watershed was subject to periodic flooding throughout its early development history. As development has decreased the natural storage capacity of the watershed and has encroached upon the natural floodplain, the costs associated with any potential flooding have become more extreme.

The ACFCWCD and Zone 7 are the agencies responsible for mitigating risks of flooding within the watershed. This responsibility includes overseeing channel maintenance, erosion control, and dredging of sediments that collect in the lower reaches of the Creek.

The major flood control measure instituted within the watershed is an approximately twelve mile U.S. Army Corps of Engineers channelization project completed in 1972 that runs from San Francisco Bay inland to near Niles Canyon. Other major channelization projects within the watershed include sections of Arroyo Mocho, Arroyo de la Laguna, and Arroyo Valle.

3. Fish

Thirteen native fish species have been collected in non-tidal portions of the Alameda Creek watershed during the past century (Table 1). Several other species may have also occurred in the watershed based on collections in tidal portions, evidence from archaeological investigations, and other accounts. Many collections include widely distributed species typical of streams in the region such as California roach, hitch, Sacramento sucker, pikeminnow (squawfish), steelhead/rainbow trout, Pacific lamprey, and prickly sculpin. Two species, speckled dace and riffle sculpin have appeared in only one or two collections. Speckled dace were reported from Arroyo Honda and Isabel Creeks, two Calaveras Creek tributaries above Calaveras Reservoir by Snyder in 1905 and in Alameda Creek at the confluence with Calaveras Creek by Shapovalov in 1938 (Leidy, 1984). Scoppettone and Smith did not find speckled dace in these areas in surveys conducted between 1972 and 1977. Riffle sculpin collected in Alameda Creek at the junction with Calaveras Creek in 1938 by Leo Shapovalov is the only report of the species in the Alameda Creek watershed. Scoppettone and Smith (1978) thoroughly sampled for riffle sculpin at sites with cool, permanent water in Isabel, Smith, Arroyo Hondo, Arroyo Mocho, and Alameda Creeks but found none. Of the 11 remaining species, 9 were collected as recently as 1981 (Leidy, 1984).

The two species not collected in 1981 were Pacific lamprey, and Sacramento blackfish. Pacific lamprey have been recently netted in the flood control channel section.[10] Sacramento blackfish have been reported in the ACWD quarry lakes.[11] Sacramento perch, one of the species collected in 1981, are native to California but there is some question as to whether they are native to Alameda Creek. Aceituno *et al*., (1976) believed that they were stocked into Calaveras Reservoir some time after 1925 and spread to the stream from there. However, Gobalet (1990) reports Sacramento perch from fish remains at an archaeological site adjacent to Arroyo de la Laguna. In any case, they have been consistently collected in Niles Canyon since 1953 and currently maintain populations in the off-channel percolation ponds adjacent to the flood control channel (Leidy, in prep.).

Sturgeon and Chinook salmon were reported by Schultz (1986) from archaeological sites in the lower Alameda Creek floodplain. Both of these species could have been captured in San Francisco Bay or other locations and transported to the site. Leidy (in prep.) believes that Alameda Creek could have supported small runs of Chinook salmon. In recent years small numbers of Chinook salmon adults have been recovered from the Alameda Creek flood control channel, as well as other streams not previously known to support salmon runs. It is generally believed that management of hatchery production has resulted in salmon straying to streams that have not traditionally supported them.

Common Name	Scientific Name	1905 Snyder	1927 Follett	1934 Seale	1938 Shapovalov	1953 Follett	1955 Follett	1957-58 Follett	1961 Hopkirk	1972 Follett	1973 CDFG	1977 Scoppettone and Smith	1984 Leidy
NATIVE SPECIES													
Pacific lamprey	*Lampetra tridentata*						X	X			X		
California roach	*Hesperoleucus*	X		X				X	X			X	X
Hitch	*Lavinia exilicauda*	X		X			X			X	X		X
Sacramento blackfish	*Orthodon microlepidotus*			X			X	X	X	X	X		
Sacramento squawfish	*Ptychocheilus grandis*	X	X	X		X		X	X	X	X	X	X
Speckled dace	*Rhinichthys osculus*				X								
Sacramento sucker	*Catostomus occidentalis*	X	X	X				X	X	X	X	X	X
Steelhead/rainbow trout	*Oncorhynchus mykiss*		X				X	X				X	
Threespine stickleback	*Gasterosteus aculeatus*			X							X		X
Sacramento perch	*Archoplites interruptus*					X	X	X		X	X	X	X
Prickly sculpin	*Cottus asper*	X	X	X			X	X			X	X	X
Riffle sculpin	*Cottus gulosus*				X								
Tule perch	*Hysterocarpus traski*	X	X	X									X
INTRODUCED													
Goldfish	*Carassius auratus*										X		
Carp	*Cyprinus carpio*						X	X		X	X	X	X
Golden shiner	*Notemigonus crysoleucas*												X
White catfish	*Ameiurus catus*						X						
Black bullhead	*Ameiurus melas*												X
Brown bullhead	*Ameiurus nebulosus*							X	X				
Mosquitofish	*Gambusia affinis*								X		X	X	X
Inland silverside	*Menidia beryllina*												X
Green sunfish	*Lepomis cyanellus*								X		X		X
Bluegill	*Lepomis macrochirus*					X	X	X				X	
Smallmouth bass	*Micropterus dolomieu*												X
Largemouth bass	*Micropterus salmoides*					X			X				X
Black crappie	*Pomoxis nigromaculatus*							X					
Percina macrolepida	*Bigscale logperch*												X

Table 1: Fishes of the Alameda Creek Watershed

Leidy (in prep) reports staghorn sculpin within the fish assemblage of tidally influenced portions of lower Alameda Creek and coho salmon from collections and historical records from Niles Canyon between the 1920s and 1950s.

Although native species persist in the watershed and are the dominant or only species in the upper parts of the watershed, introduced exotic species have increased in abundance, species representation, and distribution within the watershed (Table 1). Introduced species were reported in 1953 when bluegill and largemouth bass were collected by Follett, but may have been present as early as the 1880s when largemouth bass were introduced to the region.[12] By 1981, 13 species of introduced fish had been reported. Five of those species were reported for the first time in 1981.

In the past, the Alameda Creek watershed supported anadromous steelhead. Although photographic records document this, there are no good records of the size of steelhead spawning populations or the distribution of spawning and rearing areas. Rainbow trout have been documented above Calaveras Reservoir on several occasions since 1905 including collections from Arroyo Hondo, Isabel, and Smith Creeks (Leidy, 1984). Although there may have been some stocking of exotic trout in these streams in the past, the present self-sustaining populations are most likely derived from coastal steelhead that were isolated in the upper part of the drainage by natural processes or by construction of Calaveras Dam between 1916 and 1925. Self sustaining rainbow trout populations exist in streams of the San Antonio watershed above San Antonio Reservoir (SFEI, 1999). Similar populations exist in numerous other locations such as those in San Leandro Reservoir tributaries and in San Pablo Creek above San Pablo Reservoir (Needham and Gard, 1959). Trout populations isolated above dams often adopt an adfluvial life-history, spending most of their lives in the reservoirs and migrating to tributary streams to spawn.

Steelhead/rainbow trout have also been collected in other parts of the watershed. Follett (1974) reported observing “large young” trout immediately below the dam in Niles Canyon in 1927. Follett also collected juvenile rainbow trout at two locations in Stonybrook Canyon in 1955 and “half grown” rainbow trout at pools opposite Niles nursery in 1957. Skinner (1962) reported steelhead/rainbow trout from Alameda Creek, Arroyo Mocho Creek, Arroyo del Valle Creek, and Arroyo de la Laguna Creek. CDF&G collected multiple age classes including young in 1976 from three locations in Arroyo Mocho Creek, and in Stonybrook Canyon. Scoppettone and Smith (1978) report steelhead/rainbow trout from Alameda Creek in the vicinity of Ohlone Park and in Arroyo Mocho Creek. Gray (1988) documented the occurrence of young-of-year rainbow trout in Alameda Creek just upstream of its confluence with Calaveras Creek in 1983 and again in 1987. Sampling by Alameda County in 1999 has documented the presence of reproducing populations of rainbow trout in Arroyo Mocho and two tributaries of Alameda Creek, Welch Creek and Pirate Creek. Recent sampling by the East Bay Regional Park District has documented the presence of reproducing trout populations in Stonybrook Creek and in Alameda Creek in Sunol Park. Rainbow trout of hatchery origin are stocked in Del Valle Reservoir and Shadow Cliffs Lake by the East Bay Regional Park District and in Niles Canyon by the CDF&G.

The National Marine Fisheries Service completed a status review of West Coast steelhead populations in Washington, Idaho, Oregon, and California in response to a petition to protect these populations under the Endangered Species Act (ESA) (Busby *et al.*, 1996). The Alameda Creek watershed lies geographically within the Central California Coast Evolutionary Significant Unit (ESU) as defined by the National Marine Fisheries Service (NMFS).[13] Following its status review, the NMFS adopted a Final Rule designating steelhead trout in the Central California Coast ESU as a Federally threatened species effective October 17, 1997 (National Marine Fisheries Service, 1997). At this time, the designation applies only to naturally spawned populations of anadromous forms of *O. mykiss* residing below long-term naturally occurring or man-made impassable barriers.[14]

As discussed above, there have been well-documented reports of steelhead sighted in the Lower Alameda Creek channel below the impassable barrier, the BART weir, adjacent to the middle inflatable dam operated by the ACWD (Appendix 1). Sightings have been increasingly reported in 1998 and 1999 due either to increased numbers of fish or increased frequency of people watching for them. Beginning in 1998 some of these fish were captured by citizens groups and released in the mouth of Niles Canyon upstream of the upper inflatable diversion dam. In 1999, two of the released fish were fitted with radio transmitters and one of them, a gravid female, was tracked into Stonybrook Creek, a tributary entering Alameda Creek in Niles Canyon. Some of the steelhead, unable to pass the BART weir, spawned in Alameda Creek downstream of the middle inflatable dam. In 1998 fertilized eggs were collected from the stream bottom immediately downstream of the weir. The eggs hatched successfully in aquaria and the resulting fry were released in Alameda Creek in Sunol Park.

Currently, there are three recreational put-and-take fisheries within the Alameda Creek watershed, two at Lake Del Valle and Shadow Cliffs Regional Park near Pleasanton supported through a stocking program managed by EBRPD and a third within Niles Canyon stocked by CDF&G. Currently, hatchery-raised rainbow trout are released at both locations. Each fishery requires valid California fishing licenses to participate. EBRPD is also in the process of developing an additional venue for a put-and-take fishery at the Fremont quarry lakes also used for groundwater recharge by the ACWD. The stocking of this fishery is anticipated to be in operation by the early 2000s.

Given the presence of natural and stocked rainbow trout in the watershed, it was vital to the restoration effort to determine the origin of steelhead returning to the watershed. As mentioned previously, recent genetic analysis indicates that the returning adult steelhead are not of hatchery origin, are genetically similar to rainbow trout in the upper parts of the watershed, and should be considered part of the Central Coast ESU (Nielsen and Fountain, 1999).

III. Restoration of Steelhead

The report now turns to consideration of the status of steelhead habitat in the Alameda Creek watershed. After a general review of the habitat requirements of steelhead trout through their life-cycle, the report reviews the existing information (including results from recent surveys) regarding spawning, rearing, and migratory habitat in the watershed. This will be followed in Section IV by findings regarding the adequacy of habitat to support steelhead, and in Section V by recommendations for changes in the watershed to effect restoration of a viable steelhead population.

A. Habitat Requirements

Steelhead/rainbow trout, *Oncorhynchus mykiss*, have a very flexible life history. All *O. mykiss* hatch in the gravel substrate of coldwater streams. After a period of two to three weeks the young fry begin to emerge from the gravel and start feeding in the stream. Some begin to disperse downstream in the months following their emergence but most continue to rear in the stream. Following a rearing period of at least one year, juveniles (parr) may follow a variety of life-history patterns including residents (non-migratory) at one extreme and individuals that migrate to the open ocean (anadromous) at another extreme. Intermediate life-history patterns include fish that migrate within the stream (potamodromous), fish that migrate only as far as estuarine habitat, and fish that migrate to near-shore ocean areas. These life-history patterns do not appear to be genetically distinct, and have been observed interbreeding (Shapovalov and Taft 1954).

Juveniles that become migratory typically do so after one or two years of rearing but sometimes longer. Physiological changes (smoltification) in these fish (smolts) ultimately allow them to make a transition from freshwater to seawater. Smolts migrate to the ocean, spend a variable amount of time there (typically one to two years), grow rapidly and return to spawn, generally in the stream where they hatched.[15] This is an anadromous life history, typical of many salmon and trout as well as other fish species, and anadromous *O. mykiss* are commonly known as steelhead. Steelhead are unusual among the other Pacific salmonids in that they do not all die after spawning. Some return immediately to the ocean, others return after holding for a period in freshwater. Within a given stream, some *O. mykiss* do not migrate to the sea, and the proportion may vary considerably depending on local circumstances. These fish reach sexual maturity and spawn without entering the ocean and are often known as resident or stream rainbow trout.[16]

Anadromous steelhead exhibit two basic life history forms. Stream maturing steelhead enter spawning streams before they are sexually mature, generally during the period between spring and early fall, and spend several months in the stream before they are ready to spawn. Ocean maturing steelhead enter spawning streams during the fall and winter in fully mature state and spawn relatively soon after entering fresh water. Both forms may occur in the same river system with little or no genetic distinction.

Steelhead habitat requirements are associated with distinct life history stages including migration from the ocean to inland reproductive and rearing habitats, spawning and egg incubation, rearing, and seaward migration of smolts and spawned adults. Habitat requirements and life-history timing can vary widely over the steelhead's natural range (Barnhart, 1986; Pearcy, 1992; Busby *et al.*, 1996). Although detailed information for Alameda Creek is not available, generalization can be made from other streams of the region. Some of the best information, particularly for life-history timing, comes from a multi-year study in Waddell Creek in the Santa Cruz mountains (Shapovalov and Taft, 1954). The habitat requirements for each of these stages are discussed below.

In-migration of adult steelhead. Steelhead along the Central California coast enter freshwater to spawn when winter rains have been sufficient to raise streamflows and breach sandbars that form at the mouths of many streams during the summer. Increased streamflow during runoff events also appears to provide cues that stimulate migration and allows better conditions for fish to pass obstructions and shallow areas on their way upstream. The season for upstream migration of adults lasts from late-October through the end of May but typically the bulk of migration (over 95% in Waddell Creek) occurs between mid-December and mid-April. Steelhead have strong swimming and leaping abilities that allow them to ascend streams into small tributary and headwater reaches. Steelhead can swim at rates of up to 4 feet per second for extended periods of time and can achieve burst speeds of 12 feet per second or more during passage through difficult areas (Bell, 1986). Given satisfactory conditions, a conservative estimate of steelhead leaping ability is a height of 6 to 9 feet (Bjornn and Reiser, 1991), though other estimates range to as high as 15 feet (McEwan, 1999).

Spawning and egg incubation. Steelhead, like all Pacific salmon, select spawning sites with rather specific features. These features include gravel substrate with sufficient flow velocity to maintain circulation through the gravel and provide a clean, well-oxygenated environment for incubating eggs. Specifically, preferred gravel substrate is in the range of 0.25 to 2.5 inches in diameter and flow velocity is in the range of 1-3 feet per second. Steelhead will use substrate with larger gravel (up to 4 inches) than resident trout. Typically, sites with preferred features for spawning occur most frequently in the pool tail/riffle head areas where flow accelerates out of the pool into the higher gradient section below. In such an area, the female steelhead will create a pit, or redd, by undulating her tail and body against the substrate. This process also disturbs fine sediment in the substrate and lifts it into the current to be carried downstream, cleaning the nest area. Survival of fertilized eggs through hatching and emergence from the gravel is most often limited by radical changes in flow that can dislodge eggs from the substrate, result in sedimentation, or de-water incubation sites.

Rearing. After emergence from the gravel, trout fry inhabit low velocity areas along the stream margins. As they feed and grow they gradually move to deeper and faster water. Trout of 4-6 inches (generally in their second year of life) may be commonly found in riffle habitat, particularly in warmer streams. Trout larger than 6 inches are more often found in deeper waters where low velocity areas are in close proximity to higher velocity areas and cover is provided by boulders, undercut banks, logs, or other objects. Heads of pools generally provide classic conditions for older trout. Trout, particularly coastal steelhead/rainbow trout, can inhabit quite small streams. Often habitat for older trout may be far more limiting than habitat for younger fish. The critical period is during base flow conditions that generally occur between May and October in Central California. Streamflow can drop to very low levels with loss of depth and velocity in riffle and run habitats, or in the extreme, only isolated pools with intervening dry sections of stream.

Although standard definitions of good trout rearing habitat include baseflows of at least 25 to 50% of the average annual daily flow, 1:1 riffle to pool ratios, and depths of a foot or more, these conditions may not always be achieved in Central California streams that still support relatively good steelhead/rainbow trout populations. Steelhead/rainbow trout populations in Central California can occur in streams with relatively low baseflow and in streams varying widely in terms of standard evaluation parameters such as pool:riffle ratio and mean depth. Often, local populations thrive under conditions that may depart widely from species norms (Behnke, 1992). Steelhead respond to stream conditions that limit habitat for older trout by leaving the small streams to complete the maturation process in the more accommodating ocean environment.

Temperature is an important factor for steelhead/rainbow trout, particularly during the over-summer rearing period. The influence of water temperature on steelhead and other salmonids has been well studied and the influence on individual trout populations is complicated by a number of factors such as local adaptations, behavioral responses, other habitat conditions, daily and annual thermal cycles, and food availability. The most definitive temperature tolerance studies have been conducted in laboratory settings where experimental conditions have been highly controlled and fish were exposed to constant temperatures (Brett, 1952; Brett *et al.*, 1982). Upper lethal temperature for Pacific salmonids is in the range of 75-77°F (24-25ºC) for continuous long-term exposure. Elevated temperature below the lethal threshold can have indirect influence on survival due to depression of growth rate, increased susceptibility to disease, and lowered ability to evade predators. In some studies, steelhead have exhibited decreased migratory behavior and decreased seawater survival at temperature in excess of 55°F (13ºC) (Zaugg and Wagner, 1973; Adams *et al.*, 1975).

In most streams water temperature varies over the course of a day and from day to day, generally tracking changes in air temperature. Although the peak temperature on a given day may exceed the lethal level, steelhead can survive short periods at temperatures above the lethal threshold. In Brett's study, juvenile chinook salmon experienced no mortality at temperatures up to 75°F (24ºC) for 7 days. At 79°F (26ºC C) half the juvenile salmon survived a 5-hour exposure period and at 81°F (27ºC) half survived a 1.5-hour exposure. The temperature that the fish are acclimated to is also an important variable. Juvenile salmon acclimated to 75°F (24ºC) experienced 50% mortality after 8.5 days at 77°F (25ºC) while those acclimated to 59°F (15ºC) experienced 50% mortality after only 42 hours of exposure at 77°F (25ºC) (Brett, 1952). Some trout populations are able to thrive under temperature conditions unsuitable for other populations. Behnke (1992) has found native redband trout in intermittent desert streams thriving in water of 83°F (28ºC) and actively feeding at that temperature. These populations have apparently become adapted to conditions in the region.

Smith (1999) describes two different habitat types used by central coast steelhead and resident trout. The primary habitat is shaded pools of small, cool, low-flow upstream reaches typical of original steelhead habitat in the region. In addition, they can use warmwater habitats below some dams or pipeline outfalls, where summer releases provide high summer flows and fast-water feeding habitat. Trout metabolic rate and thus food demand increases with temperature. Trout rely heavily on insect drift for food and drift increases with flow velocity. Under conditions of low flow and high temperatures trout have increasing difficulty obtaining sufficient food to meet metabolic costs. Smith and Li (1983) found that in Uvas Creek (Santa Clara County), a relatively warm stream with summer maximum water temperature of 23-25°C, steelhead/rainbow trout move into higher velocity microhabitats in riffles and runs where sufficient food can be obtained. These habitats are created by summer releases from an upstream reservoir. Under augmented flow conditions trout can occupy warmer habitats than may otherwise be possible. A similar situation may exist in Niles Canyon where releases are made from the South Bay Aqueduct during the summer months that flow down Alameda Creek for delivery to ACWD at the mouth of Niles Canyon.

Smolt Out-migration. The exact timing of smolt out-migration has not been documented in Alameda Creek. Inference must be made from other streams, such as Waddell Creek. Trout of various ages migrated out of Waddell Creek in all months of the year but the majority migrated in April, May and June. Downstream migration of young-of-year fish (less than a year old) extended from late-April through the following spring, however this movement may have been just dispersal to downstream rearing areas and not a true seaward migration. Downstream migration of 1-year-old fish was from April through late June and 2-year-old fish from March through late May. Conditions in Alameda Creek are quite different from Waddell Creek. Alameda Creek is in a more inland, dryer, and warmer region and winter flows are expected to recede earlier in the season. There may also be substantial increases in water temperature in Alameda Creek well before June.

In addition to temperature and flow conditions, smolts are subject to predation from larger predatory fish such as pikeminnow (squawfish) and birds, particularly cormorants, mergansers, and herons. Predation by fish can be high in situations where predators congregate below dams and other obstructions and where smolts can be disoriented in turbulent flows after passing those obstructions. Predation by birds can increase under conditions where smolts have to traverse shallow sections of streams without cover. With clear water, birds can be particularly effective predators. Conditions favoring predation by birds occur in the flood control section of Alameda Creek where the channel is maintained in a wide, shallow configuration and is largely devoid of in-stream large woody debris and riparian vegetation.

Out-migration of adults. Steelhead that survive spawning return downstream to re-enter the ocean. As many as 20% of adult spawners may be repeat spawners and some fish may return to spawn up to 3 or 4 times (Shapovalov and Taft, 1954). In some streams fish return downstream immediately after spawning while in others they may remain for a period up to several months. After spawning, these fish do not typically resume feeding while in freshwater. Fish that remain in the stream for any period of time generally reside in deeper pools. In Waddell Creek the bulk of adults returned downstream from April through June.

B. Status of Existing Habitat

This section presents the results of recent surveys, and an assessment of other information, regarding the status of existing steelhead habitat in the Alameda Creek watershed. The approach taken (including assumptions made) are first described, followed by assessment of habitat for spawning, barriers to in-migration, and barriers to out-migration.

1. Approach and Assumptions

To assess the potential of the watershed to support various life stages of steelhead, we have subdivided the watershed into distinct reaches for analysis (Figure 1). These are as follows:

- *Alameda Creek Flood Control Channel* – the channelized, trapezoidal section extending from the Bay upstream to the Niles Canyon area;
- *Niles Canyon* – the area above the flood control section to the confluence of the Alameda Creek mainstem and Arroyo de la Laguna;
- *Upper Alameda Creek (above the confluence with Arroyo de la Laguna)* – the reach extending up the mainstem of Alameda Creek into the canyons of the Sunol-Ohlone Regional Wilderness Area and beyond;
- *Arroyo de la Laguna* – the reach paralleling Interstate 680 upstream of the confluence with the mainstem Alameda Creek, including the Alamo Canal;
- *Arroyo Valle* – the reach extending from the confluence with Arroyo de la Laguna upstream through Shadow Cliffs Regional Park to Del Valle Regional Park;
- *Arroyo Mocho* – the reach extending upstream from the confluence with Arroyo de la Laguna through the Livermore-Amador Valley and into unincorporated ranch and agricultural lands.

Within each of these major reaches are various subunits and tributaries that will be discussed as required.

The extent to which the Alameda Creek watershed can support anadromous steelhead/ rainbow trout populations depends on the availability of habitat within the watershed for spawning, egg incubation, and rearing and the ability of migrating fish to move between this habitat and San Francisco Bay. Several sources of information have been used here to assess the location and quality of potential habitat including results of previous sampling by others, written and photographic accounts, review of water project operations and hydrologic records, and a dry-season field reconnaissance survey conducted during October 1999. The goal of this assessment is to identify areas of the Alameda Creek watershed that have good potential to support steelhead populations, identify areas that are unlikely to support steelhead, and identify any barriers to steelhead reaching areas of potential habitat. Potential habitat is defined based on an evaluation of numerous factors including known historic distribution of steelhead within the watershed, summer water temperature, stream substrate, and meso-habitat features. Hydrologic conditions were also considered, particularly alterations in present hydrologic regimes due to water project operations. The strongest indication of potential habitat for steelhead is the presence of reproducing populations of rainbow trout.

The following assumptions, based upon our knowledge of the life history of steelhead trout in California, serve as a guide to evaluating the suitability of various reaches of the Alameda Creek watershed for steelhead/rainbow trout:

- Steelhead populations are adapted to streams with highly variable annual hydrologic conditions; steelhead populations do not need access to the ocean every year in order to persist. Populations can be sustained through drought cycles by reproduction from resident (non-migratory) fish and by the multi-year spawning capabilities of steelhead.

- Adult steelhead are expected to enter Alameda Creek and move upstream between November and April with the majority entering from December through March, primarily during storm runoff conditions.

- Migration may be impaired or blocked where natural or constructed features require steelhead to:

    (1) leap more than 6-9 vertical feet;
    (2) leap less than 6-9 vertical feet without the benefit of a pool to leap from (it is generally accepted that a pool with a depth at least 1.25 times the height of the jump will provide satisfactory conditions for leaping);
    (3) swim for extended periods through high velocity sections (Thompson (1972) reports 2.44 m/s or 8 fps as the upper limit for steelhead, and Bell (1986) reports 1.40 to 4.18 m/s sustained swimming speed for steelhead);
    (4) swim for extended periods through very shallow sections (Thompson (1972) reports 0.18 m or 0.6 feet as minimum depth for passage).

- Suitable spawning habitat includes pool/riffle, pool/run transition areas and glides with uncompacted gravel substrate relatively free of fine sediments. Populations can be sustained from a relatively small spawning area. Presence of young-of-year trout is indicative of suitable spawning and egg incubation habitat.

- Juvenile steelhead must rear in streams for at least one year before migrating to sea; late summer habitat conditions (high temperature in particular) are important in regulating steelhead populations in Central California coastal streams. In some streams, young-of-year trout may migrate downstream in the spring and rear in lagoon habitats.

- Good-quality rearing habitat is generally characterized by the following features. These should not be regarded as absolute. Populations may be supported in habitat with lower levels for one or more of these variables. Other variables may regulate populations in some settings.

  1) Presence of pools with mean depth of 0.5 to 1.0 feet or greater during late summer and with suitable cover for trout up to 6 inches.
  2) Substrate dominated by gravel or larger particles.
  3) Majority of stream section (approximately 70% or more) with canopy cover of 50% or more.
  4) Presence of areas in suitable spawning locations with gravel substrate with median diameter of 0.25 to 2.5 inches, embeddedness less than 50%, and low compaction.
  5) Minimal bank disturbance.
  6) Presence of food organisms at moderate abundance based on random samples of riffle substrate.

- Temperature is often an important factor regulating populations of steelhead/rainbow trout in central California. Available temperature data for the Alameda Creek watershed was examined as one factor influencing potential habitat for steelhead in Alameda Creek. The effect of temperature on steelhead, or other fish, is complex and is influenced by life-history stage, condition, diet, acclimation, local adaptation, behavioral responses, daily temperature cycles, spatial temperature variation, shading, and micro-habitat conditions. The response of steelhead to the complex thermal regimes present in most streams is difficult to predict with any accuracy. Nevertheless it is important to develop some guidelines for use in evaluating the potential suitability of different stream reaches. Three categories of thermal habitat are defined for the purpose of identifying potential habitat in Alameda Creek:

  1) Most Pacific salmonids are placed in life threatening conditions when temperatures exceed 23-25°C (Bjornn and Reiser, 1991). Areas with peak daily summer water temperature consistently above 24°C are usually unsuitable for rearing steelhead;

  2) areas with peak daily summer temperature frequently in the range of 20-24°C potentially support steelhead under certain conditions (Smith and Li, 1983). Other factors such as summer flow augmentation and high food availability may result in adequate rearing conditions with temperature in this range or slightly higher; and

  3) areas with peak daily summer water temperature consistently below 20°C are potentially useable by steelhead. Although peak daily summer water temperatures as warm as 20°C may be warmer than optimum or preferred, steelhead maintain populations in Central California streams with temperatures this warm and such thermal conditions should not be regarded as precluding steelhead.

- Out-migrating steelhead smolts are expected to migrate downstream in Alameda Creek primarily between March and June with older fish (age 2 and 3) generally migrating earlier (March and April) and younger fish (age 1) migrating later (May and June). Downstream migration is likely to occur throughout the period but may be concentrated during periods of increased runoff.

- A certain proportion of steelhead adults will return downstream to the ocean after spawning. The timing of adult downstream migration is variable but the majority is expected to occur between late March and the end of May.

2. Spawning and Rearing Habitat

Three reservoirs block access to much of the available coldwater habitat in the watershed. Calaveras Dam blocks access to the upper Calaveras watershed including its tributaries Arroyo Hondo, Smith, and Isabel Creeks, although natural migration barriers near the current dam site may have limited access earlier. A 1995 stream survey by CDF&G found that the reach of Calaveras Creek between the Alameda Creek confluence and Calaveras Dam has a steep gradient and the channel substrate is dominated by very large boulders (Murphy and Sidhom, 1996). Hagar also conducted a reconnaissance survey of this reach in 1992 finding similar conditions, and believes that passage through this reach under present conditions would be difficult or impossible at most flow levels. San Antonio Reservoir blocks access to the San Antonio, la Costa, and Indian Creek watersheds. Lake Del Valle blocks access to the upper Arroyo Valle watershed. Most of these tributaries likely provided habitat for steelhead/rainbow trout, lampreys, or other migratory species. Populations of self-sustaining resident trout persist in tributaries to Lake Del Valle and Calaveras and San Antonio reservoirs. These populations may retain anadromous traits as has been demonstrated for other steelhead/rainbow trout populations isolated above impassable dams. Stream habitat above these dams would be considered as potential steelhead habitat except for the presence of the dams. Stream reaches above these dams may have significant importance to the potential for steelhead restoration in the watershed since they may support populations representing a locally adapted gene pool. These populations may also produce migratory smolts. In the Guadalupe River watershed in the South Bay, smolts are produced in Guadalupe and Alamitos creeks, even though adult access has been blocked for 25 years (Smith, 1999).

Conclusions regarding the location of potential habitat for steelhead/rainbow trout are presented in Table 2 and discussed in detail by reach in the following text. In general, the highest quality steelhead habitat exists in the furthest upstream portions of the watershed (Figure 2). These areas also have the greatest number of impediments to reaching them in the form of migration barriers and partial barriers. Table 2 includes all reaches that would be at least minimally accessible with passage provided around the BART weir / middle inflatable dam (Part A), and additional habitat that could be made available with passage provided at other barriers (Part B).

Alameda Creek Flood Control Channel. The flood control channel in Lower Alameda Creek is an artificial environment, placed into former agricultural lands, with conditions that are unfavorable to many of the native species inhabiting the watershed. Before urban development Alameda Creek, like many streams tributary to the Bay, likely flowed into a system of marshes, sloughs, and seasonal ponds and percolated into the floodplain. This may have provided important habitat for steelhead/rainbow trout either as rearing juveniles or for smolts during their transition to the higher salinity Bay waters.

There is some substrate in the reach that is suitable for steelhead spawning and successful spawning (egg deposition and fertilization) has been documented downstream of the BART weir. Nevertheless, egg incubation, hatching success, and survival to emergence are likely to be poor in

REACH	Habitat Conditions	Rationale	Primary Limiting Factor	Secondary Limiting Factors
Part A				
Upper Alameda Creek - Calaveras Creek to Alameda Diversion	Cool-water, low baseflow headwater habitat typical of original regional steelhead habitat.	Historic steelhead habitat with self-sustaining resident trout	Impassable Barrier: BART weir	Partial Barriers: Little Yosemite, Inflatable dams #2 and #3, Niles Canyon barriers Altered hydrology due to Alameda diversion
Arroyo Mocho - canyon	Cool-water, low baseflow headwater habitat typical of original regional steelhead habitat.	Supports self-sustaining resident trout	Impassable Barrier: BART weir	Flows for migration between rearing habitat and Arroyo de la Laguna; Partial Barriers: Inflatable dams #2 and #3, Niles Canyon barriers, Stanley Blvd. Drop Structure
Alameda Creek tributaries: Stonybrook, Sinbad, Pirate, Welch Creeks	Cool-water, low baseflow headwater habitat typical of original regional steelhead habitat.	Supports self-sustaining resident trout	Impassable Barrier: BART weir	Partial Barriers: Inflatable dams #2 and #3, Niles Canyon barriers
Alameda Creek-SF Filter Plant to Calaveras Creek	Potential cool-water and "warmwater" type habitat w/ enhanced summer flow	Upper part supports self-sustaining trout. More flow would provide cool water and fast water summer feeding habitat	Impassable Barrier: BART weir	Partial Barriers: Inflatable dams #2 and #3, Niles Canyon barriers
Alameda Creek in Niles Canyon	Potential "warmwater" type habitat w/ enhanced summer flow	Historic records of trout presence; supports put-and-take trout fishery.	Impassable Barrier: BART weir	High temperature, possibly related to releases of SWP water for downstream delivery. Partial Barriers: Inflatable dams #2 and #3, Niles Canyon barriers
Part B				
Alameda Creek-upstream of Alameda Creek Diversion Dam	Pristine, cool-water, low baseflow headwater habitat typical of original regional steelhead habitat	Historic steelhead habitat Supports self-sustaining resident trout	Impassable Barriers: BART weir, Alameda Cr. Diversion Dam	Partial Barriers: Little Yosemite, Inflatable dams #2 and #3, Niles Canyon barriers

Table 2: Summary by Reach of Potential Steelhead Habitat in the Alameda Creek Watershed. Stream reaches in Part A of Table 2 are listed with those reaches presently supporting resident trout populations given the highest potential and those potentially supporting trout under augmented flow regimes a lower potential. Among streams supporting resident trout populations, those with the least disturbance are listed first.

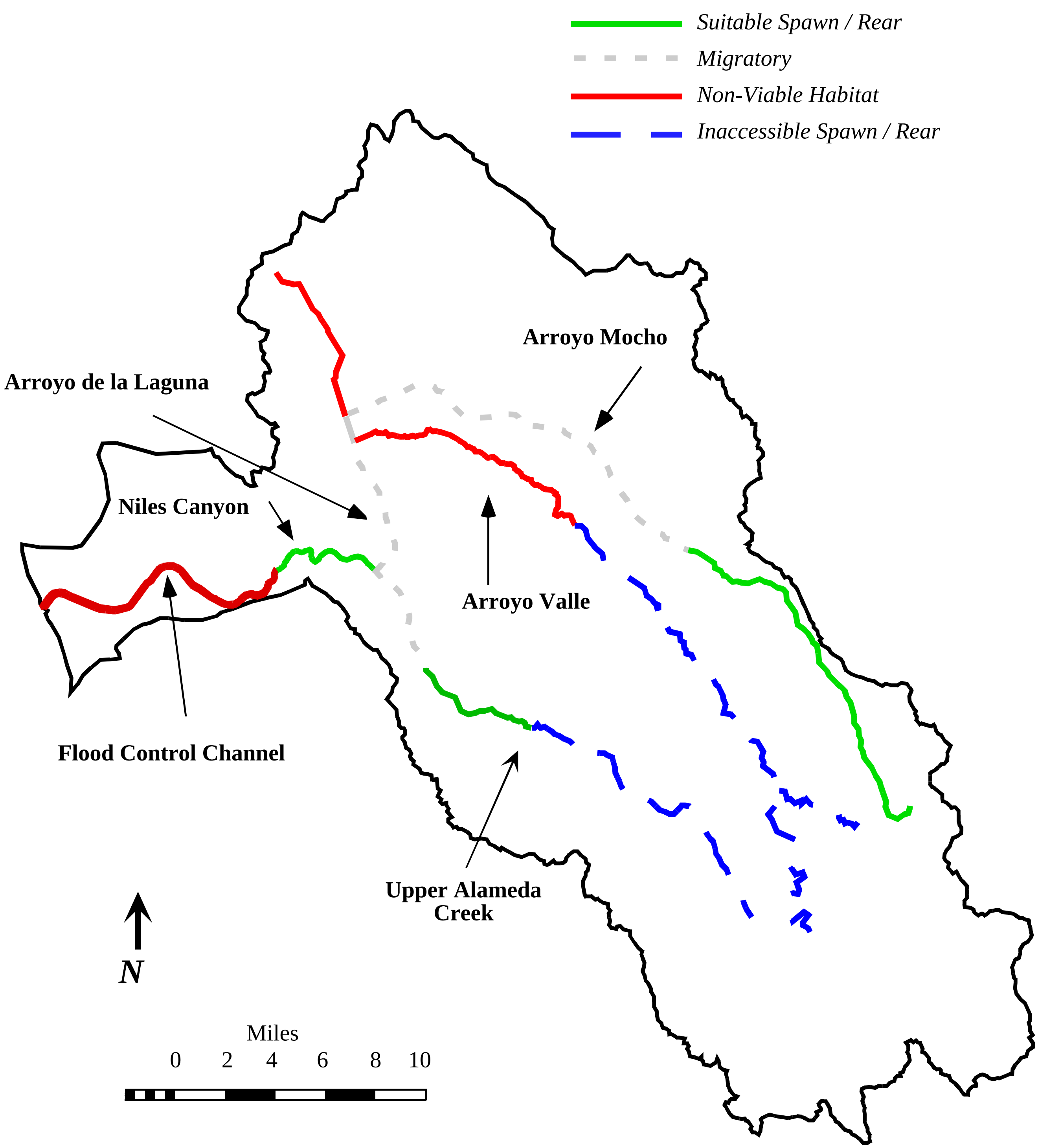


Figure 2 - Simplified Depiction of Geographic Distribution of Steelhead Habitat in the Alameda Creek Watershed

this reach due to high levels of fine sediments and frequent flow fluctuation. Stream habitat has been severely altered in this reach including removal of riparian vegetation, grading of natural banks, and loss of natural channel features including riffle/pool sequences. The reach would not be expected to support rearing steelhead for the majority of its length. Tidally influenced aquatic habitat toward the mouth of the creek may provide important transition habitat for smolts that are emigrating to the bay.

Niles Canyon. Habitat conditions in the reach appear suitable for both spawning and rearing except that summer temperature is relatively high. Migration through the reach is influenced by three potential barriers, two passable at moderate flows and one likely passable at moderate to high flows. Flows are augmented throughout this reach by runoff in the Livermore-Amador Valley, releases for municipal water supply operations, and releases from quarry operations. Water temperature recorded between May and August 1999 by ACFCWCD indicate peak daily temperatures consistently exceeding 20°C, frequently exceeding 22°C and occasionally reaching 26-28°C in the upper part of the reach. Temperature was cooler in more downstream reaches, with peak daily temperature rarely exceeding 25°C and generally within the range between 20°C and 25°C. Cooler temperatures in the downstream part of the reach may be due to cool water inflows from the tributaries or subsurface flows and/or generally cooler atmospheric conditions closer to the Bay. Daily temperature generally declines to lows of 15-19°C during night and early morning hours.

There are indications that rainbow trout may have occurred in this reach in the past (Appendix 3). This reach would potentially support steelhead, particularly in the lower sections, although temperature conditions may now be limiting. Prior to extensive development in the watershed, this reach may have supported habitat more characteristic of typical steelhead habitat in the region, with most habitat in shaded pools supported by cool subsurface flows. Currently, summer flows in Niles Canyon are dominated by surface flows emanating from Arroyo de la Laguna and Vallecitos Creek (including contributions from permitted quarry operations releases, agricultural and urban runoff, and water supply operations).[17] Though the stream temperatures within the reach are probably higher than pre-development ones, augmented flows potentially provide atypical fast-water habitat that may allow trout to obtain sufficient food to withstand the warmer temperature (see previous discussion of rearing habitat requirements).

Steelhead, like other migratory Pacific salmonids, use olfactory cues to locate their home stream. Water management practices sometimes result in transfer of water between watersheds, potentially confusing this homing response. Releases from the South Bay aqueduct result in Central Valley water flowing in portions of Alameda Creek and its tributaries at certain times. This may confuse steelhead returning to Alameda Creek if Central Valley water was not present during the imprinting period and it may attract fish that originated in Central Valley streams. The potential magnitude of this problem is not known.

Major tributaries in this reach include Stonybrook and Sinbad Creeks. Young-of-year trout were observed in Stonybrook Creek below the first crossing of Palomares Road in May, September, November, and December 1999.[18] Older trout of 7 to 13 inches in length were captured during electrofishing sampling in April 1999. Sinbad Creek supported steelhead historically based on photographic records (Alexander, 1999b). Electrofishing in Sinbad Creek in 1997 and 1998 failed to capture any fish but in September 1990 a number of juvenile Sacramento sucker were captured. Stonybrook Creek is regarded as potential steelhead habitat based on presence of several age classes of rainbow trout including young-of-year. Sinbad Creek is regarded as potential steelhead habitat based on historic occurrence but habitat may be marginal since resident trout have not persisted there. Temperature was recorded in both Stonybrook and Sinbad Creeks during the summer of 1999. Water temperature showed little fluctuation during the day and was consistently below 18°C in pools in both creeks.

Upper Alameda Creek (Sunol Valley). This reach extends from Arroyo de la Laguna to Welch Creek, near the Calaveras Filter Plant (Figure 3). The channel is wide and braided in places and may result in long sections with very shallow flow, presenting passage problems at lower flows. Substrate is suitable for spawning in parts of the reach but it is unlikely that rearing would be supported due to lack of sustained summer flow, and very poor riparian conditions, with associated potential for high temperature.

Two tributaries in this reach, Pirate Creek and Welch Creek, supported resident rainbow trout observed during electrofishing surveys in June 1999 (Appendix 3). Welch Creek was sampled in the lower quarter mile, near Calaveras Road. Trout ranged from 7 to 10.5 inches in Welch Creek with parr found in many of the pools. Natural barriers to migration exist in Welch Creek (approximately 0.3 miles above its confluence with Alameda Creek), therefore few if any steelhead trout would be able to access the middle and upper reaches of the tributary.[19] In Pirate Creek trout ranged from 6 to 8 inches (Alameda County Public Works Department, 1999). Only the lower section of Pirate Creek was sampled. Both of these tributaries would be considered potential steelhead habitat, at least in their lower reaches.

Upper Alameda Creek (Sunol Park). Stream habitat conditions potentially support steelhead/ rainbow trout spawning and rearing but summer water temperature is relatively high (Hagar *et al.*, 1993). Flow in Calaveras and Alameda Creeks has been regulated since 1925 when construction of Calaveras Dam was completed and normal hydrology may have been altered as early as 1913 when construction of the dam began. The reach currently supports populations of native warmwater fish such as California roach, Sacramento pikeminnow (squawfish) and Sacramento sucker.[20] The reach is part of a planned streamflow augmentation project to enhance conditions for native trout and native warmwater fish populations by reducing water temperature (Trihey & Associates, 1998). Under an augmented streamflow, this reach has potential to support steelhead/rainbow trout. Coolwater, high summer baseflow habitat would occur in the upper part of the reach transitioning to warmwater, high baseflow conditions further downstream.

Upper Alameda Creek (Lower Ohlone). This reach provides suitable spawning and rearing habitat for steelhead based on the presence of numerous resident rainbow trout of multiple age classes including young-of-year (Appendix 3), but use may be limited by difficult passage conditions in the Little Yosemite area. Resident trout have been consistently reported from this reach over the past decade. Summer flow is very low and the stream channel is dry in some places, but habitat is present in residual pools. Water temperature measured mid-day on September 29, 1999, ranged from 16-19.5°C.

Upper Alameda Creek (Upper Ohlone). The reach extends from the Alameda Creek Diversion Dam upstream to the headwaters (Figure 3). The Alameda Creek Diversion Dam prevents upstream migration into this reach. This reach had conditions similar to the Lower Ohlone reach in late September 1999. Resident rainbow trout of multiple age classes including young-of-year were

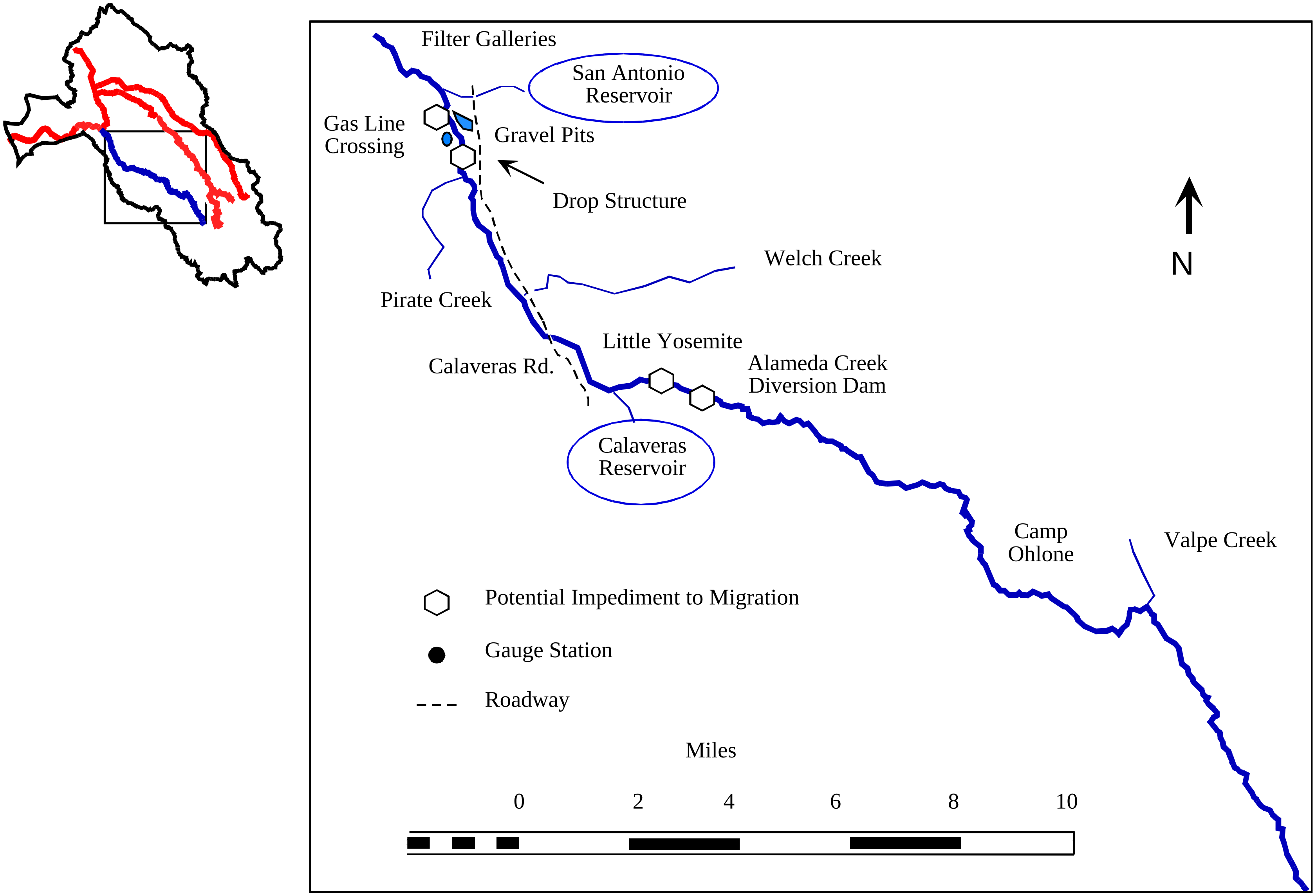


Figure 3 - Detail of Upper Alameda Creek Reach

present in all aquatic habitats upstream as far as Valpe Creek, although long sections of the creek upstream of Camp Ohlone were dry. Resident trout have been reported from previous surveys as well (Appendix 3, Appendix 4). Water temperature in pools in this reach during mid-day in late September 1999 ranged from 15 to 21.5°C. Thermal stratification of 2-3°C was present in deeper pools (1.5 feet or more) and may be indicative of the influence of subsurface flows. In early October 1999, there was no flow and few if any residual pools upstream of Valpe Creek. Valpe Creek was flowing at the confluence with Alameda Creek and supported multiple age classes of rainbow trout including young-of-year. Valpe Creek may provide additional potential steelhead habitat. The Upper Ohlone reach has relatively pristine hydrology with no influence of water supply projects. Grazing and private wells are the only potential source of alterations to hydrologic conditions.

Arroyo de la Laguna. The majority of this reach is probably unusable for steelhead except as a migration corridor between Arroyo Mocho and Alameda Creek. The substrate has a high sand component and poor pool development in many areas and is likely to have high summer temperatures. Sections closer to Arroyo Mocho have been channelized for flood control. The lowermost sections of the reach, however, do offer some potential to serve as suitable seasonal steelhead habitat.[21]

Arroyo Valle. Though there are sections in the lowermost portion of the reach that contain some suitable gravels, the accessible portion of Arroyo Valle, below the dam, offers little in the way of potential as spawning and rearing habitat. Elevated water temperatures, channelization throughout its length, extensive sedimentation, and loss of natural channel features characterize the reach. Additionally, aquatic habitat conditions are controlled by releases from the reservoir, which are managed for groundwater percolation and are likely to be rather erratic.

Arroyo Mocho Canyon. This reach begins near the USGS gauging station where Mines Road first crosses the creek (Figure 4). The reach consists of a relatively low gradient more open section for the lower two miles and a steep-walled canyon section upstream. This reach offers perhaps the greatest amount of suitable habitat that would be accessible if migratory passage was provided at barriers in the lower watershed. This reach is perhaps dryer and hotter than any other part of the watershed (except Arroyo del Valle above del Valle Reservoir). Self-sustaining populations of resident rainbow trout have been documented within the reach and trout have been collected as far downstream as the USGS gauging station just downstream from the del Valle Road turnoff (Appendix 3).

Hydrologic conditions within this reach are relatively pristine and habitat conditions are similar to the low baseflow, subsurface dominated regime typical of other headwater areas in the watershed. Flow in this reach is perennial, even in severe drought years due to fault zone seepage (Smith, 1999). Flow occurs throughout the summer at the access road to the Lawrence Livermore Laboratory pumping station near the lower end of the canyon.[22] The canyon is relatively open with fairly thin riparian vegetation but the northwest to southeast orientation of the canyon and its high, steep sides provide significant topographic shading potential. Algal growth was abundant near the LLNL access road in November 1999, indicating potentially high nutrient loading from upstream cattle operations or other sources. To our knowledge, there are no descriptions of habitat conditions within the reach. Observations from the road above the canyon area indicated the presence of intermittent flow with dry channel sections interspersed with isolated pools and some flowing sections. This would be consistent with habitat conditions in upper Alameda Creek, although Arroyo Mocho may have higher summer baseflow levels.

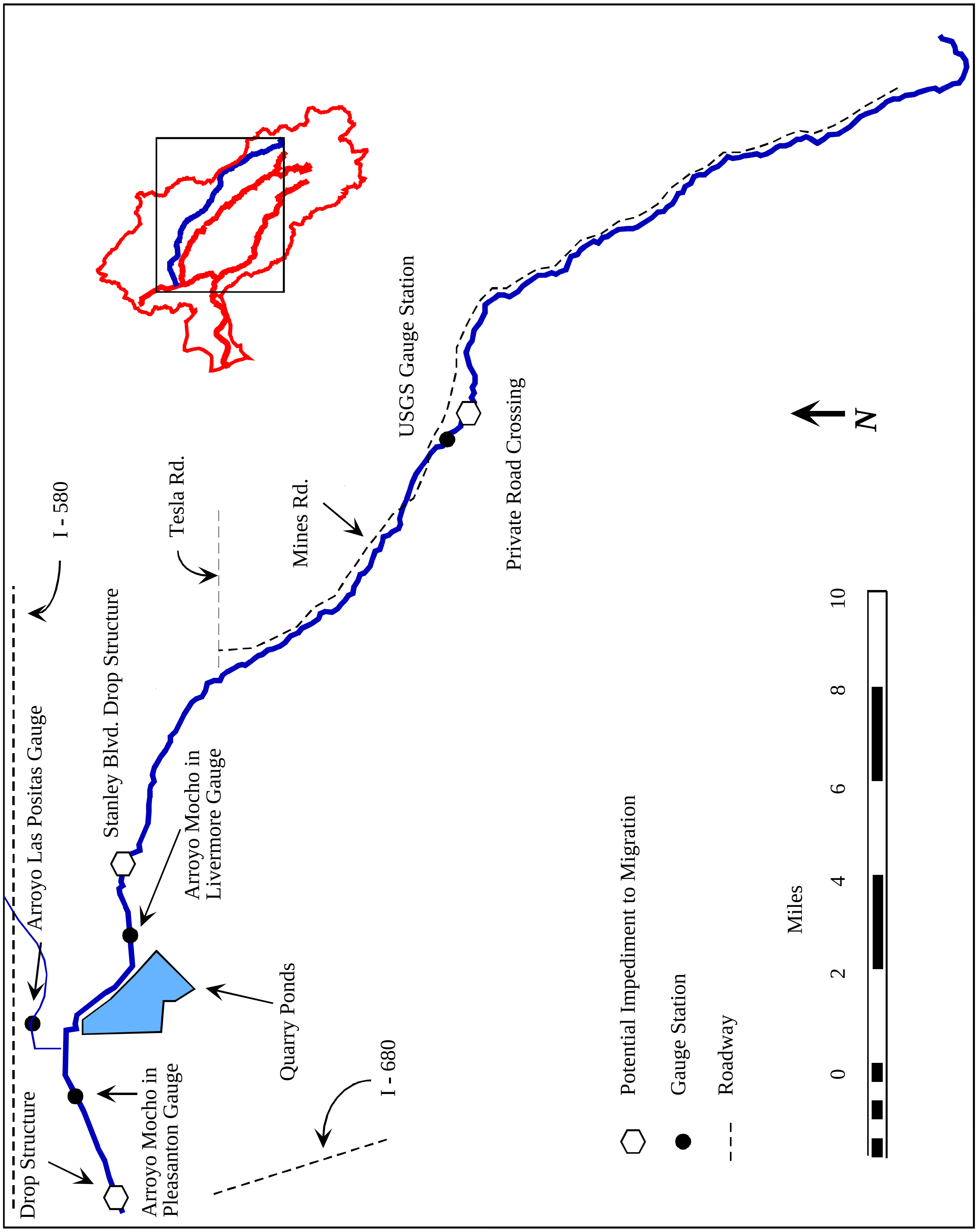


Figure 4 - Detail of Arroyo Mocho Reach

3. In-migration Barriers

The potential barriers to in-migration investigated include: (1) existing or planned man-made structures within the stream channel; (2) natural landscape features within the channel; or (3) channel segments with inadequate streamflow or unacceptable water quality.[23] Each reach within the Alameda Creek watershed had one or more of the potential barriers, and these are summarized in Table 3 and described below. The location of the barriers, according to their number in Table 3, is presented in Figure 1.

#	Location	Potential Barrier	Description
	Flood Control Channel		
1	ACWD Quarry Ponds	Lower Inflatable Dam (ACWD)	6’ high when fully inflated
2	ACWD Quarry Ponds	BART Weir	Sloping 8’ high concrete drop structure located above concrete apron
3	ACWD Quarry Ponds	Middle Inflatable Dam (ACWD)	13’ high when fully inflated
4	ACWD Quarry Ponds	Upper Inflatable Dam (ACWD)	13’ high when fully inflated
	Niles Canyon Reach		
5	Lower Canyon	Cement Apron, USGS Gauging Station	Low, but deep (approximately 10’) concrete structure
6	Adjacent to Highway 84	Niles Dam (SFPUC)	Approximately 6’ high vertical structure with non-functioning passage structure
7	Adjacent to Highway 84	Road Crossing	3 – 4’ high, 6 – 10’ deep structure
8	Adjacent to Highway 84	Sunol Dam (SFPUC)	Approximately 10 - 12’ high vertical structure with non-functioning passage structure
	Upper Alameda Creek		
9	Above Confluence with San Antonio Creek	Armored Gas Line Crossing (PG&E)	Articulated concrete mat, approximately 10’ high by 30’ deep
10	Above Gravel Pits	Weir	Approximately 6’ high by 10’ deep
11	Sunol Filter Galleries	Proposed Recapture Facility (SFPUC)	Proposed inflatable dam, specifications unknown
12	Sunol-Ohlone Regional Wilderness	Little Yosemite	Natural feature, boulder and bedrock cascade
13	SFPUC land adjacent to Sunol-Ohlone	Alameda Creek Diversion Structure (SFPUC)	Impassable dam with no fish passage provisions
	Arroyo del Valle		
14	Del Valle Regional Park	Del Valle Dam (DWR)	Impassable dam with no fish passage provisions
	Arroyo Mocho		
15	Above confluence with Arroyo de la Laguna	Drop Structure (ACFCWCD)	Small (approximately 2 - 3’ high), sloping drop structure
16	Near Quarry Ponds	Proposed Diversion Structure (Zone7)	Proposed inflatable dam, specifications unknown
17	Near Stanley Blvd.	Drop Structure (ACFCWCD)	Approximately 3-4’ vertical concrete drop structure
18	LLNL Pumping Station Access Road	Road Crossing	Concrete apron rising approximately 6’ over a 20’ horizontal distance at lower end

Table 3: Barriers to In-migration of Steelhead Trout in the Alameda Creek Watershed.

Alameda Creek Flood Control Channel. This reach contains the barriers that presumably offer the greatest impediments to migration within the entire system. Moving upstream from the Bay, the first potential barriers encountered are a series of eight erosion control sills constructed in 1974-75 to combat erosion (URS Greiner Woodward Clyde, 1999). The sills are vertical steps of approximately 2 feet each and are not anticipated to present serious impediments to migration. The first significant barrier encountered is the lower inflatable dam, a six-foot high structure when fully inflated, that was completed in 1976 (ACWD inflatable dams were reviewed during the permitting process and found to meet all environmental and regulatory requirements specified at the time of construction). Directly downstream of the dam is a concrete apron and riprap area installed to lessen potential channel scouring. Passage of steelhead at this site is possible when flows are sufficiently high and the dam is not inflated, and steelhead have been observed upstream of this location. The amount of flow required to allow passage at this structure or in the channel downstream of it is not known.

The next barrier is a combination of the middle inflatable dam and a concrete drop structure often called the “BART Weir.” The middle inflatable dam is a thirteen-foot high structure, when fully inflated, that was constructed in 1972 but is currently operated to a maximum height of eleven feet. The weir, an 8 foot sloping structure just downstream from the dam, was constructed to prevent erosion around supports for BART and railroad tracks crossing over the channel. It replaced a sheet piling and timber weir structure in the same location in approximately January 1972, and represents an impassable barrier under the flow conditions generally observed at the site. The next barrier, the upper inflatable dam, is a thirteen-foot high structure, when fully inflated, that was constructed in 1989. It is judged to be a barrier to steelhead passage when inflated.

The ACWD tries to operate its dams during the wet-season to allow each storm event’s “first flush” to bypass the capture facilities, as these waters often contain floating debris and relatively high concentrations of suspended solids. The dams are then inflated as flows subside to capture water of a higher quality. This ideal operation is not achieved in drier years, as lower quality water is captured to ensure adequate supply for groundwater recharge rather than letting it flow to the Bay. In addition, flood control agreements require the ACWD to lower the dams as flows increase in the Creek. Normally, once water overtopping the inflatable dams is one foot in depth, the dams must be lowered. For the in-migration period from December-February, data from the last 8 years indicate that there are opportunities for steelhead to migrate past the rubber dams as they are deflated during high flow periods (Figure 5). It should be noted that fish migrating upstream in December are much more likely to be impeded by inflated dams, as are fish migrating upstream in years with less storm activity.

In both 1998 and 1999, steelhead have managed to pass the lowermost dam, but have been stopped in their progress upstream by the presence of the BART weir.[24] Only artificial transport of captured fish into the Niles Canyon area has allowed some portion of migrating fish to continue upstream.

Niles Canyon. There are four potential barriers to migration on the mainstem within this reach. The lowermost structure, a concrete apron associated with the USGS gauging station, is a low structure that extends upstream approximately 17 ft. The structure is probably not a barrier at any but the lowest streamflows.

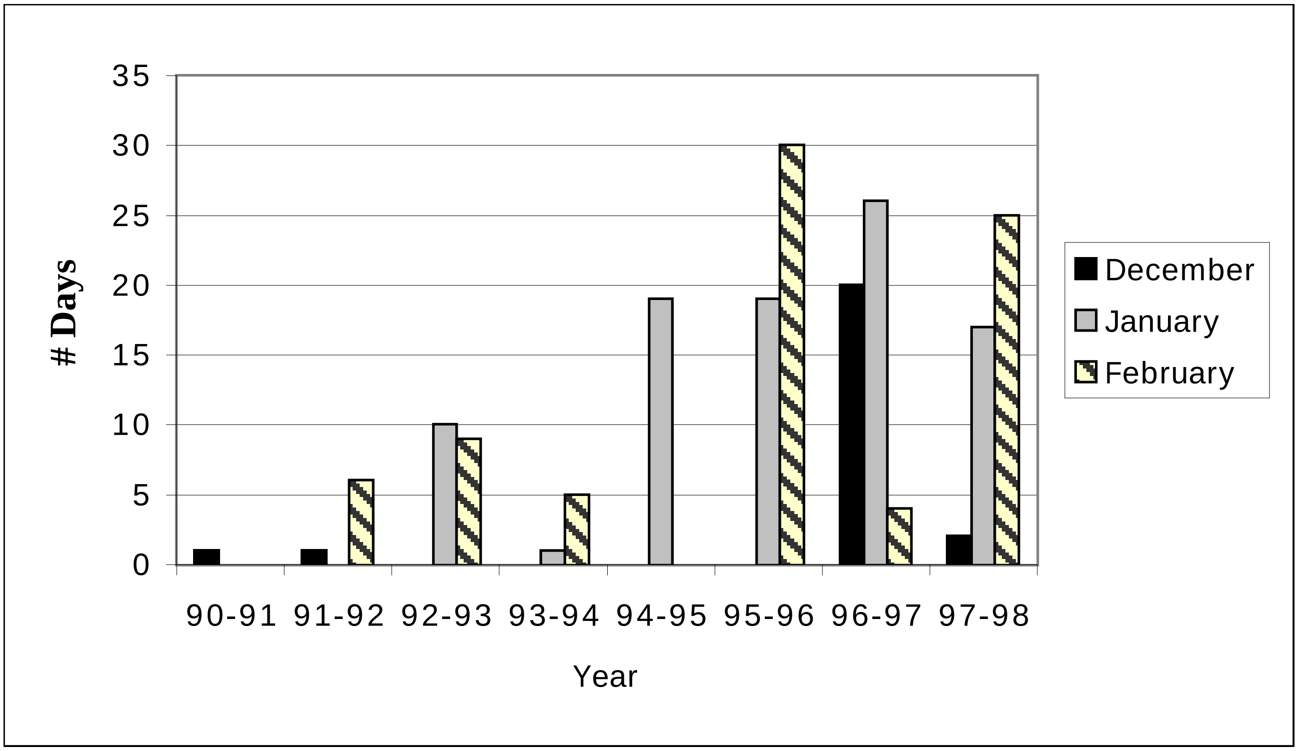


Figure 5 - Number of Days All ACWD Dams Deflated During Peak In-migration Period (ACWD, unpublished data)

Moving upstream, the next barrier encountered is the Niles Dam, managed by the SFPUC. The Niles Dam was constructed with an integral fish ladder that no longer appears functional. The dam is approximately 6 ft high and probably impassable to steelhead at relatively low flows. A radio-tagged steelhead released at the mouth of Niles Canyon passed the dam between February 25 and 26, 1999, when flow in Alameda Creek was between 233 and 397 cfs.[25] The next structure encountered, the foundation for a road crossing or bridge, is a low structure that is unlikely to impede migration except at the lowest flows. The uppermost structure, the Sunol Dam, was originally used to augment groundwater recharge in the Sunol Valley. The dam, also managed by SFPUC, had a constructed height of approximately 22 feet by 6 – 8 feet and originally had a fish passage structure that is no longer functional.[26] In November 1999 the distance from the lip of the dam to the surface of the pool below was 8 feet and the pool was at least 6 feet deep. There is a large accumulation of gravel in the channel downstream of the dam. It is not known how long this gravel has been there but it may be raising the level of the pool below the dam, making it less of an obstacle.

Stonybrook Creek, a major tributary within this reach, has some potential as suitable spawning and rearing habitat. The gradient of the creek is relatively high, and several in-stream culverts and bridge inverts currently prevent access to the upper stretches of the creek. In 1999 a returning steelhead was tracked migrating up the tributary, but currently the culvert under the first crossing of Palomares Road forms an impassable barrier.[27] The ACFCWCD is, however, examining the replacement of the culvert and inverts for flood control and passage reasons.

Upper Alameda Creek. This reach includes one impassable barrier to the uppermost stretches of Alameda Creek, the Alameda Creek Diversion Structure (Figure 3). The Diversion structure is located on SFPUC property, adjacent to the Sunol-Ohlone Regional Wilderness. The diversion dam reroutes a significant portion of flow from the Creek through a one-mile tunnel for storage within Calaveras Reservoir. The structure currently has no provisions for fish passage and therefore eliminates access to a significant amount of spawning and rearing habitat located above the structure.

Two other structures identified within the reach potentially impede steelhead migration. The lowermost, a sloping articulated concrete mat protecting a 36” natural gas pipeline (owned and operated by Pacific Gas and Electric Company [PG&E]), rises approximately 10 feet in elevation in a span of perhaps 30 feet.[28] There is no significant pool formation below the structure, nor is the structure configured to significantly increase water depth during higher flow conditions. The channel is very wide in the vicinity of the crest of the structure, which would result in shallow water except at the highest flow levels. The structure may be a barrier at all but the highest flows.

The upper structure consists of rock gabions approximately 6 feet high and 10 feet deep. There is a scour pool directly below it and at even modest flows the structure appears to present little obstacle to adult steelhead. A similar structure exists in the mouth of Pirate Creek a short distance to the south that would be a potential barrier to steelhead attempting to enter Pirate Creek. The structure in Pirate Creek is a more formidable barrier since it does not have a well-developed pool below it. Each of the structures should be observed during higher flow conditions to assess the potential to impede migration.

In addition to the man-made barriers in this reach, the “Little Yosemite” area just upstream from the Calaveras Creek confluence presents a difficult passage section. The stream channel is choked with large boulders and rock outcroppings. At the upper end there is a steep fall with a configuration impossible for steelhead to pass under low flow conditions. This area does not appear to be a barrier to migration at high flows (Leidy, in prep.). Passage through Little Yosemite is influenced by operation of the Alameda Creek Diversion Dam upstream, which diverts as much as 85% of the annual flow of the creek. Reducing the frequency of high flow periods downstream of the diversion reduces passage opportunities through Little Yosemite.

During dry-season periods, a length of this reach known as the Sunol filter galleries is often devoid of surface flow. Wet-season flows, however, are expected to be sufficient to allow for passage, though this should be verified in the field during wet season periods.

In addition to habitat in the main channel, this reach also contains a number of tributary streams that exhibit potential as steelhead spawning and rearing habitat (e.g., Indian Joe Creek, Welch Creek, Pirate Creek). Barriers have not been documented on any of these tributaries.

SFPUC is currently in the planning stages for a project to supply water augmentation for trout habitat in the portion of this reach between the Calaveras Reservoir release point and a proposed water recapture facility near the Sunol Valley Water Treatment Plant (Trihey & Associates, 1998). While this would effectively increase the amount of flow in this reach and thereby potentially create some of the best trout rearing habitat in the watershed, it would also add an additional barrier to migration in the form of a new inflatable dam to impound flows at the recapture facility. The SFPUC has committed to providing fish passage at this facility, the design of which is currently being finalized.

Arroyo de la Laguna. No barriers were identified in Arroyo de la Laguna that would impede the in-migration of steelhead. Water quality and flow appear adequate for its use as a migratory corridor for reaching suitable upstream habitat.

Arroyo Valle. The dam impounding Lake Del Valle prevents migration to the headwaters of the Arroyo. Other barriers, including a small, sloping drop structure at the confluence with Arroyo de la Laguna are minor and not expected to hinder migration. Slow-moving water and a wide, unshaded channel in this reach are indicative of stream temperatures higher than those conducive to viable steelhead populations. During field surveys, only traditionally warm-water fish were observed.

Arroyo Mocho. Two drop structures and a road crossing were noted in this section during the field surveys (Figure 4). The first, a sloping structure approximately 2-3 ft. high backed by a horizontal concrete apron, is positioned just upstream of the confluence with Arroyo de la Laguna. When observed, the flow in the channel was approximately 10-12 cfs, and the barrier, though with potential to impede migration, did not appear impassable.

The second observed structure, located in a short stretch between the upstream end of the flood control channel section and the railroad tracks paralleling Stanley Boulevard in Livermore, is a vertical drop structure presumably stabilizing the channel around the railroad bridge. The structure is approximately 3-4 ft. high with an upstream concrete apron and minimal pool development downstream. The best potential passage is in a side channel at the eastern end of the structure. Flows during the period the structure was observed ran approximately 10-12 cfs, and passage would be precluded at that level. Passage potential may be better at somewhat higher flows. Additionally, Arroyo Mocho passes through culverts beneath Wente Road in Livermore, but the design of these structures suggests they pose no apparent barrier to steelhead.[29]

A significant potential barrier exists in the lower part of the Canyon section where a road to the pumping station maintained by the Lawrence Livermore National Laboratory (LLNL) crosses the Creek. This structure is a concrete apron with a steeply sloping section of about 20 feet at its lower end and an additional 20-foot low gradient section at the top. Steelhead attempting to pass this structure would encounter a combination of shallow flow and high velocity. Preliminary measurements indicate that flow in the range of 100 to 150 cfs may provide sufficient depth but velocity would be near the upper burst potential for steelhead.

Similar to the inflatable dam proposed by SFPUC in the upper Alameda Creek reach, Zone 7 is also planning for an inflatable dam to be installed on Arroyo Mocho. This dam would impound and divert flows into the Pleasanton quarry ponds for groundwater recharge as mining operations cease and management of the ponds reverts to Zone 7. This process is not expected to occur until at least 2005, and plans for fish passage are unknown at this time.

Water quality does not appear to be a concern. However, during dry-season periods, significant lengths of the channel can experience no natural surface flows. In the upper flood control channel section, dry-season flows are almost exclusively due to the release of water purchased from the State Water Project by Zone 7 for groundwater recharge. These releases are designed to provide maximal infiltration with no water continuing downstream to Arroyo de la Laguna.[30]

4. Out-migration barriers

The successful out-migration of steelhead smolts from the Alameda Creek watershed requires that, when the fish migrate downstream, there is (1) adequate water flowing in the channel to provide continuous aquatic habitat between rearing regions and the area of tidal influence, (2) water of appropriate temperature for them to survive, and (3) suitable refuge from predators.

The existence of out-migratory barriers for the smolts is therefore dependent upon a combination of migratory behavior, precipitation patterns, and water diversion practices. In terms of migratory behavior, for example, fish migrating at night will experience lower temperature than those migrating during the day and will be less susceptible to predation. Those that migrate during elevated flows following storms have a much higher potential for passing the dams in the lower part of the creek when they are deflated. These fish will also experience higher flows through the flood control channel. They have a better chance of reaching the Bay since higher turbidity during storm flows offers some protection from predation and higher flows may result in swifter passage through this section.

Therefore, a critical piece of information for defining barriers to out-migration is the timing of fish movement downstream. Unfortunately, this information is not available for Alameda Creek, and we are thus dependent upon information from steelhead in neighboring watersheds. Information has been compiled by CDF&G on steelhead runs for streams entering San Pablo Bay (Petaluma, Novato, Miller, and Gallinas Creeks). This information, much of which is observations by fishery biologists rather than systematic smolt trapping, indicates that the adult out-migration occurs from December through April (peaking in January and February). Smolt out-migration occurs from March through June, with the peak in May (Fukushima and Lesh, 1998).

Information on out-migration of juvenile rainbow trout from San Leandro Creek into San Leandro Reservoir (a population derived from steelhead landlocked behind Chabot and San Leandro Dams) indicates that these fish may migrate preferentially during storm flow periods during the spring (Table 4). Since monitoring in this study did not begin until late March, there may have been substantial migration earlier. During the monitoring period, juvenile trout showed a definite affinity for migration during periods associated with storm flows. In this case, over 65% of juveniles migrated during periods with measurable precipitation.

We should keep in mind that unlike other Pacific salmonids, a proportion of steelhead adults survive after spawning and return downstream to the ocean. Some of these fish return to sea almost immediately while others may hold over in the spawning stream for up to several months. As many as 20% of adult spawners may be repeat spawners and some fish may return to spawn up to 3 or 4 times. The timing of adult downstream migration is variable but the majority is expected to occur between late March and the end of May. In Waddell Creek, the bulk of spawners (about 75% of those returning) returned to sea before June 1; 87% returned by July 1, and 95% returned by July 15. In Alameda Creek it is likely that streamflow and temperature conditions become unsuitable for migration by May in most years. Out-migration success for post-spawn adults is regulated by the same factors as for smolts except that there is no predation by fish and predation by birds is much more limited.

Week Ending	Young-of-year Downstream	Juvenile Downstream	Precipitation at Orinda (inches)
27-Mar	0	3	0
3-Apr	0	2	0
10-Apr	0	10	0
17-Apr	0	3	0.1
24-Apr	0	45	0.37
1-May	0	10	0
8-May	3	13	0
15-May	8	3	0
22-May	250	3	1.402
29-May	365	18	2.236
5-Jun	350	10	0.247
12-Jun	90	0	0
19-Jun	30	0	0
26-Jun	163	0	0
3-Jul	20	0	0
10-Jul	0	0	0

Table 4. Migration of trout in Upper San Leandro Creek in 1990 (EBRPD unpublished data)

The probable major barrier for out-migrating steelhead trout in Alameda Creek, both smolts and post-spawn adults, is the presence of adequate flows at the appropriate times to facilitate their passage downstream. Development, channelization, and competing uses for water within the watershed have significantly altered the levels and timing of streamflows that are fully available for fish migration. In particular, the operation of the inflatable dams in the lower watershed has the potential to impede migration by preventing flow from reaching the Bay, or by disorienting out-migrating adults.

Without measurements that relate actual channel conditions to stream flow, it is difficult to draw definitive conclusions regarding the adequacy of flows for out-migration. Existing information from water agencies and U.S.G.S. can be used to characterize the stream flows in the various reaches of the watershed, however, and with these data some qualitative assessments regarding the adequacy of flows are possible. For purposes of this analysis, we will focus upon the period of March - May to assess the adequacy of out-migratory flows, as that is the expected period for the majority of smolts to attempt out-migration.

It should be noted that flow data used for several of the following analyses were generated using data for the past 10 years. Such an analysis can be biased by climatic variations that occur over longer cycles. For example, the last 10 years have been characterized by higher precipitation in the late Spring when compared to the 15 preceding years (1975-1990; Figure 6). Given our inability to predict climatic variation (both natural and anthropogenic), we do not know how representative the data used in the following analysis of flow patterns will be of actual conditions in the coming decades. A general consensus is emerging that the California's climate in the next century will be warmer and wetter, with more winter runoff and less summer streamflow due to the substitution of rain for snow (Field *et al*., 1999). Changes cannot be predicted with confidence at the scale of the

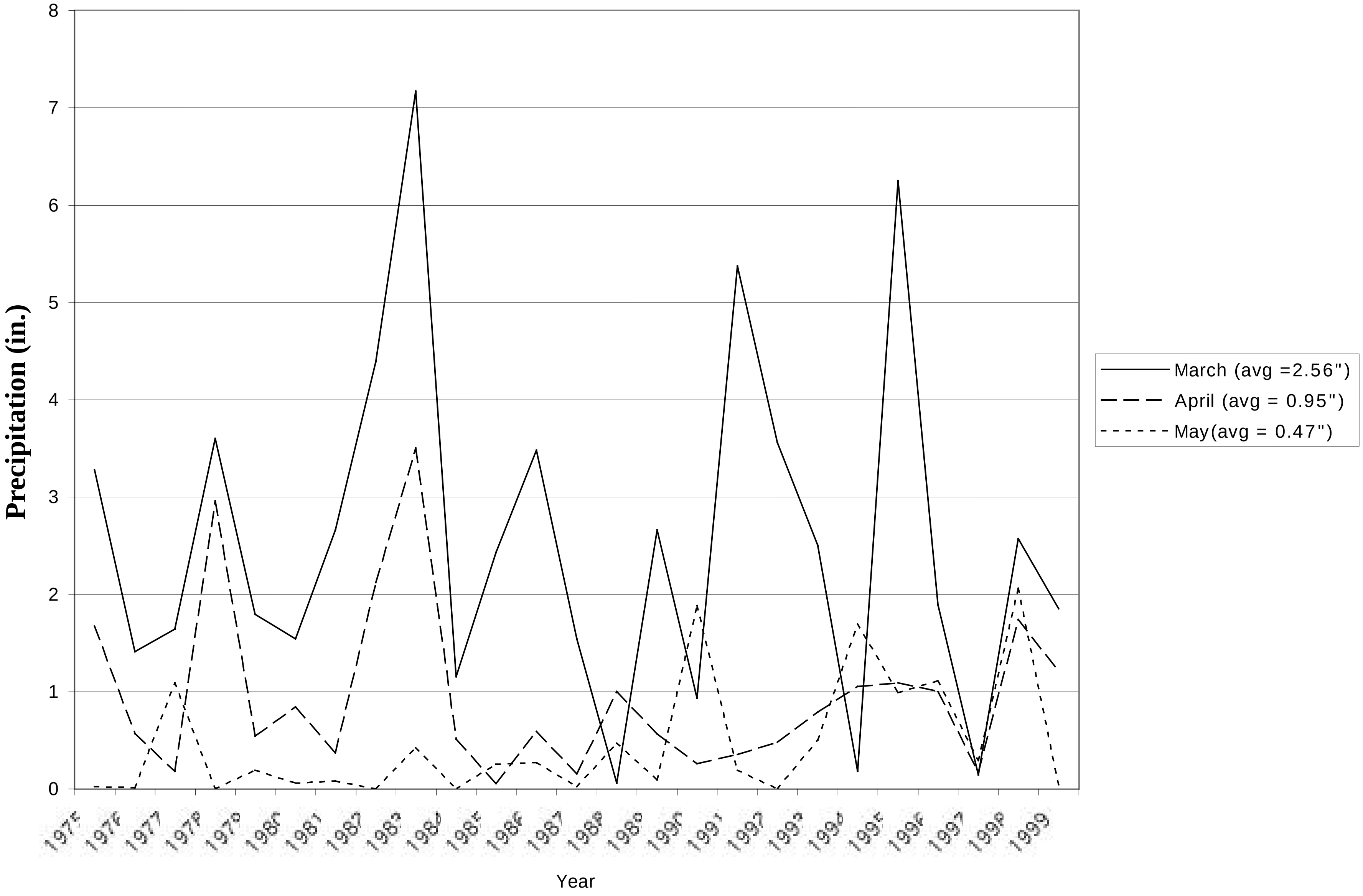


Figure 6 - Precipitation Totals by Month, Newark, CA, 1975-1999 (Western Regional Climate Center)

Alameda Creek watershed, and this is especially true for factors such as storm frequency or monthly precipitation, climatic factors likely to influence the success of steelhead restoration.

Flood control channel reach. Tidal influence falls well short of the lowermost inflatable dam,[31] and without overtopping or bypassing flows the channel below the dam can become dry. The current operation of the inflatable dams calls for the dams to be completely deflated prior to expected storm events and remain deflated until flows decrease below an acceptable level (typically around 1000 cfs). At that time, the dams are then raised to facilitate the diversion of flows into the quarry lakes.

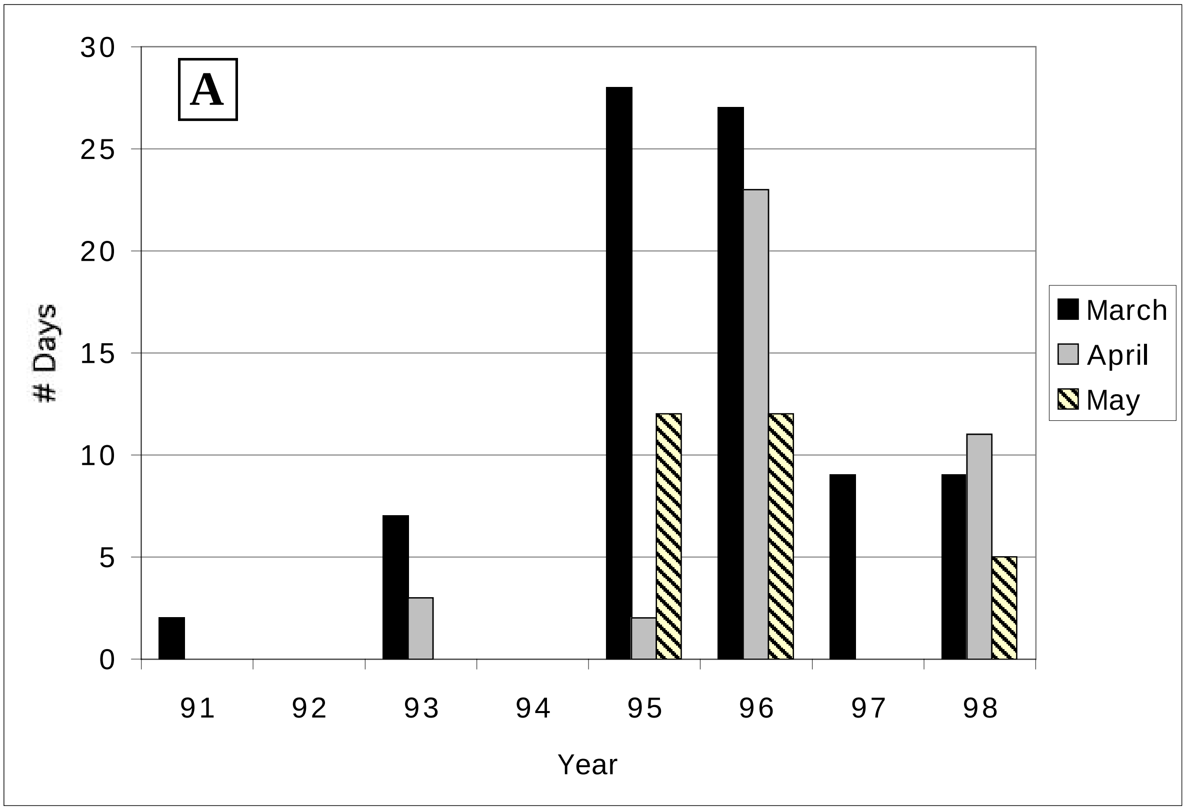
One way to assess the adequacy of flows for out-migration is to assume that when all three dams are deflated during the March-May period there is adequate flow.[32] An analysis of this condition is provided in Figure 7a, which clearly indicates that in many years there are a large number of days when suitable conditions for out-migration were available. Conditions for out-migration appeared particularly good in 1995, 1996, and 1998 when there were significant periods with higher flows when dams were down during the March-May out-migration period. It is interesting to note that favorable conditions in 1995 and 1996 were associated with increased sightings of adult steelhead below the BART weir 2-3 years later in 1997-99. There are also years, however, when there were not adequate flows (e.g., 1992 and 1994), as evidenced by no deflation of the dams during the spring out-migratory period (Figure 7a).

Another condition that might provide migratory flows in the flood control channel reach is to have enough storm flow that the inflated dams are overtopped, providing flow to the Bay for migrating smolts and adults.[33] Unfortunately, no gauge data are available recording flow rates in the flood control channel section. It is possible to estimate the number of days with overtopping by assuming that on days when the dams are inflated, any flow not diverted by ACWD or lost to infiltration or evaporation overtops the dams. Using the maximum percolation rate of approximately 70 cfs for ACWD facilities[34], the daily flow data in Niles Canyon, and an estimate for infiltration/ evaporation of 20% of Niles Canyon flow (14 cfs), a conservative estimate of the number of days with overtopping can be obtained.[35] This method can be represented by the equation:

$$\text{(Niles Daily Flow)} - 70 - 14 = \text{overtopping flow}$$

Neglecting the time required to fill the channel behind the dams,[36] for any day when all three dams are not deflated, if the above equation returns a positive number, we assume the lower dam is being overtopped.

Using this method, an analysis of overtopping during the last decade (Figure 7b) indicates that there are many days of overtopping, especially in 1993, 1995, and 1998. These days can be considered additional periods in which out-migration barriers are minimized for smolts. In fact, when periods of overtopping and deflation are considered jointly, we can see that in 1995, 1996, and 1998 there was potential for out-migration an average of 88% of days during the March-May period. Conversely, in 1992 and 1994 this average was only 6.5% of the days. A similar analysis for June indicates that regardless of the year it is very rare that suitable migration conditions are available (Figure 8).



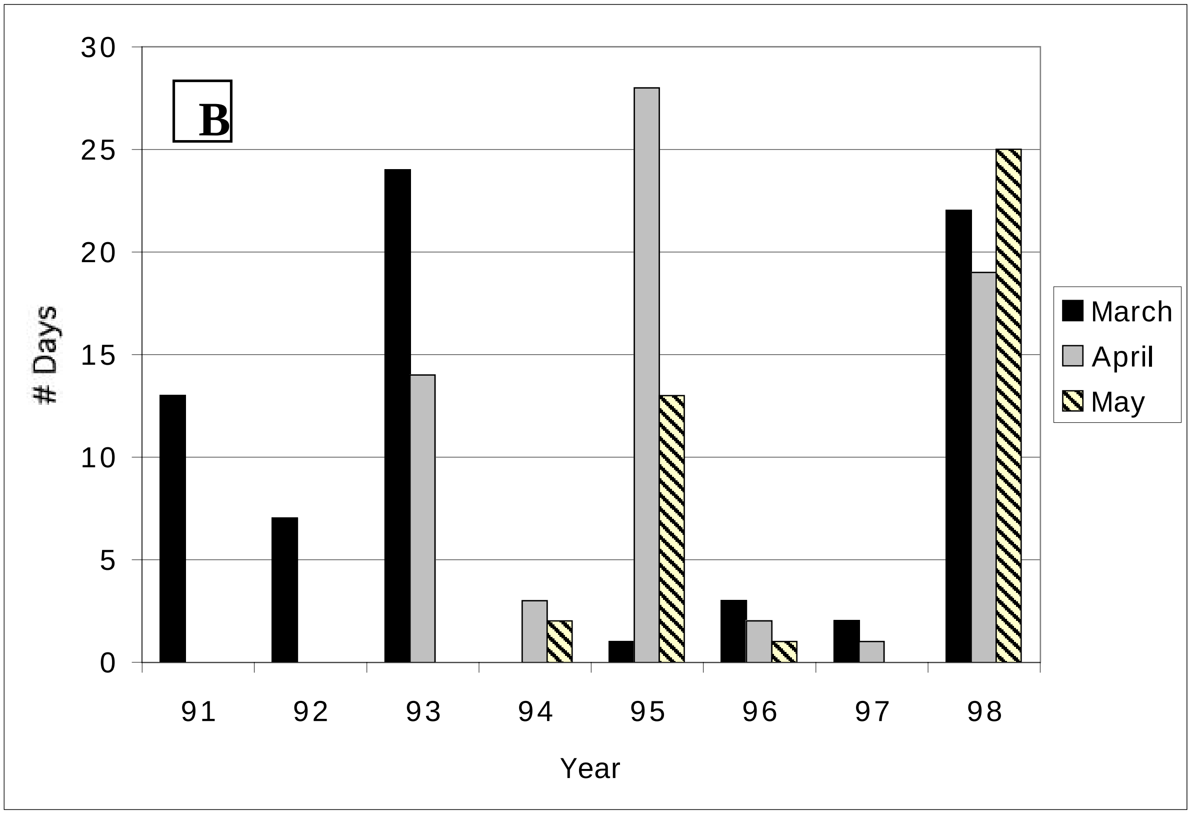


Figure 7 - Potential Out-migratory Flows Past the ACWD Dams, 1991-1998. A) Number of Days with All Dams Deflated. B) Number of Days with Estimated Overtopping Flows. (ACWD, unpublished data)

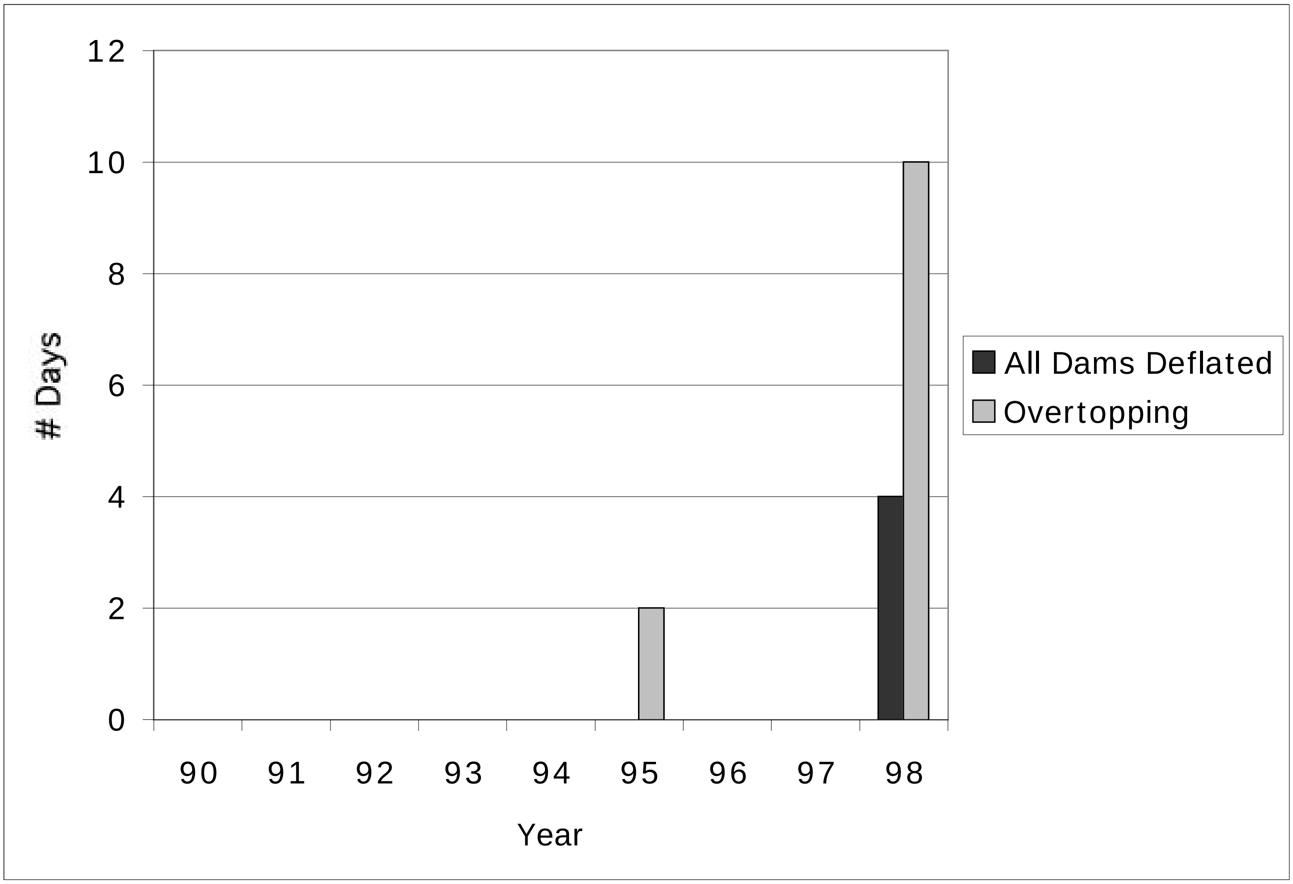


Figure 8 - Number of Days with Potential Out-migratory Flows in June, 1991-1998 (ACWD, unpublished data)

Niles Canyon. USGS has maintained an active gauging station in Niles Canyon continuously since 1891. Comparisons of monthly averages over a thirty-year period from the earliest records (1891-1921) and the most recent available records (1968-1998) show that, during the period of November through May, average streamflows maintain significant levels and historic seasonal patterns (Figure 9).

Upper Alameda Creek. USGS maintains two gauging stations of potential relevance in this reach, one above the Alameda Creek Diversion Dam and a second below the confluence with Calaveras Creek. Unfortunately, neither gives a complete indication of potential migratory flows within the overall reach. A majority of flows measured by the upper station are diverted into Calaveras Reservoir,[37] while the second station has only an incomplete record of flows for the period 1995-98. Upstream of the diversion, hydrologic conditions are relatively pristine and would only be influenced by local pumping for livestock and domestic use (if any) and potential impacts related to cattle grazing. Three years of flow data furnished by the ACWD (Figure 10) supported by anecdotal observations[38] suggest that Alameda Creek in Sunol Valley normally dries up during the month of June.

Arroyo de la Laguna. USGS gauge data, though not as extensive as data for the Niles Canyon reach and not fully continuous (no data recorded for 1984-86), is helpful in analyzing out-migration period flows. Data collected on the arroyo indicate a similar seasonal pattern as the Niles Canyon reach, but at lower average levels (Figure 9). Average flows vary from a low in the 20 to 30 cfs range in both November and May, to a high of over 280 cfs in February.

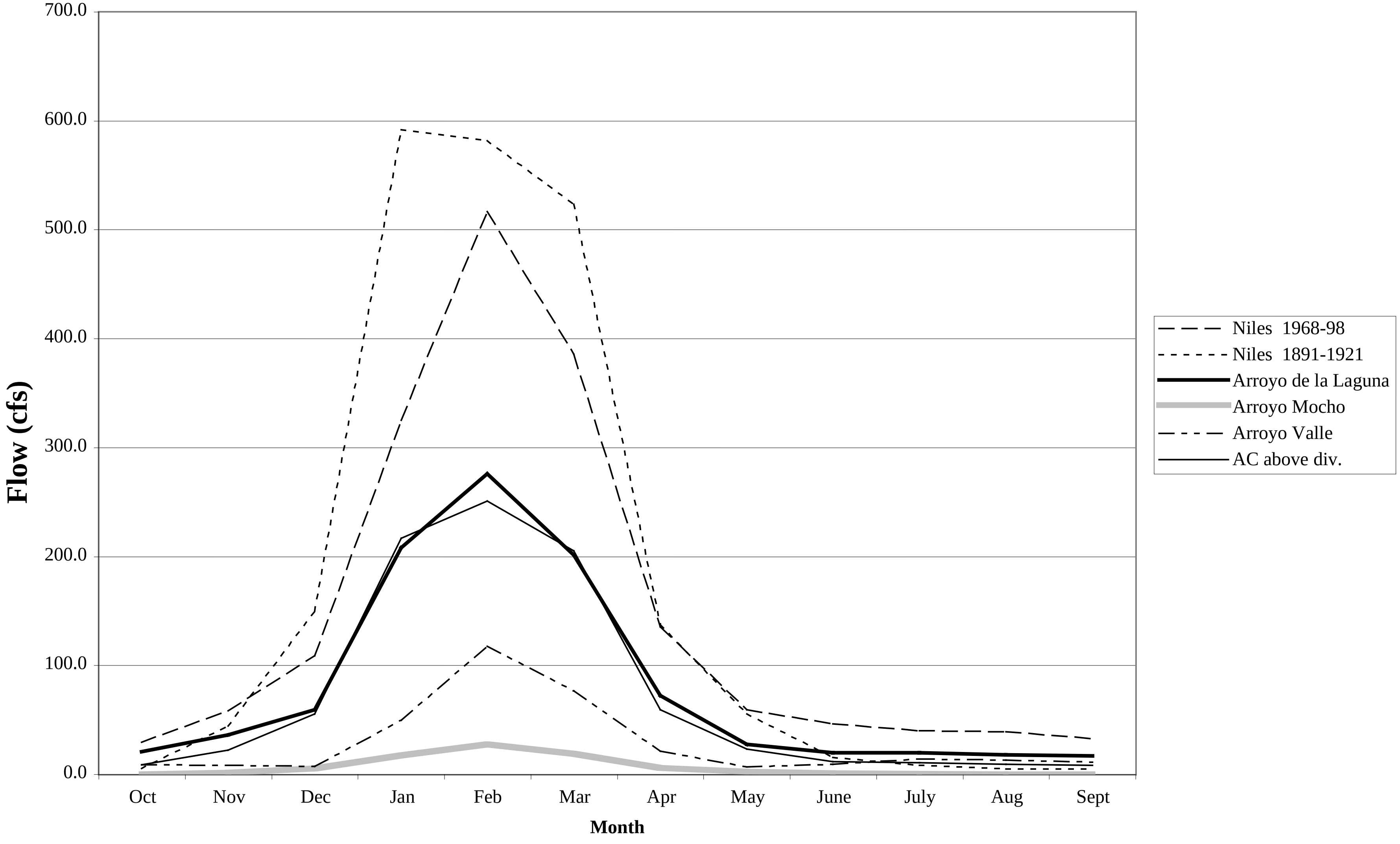


Figure 9 - Historic Flows in Alameda Creek Reaches (USGS gauge data)

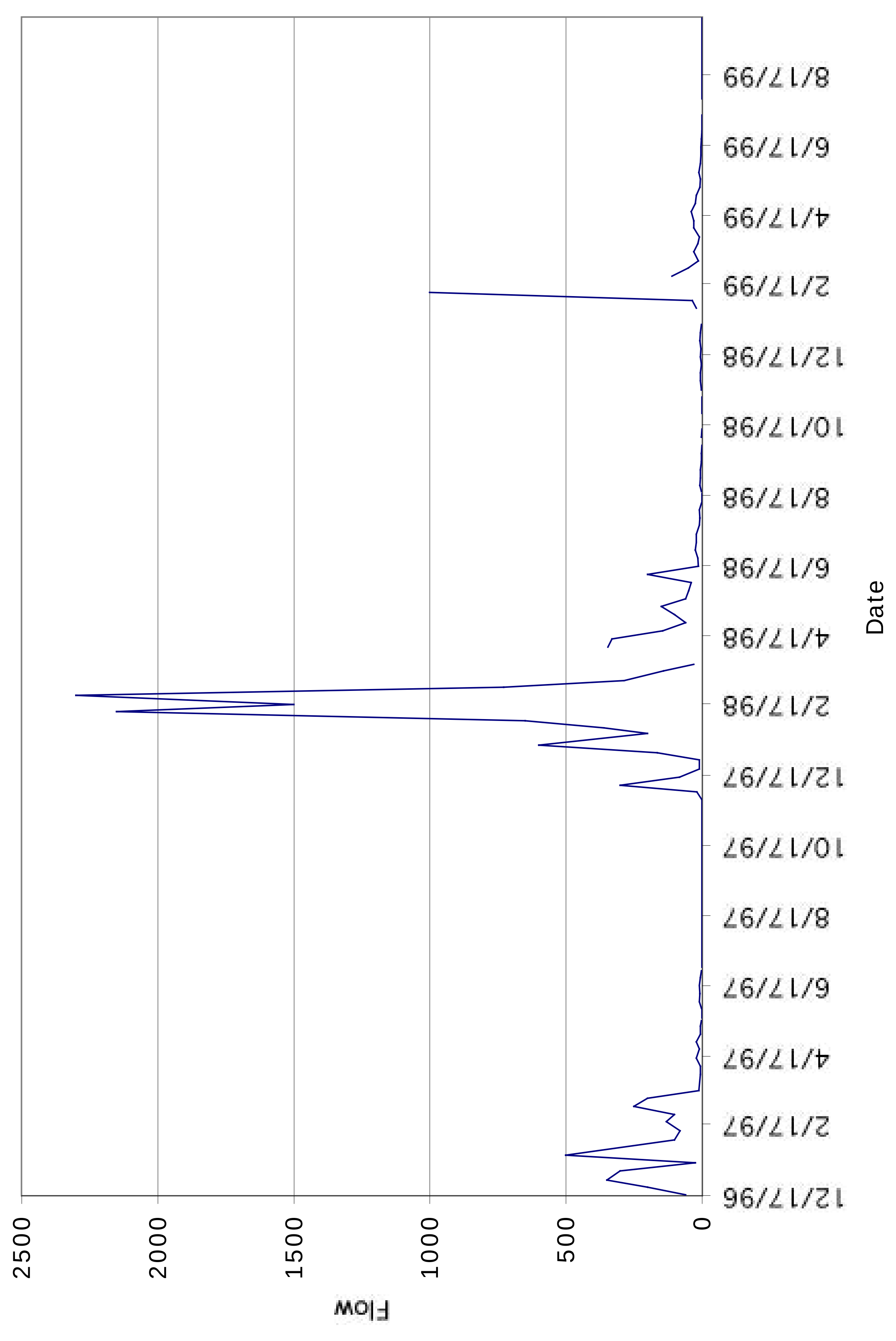


Figure 10 - Flow in Sunol Valley, Upper Alameda Creek, 1997-1999 (ACWD, unpublished data)

Arroyo Valle. The USGS data indicate that flow from Del Valle Reservoir has the potential to significantly augment Arroyo de la Laguna (Figure 9). Since the USGS gauge is close to the reservoir it is not clear how much of this flow actually reaches Arroyo de la Laguna. An apparent lack of suitable spawning and rearing habitat on Arroyo Valle below Lake del Valle makes the issue of migration within Arroyo Valle unimportant.

Arroyo Mocho. The Arroyo (Figure 4) is an extremely complicated combination of natural flows emanating from the upper reaches, artificial flows when Zone 7 uses Arroyo Mocho for delivering water purchased from the State Water Project, permitted releases by Lawrence Livermore National Laboratory into the Arroyo Las Positas tributary, and discharges from the quarry operations in Pleasanton.[39]

The USGS gauging station in the upper reaches of the Arroyo provides the best long-term data on flows in Arroyo Mocho canyon (Figure 9). These monthly averages suggest that out-migration is possible from the upper portions of the reach during the wettest months, but this must be verified with field observations.[40] Due to the high infiltration rates in the portion of Arroyo Mocho that runs across the Livermore Valley,[41] adequate flow in the Canyon reach of Arroyo Mocho does not ensure adequate flow for out-migration to Arroyo de la Laguna. This is true even with the augmentation of SWP water, as to maximize retention of purchased water, Zone 7 endeavors to not to release more water than can be captured into the groundwater basin.

The key question is thus whether there is continuous aquatic habitat that would allow fish to out-migrate from spawning and rearing areas in Arroyo Mocho Canyon across the Livermore Valley and into Arroyo de la Laguna. While it is best to make a direct assessment of this question in a critical passage analysis (see Section V below), monthly average flow data provided by Zone 7 can be used to investigate this issue. The data include measurements from three gauging stations operated by Zone 7 (Figure 4): Arroyo Mocho in Pleasanton (represents the flow in the channel downstream of the quarry ponds made up of contributions from upstream Arroyo Mocho, Arroyo las Positas, quarry pond releases, and runoff from a relatively small residential development), Arroyo las Positas at El Charro (represents the contribution of Arroyo las Positas measured at a point just upstream of the confluence with Arroyo Mocho), and Arroyo Mocho in Livermore (this represents natural flow in the arroyo plus the contribution of State Water Project releases).

The data sets have inherent limitations because of historical alterations to the flow patterns of Arroyo Mocho.[42] Wastewater releases had in the past been routed into Arroyo las Positas, but this operation ceased circa 1980. For this reason, all data prior to this period were removed from the analysis.[43]

The purpose of analyzing this data is to identify periods in which there is continuous flow of a sufficient magnitude to allow for fish passage. Average monthly flow readings for the gauge stations on Arroyo Mocho and Arroyo las Positas are shown in Figure 11a. Using an estimate of 10-12 cfs for releases from quarry ponds during the wet season, an estimate of flows in the Arroyo Mocho channel through the quarry pond area can be generated using the following formula:

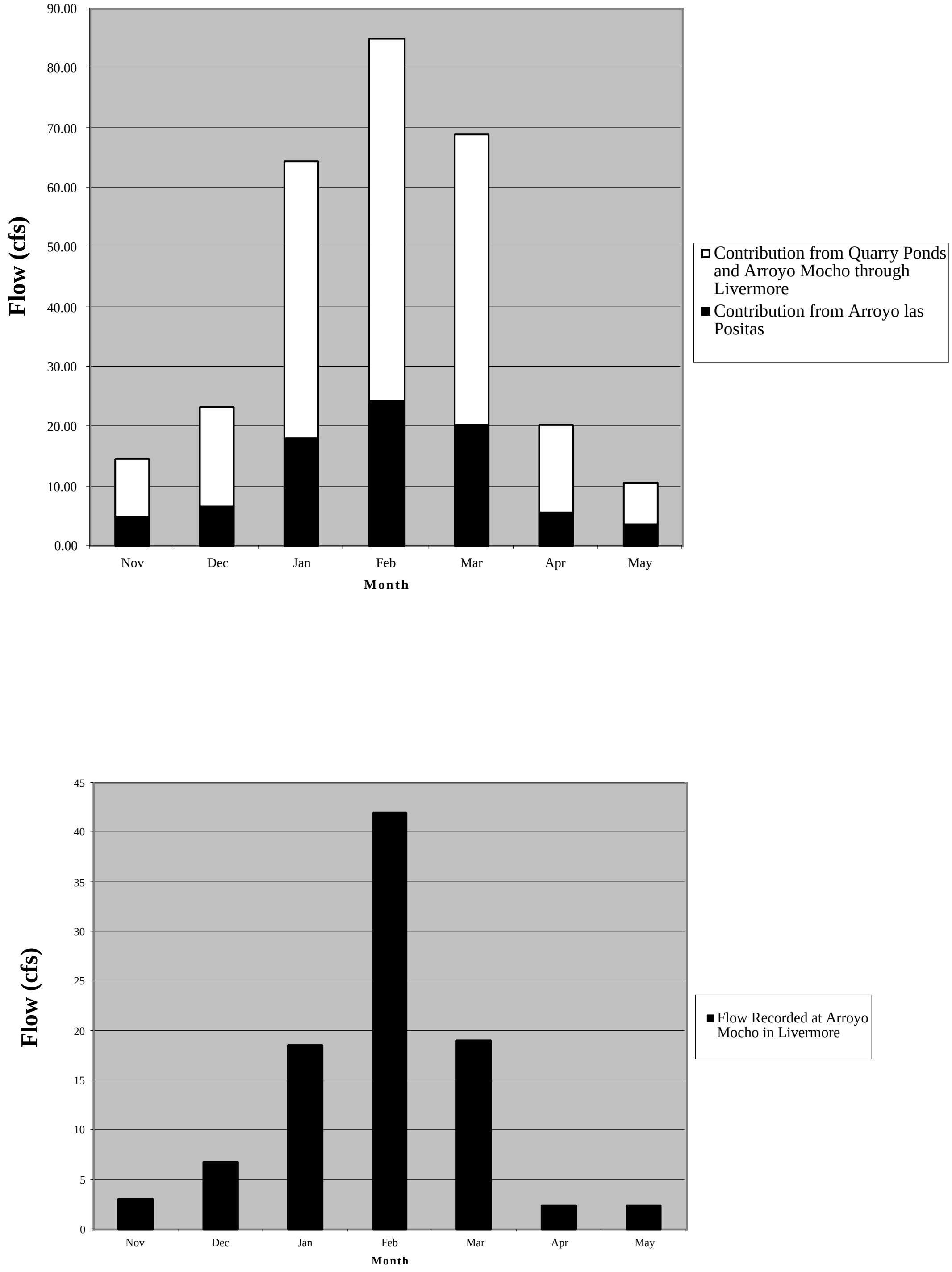


Figure 11 - Average Monthly Flows in Arroyo Mocho. A) Total Flows Recorded at Pleasanton Gauge, 1980-1998, Identified by Source. B) Flows Recorded at Livermore Gauge, 1983-1998. Location of Gauges is Shown in Figure 4. (Zone 7, unpublished data)

AMP – ALP – 12 cfs = Flow in the channel through the quarry pond area

where AMP = Flow at Arroyo Mocho in Pleasanton
ALP = Flow at Arroyo las Positas at El Charro
12 = Estimate of releases from quarry pond operators

The data suggest that there is on average a flow in the range of 20-40 cfs in the Pleasanton section of the flood control channel for the period January through March. Similarly, data suggest that average flows in April and May are minimal. Data from the Livermore gauge (Figure 11b) support these conclusions.

During the field surveys conducted in October 1999, flow levels in the 10-12 cfs range were observed in both the areas upstream of the flood control and the lower flood control channel section. In the upstream areas, this amount of flow appeared sufficient to provide adequate depth and flows for migrating fish. Due to the existence of a natural low-flow channel in the much wider flood control section, 10-12 cfs also appears sufficient in this area for fish passage. Therefore, the analysis of gauge station data suggests a continuous wetted channel adequate for migration exists at least around storm events through the January to March timeframe.

IV. Changes Required to Existing Conditions for Restoration of a Viable Steelhead Population

The previous section described the current status of steelhead trout habitat in the Alameda Creek watershed. The opportunity for steelhead to complete their life history in the watershed was considered by examining the extent of spawning and rearing habitat, and the existence of barriers for in-migration of adults from the ocean and out-migration of smolts and adults back down the creek. This section describes the changes that are likely needed in the watershed to establish a viable steelhead trout population. Some general findings of fact will be presented, followed by more detailed discussion.

From the presentation in previous sections of this report, it is clear that a viable steelhead population would be contingent upon the interaction of many factors, including climate, water diversion practices, and barrier removal. Although we cannot predict with certainty how steelhead/ rainbow trout would respond to all these factors, we believe the following points to be reasonable findings of fact based upon our review of available data.

A. Findings

1. Suitable habitat exists within the Alameda Creek watershed to support spawning and rearing of steelhead.

- The best potential spawning and rearing habitat in the watershed exists in the upper Alameda Creek, Niles Canyon and its tributaries, and the Arroyo Mocho canyon. This assessment is based primarily on the presence of self-sustaining resident rainbow trout populations with age class structures demonstrating consistent successful reproduction.

- Based on the observations to date there is no indication that available spawning habitat would significantly limit steelhead populations in the Alameda Creek watershed.

- Rearing habitat is limited in most of the areas potentially supporting steelhead by low summer stream flow. Although this has been exacerbated by development, this is a natural condition in these reaches under which steelhead have evolved. Areas do however exist with suitable water temperature conditions for rearing steelhead/rainbow trout.

- Augmented flows in Niles Canyon may provide habitat for steelhead/rainbow trout that is not typical for the watershed or the region but is similar to other augmented streams in the region used by steelhead.

2. There is evidence that native, locally adapted steelhead/rainbow trout stock survives in the watershed

- Resident trout populations in Stonybrook Creek, in tributaries of Calaveras and San Antonio Reservoirs, in upper Alameda Creek, and possibly in Arroyo Mocho are derived from native anadromous steelhead populations isolated behind dams or natural barriers. These populations may retain anadromous traits and may have the potential to generate smolts. Under certain conditions these smolts may emigrate from the watershed and complete the oceanic maturation life history stage.

- The adult steelhead recently captured at the BART weir, and the rainbow trout sampled in the upper watershed, appear to be native fish that have their closest genetic associations with other populations within the Central Coast Evolutionarily Significant Unit. The adult steelhead also exhibit close genetic associations with rainbow trout from upper parts of the watershed and may in fact have migrated as smolts from these areas. If these fish are the result of evolution in the Alameda Creek watershed or a neighboring coastal watershed, and thus are part of a locally-adapted population, they are well-suited to respond to restoration actions.

3. Steelhead are currently prevented from completing their life-history cycle within Alameda Creek due to the presence of an impassable migration barrier and are severely limited by several other impassable or partial migration barriers.

- The BART Weir represents an impassable barrier to adult steelhead, and prevents these fish from completing their life cycle in Alameda Creek. The gas line crossing in the Sunol Valley may also be an impassable barrier to adult steelhead except at the highest of flows. The Alameda Creek

Diversion dam is also an impassable barrier to steelhead, and it prevents access to a significant amount of suitable spawning and rearing habitat. It is also likely that the operation of this facility would contribute to passage problems for migrating adults in Little Yosemite.

- The inflatable dams operated by the ACWD are impassable barriers to adult steelhead when inflated, but under current operations are deflated with enough frequency to allow at least some adult fish passage into the watershed.

- Sunol Dam is potentially passable by steelhead trout, but is thought to pose enough of an impediment to migration to warrant alteration or removal.

- The ability of smolts to leave the system may be limited by existing water project operations, particularly in years with low spring storm activity, but smolt out-migration is not precluded in all years. There are significant periods of time under existing operations where it appears that smolts and adults have a reasonable opportunity to migrate downstream to the Bay.

- Migration of smolts from rearing areas in Arroyo Mocho is influenced by stream flow and groundwater management in the Livermore/Pleasanton Valley area. It may be possible to enhance migration conditions in these reaches through pulse flow augmentation following storm events in April and May.

We conclude from these findings that steelhead could complete their life-cycle in the watershed reaches listed in Part A of Table 2 with provision of fish passage at the BART weir, Sunol Dam, and the gas line crossing in Sunol Valley. The viability of a steelhead run made possible by passage at the BART weir would be greatly enhanced through removal of other passage problems including passage improvements related to operation of inflatable dams, diversions, and stream flows in the flood control channel section of Alameda Creek; maintenance of suitable out-migratory habitat in lower Arroyo Mocho at least through April and potentially into May; and provision of passage at the Alameda Creek Diversion Dam.

B. Rationale for Findings

Spawning and Rearing Habitat. Based on the results of the literature survey and limited field observations to date there is no indication that spawning habitat would significantly limit steelhead populations in Alameda Creek. Areas of the watershed that support resident trout all show evidence of successful spawning as indicated by the presence, abundant in places, of young-of-year trout. Suitable substrate conditions for spawning and egg incubation are found at some level in all stream reaches potentially supporting steelhead (Appendix 3). Given high potential fecundity of steelhead, factors other than availability of spawning habitat are likely to be more limiting. Reconnaissance surveys conducted to date are not of sufficient detail to quantify the overall extent and quality of suitable substrate. It is possible that more detailed observations would reveal potential for improving spawning habitat and enhancing production of steelhead juveniles. However, availability of spawning habitat does not appear to preclude steelhead from completing their life-cycle in the Alameda Creek watershed.

Rearing habitat is limited in most of the areas capable of supporting steelhead by low summer stream flow. In some of the stream reaches supporting the greatest numbers of resident trout, low summer stream flow results in relatively small, infrequent, isolated pools. There is no doubt that more pools or larger pools would allow greater numbers of trout to survive the low flow period. However, this is a natural condition in these reaches and one to which steelhead have adapted. Availability of late summer habitat may limit the abundance of steelhead within the watershed but it does not preclude steelhead from completing their life-cycle. Flow augmentation in some reaches may create late summer habitat where it did not previously exist or replace isolated pool habitat with warmer swift-water habitat. The ability of steelhead to make use of this habitat has not yet been demonstrated. If relatively cool water can be provided in these reaches there is a potential that steelhead would use the habitat. This is particularly true of the Niles Canyon reach where flow augmentation currently results in relatively warm conditions.

Barriers to In-migration. The literature review and field survey efforts identified a number of man-made barriers within the watershed that would appear to seriously hinder in-migration of anadromous fish. These barriers include the BART weir, the three ACWD inflatable dams, Sunol Dam, the gas line crossing, the Alameda Creek Diversion Dam, and in-stream barriers in Stonybrook Creek. The Alameda Creek Diversion Dam, Calaveras Dam, San Antonio Dam, and Del Valle Dam are barriers to upper watershed areas with potential to support steelhead. Each of these structures is far enough upstream to allow for significant amounts of spawning and rearing habitat to exist without alteration to the structures; provision of passage at the structures would, however, add significantly to the amount of available habitat. The other structures, however, are located low enough in the creek so that at most a very minimal amount of spawning and rearing habitat would exist without alterations to mitigate the barriers.

The most significant barrier, the BART weir, is totally impassable at this time. Any attempt to reintroduce a viable population of steelhead into the creek would need to include a technical solution to the issue, either by complete removal of the weir or by creating a fish passage mechanism. The need for the weir to stabilize the channel for vital regional transportation infrastructure suggests a passage structure as the best option for facilitating fish passage.

The fish passage structure associated with the BART weir should be constructed to allow passage around both the weir and the intermediate inflatable dam, to be functional when the dam is in either the deflated or inflated state. The close proximity of the weir to the dam necessitates the dam’s inclusion within the fish passage design. This would effectively remove the intermediate dam as a barrier to in-migration.

The upper and lower inflatable dams, while impassable to steelhead when inflated, appear to be deflated with enough frequency to allow passage upstream during years with higher runoff. The lower dam has in fact been negotiated by an unknown proportion of returning steelhead in each of the last two years before being stopped in their progress by the BART weir. Passage at the upper dam, while not verified by observation, appears to be well within the capability of steelhead to accomplish when the dam is deflated. Constructing a fish passage structure at either of these dams would certainly improve in-migratory habitat. The current operation of these facilities by the ACWD might be optimized for fish passage without compromising their present operation for water supply.

Both the Niles and Sunol Dams serve no useful purpose for any of the water supply agencies within the watershed. In fact, removal of the two structures would remove some of the liability concerns of the SFPUC associated with their use by the public as an unsupervised swimming area. Cost estimates for the removal of these two dams have been generated by the SFPUC. Other structures in Niles Canyon are not considered significant barriers to migration.

Finally, another potential barrier to successful in-migration of adult steelhead is recreational fishing pressure. Even in the 19th Century there were reports of heavy recreational use of Niles Canyon, and the stocking of the Canyon by the California Department of Fish and Game has been very popular with anglers (SFPUC, 1997). It is possible that the increased presence of adult steelhead in Niles Canyon (or other locations in the drainage accessible to fishermen) could result in a heavy recreational fishing response that might prevent many steelhead from reaching spawning grounds. Even if fishing is made illegal, poaching remains a distinct possibility.

It should be noted that recreational use of Niles Canyon is most intensive during the summer months. Presumably, since adult steelhead tend to migrate during high flow periods in the winter, they would not be overly exposed to potential poaching. It is becoming increasingly difficult to access Alameda Creek from Highway 84 due to heavy, high speed traffic, and increased posting and enforcement of no-parking areas. In addition, there has been some shift in the mindset of the recreating public in the past decades. While rapacious use of fish resources in Niles Canyon has been cited from the 1960s back into the late 1800’s (SFPUC, 1997), the past few decades have seen the rise of catch and release angling, creek walking, and other non-consumptive resource use, as well as animal protection advocates (Muth *et al.*, 1998). The potential return of a viable resource of such value as steelhead to the watershed would necessitate cooperation of public and community entities to address enforcement, access, and public education issues at a minimum.

Barriers to Out-migration – Flow. An analysis of current operating methods of the inflatable dams over recent water years suggests that although flows for out-migration to the Bay in the flood control reach are not provided continually during the expected steelhead out-migration period, they are provided on a fairly frequent basis, especially in years with significant spring storm activity (Figure 6).

It seems reasonable that smolts reaching the impounded water behind the inflatable dams during periods without storm flows, particularly in the early part of the out-migration season, may linger there until the next storm and resume migration when the dams are deflated to allow flood peaks to pass (subject to losses associated with entrainment in the ACWD quarry lakes; see below, and predation by birds). Consequently, it is quite possible that smolts are successfully out-migrating through the flood control channel reach in years with significant storm activity under existing operations of the inflatable dams.

Conversely, it is also clear that in years with low spring storm activity, the dams remain inflated almost continuously, and there is little overtopping flow. Under these conditions, there appears to be little likelihood of successful out-migration of smolts. The data on trout migration to San Leandro Reservoir (Table 4) suggest that out-migration is greatly increased with storm activity.

It is also likely, however, that if flows to the Bay could be augmented during spring storm periods when necessary to maintain adequate habitat, the probability of establishing a viable steelhead population could be increased. Similarly, providing additional flow in Arroyo Mocho during April and May during storm events would also increase the likelihood of successful smolt out-migration from the Arroyo Mocho canyon. These flows would probably not have to be continuous, but instead be provided in pulses to match the projected movement of smolts following storm events.

Providing such flows, however, could cause water that currently is part of municipal water supply projects to be made unavailable for that purpose. While in years when local spring precipitation provides plentiful water (e.g., 1995, 1996, 1998) there would not likely be a problem providing additional flows, during low precipitation or drought years water supply agencies such as the ACWD or Zone 7 would be releasing water that has been purchased for use in municipal supply operations. This water is, however, only “lost” to the water supply system once it is allowed to pass over the lowermost ACWD inflatable dam; prior to that point, there is still the potential to impound the water releases for groundwater recharge.

Finally, it must be kept in mind that out-migration past the inflatable dams is only of importance once smolts have traveled from their rearing locations into Niles Canyon. This requires that migratory habitat be available in the Livermore Valley reach of Arroyo Mocho and the Sunol Valley reach of Alameda Creek. The geology of these valleys results in significant loss of surface water to the groundwater basin. It would thus be extremely valuable to conduct a critical passage analysis (see Section V) of these reaches to determine precisely when they become impassable under different flow conditions.

Barriers to Out-migration – Entrainment. There are no existing fish screens and no bypass requirements for ACWD diversions (ACWD diversion facilities were reviewed during the permitting process and found to meet all environmental and regulatory requirements specified at the time of construction). Any juvenile steelhead/rainbow trout (or other species) passing downstream from Niles Canyon or residing in the ponds behind the inflatable dams would be subject to diversion into the ACWD percolation ponds, particularly during low flow periods, and would then be lost to the population. If smolts are to out-migrate past the inflatable dams they must avoid being drawn out of the Alameda Creek channel and entrained in the ACWD diversions.

Both the CDF&G and NMFS have guidelines and criteria for fish screens. The important variables influencing the size, complexity, and cost of screens at the inflatable dams include the magnitude of the diversion and the size of emigrating fish to be protected. The NMFS has different criteria for large and small screens with 40 cfs as the approximate cutoff point.[44]

The requirement for fish screens presents some challenges to the existing operations of the ACWD diversions. During high flow conditions the dams are not inflated and there are no diversions and no need for screens. At intermediate flows when the dams are inflated but water is spilling over the tops, fish can still pass over the dams. If a bypass for fish were present, presumably flow could be provided through that bypass conduit instead of, or in addition to spilling over the dam. Under low flow conditions, when there is no flow past the lower dam, the upper two inflatable dams may still pass flow. Diversion at the lower dam would presumably be accomplished under requirements for non-flowing waters.

It is important to note that both CDF&G and NMFS have some flexibility in the designs they will accept on a case by case basis. CDF&G has a procedure for providing variances where the rationale for the variance can be adequately described and justified.[45] The nature of the project as a whole represents enhancement of the fisheries resources of Alameda Creek and an improvement over existing conditions. Presumably, this would allow for some flexibility in developing screening systems that provide a degree of fish protection given existing site conditions and project constraints. The fact that diversions do not occur during high flow conditions, when smolts are most likely to out-migrate successfully, may also justify some flexibility under low flow conditions.

V. Making the Changes: Recommendations for Steelhead Restoration

This section presents recommendations for how to pursue restoration of a viable steelhead trout population in the Alameda Creek watershed. The presentation below is not meant to be comprehensive or exhaustive, but rather to provide an indication of how to proceed. It is expected that some of the activities below can be carried out in conjunction with the U.S. Army Corps of Engineers as part of an application for an environmental restoration project pursuant to §1135 of the Water Resources Development Act of 1986.

A. Essential Actions

The following recommendations are essential actions that must be taken to provide steelhead trout the opportunity to complete their life cycle in the Alameda Creek watershed.

1. Provide upstream passage for adult steelhead around the BART weir and the middle inflatable dam. There do not appear to be any constraints that would preclude the installation of fish passage facilities at the BART weir and adjacent inflatable dam.[46] Design, funding, and operation and maintenance responsibilities for fish passage facilities are key issues which need to be addressed. The proposed fish passage facilities would allow full access to potential habitat in Niles Canyon and its tributaries (~7 miles of potential habitat) and partial access to Alameda Creek and its tributaries up to Little Yosemite (~4 miles of potential habitat) and to Arroyo Mocho (up to 9 miles of potential habitat). Although certainly not at full potential, steelhead would be able to complete their life-cycle in the watershed during wetter periods.

2. Modify the PG&E gas line crossing on Alameda Creek in Sunol Valley to improve upstream passage. This would enhance access to potential habitat in Alameda Creek up to Little Yosemite. This could involve modification of the existing structure, addition of a fish ladder, and/or addition of instream structures downstream (e.g. rock weirs) to minimize grade change. PG&E, the owner of the structure, has environmental restoration grants available that could be investigated to assist with the restoration costs.

3. Passage improvements should be made at the Stanley Blvd weir and LLNL access roads on Arroyo Mocho. This would allow full access to potential habitat in Arroyo Mocho, and could be relatively easily accomplished with addition of downstream structures and/or small Denil type fish ladders.

4. Provide protection for migrating steelhead (particularly smolts) from entrainment in diversion structures. Improvement of out-migration passage conditions through modification of operations at diversion facilities or by installation of fish screens, bypass channels, or other improvements at existing diversion facilities downstream of Niles Canyon would enhance out-migration success when diversions are operating. The specifications for these facilities should be prepared in conjunction with NMFS and CDF&G.

5. Provide fish passage at or remove Sunol Dam. The SFPUC is considering the removal of Niles Dam and Sunol Dam, as neither facility is required any longer and they currently pose potential liability problems for the City of San Francisco. From the perspective of in-migration barriers, the removal of Sunol Dam is a higher priority. Although steelhead can possibly leap this structure at flows likely to occur during the migration period, removal of this barrier should enhance passage at lower flow conditions.

6. Prepare an application to the U.S. Army Corps of Engineers §1135 Program. Some or all of the above-mentioned restoration activities should form the basis for an application to the U.S. Army Corps of Engineers for funding under the §1135 of the Water Resources Development Act of 1986. Included in this proposal should be a well-designed monitoring program that will allow a judgement to be made in the future regarding the success of the restoration effort. Under the §1135 program the Corps will provide up to $5 million in environmental restoration funding (with a 25% local match) for projects in places where previous water resource projects have contributed to environmental degradation. Preliminary discussions with the Corps have indicated that they would be receptive to a project on Alameda Creek,[47] provided there was a local agency willing to act as a sponsor.

7. Modification of Recreational Fisheries Management within the Watershed. Stocking of hatchery-raised steelhead in Alameda Creek must be altered to prevent possibility of interbreeding and competition with wild stocks, and to redirect recreational fishing pressure. The planned development of the ACWD quarry lakes as an EBRPD recreational fishing venue can serve as an alternative for recreational fishers in the area, but should be developed to ensure that no fish can escape to the creek itself.

8. Improve upstream passage for adult fish at the upper and lower inflatable dams. Assuming that fish passage is provided at the middle inflatable dam and BART weir, improvement of passage at the upper and lower inflatable dams would also enhance the in-migration of adult steelhead. These enhancements could be through installation of fish passage facilities, physical alterations to the dams to enhance ability of steelhead to jump them, and / or operational changes to provide more opportunities for upstream migration.[48] If passage is determined to be best accomplished via structural improvements, it could be investigated as to its potential to be bundled into the §1135 application or other funding mechanism.

9. Identify private and public landowners in spawning/rearing habitat.. Successful restoration of a viable steelhead trout population will involve a variety of actions. The maintenance or enhancement of spawning and rearing habitat will be most successful if attempted in conjunction with the private and public land owners who are the ultimate stewards of this resource. These individuals and organizations should be identified and contacted in a systematic fashion to educate them regarding the restoration program and encourage their support and participation. This effort should be conducted in a manner to complement the Alameda Creek Watershed Management Plan process currently being conducted by the SFPUC.

B. Additional Restoration Actions

While the above essential actions provide the minimal opportunity for restoration of steelhead trout in the Alameda Creek Watershed, there are several other actions that could be taken to increase the likelihood of restoring a viable population. Each of these actions would need to be investigated further to determine potential impacts upon both the fish resources of the watershed and the other existing beneficial uses the watershed supports.

1. Improve passage for fish in Stonybrook Creek. Improved passage at road crossings in Stonybrook Canyon may enhance access to potential habitat upstream of the first road crossing. The presence of natural barriers (high gradient) and habitat conditions upstream of the first impassable culvert should be verified.

2. Improved passage for fish in Little Yosemite. Higher flow conditions associated with migratory periods should be observed to better estimate the barrier posed by Little Yosemite. If judged to be effective, modification of natural passage obstructions in the Little Yosemite area could enhance access to approximately 2.5 miles of potential habitat between Little Yosemite and the Alameda Diversion.

3. Investigate provision of fish passage at the Alameda Creek Diversion Dam. While a significant amount of suitable spawning and rearing habitat exists below the Alameda Creek Diversion Dam for steelhead trout, some of the most promising habitat in the entire watershed is located above the dam. Assuming that Little Yosemite is passable under winter flow conditions, provision of fish passage at the Alameda Creek Diversion Dam would provide access to about 8.5 miles of relatively pristine habitat for spawning and rearing. This would presumably be accomplished with some impact on water supply since some level of flow would bypass the Alameda diversion structure. However, it is possible that some of this flow could be recaptured further downstream in the SFPUC diversion facility to be constructed.

4. Revise water delivery arrangements to augment flow in lower Arroyo Mocho following spring storm events. The possibility of using Arroyo Mocho rather than Vallecitos Creek to transfer State Water Project water to the ACWD should be investigated as to its predicted impacts on costs, water supply, and water quality. There are already systems in place to allow the ACWD and Zone 7 to track how much water released in Arroyo Mocho and how much is actually delivered into Arroyo de la Laguna and Niles Canyon to be captured by the ACWD. Timed correctly, this could result in more out-migratory habitat for fish in lower Arroyo Mocho.

5. Investigate the possibility of acquiring water that can be used to augment flows in the watershed to support steelhead restoration. There is a growing awareness in California of the need to provide water rights in order to effect restoration of damaged environmental resources. This is reflected in the establishment of an “Environmental Water Account” by CALFED, and the consideration of water rights acquisition by private conservation organization such as the Packard Foundation’s Conserving California Landscapes Initiative. Though there remain many unresolved environmental, regulatory, and institutional issues in implementing water transfers, it is possible that water rights could be obtained through programs such as these that would provide additional flows in the watershed to assist with out-migration in late Spring months.

C. Further Investigations

There are several issues that merit further investigation as part of the planning for restoration of steelhead trout in the Alameda Creek watershed. These issues are presented below

1. Conduct critical passage analysis. Addressing the question of additional flow for out-migration habitat has two parts; (1) how much is needed? and (2) where will it come from? To address how much is needed, the first step is to conduct a critical passage analysis. The purpose of this analysis to identify the locations that first become impassable as flows abate in spring, and relate this in time to measured flow at a nearby gauging station. This analysis will then allow us to define, for each major migratory route, the minimal flows that provide out-migratory habitat for steelhead in the watershed and the amount of time that such flow is available under different water year types. This will help identify locations and times that flow augmentation might be beneficial.

2. Spring smolt survey. To verify the existence of steelhead smolts, a spring smolt survey should be conducted to identify regions where juvenile trout are beginning the physiological transformation into smolts. A survey of adfluvial populations residing behind San Antonio and Calaveras Reservoirs could supply valuable information regarding smolt timing. It is also possible that more detailed observations of creeks during this study would reveal potential for improving spawning or rearing habitat to enhance the production of steelhead juveniles.

3. High flow assessment. Representatives of the Workgroup should revisit some areas identified during the production of this report for which knowledge about wet weather conditions is lacking. This includes barriers that might be only passable under higher flow, such as the gas line crossing, Stanley Boulevard drop structure, and Pirate Creek weir.

4. Arroyo Mocho survey. Once access issues are resolved, representatives of the Workgroup should survey Arroyo Mocho Canyon area to identify any potential barriers and to search for existing rainbow trout populations.

5. Investigate "re-operation" of water supply activities. Once we have the knowledge of the amount of flow required, we need to determine if there is a way to obtain this water without compromising water quality. The first step in this process is to examine the potential to "re-operate" the municipal water supply activities in the watershed. Are there possible ways in which the SFPUC, ACWD, and Zone 7 can jointly manage their operations to improve conditions for fish without adversely affecting municipal water supply? One model to investigate for such a "re-operation" effort would be the Vernalis Adaptive Management Plan.[49] Other possibilities include detention of stormwaters in abandoned quarry ponds for later release, increasing the storage capacity of the watershed, water reclamation activities, use of entitlements from CALFED's environmental water account, or identification of water rights for purchase. All of these possibilities would need to be assessed in detail to determine their feasibility.

As part of this investigation, a survey of groundwater pumping and well location in regions where summertime pools exist should be conducted. It is possible that providing an alternate source of surface water to reduce groundwater pumping could increase groundwater flow in the creeks to augment summertime rearing habitat.

6. Develop Minimum Flow Requirements. While steelhead in the Alameda Creek watershed have apparently adapted to a variable hydrologic cycle, Bay area businesses and residents have come to depend upon a reliable municipal water supply. These uses will at times be in competition for limited supplies of water, specifically during times of extended drought (i.e., several years with flows insufficient to support effective out-migration). The Workgroup should work to develop operational guidelines for minimum flow requirements for steelhead during periods of prolonged drought.

7. Develop Re-operation Guidelines for Management of ACWD Upper and Lower Inflatable Dams. Workgroup members should cooperate with ACWD representatives to maximize fish passage potential over the upper and lower inflatable dams given the constraints of the municipal water supply needs.

VI. Endnotes

[1] The technical advisory committee included representatives from the Alameda County Flood Control and Water Conservation District (ACFCWCD), the ACFCWCD Zone 7, the Alameda County Water District, the San Francisco Water Department, the East Bay Regional Park District, the City of Fremont, the California Department of Fish and Game, and the California Department of Water Resources.

[2] Appendix 1 contains a record of the documented sightings of steelhead trout in the Alameda Creek watershed.

[3] San Francisco Chronicle, May 8, 1998.

[4] San Ramon Valley Herald, January 24, 1999; Livermore Independent, June 30, 1999.

[5] Meeting of the Transportation and Planning Subcommittee, October 26, 1999.

[6] A history of California salmon and steelhead fisheries is provided in (Lufkin, 1991).

[7] The NMFS defines an ESU as a distinct population segment of the biological species that is substantially reproductively isolated from other population segments and that represents an important component in the evolutionary legacy of the species.

[8] National Climate Data Center, 1961-1990 monthly temperatures recorded at Livermore, CA and Newark, CA.

[9] More information about these agencies can be found on their websites: ACWD (www.acwd.org); SFPUC (www.ci.sf.ca.us/puc/home3.htm); Zone 7 (www.zone7water.com).

[10] J. Miller, ACA, Personal communication, December 16, 1999.

[11] P. Alexander, EBRPD, Personal communication January 3, 2000.

[12] P. Alexander, EBRPD, Personal communication, January 3, 2000.

[13] The Central California Coast ESU is considered by NMFS to be distinct from the South-Central California ESU to its south, the Northern California ESU to its north and the Central Valley ESU to its east.

[14] In the final rule listing Central California Coast steelhead as threatened, NMFS indicated that resident rainbow trout may deserve inclusion in listed steelhead ESUs in cases where "(1) resident *O. mykiss* have the ability to interbreed with anadromous fish below natural or manmade barriers; or (2) resident fish of native lineage once had the ability to interbreed with anadromous fish but no longer do because they are currently above human-made barriers and are considered essential for recovery of the ESU." (62 CFR 43937).

[15] Steelhead have been caught as far as 3,000 miles offshore (Di Silvestro, 1997)

[16] There are selective advantages to both anadromous and resident strategies (Cramer et al. 1995). Anadromous fish grow faster and reach a larger size thereby gaining a potential to produce more offspring than resident fish. At the same time, however, migratory fish are exposed to many sources of mortality and there is a risk that conditions may become unsuitable for migration, particularly in California where fluctuating climatic conditions can result in long periods when streams have tenuous connection to the ocean. In California, many streams support both resident and anadromous forms with no observable genetic differentiation. During extended drought periods it is possible for populations to sustain themselves through resident spawning and then revert to an anadromous life history when suitable conditions return. Some populations of steelhead/rainbow trout have been isolated in upper watershed areas following construction of downstream reservoirs. Steelhead/rainbow trout populations in San Leandro Reservoir and its tributaries have been isolated since the construction of Chabot Dam in 1875. These populations exhibit migratory behavior with juvenile fish moving downstream into the reservoir to mature and migrating back into the tributary streams to spawn as adults.

[17] ACWD monitoring data from 1990-1998 for projected dry season months of May through October suggest flows from both Vallecitos Creek and Arroyo de la Laguna have relatively high temperatures, with grab samples ranging from the upper teens to mid-twenties ºC (ACWD, unpublished data).

[18] Jeff Miller, ACA, Personal communication, Jan. 12, 2000.

[19] P. Alexander, EBRPD, Personal communication, Jan. 3, 2000.

[20] P. Alexander, EBRPD, Personal communication, Jan. 3, 2000.

[21] R. Leidy, USEPA, Personal communication, Dec. 14, 1999.

[22] S. Matthews, Environmental Protection Department, Lawrence Livermore National Laboratory, Personal communication, November 1999.

[23] Regular discharges of untreated and partially-treated waste into Alameda Creek ended in the 1970s (David Lunn, Zone 7, Personal communication, November 3, 1999). This was hypothesized as a possible contributing factor to the downturn in the creek's steelhead population.

[24] In 1999, the ACWD cooperated with agencies and citizen groups in operating the inflatable dams to facilitate fish transport around the barriers in the flood control channel.

[25] P. Alexander, Personal communication, January 3, 2000.

[26] At one time a rudimentary wooden fish ladder was in place at the north end of the dam, but it is no longer there. There is no indication in the records of the California Fish Commission why or when the fish passage facilities were constructed on the Sunol and Niles Dams.

[27] In 1999, EBRPD personnel tracked a returning steelhead entering Stonybrook, migrating upstream but not passing the first road crossing.

[28] Frank Dauby, PG&E, Personal communication, January 5, 2000.

[29] There are several culverts running parallel to the streamflow with little elevation change through the culverts, the culverts installed in a variety of elevations to handle a variety of flow regimes, and the lowest culverts emptying at the standing water level. Additionally, expansive low-velocity refuges exist both upstream and downstream of the culverts.

[30] The water releases are requested at a sufficient rate to allow for surface flows to continue up through a point approximately 200 yards from the NPDES-permitted release from one of the quarry operators adjacent to the Arroyo.

[31] Annie Campagna, EBRPD, Personal communication, November 2, 1999.

[32] This analysis assumes that there is a low-flow channel below the lower dam, or enough water flowing to provide adequate depth for the fish. A low flow channel has been observed as a natural feature downstream of the lower inflatable dam (R. Wetzig, personal communication). The ACFCWCD is currently performing extensive dredging of the flood control channel below the lower inflatable dam along a 3 mile stretch between Ardenwood Blvd and Decoto Rd. , and an experimental program is in place to investigate alternative strategies for minimizing impacts of dredging (H.T. Harvey & Associates, 1999). A low-flow channel was dug as part of this project, although only for purposes of controlling flow near equipment during dredging.

[33] For overtopping flow to be adequate out-migratory habitat, we also assume that the migrating fish are not injured by the drop over the dams.

[34] Craig Hill, ACWD, Personal communication, September 13, 1999.

[35] A sensitivity analysis was performed in which the infiltration estimate was made equal to zero and to 7 cfs. Neither of these scenarios significantly altered the results of the overtopping analysis, and so we have presented the most conservative scenario with maximal ACWD diversion and maximal losses.

[36] The in-stream storage capacity created by the three inflatable dams is approximately 500 acre-feet (Jim Reynolds, ACWD, Personal communication, December 15, 1999). The dams are able to be raised when flows recede below 1000 cfs. Using a 500 cfs figure to estimate time before channel capacity is reached results in a twelve hour duration before overtopping is then expected to occur.

[37] Josh Milstein, SFPUC, Personal communication, November 10, 1999.

[38] Tracy Pond, Assistant Plant Manager, RMC Pacific Materials, Sunol, CA, personal communication, November 18, 1999.

[39] LLNL is discharging treated groundwater into Arroyo Las Positas as part of a Superfund clean-up program for the next 10-50 years. These discharges have created almost 2 acres of wetland habitat in the Arroyo that is currently being managed as wildlife habitat by LLNL. (S. Matthews, LLNL Environmental Protection Department, Personal communication, November 11, 1999).

[40] The land surrounding the Canyon is in private ownership, and the land owners must be identified and approached for access to the Creek.

[41] Maximum infiltration between the South Bay Aqueduct turnout and the quarry pond area is estimated at 18 cfs. Gerry Gates, Zone 7, Personal communication November 30, 1999.

[42] David Lunn, Zone 7, Personal communication November 3, 1999.

[43] There have also been manipulation of flows within and feeding into Arroyo Mocho within the study period. However, these alterations are not expected to significantly affect the flow measurements. Gerry Gates, Zone 7, Personal communication, November 30, 1999).

[44] A key design parameter for any fish screen is the approach velocity. In waters where trout fry are present the maximum allowed approach velocity is 0.33 fps. Where only fingerling are present the allowable approach velocity can be increased to 0.8 fps. Screen openings can also be larger where fry are not present. Another key parameter is the sweeping velocity (the component of flow parallel to the screen face) which is generally required to exceed the approach velocity. In flowing water situations (streams, rivers, and canals) the sweeping velocities may be provided by a fish bypass which transports fish from the screen face to a downstream location in the main migration route.

[45] Fish bypass systems are not universally required by NMFS, and the agency has the option to accept a solution that provides the highest degree of fish protection given existing site and project constraints. In non-flowing waters the diversion is generally located to minimize the potential for fish contact with the diversion.

[46] Becker, G.S. 1998. “Specifications for a Fish Ladder on a Barrier in Alameda Creek, California.” Unpublished Manuscript.

[47] Scott Miner, U.S. Army Corps of Engineers, Personal communication.

[48] The City of Santa Cruz operates an inflatable dam on the San Lorenzo River to provide passage for anadromous fish. This facility is smaller than the ACWD dams, but the methods employed at this site might prove useful to consider.

[49] The Vernalis Adaptive Management Plan (VAMP) is a 12 year experimental program that provides for a spring pulse flow during April and May for salmon out-migration in the San Joaquin river basin. Pursuant to the VAMP, fisheries experiments will be conducted during the pulse flow period to test the effect of the various inflow/export conditions on salmon smolt survival through the Delta.

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VIII. Appendices

Appendix 1

ALAMEDA CREEK STEELHEAD SIGHTINGS

Following is a summary of documented steelhead sightings within the Alameda Creek Watershed. The information was generated by Jeff Miller of the Alameda Creek Alliance and is current through November, 1999. The majority of the sightings since the 1960s occurred below an impassable barrier to migration in the lower flood control channel.

Date	Location	No. of fish	Sources
1933	Calaveras Creek	Unknown	Historic photos
1938	Sunol Dam	Unknown	CDFG Supplement Sheet, 5.19.38
5.18.38	Upper Alameda Creek at Pirate Creek	20 Captured, each approximately 12’	CDFG Supplement Sheet, 5.19.38
1940s	Sinbad Creek	5 Captured	Historic photo
1942	Alameda Creek Near Pirate Creek	Referenced as “plentiful steelhead run”	CDFG file letter, 7.8.42
1953	Sinbad Creek	2 Captured	Historic photo
7.28.53	Indian Creek (tributary to San Antonio Creek)	3000 4-5 inch fish	CDFG Intra-office correspondence, 8.5.53
8.19.53	Indian Creek (tributary to San Antonio Creek)	Unknown, 4-12 inch trout observed	CDFG Field Notes, 8.19.53
1954	San Antonio Creek	Unknown, “light steelhead run” reported	CDFG Field Notes, , 9.30.1954
10.14.55	Stonybrook Creek, 1.5 miles from confluence with Alameda Creek	Approximately 20 3-7 inch fish captured	7.11.74 letter of W.I. Follett

Date	**Location**	**No. of fish**	**Sources**
10.31.55	Stonybrook Creek, 1.2 miles from confluence with Alameda Creek	5 approximately 2 inch fish captured	7.11.74 letter of W.I. Follett
1960s	Alameda Creek	Unknown, reported as "runs"	ACWD EIR for Fabridam #2, March 1974
1973	lower creek channel	Unknown, reported as "runs"	ACWD EIR for Fabridam #2, March 1974
3.1.74	BART weir	Estimate of 11	ACWD EIR for Fabridam #2, March 1974
7.8.74	Below ACWD Fabridam #1	2, identified as RT / SH	CDFG Memorandum, 7.20.74
1974	lower creek channel	60-180 (reported as 3 runs of 20-60 fish)	ACWD EIR for Fabridam #2, March 1974
4.8.76	Stonybrook Creek (near confluence)	1 approximately 10 inch rainbow trout	CDFG Memorandum, 5.13.76
1981	Lower Creek Channel	Unknown	Fremont *Argus*, 9.13.89
1.3.84	lower creek channel	Unknown	Photos from ACWD files
9.16.87	Stonybrook Creek	4 6-8 inch rainbow trout caught	CDFG File Letter, 10.30.87
1995 or 1996	lower creek channel	1 seen	Sheree Foster, CDFG; pers. comm. with Jeff Miller
4.23.96	Calaveras Creek, below Calaveras Dam	2, 1 live and 1 skeleton, each 18-20 inch rainbow trout	Trihey & Associates Memorandum to SFPUC, 5.3.96
12.11.97	DeCoto Road	1 recovered (fin clip taken)	Robin Benavidez and Mike Forney, Pete Alexander (EBRPD), Jeff Miller (ACA)

Date	**Location**	**No. of fish**	**Sources**
3.2.98 3.3.98	Ward Creek (tributary of Old Alameda Cr.)	2 (fin clips taken)	Richard Wetzig (ACFCD), Jeff Miller (ACA), Pete Alexander (EBRPD), ACFCWCD employees; photos and video in possession of ACA
3.4.98	on ACFCD weir	1 seen	Dave Martinez (EBRPD)
3.11.98	on ACFCD weir	6-12 seen	Jeff Miller (ACA), Pete Alexander (EBRPD), George Heise (CDFG), Jon Mann and Ian Gilroy (NMFS), Bob Lepsic (ACFCWCD; photos and video in possession of ACA
3.14.98	on ACFCD weir	4 (2 dead)	Ron Engle and Jeff Miller (ACA)
3.15.98	on ACFCD weir	4 (captured, fin clips taken)	Jeff Miller (ACA), Pete Alexander (EBRPD), ACFCWCD employees, ACA members; photos and video in possession of ACA
3.17.98	on ACFCD weir	9 (4 captured, 2 dead, 3 others seen, 6 fin clips taken)	Jeff Miller (ACA), Pete Alexander (EBRPD), ACFCWCD employees, ACA members; photos and video in possession of ACA
3.19.98	on ACFCD weir	1 seen	Jeff Miller (ACA), Pete Alexander (EBRPD), ACFCWCD employees, ACA members; photos and video in possession of ACA
3.19.98	below ACWD Fabridam #2	2 seen	Jeff Miller (ACA), Pete Alexander (EBRPD),

Date	**Location**	**No. of fish**	**Sources**
3.22.98	on ACFCD weir	at least 4 seen	Mike Forney
1.24.99	on ACFCD weir	1 seen	Richard Wetzig (ACFCWCD)
2.5.99 or 2.6.99	below ACFCD weir	1 dead	ACFCD and EBRPD employees
2.18.99	on ACFCD weir	3 seen	Jeff Miller (ACA), Richard Wetzig (ACFCWCD)
2.21.99	below ACWD inflatable dam #2	1 seen	Ron Engle
2.23.99	on ACFCD weir	3 captured (fin clips taken), more observed	Jeff Miller (ACA), Pete Alexander (EBRPD) ACFCWCD employees; photos and video in possession of ACA
3.20.99	below ACWD Fabridam #2	2-3 seen	Jim Reynolds (ACWD)

Appendix 2

FIELD SURVEY SUMMARIES

Following is a summary of information gathered during the dry season field surveys performed September – October 1999. Follow-up visits to identified barriers were performed November 1999. All areas within the Alameda Creek watershed are not discussed, as areas known to offer no restoration potential were not surveyed. Similarly, areas surveyed that exhibited no potential may not be referenced within the report text.

ARROYO MOCHO

I Mainstem

Unit Description: Flood control channel extending from confluence with Alamo Canal in Pleasanton to just downstream of railroad crossing at Stanley Blvd.
Survey Date: September 29, 1999
Channel Description: Flood control channel with riprap sides, pervious bottom. The channel has experienced a high degree of sedimentation, along with heavy vegetation of channel bottom. Flow has cut a low-flow channel through the sediments.
Flow: During survey, flows of between 10 and 15 cfs were seen along the extent of the channel. These flows can be directly traced to releases from disharges from the Pleasanton quarry ponds higher up in the watershed.
Shading: Minimal, due almost entirely to road crossings over the channel.
Spawning / Rearing Potential: Migratory habitat only based on predominant substrate (silt), expected elevated water temperatures, lack of observed refuge, etc.
Potential Barriers: One potential barrier was observed in this section, a sloping drop structure located approximately 50 to 70′ upstream of the confluence. At the time of the survey, the structure was approximately 2′ above the downstream water level. An approximately 10′ wide concrete apron lies directly upstream of the structure. During the time of the survey, an active USACE levee repair project was in progress, limiting full access to the structure. Later observations (11-18-99) indicated that this barrier would probably be passable at flow levels observed (10-15 cfs) and would certainly be passable at higher flows.

Unit Description: More natural, though still constrained channel, upstream of flood control channel near railroad crossing at Bernal Ave. to end of survey length (where Wente Rd. crosses stream).
Survey Date: September 29, 1999

Channel Description: Urban stream with areas of rock gabion, riprap, and concrete slopes constraining the channel. Interspersed were parklands and other more natural segments with predominant gravel and cobble substrates.
Flow: During survey, flows of between 10 and 15 cfs were seen along the extent of the channel. These flows can be directly traced to releases from the South Bay Aqueduct witnessed higher up in the watershed.
Shading: Highly variable, some areas exhibiting almost complete coverage and others exhibiting no coverage.
Spawning / Rearing Potential: Though it is channelized throughout, the channel is broad in most spots, and has a natural bottom. Thus, the stream has a fairly "natural" appearance in this section, with some meander, and much riparian cover. The stream bed is largely gravel and cobbles. Water temperatures were generally high (up to 23 C). This section of the stream was considered to be "migratory" rather than "spawning / rearing" habitat and so was not surveyed as extensively as it might have been if it had been considered "spawning / rearing" habitat.
Potential Barriers: Two potential barriers were observed in this section. The first is a vertical drop structure located between the road crossing and railroad crossing at Stanley Blvd. near the downstream extent of the unit. The structure runs the extent of the channel and at the time of the survey was approximately 2-3′ above the downstream water surface. There is a narrow plunge pool with a maximum depth of 1.7′ located directly downstream of the structure. A second pool exists directly upstream of the structure. Higher flows have apparently created lower velocity refuges downstream of the structure. This structure is definitely a passage barrier at lower flows. The structure is very wide, making for very shallow flow at the lip and across the upstream apron. There is a side channel on the east side of the structure that offers the best potential for passage.

A second potential barrier was observed at the upstream extent of the survey. Arroyo Mocho as it flows under Wente Rd. is culverted with six approximately 40″ oval culverts to channel the flow. The culverts appear to be well designed, running parallel to the streamflow with little elevation change over the course of the culverts, culverts placed in a variety of elevations to handle a variety of flow regimes, and the lowest culverts emptying at the standing water level. Additionally, expansive lower velocity refuges exist on both sides of the channel downstream of the culverts.

With the exception of the two potential barriers mentioned, all other road crossings observed were at bridges that offered no anticipated barriers to migration.

Unit Description: Murrietta's Well to South Bay Aqueduct.
Survey Date: September 29, 1999
Channel Description: Natural channel with gravel-cobble substrate and riffle/run habitat predominant at the time of the survey
Flow: 10-12 cfs due to releases from Aqueduct
Shading: Variable from almost none to about 90%
Spawning / Rearing Potential: Water temperature was fairly cool at 21.5 C at about 11:00 (air temperature 29 C). Embeddedness was generally low (less than 25% with interstitial spaces present and little to no compaction. Spawning rearing, and migration conditions in this reach are greatly influenced by releases to the stream from the South Bay Aqueduct.
Potential Barriers: None observed

Unit Description: South Bay Aqueduct to first Mines Rd. Bridge upstream from del Valle turnoff.
Survey Date: September 29, 1999
Channel Description: Stream dry from Aqueduct upstream to 6957 Mines Rd. Trickle of flow upstream and about 0.1 cfs at the USGS gage site. Two pools with average depth of 0.5 ft and maximum depth of 1.2 ft near USGS gauge.
Flow: 0.0 to 0.1 cfs
Shading: Variable, generally less than 25%
Spawning / Rearing Potential: Water temperature was fairly cool at 20.5 C at about 11:45 (air temperature 27 C). Embeddedness was generally low (less than 25% with interstitial spaces present and little to no compaction). Roach (1-4") were abundant in pools. Trout have been captured at this location by CDFG (1976), Scopettone and Smith (1978), and Alameda County (June 1999). This reach has potential for spawning and rearing but is not expected to support high numbers of fish.
Potential Barriers: None observed

Unit Description: First Mines Rd. Bridge upstream from del Valle turnoff to near Rancho los Mochos scout camp .
Survey Date: September 29, 1999
Channel Description: Arroyo Mocho runs through canyon far below road and most of the reach was only observed from a distance. There appeared to be sections with flow of 1-3 cfs and other sections with pockets of standing water. Boulders were more prevalent in the streambed than downstream locations. Observations near the LLNL access road on 11-18-99 included the presence of several shallow pools and a relatively open channel upstream of the road crossing. Downstream there was more riparian vegetation and good shading. Large boulders were present in the channel and deeper scour pools and pocket water were formed around them. Roach (adult and young) and suckers (young-of-year) were seen downstream of the crossing, though not very abundant. Aquatic invertebrates were relatively abundant on the underside of cobbles and included mayfly and caddis larvae. A single trout of 6-8 inches was seen upstream of the crossing. There was abundant algal growth, particularly upstream in the more open channel. The substrate was composed of cobble, gravel, and sand with some suitable spawning substrate in pool tails. The stream flows at the road crossing at just about all time according to S. Mathews of LLNL. The canyon walls are steep and oriented to provide good topographic shading during much of the day.
Shading: Variable, potential topographic shading
Spawning / Rearing Potential: Trout have been found in this reach by CDFG (1976) and Scopettone and Smith (1978). Water temperature at upper end of reach was 20 C at 13:43 (air temp 29). An isolated pool with average depth of 0.8 ft and maximum depth of 1.9 feet supported numerous roach (1-3 inches), some suckers up to 4 inches, and tadpoles-possibly foothill yellow-leg frogs.
Potential Barriers: The access road to the LLNL pumping plant is a concrete pad and downstream apron extending the full width of the channel (about 65 feet) and extending from the upper edge of the road to a large pool downstream of the road (42 feet of channel length). The lower 20 feet of concrete apron drops about 6 feet to the pool. There is a lip at the bottom about 1.5 feet above the pool surface. The pool is about 3.4

feet deep at the base of the apron and there is evidence that the pool surface is 2.5 to 3 feet higher during high flow conditions. Measurements collected on 11-18-99 indicate that the crossing would have an unfortunate combination of shallow depths and high velocity during stormflows. Preliminary calculations indicate that a flow of about 130 cfs would provide minimum depth needed for passage but that flow velocity would be near the upper end of steelhead burst swimming speed. More detailed observations during high stream flow should be completed to verify this analysis.

Unit Description: Near Rancho los Mochos scout camp to County Line.
Survey Date: September 29, 1999
Channel Description: Dry stream bed interspersed with sections with minimal flow and standing pools.
Shading: Canopy 25-50%, mostly small willows
Spawning / Rearing Potential: Pools have potential to hold trout. Pools were thermally stratified with water temperatures ranging from 15-17 C around 15:00 with air temperature of about 32 C. Pools averaged about 8 feet wide with average depth of 0.3 to 0.8 feet and max depth of 0.7 to 2.1 feet. Food production may be low due to small amount of riffle habitat. Spawning habitat is low, fine sediments relatively high. Substrate is cobble/gravel/sand with relatively high embeddness and minimal interstitial space. Pool habitat was about 56% of the length of one section surveyed.
Potential Barriers: None observed

II Major Tributaries to Arroyo Mocho

Arroyo las Positas

Unit Description: From its confluence with Arroyo Mocho upstream through Arroyo las Positas and its tributaries.
Survey Date: September 27, 1999
Channel Description: Heavily incised channel running mainly through commercial, agricultural, and ranchlands. Flood control channel in lower section with a more natural area upstream where predominant substrate is silt.
Flow: Minor flows, dependent upon releases from Lawrence Livermore National Laboratory.
Shading: Minimal
Spawning / Rearing Potential: None. Through agricultural and grasslands, channel is heavily grazed along its length and water is highly turbid.. Substrate is predominantly silt through all areas observed. Several tributaries to Arroyo Las Positas (Altamont Creek, Cayetano Creek, Collier Canyon, Arroyo Seco, and Cottonwood Creek) were also surveyed and also offered no suitable spawning or rearing habitat. In each case, these creeks either cut through heavily used agricultural / ranch lands or were hardened flood control channels with no restoration potential.
Potential Barriers: No structural barriers to migration were observed.

Tassajara Creek

Unit Description: Mostly natural channel draining areas south of Mt. Diablo entering Arroyo Mocho in a flood control channel in Pleasanton.
Survey Date: September 29, 1999
Channel Description: The creek currently consists of two distinct channel segments with an indeterminate connection. The lowermost section is a flood control channel that extends from the confluence with Arroyo Mocho north to near Dublin Boulevard. The northern section is a fairly natural section that contains a thin, but functional stream buffer surrounding a series of pools and riffles. Connecting the two sections is an area currently experiencing rapid development of single family homes and associated roadways. An additional length of the creek is currently being converted into flood control channel.
Flow: At the time of the survey, the northern segment contained flows of approximately 1 cfs. Flow was diverted near the construction area and no flow exited into the flood control channel.
Shading: Minimal in flood control channel; moderate in higher sections
Spawning / Rearing Potential: Unknown.
Potential Barriers: Unable to verify due to construction in channel.

ARROYO VALLE

Unit Description: Constrained channel running through Pleasanton extending from confluence with Arroyo de la Laguna upstream to pedestrian bridge just below Shadow Cliffs Regional Park.
Survey Date: September 29, 1999
Channel Description: Channelized urban stream bordered mostly by riprap sides and pervious bottom. Predominant substrate is silt.
Flow: During survey, very minimal flows were witnessed. Majority of anticipated flows in this reach are dictated by releases at del Valle Dam, operated by California Department of Water Resources.
Shading: Shading was moderate to full throughout the areas observed.
Spawning / Rearing Potential: No habitat offering good potential as spawning or rearing habitat was observed. Elevated water temperatures, little meandering, and backwater conditions characterize this segment. Bluegill, largemouth bass, and squawfish were predominant in this section.
Potential Barriers: One potential barrier was observed in this section, a vertical drop structure that extends for approximately 10′ of the channel length. At the time of the survey, the structure was approximately 0.5′ above the downstream water level.

Unit Description: Wide impounded water areas running along Shadow Cliffs Regional Park from pedestrian bridge westward.
Survey Date: September 29, 1999

Channel Description: Wide channel (approximately 150′ wetted at the time of survey), very low gradient with heavy sedimentation and channel vegetation (cattails, willows) throughout the unit.
Flow: During survey, very minimal flows were witnessed. Majority of anticipated flows in this reach are dictated by releases at Del Valle Dam, operated by California Department of Water Resources.
Shading: Shading was low throughout the unit.
Spawning / Rearing Potential: No habitat offering good potential as spawning or rearing habitat was observed. Little shading, elevated water temperatures, and backwater conditions characterize the segment.
Potential Barriers: No structural barriers were noted in the segment

ALAMEDA CREEK, SUNOL-OHLONE REGIONAL WILDERNESS AREA

Unit Description: Mainstem, Little Yosemite to Alameda Creek Diversion
Survey Date: October 4, 1999
Channel Description: Natural throughout its entirety. At the time of the survey, there were dry sections separating mixed riffle and pool habitats. Channel substrate is mostly gravel / cobble, with an increasing abundance of larger substrate near the Alameda Creek diversion structure.
Flow: Minimal, ranging between an estimated < 0.1 cfs to 0.2 cfs in the wetted sections.
Shading: Low, typically < 30%.
Spawning / Rearing Potential: Spawnable habitat was observed in association with each of the pools surveyed, ranging from an estimated 10 to 45 ft^2 per habitat unit. Benthic invertebrates were typically seen in moderate to abundant numbers. Trout were observed in most of the pools encountered, ranging from Y-O-Y to a maximum observed length of 12″. Additionally, abundant roach and several foothill yellow-leg frogs were observed. Water temperatures ranged from a high of 19.5 C (at 1215) to a low of 16 C (at 1125).
Potential Barriers: Potential natural barrier at Little Yosemite.

Unit Description: Mainstem, Alameda Creek Diversion to just south of Camp Ohlone
Survey Date: October 4, 1999
Channel Description: Natural throughout its entirety. This section is comprised of three fairly distinct subsections: (1) a low gradient section in the lowest part of the section, (2) a higher gradient intermediate section, and (3) a return to a lower gradient section. The initial lower gradient sections of the stream (approximately 60 to 65% of the section length) were mixed riffle and pool habitat. Farther from the dam, the higher gradient sections had larger substrate (cobble and boulder) and deeper pools. A lower gradient section followed the cobble / boulder section and extended through to the Camp Ohlone area.
Flow: With the exception of the first 100 - 150 ft directly upstream of the diversion dam (being dredged at the time of survey), this entire section was observed with flows of between 5 and 10 cfs. There are no upstream structures to regulate flow through this section.
Shading: Moderate to good throughout most of section, with the exception of two areas

devoid of shading of approximately 800′ and 1000′ respectively.
Spawning / Rearing Potential: Gravel appropriate for spawning is associated with most of the pools. Abundant numbers of trout were observed in most pools, ranging from Y-O-Y up to 10″. An abundant number of roach and one unidentified centrarchid were also observed. Sampled water temperatures ranged from 18 – 19 C.
Potential Barriers: The Alameda Creek Diversion Dam is currently an impassable barrier. The natural barriers within the section, similar but lower gradient than Little Yosemite, do not appear to pose an impassable barrier.

Unit Description: Mainstem, Camp Ohlone upstream
Survey Date: October 4, 1999
Channel Description: This section is comprised of four fairly distinct subsections: (1) a section of fairly long, shallow pools separated by short riffles or hydraulic controls that make up approximately 10% of the total surveyed section length, (2) a section of dry units separating shorter, deeper pools at the edges of the channel making up approximately 20% of the section, (3) a long, completely dry section making up approximately 60% of the section, and (4) a section with very good pool and riffle habit that made up the remainder of the surveyed length and continued beyond.
Flow: Zero to minimal flows in the lower three subsections; consistent flows of between 0.1 to 0.5 cfs in the uppermost section. There are no upstream structures to regulate flow through this section.
Shading: Little shading in the lower three subsections, generally less than 25%. Moderate to good shading in the uppermost section (low of 30% to a high of 90%).
Spawning / Rearing Potential: Spawnable habitat was observed in association with many of the pools surveyed. Benthic invertebrates, mainly caddisflies, stoneflies, and mayflies, were in at least moderate abundance in the majority of pools. Trout were observed in most of the pools encountered, ranging from Y-O-Y to a maximum observed length of 8″. Abundant roach were also observed and foothill yellow-leg frogs were abundant in places, particularly the first (lowest) section . Water temperatures ranged from a high of 21.5 C (in a stratified pool in one of the lower sections) to a low of 15 C in the uppermost section. Pools were thermally stratified.
Potential Barriers: No barriers to migration were observed in this section, however, the downstream Alameda Diversion Dam is currently an impassable barrier to upstream migration and the Little Yosemite area may be impassable under some flow conditions.

Appendix 3

DOCUMENTATION OF SALMONIDS WITHIN ALAMEDA CREEK

Following is a compilation of data obtained from historic reported sightings of salmonids within the Alameda Creek Watershed. The list was compiled from published literature and unpublished monitoring data from within the watershed.

Reach	Stream	Date	Location	Number	Ageclass	Reference
Alameda Creek Flood Control Channel	Alameda Creek	12/5/98	ACFCC	1 Chinook, decomposing	762 mm	Alameda County Public Works
Alameda Creek Flood Control Channel	Alameda Creek	2/5/99	ACFCC	1	615 mm	Alameda County Public Works
Alameda Creek Flood Control Channel	Alameda Creek	2/23/99	ACFCC	4	468-692 mm	Alameda County Public Works
Niles Canyon[1]	Alameda Creek	3/25/57	Opposite Niles nursery	3	Half grown	Follett and Peckham (Cited in Leidy 1984)
Niles Canyon	Alameda Creek	7/24/27	immediately below dam in Niles Canyon	1	large young	W.I. Follett (Cited in Leidy 1984)
Niles Canyon	Stoneybrook Canyon Creek	10/13/55	ca. 1.5 miles above junction with Alameda Creek, elev. 600'	20	TL 3-7 in	Follett and Peckham (Cited in Leidy 1984)
Niles Canyon	Stoneybrook Canyon Creek	10/31/55	ca. 1.2 miles above junciton with Alameda Creek	5	TL ca. 2 in.	Follett and Peckham (Cited in Leidy 1984)

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[1] Sample location was identified as “opposite Niles nursery (Calif. Nursery Co.)” in Leidy 1984. Assumption is made that the California Nursery Company was located either in the town of Niles or upstream within the canyon, exact location unkown.

Reach	Stream	Date	Location	Number	Ageclass	Reference
Niles Canyon	Stoneybrook Canyon Creek	4/8/76	100 yds upstream from Alameda Creek	1	FL 10 in	CDFG (Cited in Leidy 1984)
Niles Canyon	Stoneybrook Canyon Creek	4/14/99	n.r.	8	189-335 mm	Alameda County Public Works
Upper Alameda Creek	Alameda Creek-SF Filter Plant to Calaveras Creek	10/24/96	Just downstream of Sunol Park boundary	10	FL 62-87 mm	EBRPD
Upper Alameda Creek	Alameda Creek-SF Filter Plant to Calaveras Creek	6/3/97	EBRPD station 2 in Sunol Regional Park	2	10-18 in	EBRPD
Upper Alameda Creek	Alameda Creek-SF Filter Plant to Calaveras Creek	6/3/97	EBRPD Station 3 in Sunol Regional Park	1	FL 196 mm	EBRPD
Upper Alameda Creek	Alameda Creek-Calaveras Creek to Alameda Diversion	n.r.	0.5 km upstream from Calaveras Creek	n.r	n.r	Scoppetone and Smith 1978)
Upper Alameda Creek	Alameda Creek-Calaveras Creek to Alameda Diversion	10/31/95	Little Yosemite, 2 pools at bottom of trail amongst boulders	4	FL 113-188 mm	EBRPD
Upper Alameda Creek	Alameda Creek-Calaveras Creek to Alameda Diversion	10/31/95	EBRPD station below Calaveras Diversion	24	FL 71-189 mm	EBRPD
Upper Alameda Creek	Alameda Creek-Calaveras Creek to Alameda Diversion	10/30/96	boulder pools below rockfalls at Little Yosemite	54	FL 57-182 mm	EBRPD
Upper Alameda Creek	Alameda Creek-Calaveras Creek to Alameda Diversion	10/30/96	Pool below diversion dam	18	FL 75-282 mm	EBRPD

Reach	Stream	Date	Location	Number	Ageclass	Reference
Upper Alameda Creek	Alameda Creek-Calaveras Creek to Alameda Diversion	7/3/97	0.25 mi below Little Yosemite	6	FL 54-102 mm	EBRPD
Upper Alameda Creek	Alameda Creek-upstream of Alameda Diversion	n.r.	Milepost 5, Ohlone Camp Rd.	63	n.r.	Scoppetone and Smith 1978
Upper Alameda Creek	Alameda Creek-upstream of Alameda Diversion	10/23/95	EBRPD Station AO-02-95 in Camp Ohlone	10	FL 88-207 mm	EBRPD
Upper Alameda Creek	Alameda Creek-upstream of Alameda Diversion	10/23/95	Camp Ohlone, just above Laurel Camp stream crossing. EBRPD Station AO-03-95	24	FL 101-212 mm	EBRPD
Upper Alameda Creek	Alameda Creek-upstream of Alameda Diversion	10/16/96	EBRPD Station AO-33-96 in Camp Ohlone	43	FL 50-240 mm	EBRPD
Upper Alameda Creek	Alameda Creek-upstream of Alameda Diversion	10/16/96	EBRPD Station AO-34 in Camp Ohlone	15	FL 70-230 mm	EBRPD
Upper Alameda Creek	Alameda Creek-upstream of Alameda Diversion	10/16/96	Camp Ohlone, middle section	2	FL 200 mm	EBRPD
Upper Alameda Creek	Alameda Creek-upstream of Alameda Diversion	10/24/96	EBRPD Station AO-20-96 in Camp Ohlone	20	FL 61-254 mm	EBRPD

Reach	Stream	Date	Location	Number	Ageclass	Reference
Upper Alameda Creek	Alameda Creek-upstream of Alameda Diversion	10/24/96	EBRPD Station AO-02B2 in Camp Ohlone	9	FL 62-85 mm	EBRPD
Upper Alameda Creek	Alameda Creek-upstream of Alameda Diversion	10/24/96	EBRPD Station AO-02 in Camp Ohlone	22	FL 59-222 mm	EBRPD
Upper Alameda Creek	Alameda Creek-upstream of Alameda Diversion	10/24/96	EBRPD Station AO-34 in Camp Ohlone	66	FL 60-214 mm	EBRPD
Upper Alameda Creek	Alameda Creek-upstream of Alameda Diversion	10/30/96	Above diversion dam	19	FL 66-217 mm	EBRPD
Upper Alameda Creek	Alameda Creek-upstream of Alameda Diversion	7/7/97	Upstream of northern Camp Ohlone border	14	FL 51-200 mm	EBRPD
Upper Alameda Creek	Indian Joe Creek	6/12/97	At Alameda Creek confluence	9	FL 44-154 mm	EBRPD
Upper Alameda Creek	Indian Joe Creek	6/24/99	100 yds upstream from Alameda Creek	63	FL 38-68 mm	EBRPD
Upper Alameda Creek	Pirate Creek	6/24/99	Plunge pool at culvert past ranch house # 1501 off Calaveras Rd	5	FL 161-207 mm	Alameda County Public Works
Upper Alameda Creek	W Tree Creek	6/15/99	Ca. 75 ft upstream of “road”	12	FL 53-60 mm	EBRPD
Upper Alameda Creek	Welch Creek	6/18/99	295 m upstream of Alameda Creek confluence	1	139 mm	Alameda County Public Works

Reach	Stream	Date	Location	Number	Ageclass	Reference
Upper Alameda Creek	Welch Creek	6/18/99	310 m upstream of Alameda Creek confluence	1	183 mm	Alameda County Public Works
Upper Alameda Creek	Welch Creek	6/18/99	20 m down road from .24 mile marker	1	236mm + "parr found in many of the pools"	Alameda County Public Works
Upper Alameda Creek	Welch Creek	6/18/99	300 m upstream of Alameda Creek confluence	1	273 mm	Alameda County Public Works
Arroyo de la Laguna	Arroyo de la Laguna	n.r.		n.r.	n.r.	Skinner 1962 (Cited in Leidy 1984)
Arroyo del Valle	Arroyo del Valle	n.r.		n.r.	n.r.	Skinner 1962 (Cited in Leidy 1984)
Arroyo Mocho	Arroyo Mocho	n.r.	1 km above Del Valle Road	n.r.	n.r.	Scoppetone and Smith 1978
Arroyo Mocho	Arroyo Mocho	n.r.		n.r.	n.r.	Skinner 1962 (Cited in Leidy 1984)
Arroyo Mocho	Arroyo Mocho	n.r.	Lawrence Laboratory pumping station	n.r.	n.r.	Scoppetone and Smith 1978
Arroyo Mocho	Arroyo Mocho	2/3/76	Cedar Brook Ranch	27	67-318 mm	CDFG (Cited in Leidy 1984)
Arroyo Mocho	Arroyo Mocho	2/3/76	Lawrence Laboratory pumping station	12	FL 68-172	CDFG (Cited in Leidy 1984)
Arroyo Mocho	Arroyo Mocho	2/3/76	on Mines lRoad approx. 0.5 miles above Del Valle Road	5	FL 165-233 mm	CDFG (Cited in Leidy 1984)
Arroyo Mocho	Arroyo Mocho	6/18/99	At USGS Station on Mines Rd	1	212 mm	Alameda County Public Works

Appendix 4

ALAMEDA CREEK STEELHEAD SIGHTINGS

The following data was excerpted from R. Leidy's research within the Alameda Creek Watershed. C
http://www.sfei.org.

REACH	STREAM	DATE	SAMPLE LOCATION	# OF YOY TROUT	# OF JUVENILE TROUT	# OF ADULT TROUT	TOTAL # OF TROUT
Alameda Creek-Flood Control Channel	Alameda Creek	8/2/93	Alameda Ck, at isolated pool 400 m downstream from Isherwood Way bridge	0	0	0	0
Alameda Creek-Flood Control Channel	Alameda Creek	8/2/93	Alameda Ck, downstream of Alvarado Rd, opposite Falcon Dr/Lowry Rd junction	0	0	0	0
Alameda Creek-Flood Control Channel	Alameda Creek	10/18/93	Alameda Ck, at Alameda Flood Control Park, opposite Kaiser Quarry	0	0	0	0
Niles Canyon	Alameda Creek	4/29/92	Alameda Ck, 1 km downstream from confluence with Arroyo Laguna Ck	0	0	0	0
Niles Canyon	Alameda Creek	5/7/92	Alameda Ck, 0.3 km upstream from railroad tunnel at entrance to SFWD access road	0	0	2	2

REACH	STREAM	DATE	SAMPLE LOCATION	# OF YOY TROUT	# OF JUVENILE TROUT	# OF ADULT TROUT	TOTAL # OF TROUT
Niles Canyon	Alameda Creek	3/24/93	Alameda Ck, 0.3 km upstream from railroad tunnel at entrance to SFWD access road	0	0	0	0
Niles Canyon	Alameda Creek	3/24/93	Alameda Ck, 0.4 km upstream from railroad tunnel at entrance to SFWD access road	0	0	0	0
Niles Canyon	Alameda Creek	3/24/93	Alameda Ck, 0.45 km upstream from railroad tunnel at entrance to SFWD access road	0	0	0	0
Niles Canyon	Alameda Creek	8/10/93	Alameda Ck, at pool immediately downstream of Old Spring Valley Water Co. Diversion	0	0	0	0
Niles Canyon	Alameda Creek	8/10/93	Alameda Ck, opposite Pacific Nursery, 0.5 km downstream from Old Spring Valley Water Co. Diversion	0	0	0	0
Niles Canyon	Alameda Creek	10/19/93	Alameda Ck, at pool immediately downstream of Old Spring Valley Water Co. Diversion	0	0	1	1
Niles Canyon	Alameda Creek	11/18/93	Alameda Ck, at pool immediately downstream of Old Spring Valley Water Co. Diversion	0	0	0	0

REACH	STREAM	DATE	SAMPLE LOCATION	# OF YOY TROUT	# OF JUVENILE TROUT	# OF ADULT TROUT	TOTAL # OF TROUT
Niles Canyon	Alameda Creek	4/27/94	Alameda Ck, at pool immediately downstream of Old Spring Valley Water Co. Diversion	0	0	0	0
Niles Canyon	Alameda Creek	8/30/96	Alameda Ck, at base of Old Spring Valley Water Co. Diversion Dam	0	0	0	0
Niles Canyon	Alameda Creek	8/30/96	Alameda Ck, immediately downstream of Old Spring Valley Water Co. Diversion Dam (run-pool-riffle area)	0	0	0	0
Upper Alameda Creek	Alameda Creek-Arroyo Laguna to SF Filter Plant	4/29/92	Alameda Ck, 100 m upstream from confluence with Arroyo de la Laguna Ck	0	0	0	0
Upper Alameda Creek	Alameda Creek-Arroyo Laguna to SF Filter Plant	5/28/93	Alameda Ck, 50 m downstream from confluence with Arroyo Laguna Ck	0	0	0	0
Upper Alameda Creek	Alameda Creek-Arroyo Laguna to SF Filter Plant	6/3/93	Alameda Ck, at treatment plant bridge 0.6 km downstream of Calaveras Rd. crossing	0	0	0	0
Upper Alameda Creek	Alameda Creek-Arroyo Laguna to SF Filter Plant	4/27/94	Alameda Ck, 100 m downstream of Highway 680 crossing	0	0	0	0

REACH	STREAM	DATE	SAMPLE LOCATION	# OF YOY TROUT	# OF JUVENILE TROUT	# OF ADULT TROUT	TOTAL # OF TROUT
Upper Alameda Creek	Alameda Creek-Arroyo Laguna to SF Filter Plant	4/27/94	Alameda Ck, 400 m downstream from Highway 680 crossing, at bluff base adjacent to golf course	0	0	0	0
Upper Alameda Creek	Alameda Creek-SF Filter Plant to Little Yosemite	4/10/92	Alameda Ck, 75 m upstream from confluence with Calaveras Creek	0	0	0	0
Upper Alameda Creek	Alameda Creek-SF Filter Plant to Little Yosemite	6/18/92	Alameda Ck, below Little Yosemite bedrock falls	7	7	9	23
Upper Alameda Creek	Alameda Creek-SF Filter Plant to Little Yosemite	9/17/92	Alameda Ck, at Little Yosemite, 100 m downstream from cattle grate on dirt road	50	50	11	111
Upper Alameda Creek	Alameda Creek-SF Filter Plant to Little Yosemite	5/26/93	Alameda Ck, 200 m upstream from crossing of wooden car bridge above staging area	0	0	0	0
Upper Alameda Creek	Alameda Creek-SF Filter Plant to Little Yosemite	8/2/93	Alameda Ck, 0.8 km upstream from Old Canyon Rd. bridge crossing	0	0	0	0
Upper Alameda Creek	Alameda Creek-Little Yosemite to Alameda Diversion	6/18/92	Alameda Ck, 1.2 km downstream from Alameda Diversion Tunnel Dam	0	0	4	4

REACH	STREAM	DATE	SAMPLE LOCATION	# OF YOY TROUT	# OF JUVENILE TROUT	# OF ADULT TROUT	TOTAL # OF TROUT
Upper Alameda Creek	Alameda Creek-Little Yosemite to Alameda Diversion	8/10/93	Alameda Ck, 400 m downstream from Alameda Diversion Tunnel Dam	0	4	1	5
Upper Alameda Creek	Alameda Creek-Little Yosemite to Alameda Diversion	8/10/93	Alameda Ck, approx. 350 m downstream from Alameda Diversion Tunnel Dam	1	10	3	14
Upper Alameda Creek	Alameda Creek-Little Yosemite to Alameda Diversion	8/10/93	Alameda Ck, immediately downstream from Alameda Diversion Tunnel Dam	0	5	2	7
Upper Alameda Creek	Alameda Creek-above Alameda Diversion	2/7/92	Alameda Ck, at rock cascade pools approx. 0.8 km downstream of Camp Ohlone	1	4	7	12
Upper Alameda Creek	Alameda Creek-above Alameda Diversion	4/10/92	Alameda Ck, 0.8 km downstream from Camp Ohlone at bottom of rock plunge pool.	0	4	1	5
Upper Alameda Creek	Alameda Creek-above Alameda Diversion	6/11/92	Alameda Ck, approx. 0.8 km downstream of Camp Ohlone, at bedrock-boulder reach	16	1	2	19
Upper Alameda Creek	Alameda Creek-above Alameda Diversion	9/17/92	Alameda Ck at rock falls area approx. 0.75 km downstream of Camp Ohlone	330	170	16	516

REACH	STREAM	DATE	SAMPLE LOCATION	# OF YOY TROUT	# OF JUVENILE TROUT	# OF ADULT TROUT	TOTAL # OF TROUT
Upper Alameda Creek	Alameda Creek-above Alameda Diversion	11/14/92	Alameda Ck, at Camp Ohlone, directly opposite entrance, approx. 100 m upstream of road crossing.	0	0	0	0
Upper Alameda Creek	Alameda Creek-above Alameda Diversion	11/14/92	Alameda Ck, at Camp Ohlone, opposite Walnut Orchard.	0	0	0	0
Upper Alameda Creek	Alameda Creek-above Alameda Diversion	11/14/92	Alameda Ck, at Camp Ohlone. Isolated pools across from Caretaker's residence-2 pools 100 m apart.	0	0	0	0
Upper Alameda Creek	Alameda Creek-above Alameda Diversion	5/26/93	Alameda Ck, approx. 0.75 km downstream from Camp Ohlone, at bedrock falls area	5	8	9	22
Upper Alameda Creek	Alameda Creek-above Alameda Diversion	5/26/93	Alameda Ck, approx. 0.75 km downstream from Camp Ohlone, at bedrock falls area	5	1	4	10
Upper Alameda Creek	Alameda Creek-above Alameda Diversion	11/19/93	Alameda Ck, at Camp Ohlone immediately opposite Caretaker's residence.	0	2	0	2
Upper Alameda Creek	Indian Joe Creek	2/5/97	Indian Joe Ck, 0.3 km upstream from road crossing along San Antonio Reservoir	1	3	0	4

REACH	STREAM	DATE	SAMPLE LOCATION	# OF YOY TROUT	# OF JUVENILE TROUT	# OF ADULT TROUT	TOTAL # OF TROUT
Upper Alameda Creek	La Costa	10/1/93	La Costa Ck, 400 m upstream from confluence with San Antonio Ck	10	5	0	15
Upper Alameda Creek	La Costa	10/14/93	La Costa Ck, 100 m downstream from ranch house at SFWD property boundary	12	6	0	18
Upper Alameda Creek	La Costa	10/14/93	La Costa Ck, 400 m upstream from confluence with San Antonio Ck	1	4	2	7
Upper Alameda Creek	San Antonio	2/5/97	San Antonio Ck, at first upstream road crossing from reservoir	3	7	0	10
Upper Alameda Creek	San Antonio	2/5/97	San Antonio Ck, from confluence with La Costa Ck, upstream 30 m	9	4	0	13
Upper Alameda Creek	Vallecitos Creek	10/14/93	Vallecitos Ck, at South Bay Aqueduct input, at San Antonio Rd crossing	0	0	0	0
Upper Alameda Creek	Arroyo Hondo Creek	9/21/93	Arroyo Hondo Ck, 0.3 km upstream of Marsh Rd. bridge, above Calaveras Reservoir	2	3	1	6
Upper Alameda Creek	Arroyo Hondo Creek	9/21/93	Arroyo Hondo Ck, 0.25 km upstream of Marsh Rd. bridge, above Calaveras Reservoir	1	2	0	3

REACH	STREAM	DATE	SAMPLE LOCATION	# OF YOY TROUT	# OF JUVENILE TROUT	# OF ADULT TROUT	TOTAL # OF TROUT
Upper Alameda Creek	Arroyo Hondo Creek	9/30/93	Arroyo Hondo Ck, 1.25 km upstream of Marsh Rd. bridge, above Calaveras Reservoir	1	2	0	3
Upper Alameda Creek	Arroyo Hondo Creek	9/30/93	Arroyo Hondo Ck, 1.25 km upstream of Marsh Rd. bridge, above Calaveras Reservoir	2	2	3	7
Upper Alameda Creek	Arroyo Hondo Creek	9/30/93	Arroyo Hondo Ck, 1 km upstream from Marsh Rd. bridge, above Calaveras Reservoir	12	1	0	13
Arroyo de la Laguna	Arroyo de la Laguna	3/22/93	Arroyo Laguna Ck, 100 m upstream from confluence with Alameda Ck	0	0	0	0
Arroyo de la Laguna	Arroyo de la Laguna	5/28/93	Arroyo Laguna Ck, 250 m upstream from confluence with Alameda Ck	0	0	0	0
Arroyo de la Laguna	Arroyo de la Laguna	5/28/93	Arroyo Laguna Ck, just upstream of confluence with Alameda Ck	0	0	0	0
Arroyo de la Laguna	Arroyo de la Laguna	6/2/93	Arroyo Laguna Ck, 0.8 km upstream from Highway 84 bridge crossing	0	0	0	0
Arroyo de la Laguna	Arroyo de la Laguna	6/2/93	Arroyo Laguna Ck, just downstream of abandoned railroad bridge crossing	0	0	0	0

REACH	STREAM	DATE	SAMPLE LOCATION	# OF YOY TROUT	# OF JUVENILE TROUT	# OF ADULT TROUT	TOTAL # OF TROUT
Arroyo de la Laguna	Arroyo de la Laguna	6/3/93	Arroyo Laguna Ck, at footbridge crossing off Pleasanton-Sunol Rd (pool downstream of bridge)	0	0	0	0
Arroyo de la Laguna	Arroyo de la Laguna	6/3/93	Arroyo Laguna Ck, at footbridge crossing off Pleasanton-Sunol Rd (pool upstream of bridge)	0	0	0	0
Arroyo de la Laguna	Arroyo de la Laguna	10/19/93	Arroyo Laguna Ck, just upstream of confluence with Alameda Ck	0	0	0	0
Arroyo de la Laguna	Arroyo de la Laguna	12/30/93	Arroyo Laguna Ck, 0.5 km downstream from Bernal Rd bridge	0	0	0	0
Arroyo de la Laguna	Arroyo de la Laguna	12/30/93	Arroyo Laguna Ck, just upstream of Castlewood Rd bridge	0	0	0	0
Arroyo de la Laguna	Arroyo de la Laguna	5/4/94	Arroyo Laguna Ck, just upstream of Bernal Rd bridge	0	0	0	0
Arroyo de la Laguna	Arroyo de la Laguna	7/18/96	Arroyo Laguna Ck, at Castlewood Rd bridge	0	0	0	0
Arroyo del Valle	Arroyo del Valle	8/11/93	Arroyo del Valle Ck, opposite Veterans Administration Hospital, below Del Valle Reservoir	0	0	0	0
Arroyo del Valle	Arroyo del Valle	5/4/94	Arroyo del Valle Ck, at Bernal Corporate Park	0	0	0	0

REACH	STREAM	DATE	SAMPLE LOCATION	# OF YOY TROUT	# OF JUVENILE TROUT	# OF ADULT TROUT	TOTAL # OF TROUT
Arroyo del Valle	Arroyo del Valle	7/18/96	Arroyo del Valle Ck, opposite North Creek Business Park, 0.8 km upstream from confluence with Arroyo Laguna Ck	0	0	0	0
Arroyo Mocho	Arroyo Mocho	12/30/93	Arroyo Mocho Ck, at Wente Rd. crossing	0	0	0	0