Summary and Analysis of Annual Fishery Monitoring in the Lower Santa Ynez River

1993-2004

Santa Ynez River Adaptive Management Committee

June 2009

SUMMARY AND ANALYSIS OF ANNUAL FISHERY MONITORING IN THE LOWER SANTA YNEZ RIVER 1993 – 2004

Prepared by:

Santa Ynez River Technical Advisory Committee,
Adaptive Management Committee

Contact Information:

Timothy H. Robinson, Ph.D.
Sr. Resource Scientist,
Cachuma Conservation Release Board (CCRB)
3301 Laurel Canyon Road
Santa Barbara, CA 93105-2017

805-569-1391

June 30, 2009

TABLES

FIGURES

AFY	acre-feet per year
AMC	Adaptive Management Committee
BA	Biological Assessment
BMI	Benthic macroinvertebrates/aquatic insects
BO	Biological Opinion
Caltrans	California Transportation Department
CBW	California Bioassessment Worksheet
CC	Consensus Committee
CCRB	Cachuma Conservation Release Board
CDFG	California Department of Fish and Game
CEMR	Center for Ecosystem Management and Restoration
cfs	cubic feet per second
CIMIS	California Irrigation Management Information System
CPWA	Cachuma Project Water Agency
CPUE	catch-per-unit-effort
DO	Dissolved oxygen
DPS	Distinct Population Segment
EPA	U.S. Environmental Protection Agency
EPT Ratio	Ratio of *Ephemeroptera, Plecoptera* and *Tricoptera* taxa
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
F.I.S.H.	Funding for Improved Salmonid Habitat
FMP	Fish Management Plan
GIS	geographic information system
GPS	Global Positioning System
HCP	Habitat Conservation Plan
HCWS	Hilton Creek Watering System
LSYR	Lower Santa Ynez River
NMFS	National Marine Fisheries Service
NTU	Nephelometric Turbidity Units
MOU	Memoranda of Understanding
ORP	oxidation-reduction potential
pH	potential of hydrogen
PIT	passive integrated transponder
RM	river miles
RTDG	Real Time Decision Making Group
SWP	State Water Project
SWRCB	State Water Resources Control Board
SYRTAC	Santa Ynez River Technical Advisory Committee
SYRWCD	Santa Ynez River Water Conservation District
TDS	Total dissolved solids
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
VAFB	Vandenberg Air Force Base
YOY	Young-of-the-year
YSI	Yellow Springs Instrument

LIST OF PREPARERS

Chuck Hanson, Ph.D., Hanson Environmental Consulting

Tim Robinson, Ph.D., Cachuma Operation and Maintenance Board (COMB)

Scott Engblom, Cachuma Operation and Maintenance Board (COMB)

Scott Volan, Cachuma Operation and Maintenance Board (COMB)

Jean Baldrige, M.S., Fisheries, ENTRIX, Inc.

Laura Riege, M.S., Biology, ENTRIX, Inc.

Bruce Wales, Ph.D., Santa Ynez River Water Conservation District

Ali Shahroody, Stetson Engineers

Curtis Lawler, Stetson Engineers

Executive Summary

Steelhead (*Oncorhynchus mykiss*) inhabit a number of river systems in California and the Pacific Northwest, including the Lower Santa Ynez River (LSYR) downstream of Bradbury Dam. The LSYR steelhead population, located in Santa Barbara County, California, is part of the Southern California Distinct Population Segment (DPS), formerly the Southern California Evolutionarily Significant Unit (ESU), identified by the National Marine Fisheries Service (NMFS) in 1997 as an endangered species under the federal Endangered Species Act (ESA). The LSYR and tributaries also support a population of resident rainbow trout.

The LSYR has been the focus of a collaborative effort since 1993 to characterize habitat quality, habitat availability, and limiting factors for various life-history stages of steelhead within the lower river and its tributaries. The studies also provide technical information used to identify management actions that protect and enhance habitat conditions anticipated to ultimately contribute to increased population abundance of steelhead/rainbow trout within the river and recovery of the species. Information developed from the 1993-1996 fishery and habitat monitoring program was compiled and analyzed in a 1997 Synthesis Report produced by the Santa Ynez River Technical Advisory Committee (SYRTAC; SYRTAC 1997). The 1997 Synthesis Report was designed to provide the scientific and technical foundation, as it existed through the initial 4-years of the investigations, for use by the SYRTAC and Consensus Committee (CC) in developing the LSYR Fishery Management Plan (FMP; SYRTAC 2000) and guiding subsequent monitoring activities. The fishery and habitat monitoring results were also summarized in the U.S. Bureau of Reclamation Biological Assessment for Cachuma Project Operations and the Lower Santa Ynez River (Proposed Action) (Reclamation 1999 and 2000) and used in the NMFS ESA consultation as part of the technical foundation for developing the NMFS Biological Opinion for Cachuma Project operations (BO; NMFS 2000a). Management actions designed to benefit steelhead are identified in the LSYR FMP and the Proposed Action. Reasonable and Prudent Measures and Terms and Conditions to protect steelhead and its habitat are described in the BO.

Since the 1997 Synthesis Report was prepared, fishery and habitat monitoring has continued on the LSYR over a broad range of hydrologic and environmental conditions affecting habitat within the watershed for steelhead/rainbow trout. Given the high inherent variability in hydrologic conditions occurring within the watershed, no individual year of fishery monitoring can be considered to be representative of conditions on the river affecting steelhead/rainbow trout population dynamics, migration, or geographic distribution. In this updated synthesis report, data from the 12-year monitoring period extending from 1993 through 2004 are used to review long-term trends in steelhead population and environmental conditions in the LSYR and to evaluate the success of management actions that have been implemented during this period. Earlier findings and conclusions from the 1997 Synthesis Report are re-evaluated to further strengthen and refine elements of the FMP. Results of the habitat, water quality, and fishery monitoring program also are examined to identify recommended changes to the program to further refine and improve existing monitoring activities.

The scientific and technical direction of the FMP and Proposed Action activities were delegated by the Proposed Action to an Adaptive Management Committee (AMC). The AMC includes representatives from U.S. Bureau of Reclamation (Reclamation), NMFS, California Department of Fish and Game (CDFG), U.S. Fish and Wildlife Service (USFWS), Cachuma Project Member

Units and the downstream interests represented by the Santa Ynez Water Conservation District (SYRWCD) and City of Lompoc. Implementation of the long-term monitoring program and primary data collection and dissemination has become the responsibility of the Cachuma Conservation Release Board (CCRB) and Santa Ynez River Water Conservation District Improvement District No.1 (ID No. 1) (collectively referred to as the Cachuma Project Water Agencies or CPWA). The CPWA works in close coordination with the AMC to provide monitoring information required under the terms and conditions of the BO and needed to make informed technical and management decisions regarding implementation of actions identified in the FMP and Proposed Action. The monitoring program is two-tiered, including both a long-term monitoring element to provide the continuity of baseline monitoring, and short-duration studies of particular environmental circumstances or events. Both aspects of the monitoring program collect data on fisheries and relevant environmental conditions that can be used effectively by the AMC in evaluating the performance of management actions and developing recommended changes, if needed, to the implementation of the management actions.

This report presents the scientific data collected by the CPWA through their implementation of the monitoring program over the 12-year period from 1993 to 2004. The purpose of the report is to re-evaluate findings and recommendations from the original compilation of monitoring data (SYRTAC 1997) to ascertain (1) if the conclusions of that report still reflect our best understanding of the LSYR system and factors contributing to productive steelhead habitat within the system, (2) if the management actions in place have begun to produce the expected response, and (3) if modifications or refinements to the management actions or monitoring program are warranted. Specific objectives of this 2004 Synthesis Report are to:

- Compile and summarize monitoring data collected on hydrology (Section 2), water quality (Section 3), habitat (Section 4), fishery populations (Section 5), and habitat enhancement actions (Section 6) over the 12-year study period;
- Analyze information collected as part of the 12-year monitoring program to re-evaluate findings and conclusions drawn from the 1997 Synthesis Report;
- Evaluate the success of management actions that have been implemented under the framework of the FMP, Proposed Action, and BO since 2000;
- Compare LSYR fishery management results to other steelhead recovery and monitoring efforts within the DPS to better understand regional trends and management techniques and results (Section 7);
- Improve upon the existing framework for developing a data management and organization system and further refining the monitoring program (Section 8), and
- Make data summaries available for use by resource agencies and interested parties in reviewing the fishery and habitat monitoring plan.

The 2004 Synthesis Report also serves the purposes of providing a compilation of information from previous annual monitoring efforts and provides a technical foundation for future annual reporting.

Summary of Findings

Information collected as part of the 1993-2004 monitoring program on hydrology, water quality, fishery habitat, and characteristics of the steelhead/rainbow trout population on the LSYR has contributed directly to a substantially improved understanding of the river system and the integration of management actions as part of the FMP and Proposed Action into the program. Key findings from these investigations and analyses are presented in the individual sections of this report and have been summarized in Table ES-1. Table ES-1 summarizes findings based on the results of monitoring of flows, water quality, habitat, and fisheries over the 12-year period from 1993 to 2004 for the LSYR and its tributaries. These results and findings are discussed in detail in Sections 2 through 5 of this report.

The results and findings of fishery and habitat monitoring on the LSYR and tributaries (Table

ES-1) are consistent with results and findings presented in the 1997 Synthesis Report. Results of fishery and habitat monitoring over the 12-year period reflect greater variation in hydrologic conditions than the initial 4-year period, however the fundamental conclusions regarding habitat conditions, and the effects of various water quality conditions as potentially limiting factors for steelhead/rainbow trout are similar to the earlier studies (SYRTAC 1997; SYRTAC 2000; NMFS 2000).

Results of the multidisciplinary approach to fishery and habitat monitoring on the LSYR show trends and potential limiting factors for steelhead/rainbow trout that are similar to many other Southern California coastal streams and rivers, including San Luis Obispo Creek, Arroyo Grande Creek, San Jose Creek, Matilija Creek, Carpinteria Creek, Ventura River, Sespe Creek, and other watersheds within San Luis Obispo, Santa Barbara, and Ventura counties (see Section 7). Seasonally low to nonexistent flows in portions of the LSYR and its tributaries, exposure to seasonally elevated water temperatures, diel depression in dissolved oxygen (DO), sediment erosion and deposition, lack of intact riparian vegetation, and passage barriers and impediments have been identified as constraints on steelhead/rainbow trout habitat within the watershed. The FMP and Proposed Action are consistent with the strategy and approach being used in several other Southern California watersheds for identifying potentially limiting factors and developing and implementing management actions (e.g., Arroyo Grande Creek, San Jose Creek, Carpinteria Creek, and Ventura River). The Cachuma Project BO is consistent with NMFS recovery planning for southern steelhead in addressing the issues described above.

The FMP and Proposed Action identify specific management actions designed to protect and enhance habitat conditions for Southern California anadromous steelhead and rainbow trout inhabiting the LSYR and its tributaries. Results of this synthesis support continued implementation of habitat and passage improvement actions identified in the FMP and Proposed Action. No additional actions or major modifications to those management actions are identified. It is anticipated that the management actions below Bradbury Dam need to be in place for a period of time before the extent of restoration and species recovery can become realized and observed. The BO was adopted in September 2000 and the required actions have been in place for about four years or less during this 12-year reporting period. Restoration actions identified and implemented as part of the FMP and Proposed Action on the LSYR are expected to provide long-term benefits to steelhead/rainbow trout, however, given the phased implementation of actions and variability in hydrology among years, variability in ocean rearing conditions and survival of steelhead, among other factors, it is expected that a number of additional years will be needed before the full biological benefits of the FMP and Proposed Action management actions will be observed in the monitoring program.

It is also important to recognize that some of the important management actions outlined in the Proposed Action (e.g., Hilton Creek Watering System (HCWS), passage supplementation, barrier removals, etc.) did not take place until the later end or after this synthesis compilation

(1993-2004). Additional management actions identified in the FMP and Proposed Action are currently in the process of being funded, permitted, designed, or are under construction. Therefore, benefits of these additional actions are not reflected in results of the 1993-2004 monitoring program but are acknowledged as accomplishments (underway) of the program.

Accomplishments and Evaluation of Management Actions

The FMP and Proposed Action identify specific management actions designed to protect and enhance habitat conditions for Southern California anadromous steelhead and rainbow trout inhabiting the LSYR and its tributaries. The primary accomplishments in the FMP and Proposed Action implementation by the CPWA over the 12-year period are briefly summarized below. Actions that were initiated, but not necessarily completed, during the 1993-2004 period of this report are also identified. These program accomplishments include:

- Implementation of the habitat and passage improvement actions identified in the FMP and Proposed Action (2000 to present);
- Maintenance of year-round baseflow releases from the reservoir to provide habitat within the mainstem river, primarily in the Highway 154 Reach (Bradbury Dam downstream to the Highway 154 Bridge), to support steelhead/rainbow trout migration, spawning, and rearing (1993 to present);
- Flow augmentation during storm events in the winter and early spring period of adult and juvenile steelhead migration, which provides enhanced mainstem river passage opportunities for adult and juvenile steelhead (2006 to present);
- Installation of gate extensions, or “flashboards” on the Bradbury Dam radial gates that allow Lake Cachuma to be surcharged by 3 feet resulting in up to 9,200 acre feet of water being available for fish passage and habitat maintenance (2004 to present);
- Additional releases below Bradbury Dam following spill events greater than 20,000 acre-feet and the year after such spills to extend baseflows in the mainstem through the Alisal Reach (2005 to present);
- Installation and operation of the HCWS supports year-round habitat for steelhead/rainbow trout in the lower reaches of Hilton Creek from the Upper Release Point to the confluence (3000 ft) resulting in increased steelhead/rainbow trout spawning, juvenile rearing, and production of smolts within Hilton Creek (2000 to present);
- Planting of willow waddles to promote recruitment of riparian vegetation along Hilton Creek to increase overhead cover, increase habitat diversity and complexity, provide stream shading, and provide wildlife benefits (2000 to present);
- Improved fish passage within Hilton Creek (Cascade Chute barrier removal) allows access to upstream habitat for steelhead/rainbow trout spawning, egg incubation, and juvenile rearing (2005);
- Continued groundwater evaluations and preliminary engineering designs to assist in examining the feasibility of extending the existing Hilton Creek channel further downstream to provide additional high-quality steelhead/rainbow trout habitat (2000 to present);
- Construction of fish ladders have improved upstream passage for adult steelhead/rainbow trout within Salsipuedes Creek at the Highway 1 Bridge crossing (2002) and the Jalama Bridge crossing (2004);

- Fish passage improvement projects have been identified and/or implemented on El Jaro Creek. These fish passage enhancement projects include the Rancho San Julian Project (completed 2008) and the Cross Creek Ranch Project (scheduled to be completed in 2009);
- Installation of erosion control measures and culvert restoration have improved bank and channel stabilization and reduced erosion on El Jaro Creek (2002);
- Fish passage enhancement projects have been identified at nine road crossings on Quiota Creek that will allow improved access to upstream habitat for steelhead/rainbow trout spawning and juvenile rearing (ongoing);
- Development of a fish rescue and relocation plan for juvenile steelhead/rainbow trout rearing within Hilton Creek (2000) to be implemented under adverse hydrologic and water quality conditions when the HCWS is not able to provide suitable water temperature conditions within the creek (the AMC has recently begun discussions regarding development of a similar management action to be implemented on the mainstem river);
- Investigations within the watershed upstream of Lake Cachuma to assess habitat conditions and suitability for various life-history stages of steelhead/rainbow trout (ongoing); and
- A public education and outreach program provides information to interested parties about implementation of the FMP and Proposed Action specific to the goal of increasing protection and enhancing habitat conditions for steelhead, and contributing to recovery of the species (2000 to present).

Summary of Recommendations

Analysis of the 12-year monitoring program leads to a series of recommendations for (1) a more rigorous quantitative monitoring and reporting program; and (2) additional monitoring to assess the response of steelhead/rainbow trout to specific environmental conditions and to management actions implemented as part of the FMP. Recommendations are the following:

- Establish linkages between each monitoring program goal and specific management actions or decision points within the framework established by the FMP and Proposed Action;
- Update the established monitoring plan in Reclamation (2000). Develop a two-tiered long-term monitoring program to include (1) systematic quantitative baseline monitoring of changes in steelhead abundance and distribution within and among years along the mainstem river and major tributaries in response to various environmental variables, and (2) focused investigations to address and evaluate specific management objectives, and/or evaluate specific physical or biological responses and functional relationships;
- Refine the annual monitoring plan to clearly identify program priorities and protocols for conducting baseline monitoring and focused experimental investigations for review by the AMC prior to implementation.
- The annual monitoring plan should provide a framework for linking study objectives, sampling designs and protocols, statistical analyses, sampling protocols, methods, and schedules for instrument calibration and validation, quality control procedures, and integrated data management within a relational database and geographic interface (e.g., GIS);
- Prepare an annual technical report that synthesizes findings in relation to long-term trends so that issues may be identified and addressed by the AMC on an annual basis. The annual

reports should test specific hypotheses and examine trends and relationships among hydrologic, water quality, habitat, and fishery parameters observed during the current year in context with results from previous monitoring on the river. The reports should summarize the data collected within a given year, describe any significant events that have affected monitoring procedures or management actions, and describe any changes in monitoring or research protocols proposed for the next year;

- Recognize the inherent limitations and constraints imposed by access restrictions, periodic high flow events, and other factors on achieving the goals of the monitoring program;
- Increase access to key reaches of the mainstem river (e.g., Reclamation property boundary downstream to Highway 154 Bridge) and tributaries (e.g., Salsipuedes and El Jaro creeks, and other tributaries) for monitoring and habitat enhancement. It is strongly recommended that a standard access agreement be developed that ensures that landowners who allow access to their properties will not be required to change their current management practices as a result of fisheries survey data (e.g., Safe Harbor Agreement with NMFS). This agreement should protect property owners who voluntarily cooperate by managing land use to minimize impacts to steelhead/rainbow trout and their habitat, and to enhance habitat conditions. Conservation easements and other agreements that allow access for monitoring and habitat enhancement should be made available to landowners, particularly in areas where restoration projects would be most beneficial for steelhead/rainbow trout. In the absence of securing greater access to private lands, it is recommended that alternative methods (i.e., the use of high-resolution aerial photographs) be included in the monitoring program to assess trends and changes in habitat conditions throughout the lower river watershed, to the extent possible;
- Establish a routine procedure for triggering discussions with the AMC and with regulatory agencies regarding refinements to implementing management actions and monitoring procedures. One goal of the monitoring program is to identify issues to be addressed by the AMC and ensure that monitoring data are available in a timely manner to make informed adaptive management decisions. This is essential for the AMC to perform its mandated function of providing oversight of the monitoring and management effort. To this end, at a minimum, bi-annual meetings of the AMC and CPWA staff are proposed to discuss issues, review findings, and make recommendations to improve the fisheries program;
- Continue to refine the fishery, water quality, and habitat monitoring program to provide quantifiable data measuring the response of steelhead/rainbow trout and their habitat conditions to FMP and Proposed Action management actions over a range of hydrologic and other environmental conditions to establish a long-term trend analysis;
- Conduct focused investigations to acquire information on the following topics:
- Additional information on the river flows and environmental conditions that breach the sand bar at the mouth of the lagoon, and provide opportunities for migration by anadromous steelhead;
- Information on the abundance and geographic distribution of predatory species, the importance of predation mortality on steelhead/rainbow trout within the watershed, and appropriate means of controlling predators;
- Further information on the dynamics of mainstem pools and the role of algae in water quality degradation within pools as a factor affecting habitat for steelhead/rainbow trout. The

relationship between pool stratification and thermal refugia warrants further investigation. Variation in water temperatures and DO within stratified pools, and the factors that contribute to pool stratification and destratification, should be studied in future monitoring activities;

- Evaluate the positive and negative influences of beaver activity within the mainstem and tributaries on steelhead passage and habitat conditions for steelhead/rainbow trout; and
- Participate in collaborative discussions with NMFS staff regarding coordinated monitoring and integration of LSYR management actions into the broader scope of regional recovery planning for Southern California steelhead. Information collected as part of monitoring and the identification and implementation of management actions on the LSYR, building on results of the long-term monitoring program currently in place as part of the FMP, Proposed Action, and BO is expected to contribute to regional recovery planning. One of the specific objectives to be addressed is assessing the relative contribution of management actions implemented on the LSYR, and the resulting change in steelhead abundance, on meeting the overall recovery objectives for the DPS.

Table ES-1. Summary of findings of the 2004 Synthesis Report

Hydrology (Section 2)
Precipitation
Most precipitation occurred from December through May; June through November precipitation was consistently low. Winter precipitation, both in wet and dry years, is highly variable in temporal distribution.
The amount and distribution of precipitation differ dramatically from one year to the next. The period 1993 through 2004 included one of the wettest (1998) and driest (2004) years on record.
Lake Cachuma
Over the 12-year period, there were reservoir spills in five years, downstream water rights releases in six years, and releases for fisheries in all 12 years. Total downstream discharge in the period 1993 through 2004 ranged from a high of 391,987 acre-feet in 1998 to a low of 3,882 acre-feet in 1999. Fishery releases from Bradbury Dam over the study period ranged from 2 cfs to about 15 cfs and were in compliance with Proposed Action and FMP interim flow targets, providing continuous baseflows downstream of the dam.
The Hilton Creek Watering System (HCWS) installed in 2000, maintained surface water target flows of a minimum of 2.0 cfs in lower Hilton Creek throughout the 2000-2004 period.
LSYR Watershed
The runoff in the LSYR watershed during the 1993-2004 was typical of Southern California hydrology, being characterized by high variability and rapid increases and decreases in flows (flashy) in response to precipitation. Hydrographs for each year at all locations in the LSYR watershed show large flows during winter storm events to very low or nonexistent flows during the summertime.
During storm events, flows increase as a function of distance downstream from Bradbury Dam due to the increase in tributary contributions. However, during the dry season, flows in the river decrease with distance from Bradbury Dam due to percolation into the river channel.
Low flows in the mainstem are characterized as rapidly changing over short distances, particularly in braided sections of the mainstem, which is most likely due to the water traveling underground as sub-surface flow.
Stream discharge in the tributaries is characterized by high variability and flashy nature. Most tributaries typically dried up in the lower reaches during the summer. At higher elevations, tributary characteristics include dry channel sections alternating with wetted pools and riffles. In these pool reaches, summer flows were frequently below 1 cfs.
Salsipuedes Creek is the largest, perennial tributary in the LSYR watershed. Flows continued in Salsipuedes Creek throughout the 1993-2004 period.
Flows from Salsipuedes Creek alone are capable of breaching the lagoon due to the creek's flashy characteristics, sizable watershed, and proximity to the lagoon.
Water Quality (Section 3)
Lake Cachuma
Lake Cachuma becomes thermally stratified during the summer and early fall and destratified during the late fall and winter. Reservoir turnover occurred each year in the fall. During the period of stratification, water temperature and DO concentrations are greatest in the upper part of the water column (epilimnion), with the coolest water temperatures and DO concentrations decreasing below 2 mg/l within the lower part of the water column (hypolimnion). After fall turnover, water temperature and DO concentrations (6-8 mg/l) were relatively uniform throughout the reservoir.
Mainstem of the LSYR

Table ES-1. Summary of findings of the 2004 Synthesis Report

Mainstem river water temperature increased during the spring and summer, and decreased during the fall and winter, coincident with the seasonal pattern in air temperature and solar radiation.
Water temperature, particularly during summer, is lowest near Bradbury Dam, with a longitudinal gradient of increasing temperature moving downstream until a dynamic thermal equilibrium between air and water temperatures is reached approximately 3 to 5 miles downstream of Bradbury Dam.
Water temperatures are within acceptable ranges at all locations downstream of Bradbury Dam during the late fall, winter, and early spring. Summer water temperatures were within the range considered to be suitable for steelhead rearing within the reach from Bradbury Dam downstream to the Highway 154 Bridge.
Water temperatures at a number of mainstem pool monitoring sites downstream of the Highway 154 Bridge exceeded temperature guidelines for steelhead/rainbow trout during the summer. Steelhead/rainbow trout inhabiting mainstem pools survived exposure to summer water temperatures greater than the indices of habitat suitability.
In the summer, groundwater upwelling and high water levels in some pools may create temporary stratified conditions, with areas of low temperature along the bottom of the pools, which allows refuge areas for steelhead/rainbow trout. Stratification in isolated pools may also result in a diel cycle of depressed DO concentrations near the pool bottom during the night and early morning hours associated with algal respiration and reduced mixing. Daytime and nighttime DO concentrations were greatest near the surface with a marked decline in DO near the bottom.
High algal production within the mainstem river, primarily in pool habitats within the Alisal and Refugio reaches, between late spring and early fall contributes to substantial diel variation in DO concentrations. DO concentrations at night within isolated pools during low-flow summer periods was observed to decrease to as low as 1 to 3 mg/l. A vertical gradient in DO concentrations was observed at several deeper pools; daytime DO concentrations were greatest near the surface with a marked decline in DO near the bottom.
River flow provided by the WR 89-18 releases in 2002 and 2004 was sufficient to remove much of the algae from pool habitats and create sufficient mixing to sustain higher DO concentrations (>7 mg/l) in most, but not all, mainstem habitats.
Santa Ynez River Lagoon
When the lagoon was both open and closed, differences in water temperature, DO, and electrical conductivity (EC) were observed between upstream and downstream locations within the lagoon indicating tidal prism influences.
Water depth increased after the sand bar closed; vertical gradients were observed in water temperature, DO, and EC within deeper areas.
Summer water temperatures were consistently lower within the lagoon compared to upstream mainstem monitoring locations, with the exception of locations immediately downstream from Bradbury Dam. Lower summer water temperatures reflect the influence of the marine climate and fog on water temperatures within the lagoon.
EC followed a consistent longitudinal pattern, with salinity near brackish/full strength sea water at Ocean Park (LSYR-47.75), decreasing to freshwater at the upstream location (LSYR-46.6) when the lagoon is closed and when open the salinity gradient was tide dependent. Salinity reflected seasonal variation in freshwater inflow and tidal influence. Higher salinity concentrations were observed at high tide at all three sites, particularly when the lagoon was breached.
Tributaries of the LYSR
Seasonal flows and water temperatures within Hilton Creek prior to implementation of the HCWS, resulted in exposure to elevated water temperatures and fragmentation of habitats. After the HCWS began operations, flows have been stable and seasonal water temperatures are almost always less than 20 °C (and generally less than 18 °C) in the reach immediately downstream of the water system release points. Water temperatures during the summer increased as a function of distance downstream of the watering system release points. Maintaining year-round flows has resulted in increased riparian growth, shading, and reduced seasonal water temperatures. These changes have substantially improved habitat conditions for steelhead/rainbow trout within lower Hilton Creek. Fishery observations confirm that Hilton Creek provides suitable steelhead/rainbow trout spawning and juvenile rearing habitat.
Upper Salsipuedes Creek is characterized by having an intact riparian corridor with abundant canopy where water temperatures were substantially cooler during the low-flow summer season than those observed in either El Jaro or lower Salsipuedes Creek. Results of water temperature monitoring suggest that habitat conditions were suitable for steelhead/rainbow trout. Fishery observations documented successful spawning and rearing by steelhead/rainbow trout within upper Salsipuedes Creek habitats.
Lower Salsipuedes Creek is characterized by a wider streambed and less abundant riparian canopy when compared to the upper reaches of Salsipuedes Creek. Water temperatures were higher during the summer months within the lower reaches of the creek. Although results of water temperature monitoring showed maximum daily temperatures frequently above 24 °C and average daily temperatures above 20 °C, fishery surveys documented that steelhead/rainbow trout inhabit the lower reaches of the creek.
Inflow during the summer from El Jaro Creek contributes to higher water temperatures within lower Salsipuedes Creek. Water temperatures within Salsipuedes Creek downstream of the confluence with El Jaro Creek frequently exceeded an average daily temperature of 20 °C and a maximum daily temperature of 24 °C during summer months. Average daily water temperatures within El Jaro Creek upstream of the confluence with Salsipuedes Creek exceeded 20 °C over extended periods (weeks or months) in many years representing stressful/potentially unsuitable habitat conditions for steelhead/rainbow trout. Maximum daily temperatures exceeded 27 °C on occasion, representing conditions above the incipient lethal level for steelhead/rainbow trout. The fact that steelhead/rainbow trout have been observed inhabiting El Jaro Creek where summer water temperatures are elevated is consistent with the hypothesis that southern steelhead/rainbow trout have higher thermal tolerance than more northerly populations and/or that these fish are able to take advantage of microhabitat thermal refugia and successfully oversummer.
Water temperatures within Quiota Creek seldom exceeded 20 °C indicating suitable habitat conditions for oversummering salmonids.
Water temperature monitoring within San Miguelito Creek indicates that suitable habitat conditions occurred for steelhead/rainbow trout which is consistent with fishery observations documenting that steelhead/rainbow trout inhabit the creek.
Habitat (Section 4)
Pools in the Highway 154, Refugio, and Alisal reaches (up to 10.5 miles downstream of Bradbury Dam) have supported steelhead/rainbow trout, and other fish species inhabiting the river. Suitable pool habitat exists in the mainstem between Bradbury Dam and Alisal Bridge even at low flows, but the quality of pool habitats is limited, especially in the Refugio and Alisal reaches.

Table ES-1. Summary of findings of the 2004 Synthesis Report

The availability of suitable stream habitat for steelhead/rainbow trout mainly occurs within the tributaries. Habitat conditions within many of the tributaries at higher elevations are characterized by cooler seasonal water temperatures, greater instream cover, and greater riparian vegetation growth that contribute to improved habitat for steelhead/rainbow trout spawning and rearing. Water temperatures during the late spring, summer, and early fall have been observed to increase in the lower reaches of the tributaries, contributing to reduced habitat quality and availability for summer rearing.
Suitable habitat within the mainstem river extends downstream from Bradbury Dam on Reclamation property. Approximately 2.5 additional miles of habitat directly downstream of Reclamation property (downstream to the Highway 154 Bridge) appears to be suitable year-round based on aerial photographs, but cannot be surveyed due to access restrictions. The mainstem reach between Bradbury Dam and the Highway 154 Bridge has been identified as the primary management zone for steelhead/rainbow trout habitat under the FMP and the Proposed Action
Elevated water temperatures and depressed DO have been identified as significant environmental factors affecting the habitat quality and availability for steelhead/rainbow trout both within the mainstem river and tributaries during the summer and fall periods.
Riparian vegetation is poorly developed along the lower mainstem river and does not provide significant shade or cover, except between Bradbury Dam and the Highway 154 Bridge. Riparian vegetation in many of the tributary reaches is intact and provides bank protection from erosion, cover, and stream shading.
Instream vegetation in the mainstem river in the form of "algal mats" can be extensive during summer months and can negatively influence dissolved oxygen. Algae is not usually extensive in the reach immediately downstream of Bradbury Dam, but can dominate the aquatic habitat in the Refugio (miles 5.0-7.8) and Alisal (miles 7.8-10.5) reaches, as well as further downstream, during summer low flow conditions.
Substrate in the form of gravel of suitable size for steelhead/rainbow trout spawning on the mainstem river is located primarily in the Highway 154, Refugio and Alisal reaches, and within various tributaries. Quality of spawning substrate in the Lompoc Reach and further downstream was poor due to the sand-bedded channel.
Fishery Resources (Section 5)
Mainstream Steelhead Population Characteristics
In general, steelhead/rainbow trout were most abundant near the dam and less abundant in the Refugio and Alisal reaches. Steelhead/rainbow trout most likely have been produced and rear in the Highway 154 Reach, however, lack of access has precluded surveys to determine production in this reach.
Steelhead/rainbow trout have not been observed in large numbers downstream of the Highway 154 Bridge during dry years. However, in wet years steelhead/rainbow trout were observed in greater numbers in downstream reaches (e.g., Refugio and Alisal reaches).
Juvenile and adult steelhead/rainbow trout are found rearing more frequently in the tributaries (where more suitable habitat is present) as compared to the mainstem river.
Steelhead/rainbow trout appear to migrate and spawn in the mainstem river and upstream tributary areas. Favorable environmental conditions typically result in an increase in juvenile production.
Steelhead/rainbow trout juveniles survived, apparently in healthy condition, in isolated pools in the mainstem river through the summer and fall despite exposure to elevated water temperature and depressed DO conditions that exceeded standard tolerance criteria for the species. Survival in these habitats may be related to upwelling of cool water forming thermal refugia within the pools under low flow conditions, higher tolerance levels of LSYR steelhead/rainbow trout, or a combination of factors.
Tributary Steelhead Population Characteristics
The geographic distribution of steelhead/rainbow trout extends further downstream within the mainstem river and tributaries in response to wet hydrologic conditions and is generally limited to upstream tributaries and areas near Bradbury Dam in dry years.
Juvenile steelhead /rainbow trout exhibiting evidence of smoltification in downstream migrant traps within both Hilton Creek and Salsipuedes Creek indicate the presence of anadromous traits within the population.
Steelhead/rainbow trout successfully reproduce and rear in Hilton Creek.
No evidence of steelhead /rainbow trout spawning or rearing has been observed in Nojoqui Creek but good spawning and rearing habitat exists there during wetter years. The lower section of Nojoqui Creek has been dry every summer over the 12-year monitoring period.
Juvenile steelhead/rainbow trout have been observed in San Miguelito Creek near the City of Lompoc. However, physical barriers block all anadromous steelhead migration into the creek.
The observation of various lifestages of steelhead/rainbow trout inhabiting the tributaries provides direct evidence of the importance of tributary habitat in supporting successful spawning and egg incubation, oversummering survival, and the contribution of tributary habitat to the population dynamics, production, and overall abundance of steelhead/rainbow trout within the watershed. The FMP and Proposed Action identified improvements to fish passage within the tributaries as a high priority management action and results of the 12-year monitoring program support these actions; passage improvements on several tributaries have been implemented.
Access to suitable habitat within many of the tributaries by migrating steelhead/rainbow trout has been blocked or impeded by instream passage barriers.
Other Fish Species
Other native species present include stickleback and sculpin.
The introduced arroyo chub and mosquitofish are widespread. The mainstem river supports fluctuating and transient populations of introduced fish including largemouth and smallmouth bass, green sunfish, bluegill, redear sunfish, channel and bullhead catfish which are thought to be both predators and competitors with steelhead/rainbow trout.

SECTION 1

INTRODUCTION

Section 1: Introduction

1.1 Introduction

Steelhead (*Oncorhynchus mykiss*) inhabit a number of river systems in California and the Pacific Northwest, including the Lower Santa Ynez River (LSYR) downstream of Bradbury Dam located in Santa Barbara County, California (Figure 1-1). These rivers are used as a corridor for adult steelhead migration between coastal marine waters and freshwater spawning habitat, and as juvenile rearing habitat. The LSYR is located near the southern boundary of the geographic distribution for anadromous steelhead. As a result of declining abundance and concerns regarding the status of steelhead, many of the populations have been identified for protection under the federal Endangered Species Act (ESA). The LSYR steelhead population is part of the Southern California Distinct Population Segment (DPS), formerly the Southern California Evolutionarily Significant Unit (ESU), identified by the National Marine Fisheries Service (NMFS) as an endangered species. The LSYR and tributaries also support a population of resident rainbow trout. Since Bradbury Dam is a complete barrier to upstream migration of anadromous steelhead, the scope of this report focuses on monitoring and management actions identified in the Lower Santa Ynez River Fish Management Plan (FMP) (SYRTAC 2000) and the U.S. Bureau of Reclamation Biological Assessment (BA) for Cachuma Project Operations and the Lower Santa Ynez River (BA Proposed Action) (Reclamation 1999 and 2000) within the LSYR and its tributaries (e.g., Bradbury Dam to the Pacific Ocean), and required by the Reasonable and Prudent Measures and Terms and Conditions set forth by the NMFS Biological Opinion (BO) (NMFS 2000a).

This report presents the results of the monitoring program from 1993 to 2004 which are used to re-evaluate findings and recommendations from the original compilation of monitoring data in 1997 (SYRTAC 1997) to ascertain if the conclusions of the 1997 report still reflect (1) our best understanding of the system and factors contributing to productive steelhead habitat, (2) if the management action have produced the expected response, and (3) if modifications need to be made to the management actions or the monitoring program. It is anticipated that in order to see an increase in the population of steelhead/rainbow trout below Bradbury Dam, the management actions need to be in place for a period of time before the extent of restoration and species recovery can become realized and observed. It should also be known that some of the important management actions outlined in the BA Proposed Action (i.e., Hilton Creek Watering System [HCWS], passage supplementation, target flows, barrier removal, etc.) had not taken place until the later end of this synthesis compilation.

The Santa Ynez River provides water to the South Coast communities and water users within the Santa Ynez Valley (Figure 1-1). Water is provided to the South Coast through the Doulton Tunnel (Juncal Dam and Jameson Reservoir), Mission Tunnel (Gibraltar Dam and Reservoir), and Tecolote Tunnel (Bradbury Dam and Lake Cachuma). The U.S. Bureau of Reclamation (Reclamation) Cachuma Project (referred to as The Cachuma Project) is the primary source of water for the City of Santa Barbara, Goleta Water District, Carpinteria Valley Water District, and the Montecito Water District on the South Coast, and also serves the Santa Ynez River Water Conservation District Improvement District No. 1 (ID#1) in the Santa Ynez Valley. Implementation of the long-term monitoring program and primary data collection and dissemination has become the responsibility of the Cachuma Conservation Release Board

(CCRB) and Improvement District No. 1 (collectively referred to as the Cachuma Project Water Agencies or CPWA).

Construction of Bradbury Dam was completed in November 1953. Under the continuing jurisdiction of the California State Water Resources Control Board (SWRCB), operation of the Cachuma Project also provides protection of downstream water rights (groundwater recharge), and public trust resources including instream flow releases to protect fishery resources and other beneficial uses. During the 1990 SWRCB hearing pertaining to the Santa Ynez River, the SWRCB directed Reclamation to initiate studies of steelhead downstream of Bradbury Dam. During the winter of 1993, a wet year characterized by increased flows within the Santa Ynez River downstream of Bradbury Dam, the first adult steelhead/rainbow trout after the SWRCB hearing were observed within the river. Reclamation and Cachuma Project Member Units initiated a series of fishery and habitat surveys designed to provide initial information on habitat conditions within various portions of the mainstem LSYR downstream of Bradbury Dam and its tributaries. The studies were designed to identify factors affecting habitat quality or availability for various life-history stages of steelhead/rainbow trout and to identify potential factors limiting steelhead/rainbow trout within the LSYR watershed. The studies were also designed to provide technical information that could be used to identify management actions that would protect and enhance habitat conditions, and ultimately contribute to an increased population of steelhead/rainbow trout spawning and rearing within the river system. Field investigations included measurements of water temperature and dissolved oxygen (DO) concentrations, river and tributary flows, habitat characteristics, barriers or impediments to adult and juvenile migration, and fishery studies designed to characterize the species composition, relative abundance, habitat use, spawning run timing, and geographic distribution of steelhead/rainbow trout and other fishery resources. Sampling locations and study elements included in the field investigations are summarized in Table 1-1.

As part of the monitoring program, reaches of the mainstem river were identified, principally by geographic landmarks that served as part of the foundation for the habitat, water quality, and fishery monitoring activities. Reaches of the mainstem river and their locations with respect to various tributaries and other key features of the watershed are shown in Figure 1-2. Specific monitoring locations for the study elements are identified in Table 1-1 and are depicted in Figures 1-3 and 1-4.

The fishery investigations have been managed through several Memoranda of Understandings (MOUs) for Cooperation in Research and Fish Maintenance on the Santa Ynez River, downstream of Bradbury Dam. The MOUs established the Consensus Committee (CC), the Santa Ynez River Technical Advisory Committee (SYRTAC), and the Adaptive Management Committee (AMC). The CC, SYRTAC, and AMC included participation by Reclamation, California Department of Fish and Game (CDFG), U.S. Fish and Wildlife Service (USFWS), NMFS, Cachuma Project Member Units, Santa Ynez River Water Conservation District (SYRWCD), downstream water right holders, and representatives of the local environmental community. The CC functions primarily in a management and policy role. The SYRTAC and AMC have been primarily responsible for providing guidance and direction to the scientific investigations and monitoring activities.

Information developed from the fishery and habitat monitoring program during the early phase of the investigations (1993 – 1996) were compiled and analyzed in the development of a synthesis report produced by the SYRTAC in 1997 (SYRTAC 1997). The 1997 Synthesis Report was designed to provide the scientific and technical foundation, as it existed through the initial phase of the investigations, for developing a long-term fishery management plan and guiding subsequent monitoring activities under the management and policy leadership provided by the CC. Information developed in the 1997 Synthesis Report was used by the SYRTAC and CC as part of the technical foundation for developing a long-term FMP for the LSYR (SYRTAC 2000). Information presented in the 1997 Synthesis Report was also integrated as a key element in both the BA submitted by Reclamation to NMFS and the 2000 NMFS BO for Cachuma Project operations as part of a formal Section 7 consultation regarding project effects on steelhead in compliance with the federal ESA.

Data and analyses presented in the 1997 Synthesis Report were limited to information collected during the first phase of the monitoring program (1993 – 1996) which, although extremely useful, reflected environmental variation within the watershed over a relatively short period of time. Fishery and habitat monitoring has been continuing on the LSYR and can be used to re-examine many of the earlier findings presented in the 1997 Synthesis Report within the context of a broader range of hydrologic conditions and other environmental variables affecting conditions within the watershed for steelhead/rainbow trout. Using data from a 12-year monitoring period, extending from 1993 through 2004, results of the earlier findings and conclusions can now be re-evaluated, and modified if necessary, to further strengthen and refine elements of the FMP and long-term monitoring program. As part of the re-examination of the earlier findings in light of the 12-year monitoring database, key areas of interest with specific management implications examined include:

- Factors affecting the quality and availability of steelhead/rainbow trout spawning and rearing habitat;
- The role of tributary spawning and rearing habitat for steelhead/rainbow trout;
- Summer-fall habitat fragmentation in the mainstem river and in the tributaries;
- The relationship between wet and dry year hydrology, migration and spawning by anadromous steelhead;
- The dynamic nature of the mainstem and tributary channels, especially during periods of high flow;
- The role of impediments and barriers to migration; and
- Predation by warm-water fish species.

In addition to using the long-term monitoring dataset to re-examine the earlier analyses and findings regarding these and other issues affecting steelhead/rainbow trout within the watershed, results of the 1993 – 2004 habitat, water quality, and fishery monitoring program were also examined to identify recommended changes and modifications to the long-term monitoring program to further refine and improve existing monitoring activities.

Based on results of the fishery and habitat monitoring, findings of the 1997 Synthesis Report, and the FMP, a series of management actions were developed that would serve to protect and enhance habitat conditions for steelhead within the mainstem river and tributaries. These management actions included, but were not limited to, minimum instream flow releases from Bradbury Dam, water supplies to Hilton Creek, and a variety of modifications at passage barriers and impediments within the tributaries to improve the ability of steelhead to access suitable upstream habitat for spawning and juvenile rearing. These management actions were described in the Proposed Action included in the BA of the Section 7 consultation with NMFS under the federal ESA. After critically reviewing the management actions outlined in the BA, NMFS agreed that implementation of the proposed management plan would avoid jeopardy to steelhead. The subsequent BO issued by NMFS acknowledged the management plan, established a specific schedule for implementation of the management actions, and issued an incidental take permit for the continued operations of the Cachuma Project in accordance with the management plan outlined in the BA and BO. Section 6 discusses these management actions in more detail.

As part of implementing the BA Proposed Action, the Terms and Conditions of the NMFS BO and the MOU that sets forth the administration of the program, the scientific and technical direction of the FMP and BA Proposed Action activities were delegated to the AMC. Implementation of the long-term monitoring program and primary data collection and dissemination has become the responsibility of the CPWA, which works in close coordination with the AMC to provide monitoring information needed to make informed technical and management decisions regarding implementation of actions identified within the framework of the FMP and BA Proposed Action. The long-term monitoring program, therefore, has been designed to provide continuity of long-term baseline monitoring. The monitoring program is also responsive to short-duration environmental circumstances or events to collect specific monitoring information that can be used effectively by the AMC in evaluating the performance of management actions and developing recommended improvements in the spirit of adaptively managing implementation of various program actions. The ability to design and implement the monitoring program has, however, been affected by limitations on the ability to access various private lands located along the mainstem river and tributaries, as well as changes in access to private lands that have occurred over the 12-year monitoring period described in this report.

One of the objectives of the 2004 Synthesis Report (1993 – 2004), in addition to providing recommendations for future modifications or refinements to the long-term monitoring program, was to establish a standardized nomenclature in support of developing a more comprehensive and integrated database management system. A standardized system has been established for identifying habitat, water quality, and fishery monitoring locations, that has been reconciled with earlier monitoring activities to develop a unified database structure. The standardized nomenclature and reconciliation with earlier naming conventions is shown in Table 1-1 and was developed in a geographic information system (GIS) database structure.

Specific objectives of the 2004 synthesis and analysis of information from the LSYR fishery and habitat monitoring program include:

- Compile and summarize data collected on hydrology, water quality, habitat, fishery populations, and enhancement actions over the study period;
- Provide a catalog reference source of information related to the LSYR monitoring program, that periodically could be updated in the future as additional information becomes available;
- Provide a basis and framework for developing a data management system for organization, quality control, and access of monitoring data collected as part of the program;
- Analyze information collected as part of the monitoring program to re-evaluate findings and conclusions drawn from the 1997 Synthesis Report regarding the identification and performance of management actions using the more comprehensive monitoring data set available now and in the future;
- Review and recommend revisions or refinements to the monitoring protocols and data collection efforts; and

- Compile and document results of the 12-years of monitoring (1993 – 2004) for use by resource agencies and interested parties in reviewing the fishery and habitat monitoring program, providing peer review, and re-evaluating priorities for the monitoring activities as part of a periodic critical review of the LSYR fishery program.

The synthesis and analysis of scientific information collected on the fishery resources and habitat conditions of the LSYR and tributaries includes data characterizing hydrologic conditions and reservoir operations at Bradbury Dam (Section 2). Water quality monitoring has also been conducted, focusing on water temperature and DO, collected at various locations within the watershed including Lake Cachuma, along the longitudinal gradient of the mainstem LSYR from Bradbury Dam downstream to the lagoon near the ocean, and within major tributaries (Section 3). Stream channel habitat mapping surveys have been conducted within the mainstem river, lagoon, and tributaries (Section 4). Fishery resources observed from locations downstream of Bradbury Dam, including major tributaries and the lagoon have also been compiled (Section 5). Section 6 summarizes information on fish passage and habitat enhancement actions implemented as part of this program. Section 7 presents analyses and discussions of specific fishery management issues. Section 8 presents a series of recommendations for potential modifications and refinements to the monitoring program.

THIS PAGE INTENTIONALLY LEFT BLANK

Figure 1-1. Santa Ynez River watershed showing major hydrologic features (Source: Stetson 2005, modified by Hanson Environmental)

THIS PAGE INTENTIONALLY LEFT BLANK

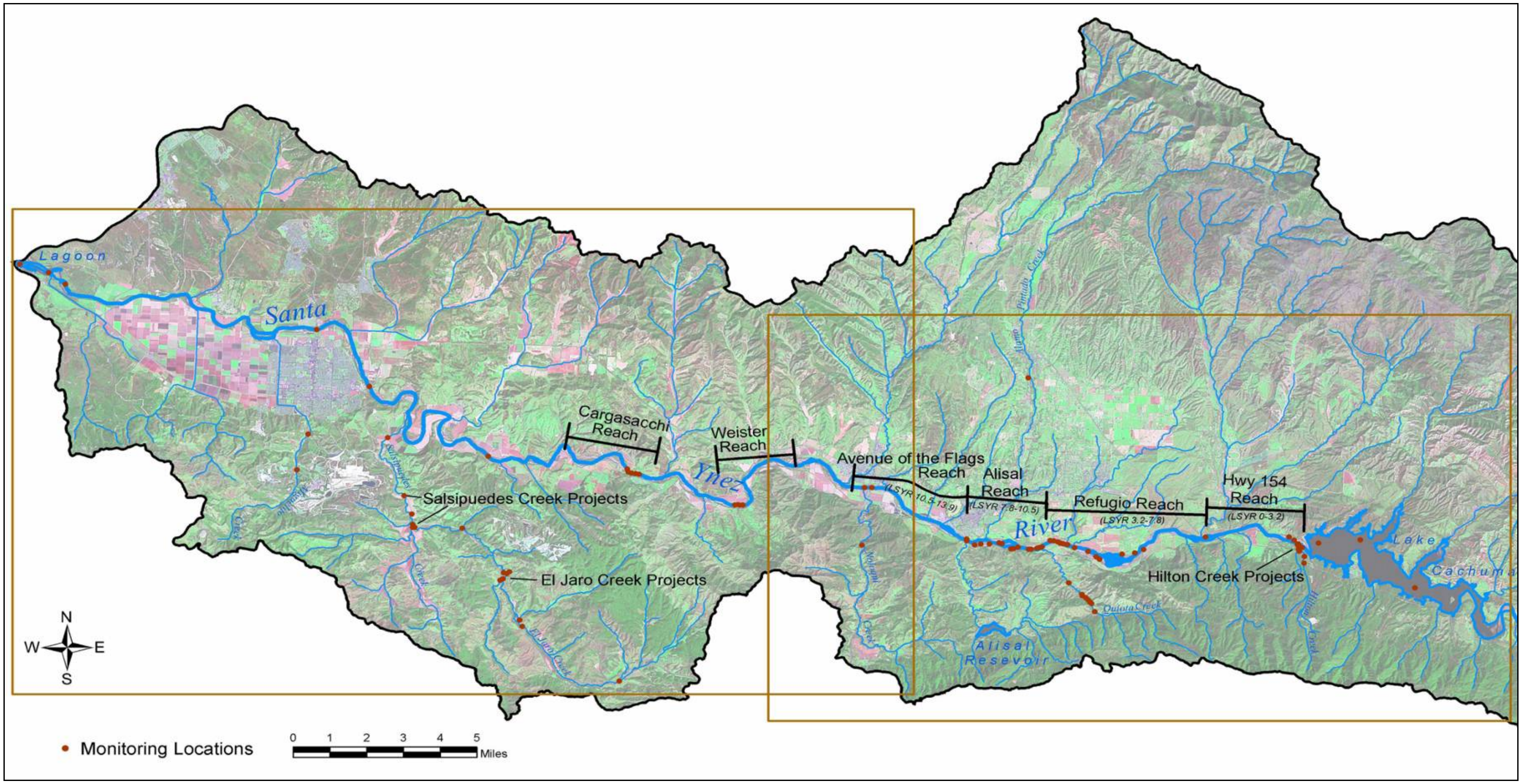


Figure 1-2. Study reaches on the Lower Santa Ynez River downstream of Bradbury Dam
(Red dots indicate monitoring sites; see Table 1-1 for site-identifications (Source: CPWA 2004, Landsat 2000, Stetson 2005))

THIS PAGE INTENTIONALLY LEFT BLANK

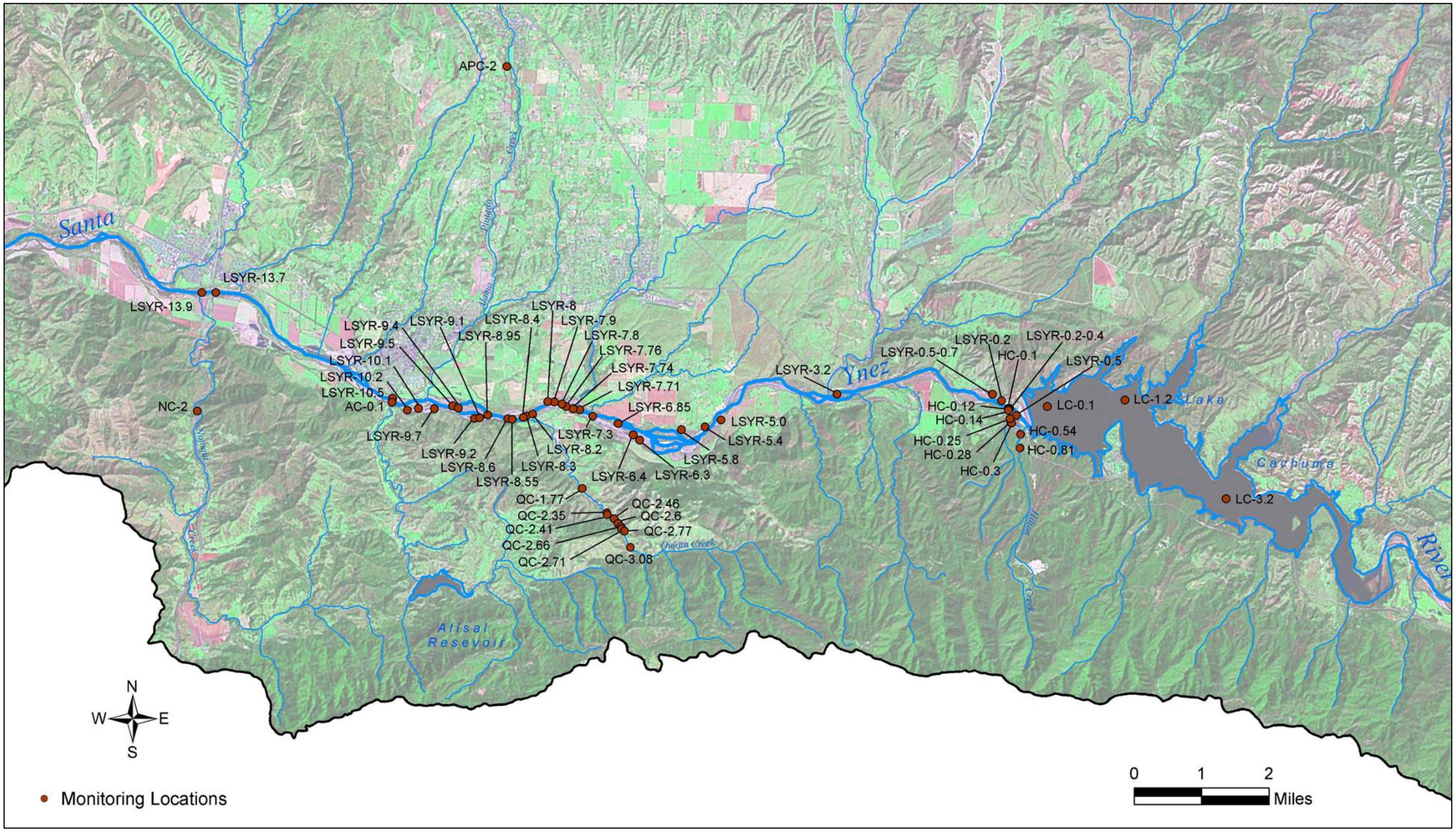


Figure 1-3. Data collection sites in the eastern portion of the Lower Santa Ynez River (see Table 1-1 for site information (Source: CPWA 2004; Landsat 2000; Stetson 2005))

THIS PAGE INTENTIONALLY LEFT BLANK

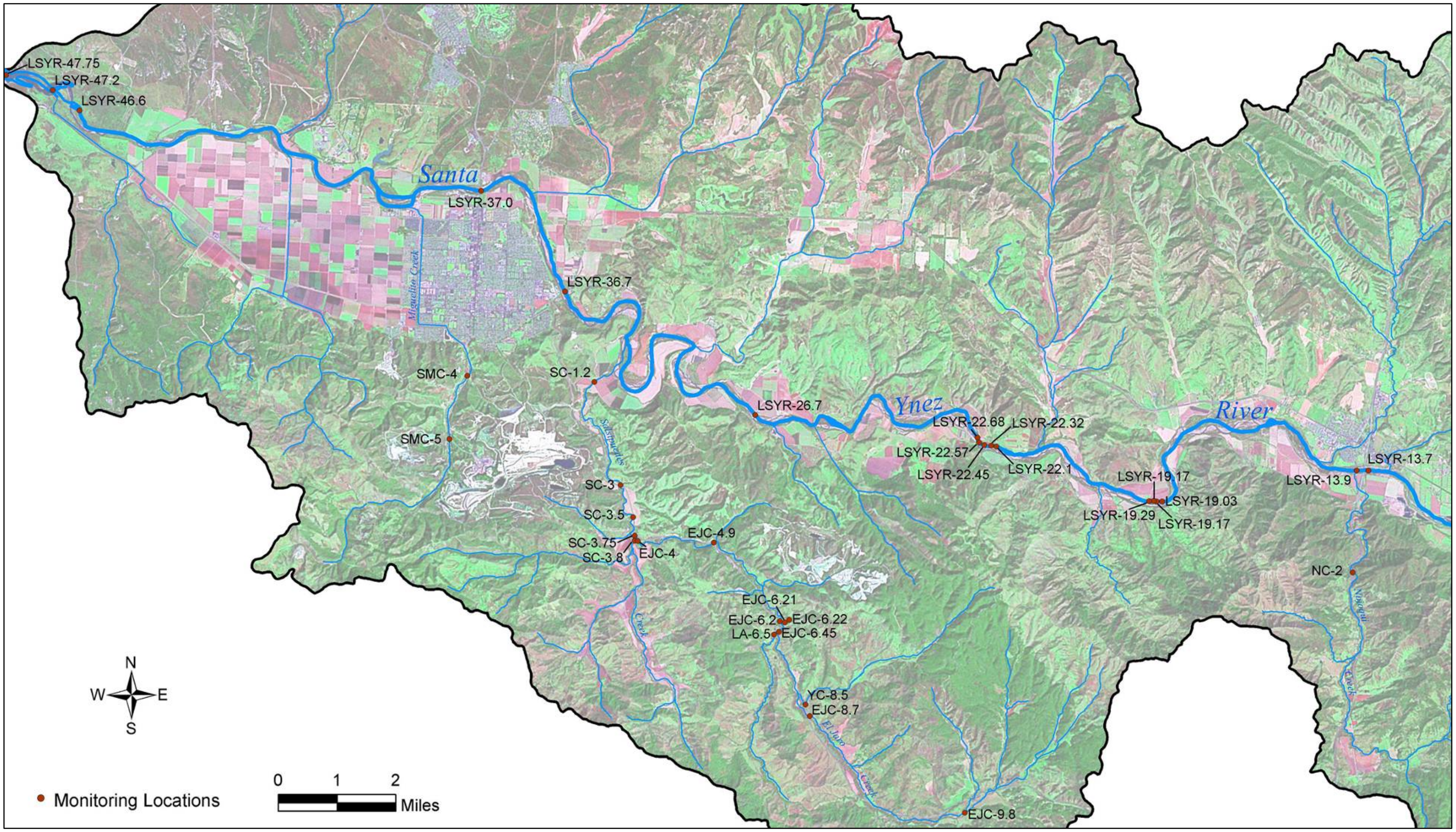


Figure 1-4. Data collection sites in the western portion of the Lower Santa Ynez River (see Table 1-1 for site information (Source: CPWA 2004, Landsat 2000, Stetson 2005))

THIS PAGE INTENTIONALLY LEFT BLANK

Table 1-1. Sampling locations and study elements included in the Lower Santa Ynez River fishery and habitat monitoring program

Sampling Type:		Snorkel Survey	Redd Survey	Habitat Mapping	Fish Trapping	Fish Rescue	Beaver Dam Removal	Hilton Creek Transects	Piezometer	Mitigation Monitoring	Thermograph	Diurnal WQ*	Benthic Macroinvertebrates	Discharge	Photo Points
	Extent:	Site	Site	Reach	Site	Site	Site	Reach	Site	Site	Site	Site	Site	Site	Site
Location	Site-ID's														
Spill basin - SYR	LSYR–0.2	X				X			X		X				
Reach between Spill basin + Long Pool	LSYR-0.2 – 0.4	X	X	X		X			X				X		
Long Pool	LSYR-0.5	X		X		X	X		X		X	X			X
Reach between Long Pool + BOR	LSYR-0.5 – 0.7	X	X	X		X	X					X		X	
Highway 154 Bridge – SYR	LSYR-3.2	X										X	X	X	X
Meadowlark Crossing – SYR	LSYR-5.0	X	X	X										X	X
Meadow Lark Pool – SYR	LSYR-5.4	X	X	X		X					X	X		X	
Sycamore Pool – SYR	LSYR-5.8	X	X	X		X					X	X			
Refugio Reach	LSYR-6.3	X													
Lower Gainey Crossing – SYR	LSYR-6.4	X	X	X		X					X	X	X	X	X
Mid-Refugio Reach Pool – SYR	LSYR-6.85	X	X	X		X					X	X			
Lower Refugio Reach Pool – SYR	LSYR-7.3	X	X	X							X	X			
Refugio Reach – Site C	LSYR-7.71	X										X			
Refugio Reach – Site B	LSYR-7.74	X													
Refugio Reach – Site A	LSYR-7.76	X													
Refugio Bridge – SYR	LSYR-7.8	X	X	X								X	X	X	
Alisal Reach	LSYR-7.9	X													
Pool down from Refugio Bridge	LSYR-8	X	X	X			X				X	X	X		
Alisal Reach	LSYR-8.2	X													
Alisal Reach	LSYR-8.3	X													
Quiota Creek Confluence - SYR	LSYR-8.4	X	X	X								X			
Alisal Reach – Snorkel Site	LSYR-8.55	X													
1 Mile down from Refugio	LSYR-8.6	X	X	X								X			

Table 1-1. Sampling locations and study elements included in the Lower Santa Ynez River fishery and habitat monitoring program

Sampling Type:		Snorkel Survey	Redd Survey	Habitat Mapping	Fish Trapping	Fish Rescue	Beaver Dam Removal	Hilton Creek Transects	Piezometer	Mitigation Monitoring	Thermograph	Diurnal WQ*	Benthic Macroinvertebrates	Discharge	Photo Points
	Extent:	Site	Site	Reach	Site	Site	Site	Reach	Site	Site	Site	Site	Site	Site	Site
Location	Site-ID's														
Bridge															
Alisal Reach	LSYR-8.95	X													
Alisal Reach – Snorkel Site	LSYR-9.1	X													
Mid-Alisal Deep Pool	LSYR-9.2	X	X	X							X				X
Mid-Alisal Reach – SYR	LSYR-9.4	X	X	X	X										X
Alisal Reach	LSYR-9.5	X													
Run 1 mile above Alisal Bridge – Dead Oak	LSYR-9.7	X	X	X								X			
Alisal Reach	LSYR-10.1	X													
Bedrock Pool 1/3 mile upstream of Alisal	LSYR-10.2	X	X	X											
Alisal Bridge – SYR	LSYR-10.5	X	X	X							X			X	
Highway 101 Bridge/Nojoqui Creek Confluence	LSYR-13.7	X	X	X											
Avenue of the Flags Bridge – SYR	LSYR-13.9	X	X	X							X	X		X	
Sanford-Weister Ranch Border – Site D	LSYR-19.03	X													
Sanford-Weister Ranch Border – Site C	LSYR-19.08	X													
Sanford-Weister Ranch Border – Site B	LSYR-19.17	X													
Sanford-Weister Ranch Border – Site A	LSYR-19.29	X													
Cadwell Property – Santa Rosa Park – Site E	LSYR-22.11	X													
Cadwell Property – Santa Rosa Park – Site D	LSYR-22.32	X													

Table 1-1. Sampling locations and study elements included in the Lower Santa Ynez River fishery and habitat monitoring program

Sampling Type:		Snorkel Survey	Redd Survey	Habitat Mapping	Fish Trapping	Fish Rescue	Beaver Dam Removal	Hilton Creek Transects	Piezometer	Mitigation Monitoring	Thermograph	Diurnal WQ*	Benthic Macroinvertebrates	Discharge	Photo Points
	Extent:	Site	Site	Reach	Site	Site	Site	Reach	Site	Site	Site	Site	Site	Site	Site
Location	Site-ID's														
Cadwell Property – Santa Rosa Park – Site C	LSYR-22.45	X													
Cadwell Property – Santa Rosa Park – Site B	LSYR-22.57	X													
Cadwell Property – Santa Rosa Park – Site A	LSYR-22.68	X													
Sweeney Road Crossing – SYR	LSYR-26.7	X		X							X			X	X
Robinson Bridge at Highway 246 – SYR	LSYR-36.7													X	
H Street Bridge – Lompoc – SYR	LSYR-37.0													X	
Upper Outlet Lagoon – SYR	LSYR-46.6				X						X				X
Mid-Outlet Lagoon – SYR	LSYR-47.2				X						X				X
Lower Outlet Lagoon – SYR	LSYR-47.75				X						X				X
Confluence with SYR – Hilton Creek	HC-0.01	X	X	X				X	X	X					X
Lower Thermograph – Hilton Creek	HC-0.12	X	X	X				X	X	X	X		X	X	X
Trap Site – Hilton Creek	HC-0.14	X	X	X	X			X	X	X			X		X
Los Amoles Reach – Los Amoles Creek	LA-6.5		X												
Bridge – Ytias Creek	YC-8.2	X	X												X
Bridge 3 – El Jaro Creek	EJC-8.4		X												X
San Julian Ranch – El Jaro Creek	EJC-9.8		X												
Stillman Creek Crossing – San Miguelito	SMC-4.0		X		X						X			X	X
San Miguelito	SMC-5.0		X											X	

Table 1-1. Sampling locations and study elements included in the Lower Santa Ynez River fishery and habitat monitoring program

Sampling Type:		Snorkel Survey	Redd Survey	Habitat Mapping	Fish Trapping	Fish Rescue	Beaver Dam Removal	Hilton Creek Transects	Piezometer	Mitigation Monitoring	Thermograph	Diurnal WQ*	Benthic Macroinvertebrates	Discharge	Photo Points
	Extent:	Site	Site	Reach	Site	Site	Site	Reach	Site	Site	Site	Site	Site	Site	Site
Location	Site-ID's														
Reach – San Miguelito Creek															
Lake Cachuma – Dam + Buoyline	LC-0.1														
Lake Cachuma – Tequetis Point	LC-1.2														
Lake Cachuma – Tecalote Tunnel Intake	LC-3.2														

*Dissolved oxygen (DO), temperature, pH, turbidity, conductivity, oxygen reduction potential (ORP).

Additional information on specific monitoring locations is provided in Sections 3 (water quality), 4 (habitat), and 5 (fishery monitoring).

Source: CPWA 2005.

SECTION 2

SANTA YNEZ RIVER HYDROLOGY

Section 2: Santa Ynez River Hydrology

2.1 Introduction

Flow conditions within the LSYR and its tributaries are a significant factor affecting habitat quality and availability for various life stages of steelhead and other aquatic resources. The purpose of this section is to provide the available hydrologic data to support analyses and interpretation, to the extent possible, of fishery data obtained in the period 1993 – 2004 (12 years). Hydrologic monitoring data is available from several sources including Reclamation, U.S. Geological Survey (USGS), and as part of the fishery habitat monitoring program (CPWA, Table 1-1). Reclamation monitoring data includes operations of Bradbury Dam and Lake Cachuma. The locations of USGS and CPWA flow measurement sites in the LSYR and its tributaries downstream of Lake Cachuma for the period 1993 – 2004 are shown in Figure 2-1. Results of hydrologic monitoring, showing inter- and intra-annual variability in reservoir storage, river flows, and tributary flows are briefly summarized below.

2.2 Hydrologic Monitoring Data

2.2.1 Daily Monitoring Data

Reclamation publishes annual reports that include the daily Lake Cachuma operations data for each water year (October 1st – September 30th). In addition to the annual report, Reclamation maintains a daily report referred to as Lake Cachuma Daily Operations. The Lake Cachuma Daily Operations Report is used to monitor daily conditions affecting the reservoir storage including: rainfall, inflow, State Water Project (SWP) imports, lake evaporation, deliveries to the South Coast through Tecolote Tunnel, and downstream releases and spills. Daily real-time monitoring data for the current month is available online at http://www.usbr.gov/mp/cvo/vungvari/cchdop.pdf.

During the 12-year study period, USGS monitored 11 gaging stations (Table 2-1 and Figure 2-1) downstream of Lake Cachuma as well as published storage data in their annual water data reports. Table 2-1 indicates that most of the flow gages are available for real-time monitoring available online at http://waterdata.usgs.gov/ca/nwis/current/?type=flow. Quality control for instrument calibration and data summaries for Lake Cachuma and Bradbury Dam operations and streamflows are the responsibility of Reclamation and USGS, respectively.

2.2.2 Instantaneous Flow Measurements

Over the period from 1997 through 2004, instantaneous flow measurements periodically have been made on the mainstem and its tributaries by CPWA biologists working on the fishery and habitat monitoring projects. Table 2-2 and Figure 2-1 indicate where instantaneous flow measurements were taken by CPWA. The rationale for the location of these measurement sites involves a combination of factors such as: access issues on private property, lack of USGS gaging stations in the study area, verification of USGS telemetered flow readings, and ability to monitor key habitats including refuge pools, tributaries, and project action sites. These instantaneous flow measurements both verify and supplement existing hydrologic monitoring data by the Reclamation and USGS. Sites with more than three instantaneous measurements are shown on Table 2-2 and Figure 2-1.

CPWA flow measurements were made using a Marsh – McBirney Flo-Mate Electromagnetic Flow Meter (Model 2000), which averages flow velocity over a 15-second period and displays the instantaneous rate (ft/sec). The flow meter was calibrated in accordance with manufacturer's specifications and protocols.

Lagoon Breaching

The sand bar located along the beach at the mouth of the Santa Ynez River blocks surface water flow, and migration by steelhead, when the bar is closed. Breaching of the bar occurs naturally in response to river flows, tides, and wave action. Over the period from 1993 through 2004, the condition of the sand bar across the mouth of the Santa Ynez River was periodically observed visually by CPWA biologists. Monitoring of the breach has been limited due to restricted access to install instruments to measure water surface elevations in the lagoon within Vandenberg Air Force Base property. As a result of restricted access, monitoring the status of the sand bar has been limited to visual observations.

2.3 Results

Hydrologic data collected during 1993 – 2004 are summarized below, including precipitation, Lake Cachuma and Bradbury Dam operations, mainstem flows, tributary flows, and breaching of the lagoon in the LSYR watershed.

2.3.1 Precipitation

Daily precipitation records from Reclamation operations at Lake Cachuma have been analyzed for the study period 1993 – 2004. The monthly and annual precipitation at Lake Cachuma is summarized in Table 2-3. Annual precipitation for the period from 1993 through 2004 ranged from 8.8 inches (2002) to 53.7 inches (1998) at Bradbury Dam (Table 2-3). The long-term average annual precipitation (1953 – 2004; 52 years) measured at Lake Cachuma is 20.3 inches. Figure 2-2 shows the average monthly distribution of rainfall at Lake Cachuma for both the periods 1953 – 2004 and 1993 – 2004. The average annual precipitation over the period from 1993 through 2004 (12 years) was 24.3 inches, which is approximately 120 percent of the historical average for the period 1953 – 2004. The period included the wettest year on record (1998) and one of the driest years on record (2002, the second driest year on record) within the basin. As shown in Figure 2-2 and Table 2-3, there are general patterns in the monthly 1993 – 2004 precipitation data, as follows:

- Most precipitation occurred from December through May; June through November precipitation was consistently low;
- Winter precipitation, both in wet and dry years, is highly variable in temporal distribution; and
- The amount and distribution of precipitation can differ dramatically from one year to the next (i.e., total annual precipitation ranged from 46 inches to 13 inches in 1995 and 1996 respectively, 54 inches to 17 inches in 1998 and 1999 respectively, and 32 inches to 9 inches in 2001 and 2002 respectively).

2.3.2 Lake Cachuma Operations

Flows on the mainstem LSYR are affected by operations of Lake Cachuma in several ways. The reservoir captures winter season inflows and thus reduces downstream flow and peak flow during the rainy season. Reservoir releases to the mainstem river are made: (1) through uncontrolled spills when inflow to the reservoir exceeds storage capacity; (2) to meet downstream water rights under SWRCB Order WR 89-18; and (3) to provide target flows for steelhead/rainbow trout within lower Hilton Creek and the mainstem river, primarily within the reach from the dam downstream to the Highway 154 Bridge (Highway 154 Reach, Figure 1-2).

Table 2-4 summarizes annual Cachuma Project operations from 1993 – 2004. All data concerning Lake Cachuma and Bradbury Dam operations are from the Reclamation. The average inflow for the 12-year period 1993 through 2004 was 128,041 acre-feet per year (AFY), which is 150 percent of the average inflow of 85,093 AFY for the period 1953 through 2004 (52 years). From 1993 to 2004, the total downstream releases and spills into the LSYR averaged 103,394 AFY or about 80 percent of the inflow. Reservoir inflows for water years 1993 – 2004 are summarized in Table 2-4 and illustrated in Figure 2-3.

In water years 1993 through 2004, end of September storage exceeded 120,000 acre-feet in 10 out of the 12 years as shown in Figure 2-4 and Table 2-4. In water year 2004, Lake Cachuma dropped below 120,000 acre-feet in part due to drought. End of year storage ranged from approximately 185,000 acre-feet to 71,000 acre-feet. Starting in 1998, the reservoir was surcharged an additional 0.75 feet above the 750.0-foot elevation (full reservoir) for an additional storage of 2,300 acre-feet. This surcharge used the existing 1-foot flashboard, which left only 0.25 feet of freeboard at the maximum water surface elevation with the spillway gates closed. In the summer of 2004, a 4-foot flashboard was installed. Also, as a result of a new capacity survey, the reported storage in Lake Cachuma was reduced by 2,379 acre-feet effective July 1, 2001. The reservoir capacity at elevation 750.0’ was reduced from 190,409 (1989 survey) to 188,030 acre-feet (2000 survey), which resulted in about a one percent reduction in capacity due to sedimentation. In addition, it should be noted in Figure 2-4 that the lower reservoir levels during the period 1995 – 1997 were affected by storage restrictions due to a safety of dams concern which was remedied subsequently.

Over the 12-year period (1993 – 2004), there were reservoir spills in five years, downstream water rights releases in six years (calendar years), and releases for fisheries in all 12 years (Table 2-4). Figures 2-5 and 2-6 show daily hydrographs of the downstream releases and spills from Lake Cachuma for 1993 – 2004, on logarithmic and linear scales, respectively. Total releases and spills in the period 1993 through 2004 ranged from a high of 391,987 acre-feet in 1998 to a low of 3,882 acre-feet in the following year of 1999 (Table 2-4). Downstream releases and spills from Lake Cachuma are discussed in detail below.

2.3.2.1 Spills

Generally, the major amount of water discharged downstream from Lake Cachuma occurs during spill events. Due to the flashy nature of the Santa Ynez River watershed, a large percentage (60 - 75 percent) of the inflow into Lake Cachuma is spilled after big storm events. Table 2-5 shows a summary of the five spill occurrences for the period 1993–2004. Figure 2-7 shows a hydrograph of the Lake Cachuma spills using a monthly timestep. As a result of the buffering effect of the reservoir on inflow/outflow relationships, reservoir releases and downstream mainstem peak flows (Figure 2-7) do not coincide with inflow to Lake Cachuma (Figure 2-3) except during large spills. Spill volumes ranged from 6,067 acre-feet (2000) to 386,055 acre-feet (1998).

2.3.2.2 WR 89-18 Releases

Water rights releases for users downstream of Lake Cachuma are made in accordance with SWRCB Order WR 73-37, as amended in 1989 (WR 89-18). Releases under WR 89-18 are made to meet water rights of the above and below Narrows areas. The Narrows is located near the confluence of Salsipuedes Creek and the Santa Ynez River, immediately upstream of the City of Lompoc. Water rights releases are made to recharge the riparian groundwater basin along the LSYR (above Lompoc Narrows) and the Lompoc groundwater basin (below Lompoc Narrows). Table 2-6 summarizes the quantity of water rights releases based on a calendar year. Releases under WR 89-18 (Table 2-6; Figures 2-8 and 2-9) generally are made during periods when there would otherwise be little or no flow in the lower river. When made, WR 89-18 releases generally occur between July and October, although there are some instances of earlier and later releases (Figure 2-9). The timing of releases in 1997 and 2000 was affected by reservoir seismic safety operations and municipal well field development downstream, respectively. Release rates are typically high early in the release and then decline over the release period (Figure 2-9) once the water reaches the desired target area for recharge. The total duration of the water rights releases varied from 73 days (2000) to 126 days (1997 and 2002) during the period 1993 – 2004. The annual amounts of water rights releases by calendar year are shown in Table 2-6. Water rights releases ranged from zero to sixteen thousand acre-feet during the period from 1993 through 2004[1].

2.3.2.3 Releases for Fish

Table 2-4 shows the annual releases for fish. Beginning in 1993 and continuing through 2004 fishery releases have ranged from 494 acre-feet (1994) to 2,999 acre-feet (1999). These releases for fish were made in addition to spills and water rights releases.

Two different criteria were used for releases for fish in the period from 1993 to 2004. From 1993 through September 2000 (prior to the BO), releases for fish were made according to the MOU for Cooperation in Research and Fish Maintenance on the Santa Ynez River Downstream of Bradbury Dam (MOU 2004). A Fish Reserve Account was established, which received 2,000 acre-feet each year and 3,000 acre-feet in a spill year with a 0.75-foot surcharge of the reservoir. From October 2000 through September 2004, releases for fish were made according to the BA Proposed Action and FMP. Table 2-7a shows the interim fish flow targets of the BA Proposed Action/FMP for the mainstem in effect for this period of time. Table 2-7b shows the long-term fish flow targets under the BA Proposed Action/FMP for the mainstem which went into effect in 2005, after the study period for this report (1993 – 2004).

Figure 2-10 shows the historical daily fish water releases from Lake Cachuma from June 1993 through September 2004. Figure 2-10 does not include spills or downstream water rights releases. From June 1993 through September 2000 (7.3 years), the median release for fish under

[1] Annual totals for water rights releases shown in Table 2-4 are based on water year compared to Table 2-6 which are based on calendar year.

fish studies was about 3.0 cfs excluding spills and water rights releases. From October 2000 through September 2004 (4 years), when implementation of the BA Proposed Action and FMP were in effect for interim flow targets in the Highway 154 Reach, the median release for fish was about 4.0 cfs excluding spills and water rights releases. Over the study period, fishery releases varied from 2 to about 15 cfs. Figure 2-11 shows both spills and releases from Bradbury Dam and flow measurements from the Long Pool for the 1993 – 2004 period.

With the installation of the HCWS in 2000, surface water flows have been maintained in lower Hilton Creek throughout the 2000 – 2004 period. The HCWS has two release points in Hilton Creek, and one release point in the stilling basin. The lower Hilton Creek release point (HC-0.3) began operation in 2000. The upper Hilton Creek release point (HC-0.54) was not operated continuously until after 2004, and flows prior to this date reflect natural conditions. Releases for fish have the longest duration compared to other types of releases from Lake Cachuma. Releases for fish averaged about 230 days per year during the period 1993 - 2004 and 290 days per year during the period 2000 – 2004.

2.3.3 Flow in the Mainstem

There are two sources of information on flows in the lower mainstem Santa Ynez River, including the USGS and CPWA (Figure 2-1). The USGS measures flow in the mainstem river at gaging stations at the Long Pool on the LSYR near Bradbury Dam (ID No. 11126000; LSYR-0.5), the Solvang Bridge at Solvang (ID No. 11128500; LSYR-10.5), and the Narrows near Lompoc (ID No. 11133000; LSYR-36.1) as shown on Figure 2-1 and Table 2-1. Figures 2-11, 2-12, and 2-13 show the daily flow hydrographs for each USGS gage for the study period along with instantaneous flow measurements by CPWA at or near these sites. During storm events, flows increase as a function of distance downstream from Bradbury Dam due to the increase in tributary contributions. However, during the dry season, flows in the river resulting from releases for either fish or WR 89-18 decrease with distance from Bradbury Dam due to percolation into the river channel. The gaging station at Solvang is not considered as reliable or accurate as the USGS gage located at the Narrows due to the channel configuration.

The current-meter instantaneous flow measurements by CPWA (Table 2-2) are useful in describing the routing of low flows in the LSYR. CPWA measurements of low flows in the LSYR channel indicate that low flows are very non-uniform, even within short distances. For example, on November 26, 2001 flow of the LSYR was measured at 3.4 cfs at the transect near the old Highway 154 Bridge (immediately downstream of current Highway 154 Bridge, about 3.2 river miles (RM) downstream of Bradbury Dam; LSYR-3.2). However, approximately 200 feet upstream the flow underneath the existing Highway 154 Bridge was measured at 1.4 cfs. This difference in flow of two cfs occurred over a short distance of about 200 feet and illustrates how rapidly low flow changes, particularly in braided sections of the mainstem, which is most likely due to the water traveling underground as sub-flow. Conversely, other areas in the LSYR channel receive groundwater upwelling and form pools.

Figures 2-14 through 2-17 show the flows in the mainstem after the spill and recession of tributary flows in the year 2001. During the spring and summer, the mainstem channel was typically kept in a wetted condition for the first 3.2 miles downstream of Bradbury Dam, with the remaining river channel consisting of a series of isolated pools separated by segments of dry channel. Figure 2-16 shows the situation where the flow dried up at the Meadowlark Crossing at

RM 5.0 (LSYR-5.0) but resurfaces at Refugio Bridge at river mile 7.8 (LSYR-7.8, Figure 2-17). Changes in channel location, gradient and channel bed, the amount of sub-surface flow, and other factors affect the reliability of stream gaging records for low flows for various locations along the lower river.

Flow monitoring under the BA Proposed Action at the Highway 154 Bridge (LSYR 3.2) has been complicated by lack of a reliable site for flow monitoring and access issues. The river channel at the Highway 154 Bridge area is physically unsuitable for low flow measurements in the LSYR. The river channel is braided and wide with large changes in the sub-surface flow rate. Measurements cannot be taken upstream or downstream of the current Highway 154 Bridge because of restrictions on access to private lands, which constrains the ability to modify or relocate the gaging station. Flow monitoring is being done using the Reclamation flow data at Bradbury Dam and accounting for downstream flow depletions (including uses by phreatophytes and agriculture) and tributary inflows (Stetson 2004). In 2004, NMFS approved this monitoring plan for releases at Bradbury Dam to maintain flows in the Highway 154 Reach (NMFS 2004).

2.3.4 Flow in the Tributaries

Flow measurements in the tributaries to the LSYR (Figures 2-18 to 2-24) were characterized by high variability and rapid increases and decreases in flows (flashy) in response to precipitation and storm water runoff. Instantaneous measurements of tributary flows are available from the fishery and habitat monitoring program over the period from 1998 through 2004. The peak flows observed within a tributary reflect, in part, the characteristic and size of the watershed. South side tributaries generally receive more rainfall but have smaller drainage areas than the north side tributaries (except for Salsipuedes Creek). Only Salsipuedes Creek was observed to generate flows in excess of 1,000 cfs, which occurred twice during the period from 1998 to 2004 as shown at the USGS gaging station location on Salsipuedes Creek (Figure 2-18). High flows have also been observed periodically in Hilton, Alisal, and Nojoqui creeks in response to large storms. Many of the other smaller tributaries seldom generated flows of more than 100 cfs due to small drainage areas and other watershed factors.

The drainage areas of the LSYR tributaries below Lake Cachuma (Bradbury Dam to the Narrows) are roughly equal to the drainage areas of the tributaries above Lake Cachuma (Figure 1-1). Although in general less rain falls in the lower watershed, the cumulative tributary flow contributions to the lower river become important during winter storms. The contribution of flow by the tributaries during storm events is highly variable. For example, in 2000 (in which Lake Cachuma had a small late season spill in April and May), the LSYR flow at the Narrows totaled 18,630 acre-feet in the month of February (before the spills) compared to a computed inflow of 15,023 acre-feet into Lake Cachuma for the same month. Given that Jameson and Gibraltar reservoirs (Figure 1-1) stored about 4,500 acre-feet during that month, the watershed above and below Lake Cachuma contributed about the same amount of runoff for that particular month. Conversely, in 2003, the Narrows flow totaled 1,200 acre-feet in the month of May, while inflows into Lake Cachuma totaled around 6,000 acre-feet. Thus, the same general storm may create quite different precipitation and streamflow conditions in nominally nearby tributary watersheds. Local topography interacts with variable storm conditions to create variable precipitation and runoff in tributary watersheds within the basin, which varies season-to-season and year-to-year.

Figures 2-18, 2-19, and 2-20 show the USGS flow gage data for Salsipuedes, Hilton, and San Miguelito creeks, respectively, along with instantaneous flow measurements by CPWA at or near these sites (Table 1-1). Figures 2-21 through 2-24 show instantaneous flow measurements by CPWA for Quiota, Nojoqui, Upper Salsipuedes, and El Jaro creeks, respectively (see Table 1-1 for tributary monitoring locations). As illustrated in Figures 2-18 through 2-24, flows in the tributaries declined rapidly following peak response to rainfall, and flows during dry years drop below 1 cfs in the downstream tributary locations where flow was measured. Most tributaries typically dry up in the lower reaches in the summer. At higher elevations, tributary flow characteristics include dry channel sections alternating with wetted sections of pools and riffles associated with bedrock formations forcing groundwater to the surface. In these pool reaches, summer flows were frequently below 1 cfs.

In the period from 1993 through 2004, the largest change in tributary flows has occurred in Hilton Creek due to operation of the year-round watering system. Use of the HCWS has resulted in consistently wet conditions supporting steelhead/rainbow trout habitat within lower Hilton Creek since 2000, with flows released from the dam through the watering system typically within the range of 2.5 – 5 cfs (Figure 2-19).

2.3.5 Breaching of the Santa Ynez Lagoon

Observations indicate that flows from Salsipuedes Creek alone are capable of breaching the lagoon due to the creek’s sizable, flashy watershed, and proximity to the lagoon. As a result of restrictions on access to the site, difficulty in obtaining permission to install staff gages to continuously monitor water surface elevations within the lagoon, and other factors, information collected on the relationship between breaching and closing of the sand bar in response to river and tributary flows is limited. Based on the information collected to date, no quantitative relationships have been developed between the magnitude of flow required to breach the sand bar, the duration or volume of flow entering the lagoon, the flow rate required to maintain the breached bar, or the influence of other physical processes on the opening and closing of the bar (e.g., tidal stage, wave action, etc.). Suggested future monitoring will include more systematic measurements to help establish the relationship between river flow and breaching of the sand bar.

Observations by CPWA biologists suggest that storm flows from Salsipuedes Creek have breached the lagoon, independent of significant upstream flows. Given that flows in excess of 100 cfs may be needed to breach the lagoon, flow records analyzed from the USGS gage at the Narrows (Figures 2-1 and 2-13) can be used to estimate periods of time when the sand bar at the lagoon may have been breached. Based on direct observation and/or rate of flows at the Narrows, lagoon breaching appears to have been highly variable from 1993 through 2004 (Table 2-8). Lagoon breaching does not occur every year. Also, the data in Table 2-8 indicates that the lagoon may remain open for only short periods of time. For example, short periods of breaching occurred following brief, but intense storms in 1999 and 2003 that may have resulted from increased flow and/or wave and tidal currents from the ocean.

THIS PAGE INTENTIONALLY LEFT BLANK

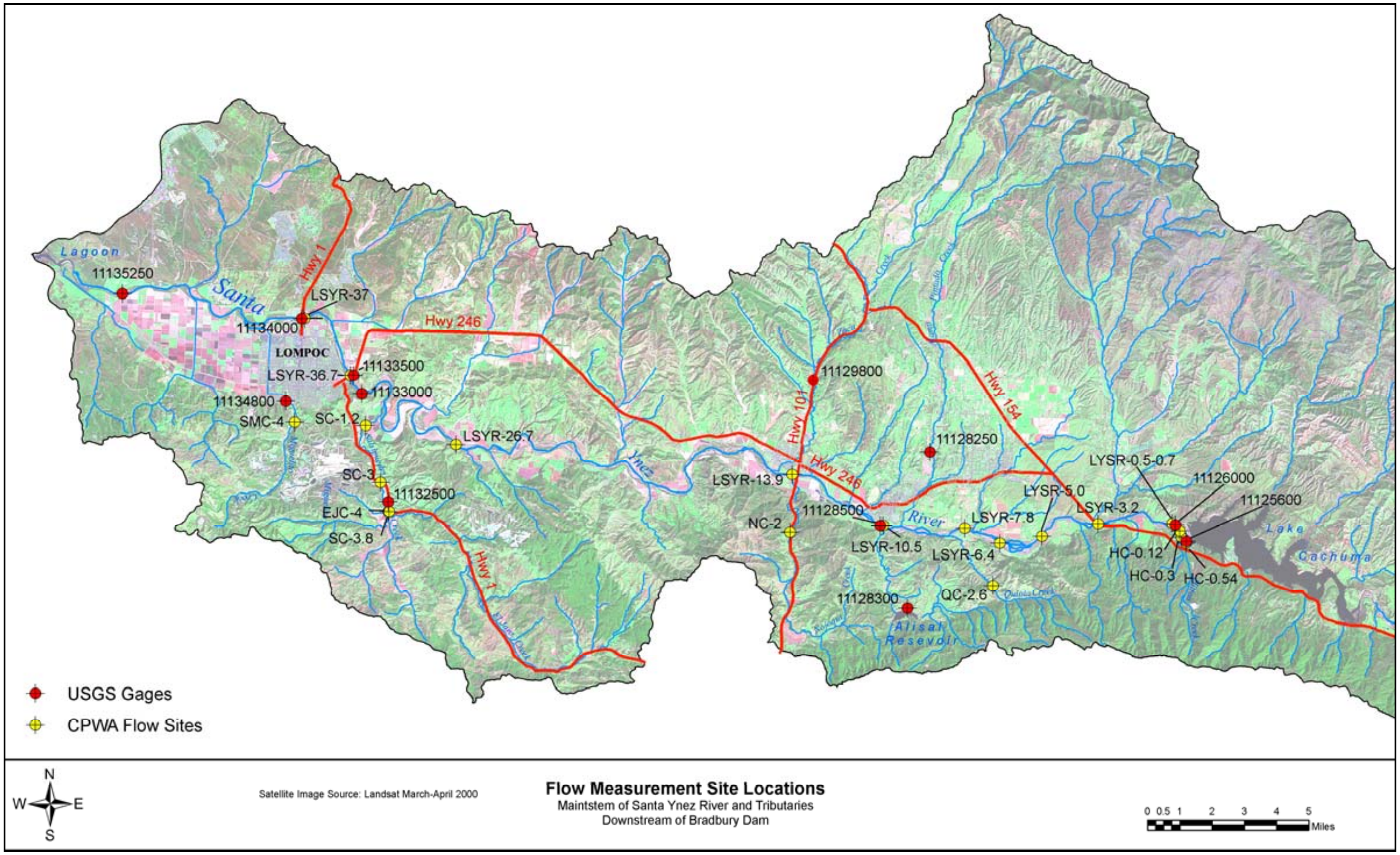


Figure 2-1. Surface water flow measurement locations in the LSYR mainstem and tributaries (see Table 1-1 for site information (Source: CPWA 2005, Landsat 2000, Stetson 2005))

THIS PAGE INTENTIONALLY LEFT BLANK

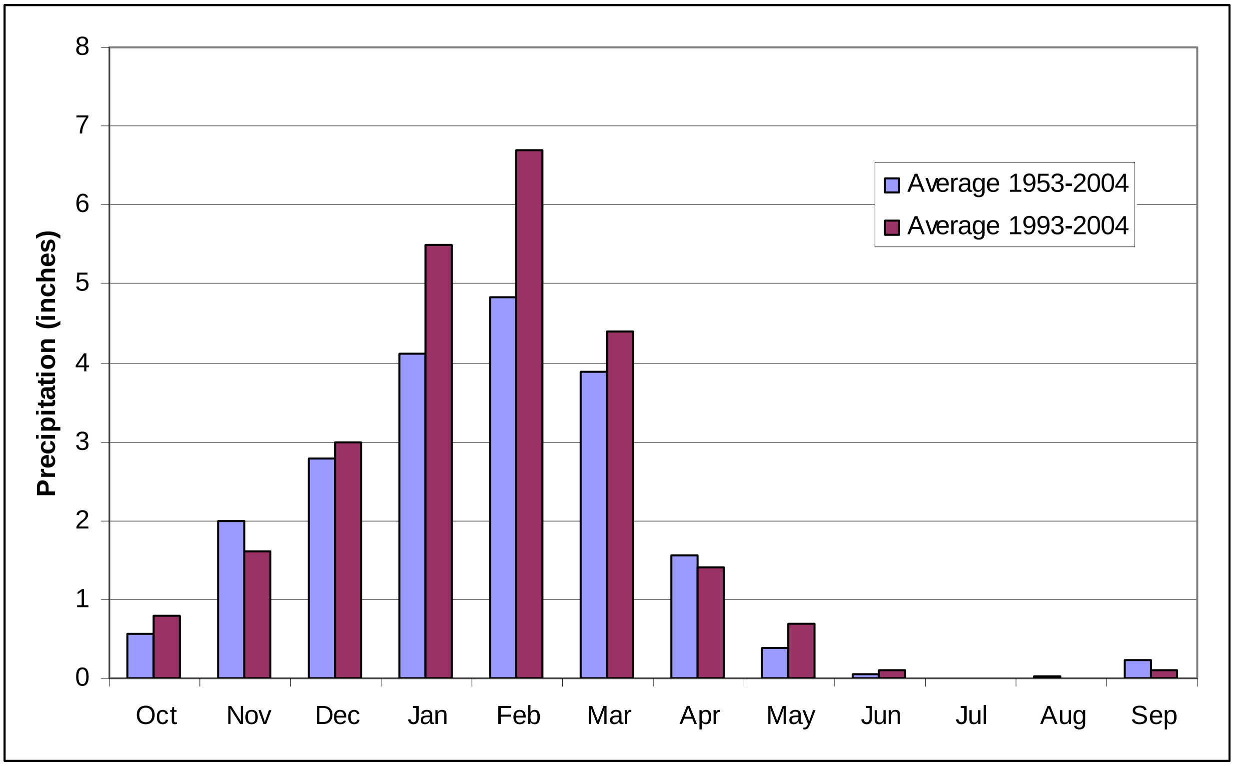


Figure 2-2. Average monthly rainfall measured at Lake Cachuma, 1953 – 2004 and 1993 – 2004

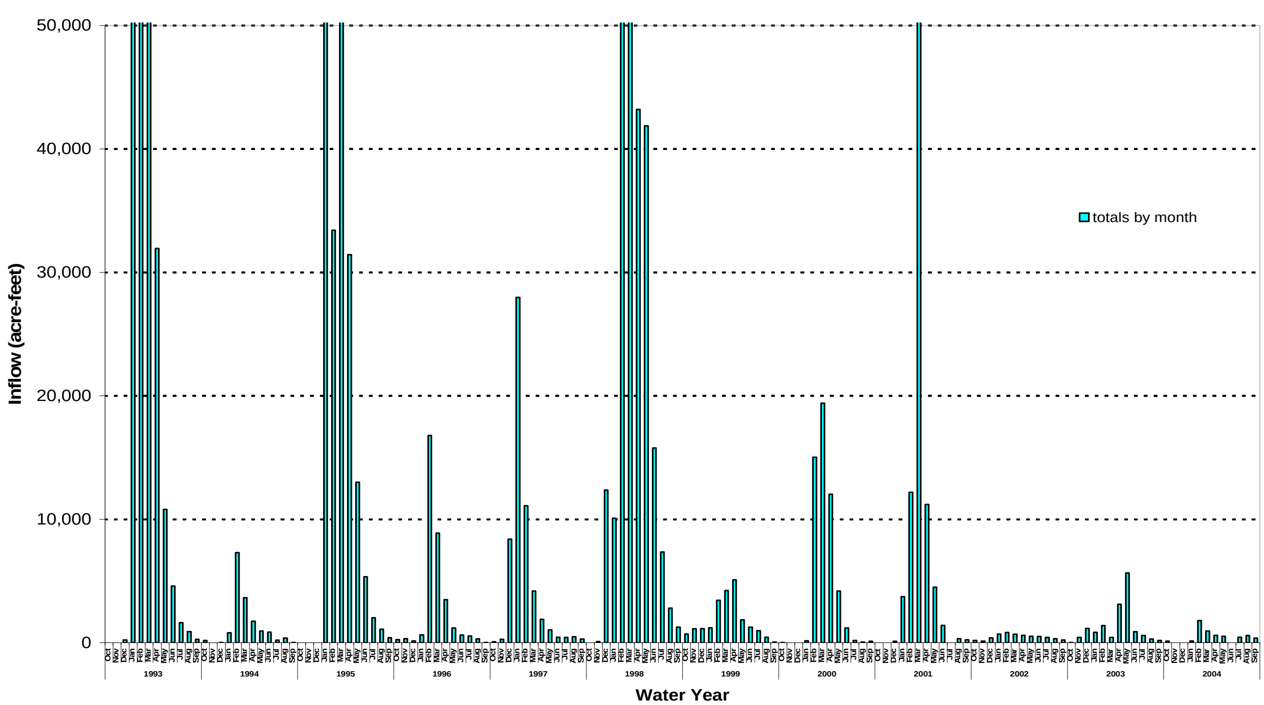


Figure 2-3. Computed monthly inflow to Lake Cachuma, 1993 – 2004 (Source: Reclamation annual progress reports)

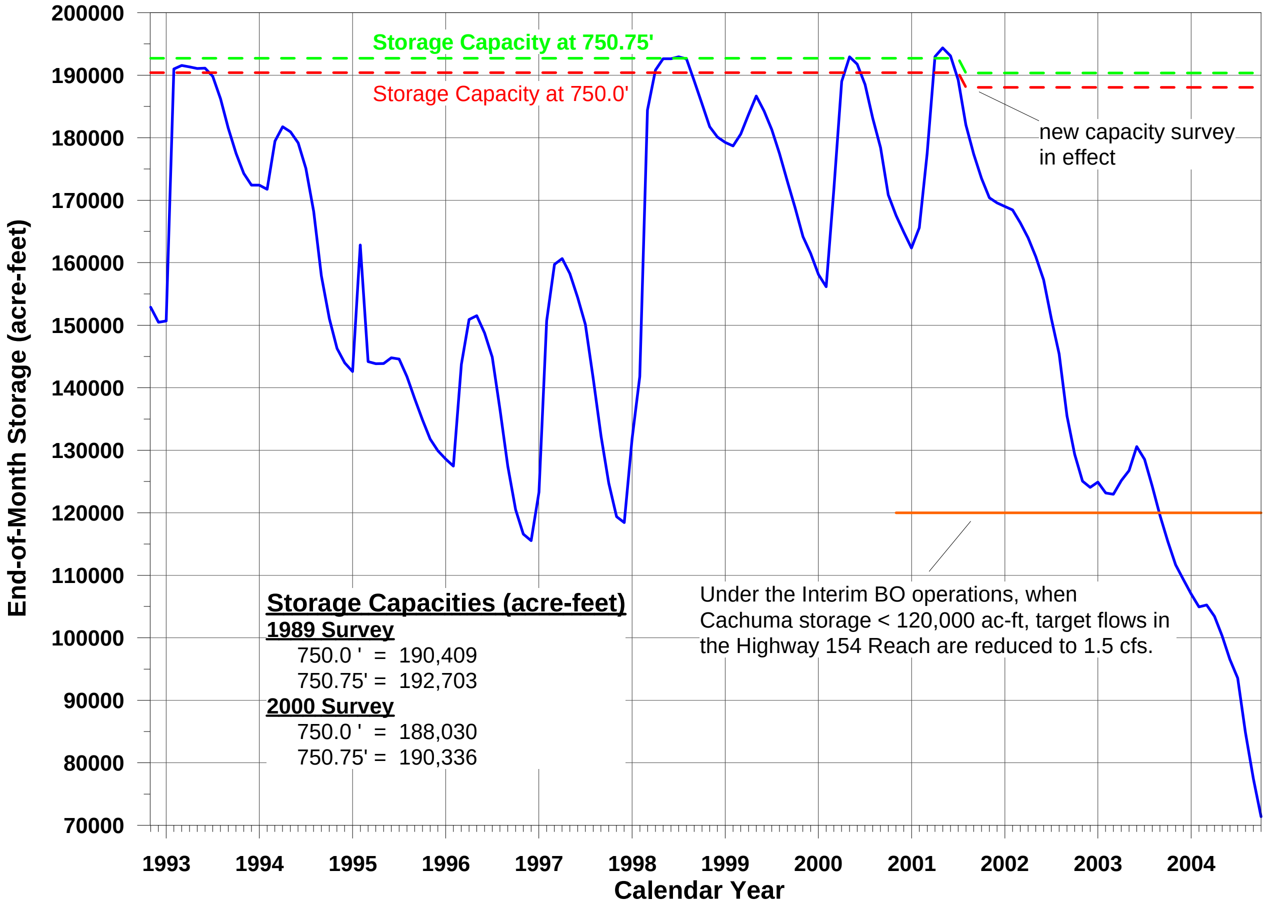


Figure 2-4. End-of-month storage volume in Lake Cachuma (Source: CPWA 2005; Stetson 2005)

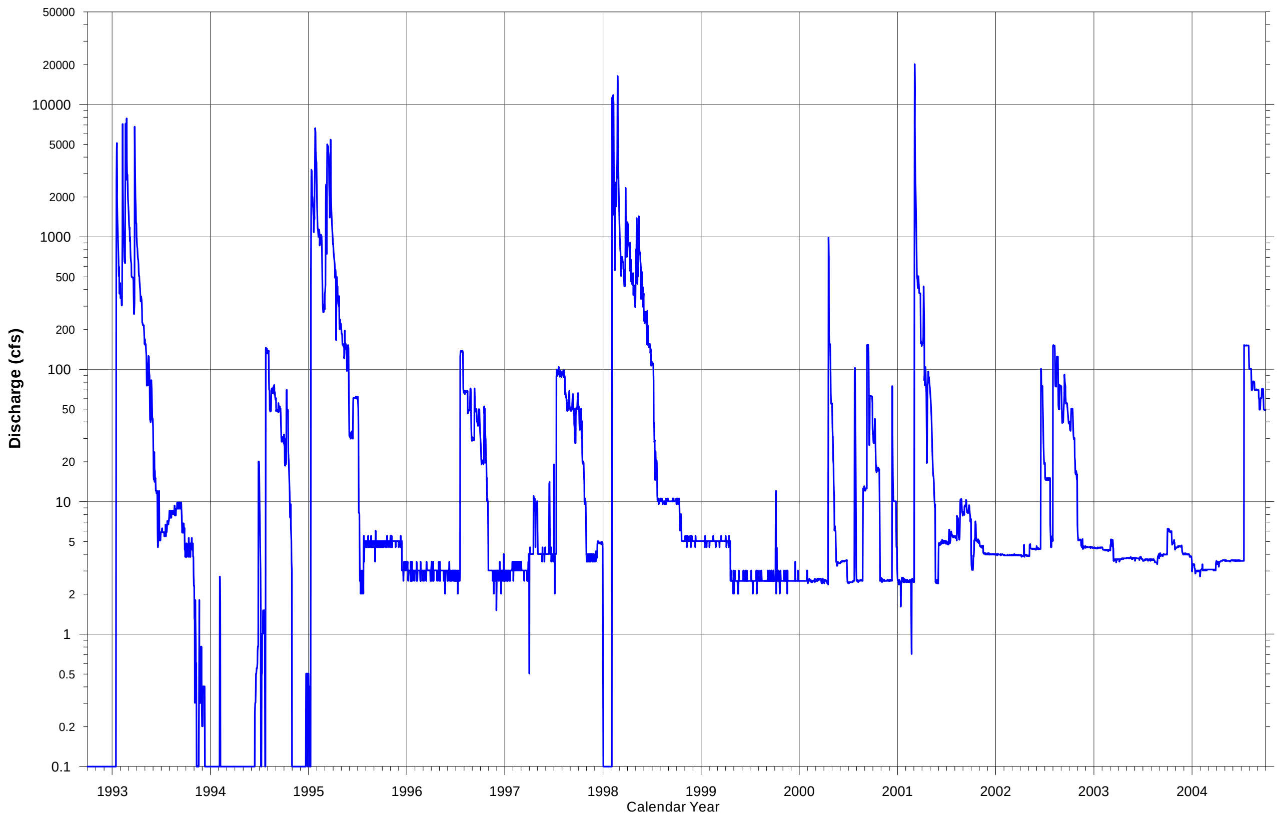


Figure 2-5. Daily discharge from Lake Cachuma shown on log scale (not including leakage; Source: CPWA 2005; Stetson 2005)

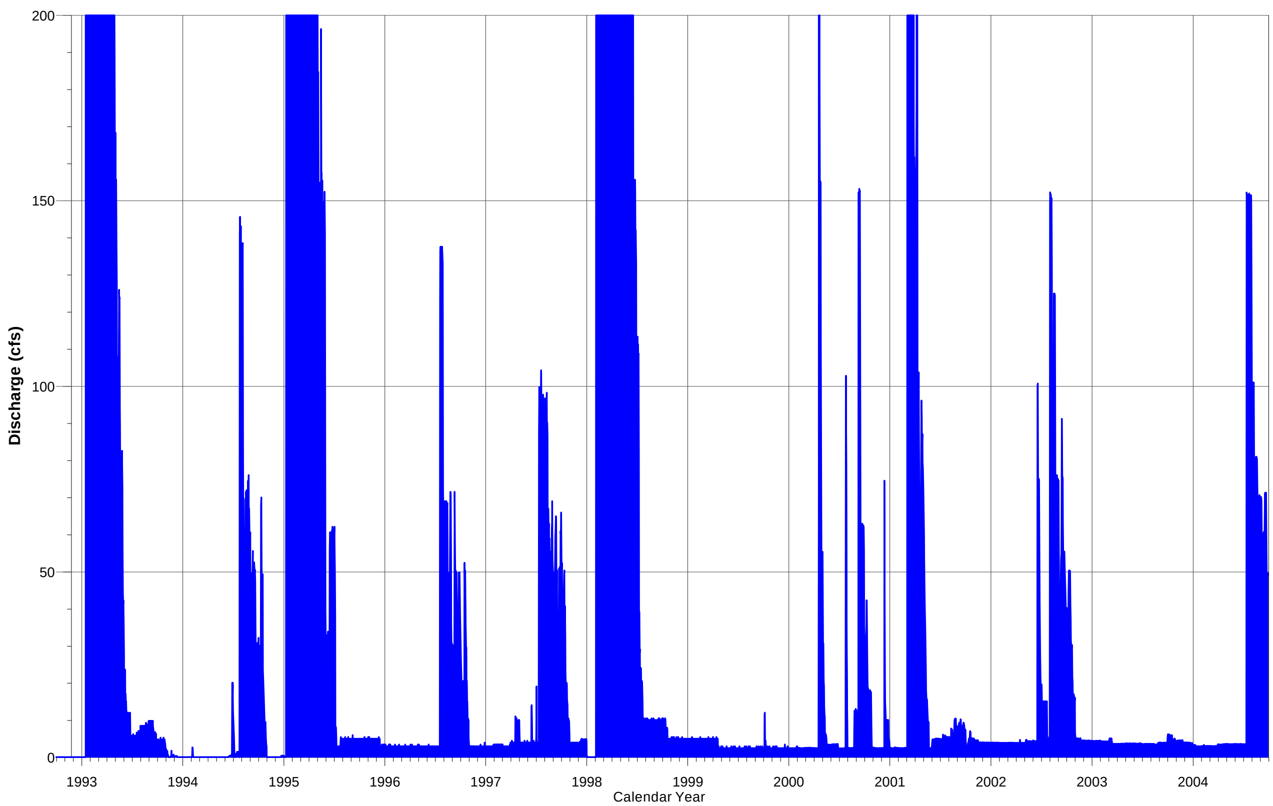


Figure 2-6. Daily discharge from Lake Cachuma shown on linear scale (not including leakage; Source: CPWA 2005; Stetson 2005)

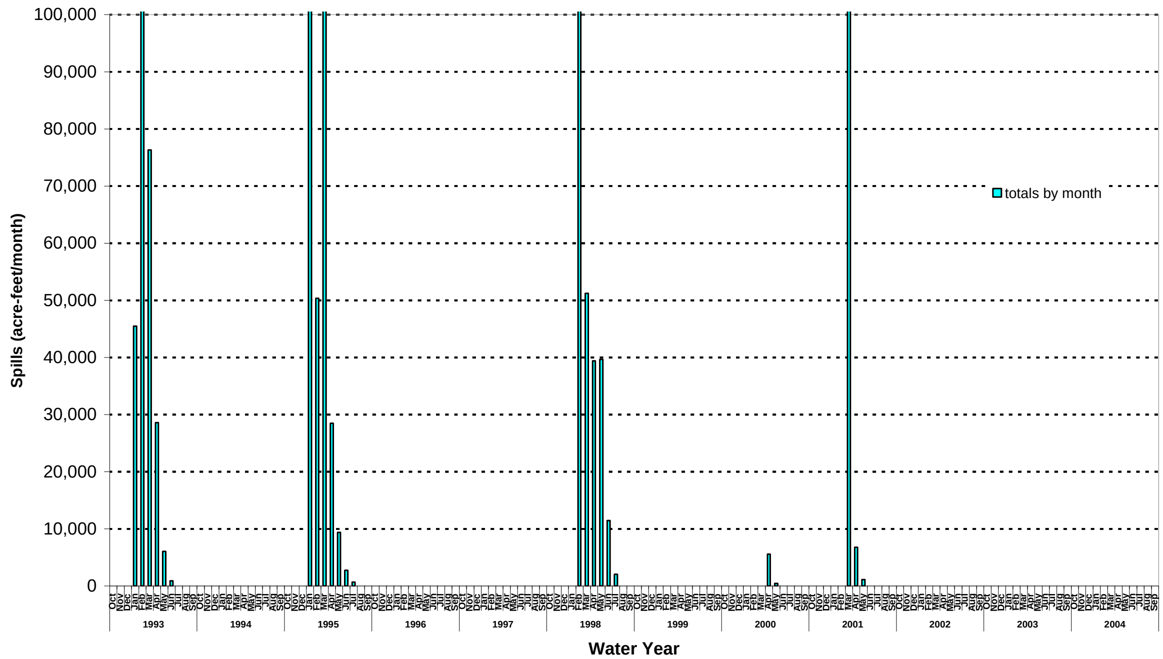


Figure 2-7. Monthly spills from Lake Cachuma, 1993 – 2004 (Source: Reclamation 2005; Stetson 2005)

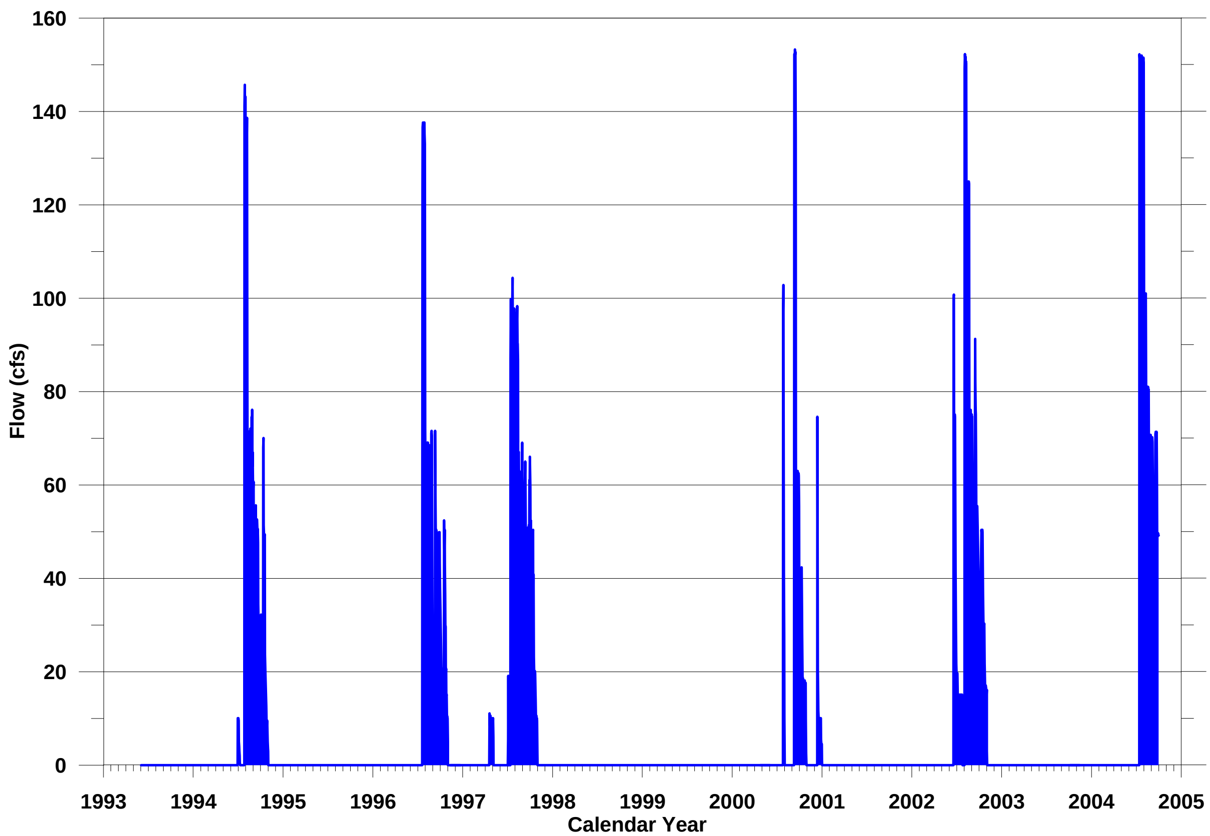


Figure 2-8. Daily water rights releases from Lake Cachuma under WR 89-18, 1993 – 2004 (Source: Reclamation 2005; Stetson 2005)

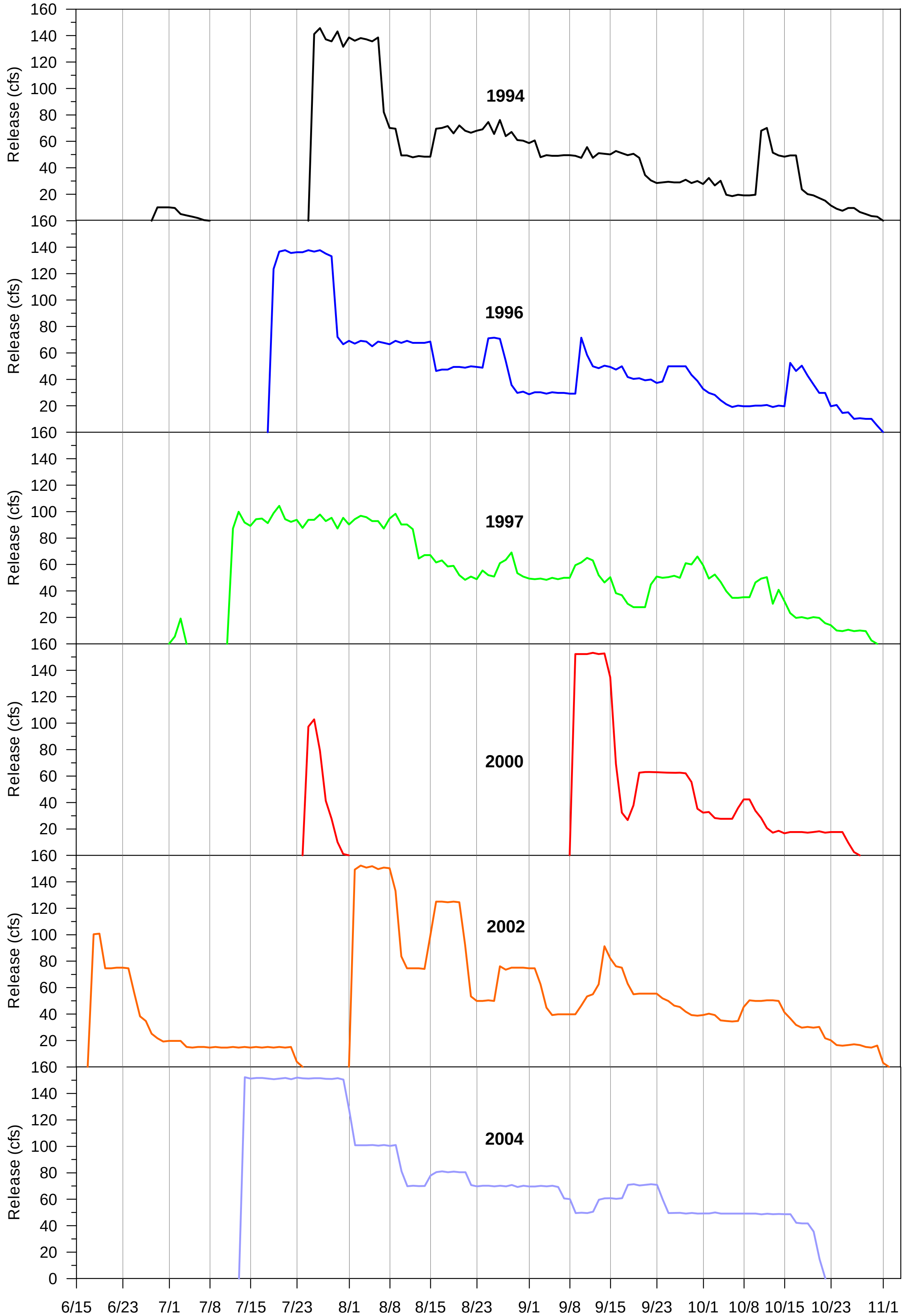


Figure 2-9. Similarity in timing and magnitude of WR 89-18 Releases, 1993 – 2004 (Source: Reclamation 2005; Stetson 2005)

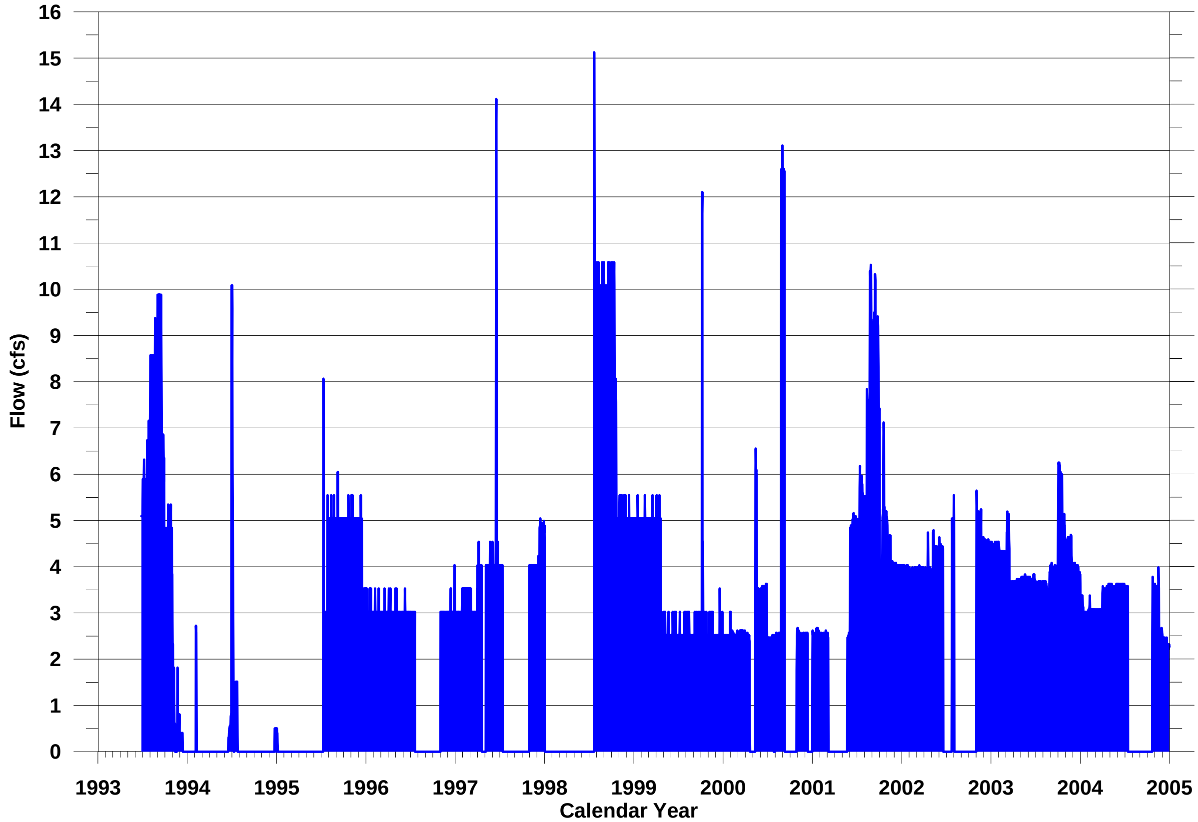


Figure 2-10. Daily releases from Lake Cachuma under fish reserve account (June 1993 to September 2000) and the Proposed Action/FMP (October 2000 to December 2004) (Source: Reclamation 2005; Stetson 2005)

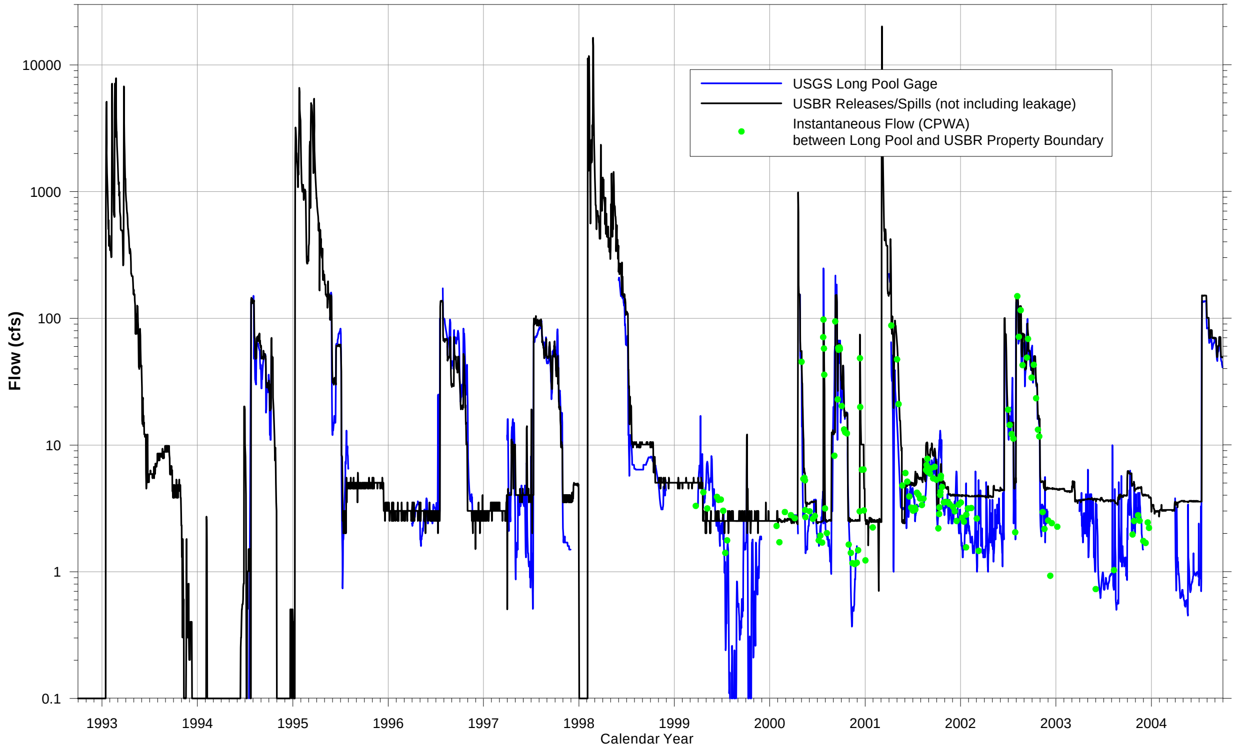


Figure 2-11. Daily flow hydrograph for USGS Gage at Long Pool (ID No. 1112600) and other flow measurements (Source: USGS 2005, Stetson 2005; CPWA 2005)

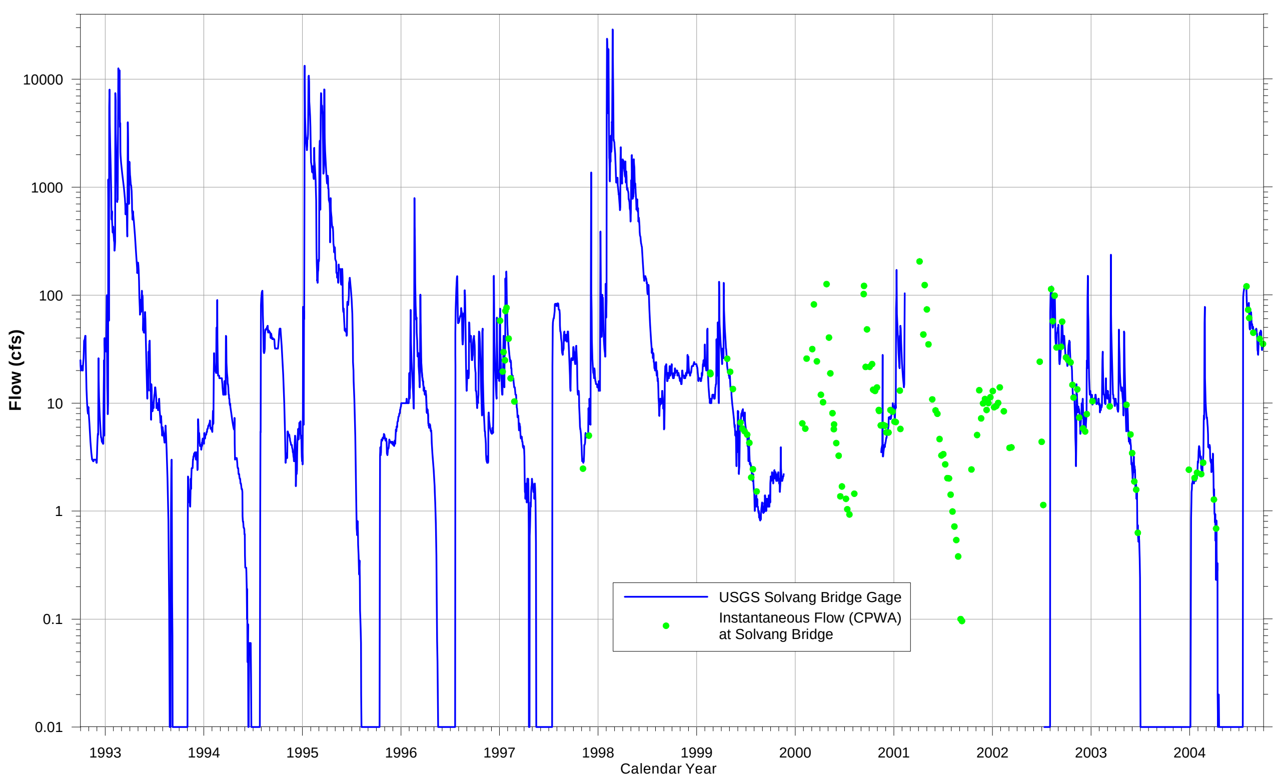


Figure 2-12. Daily flow hydrograph for USGS Gage at Solvang Bridge (ID No. 1112850) and other flow measurements (Source: USGS 2005, CPWA 2005, and Stetson 2005)

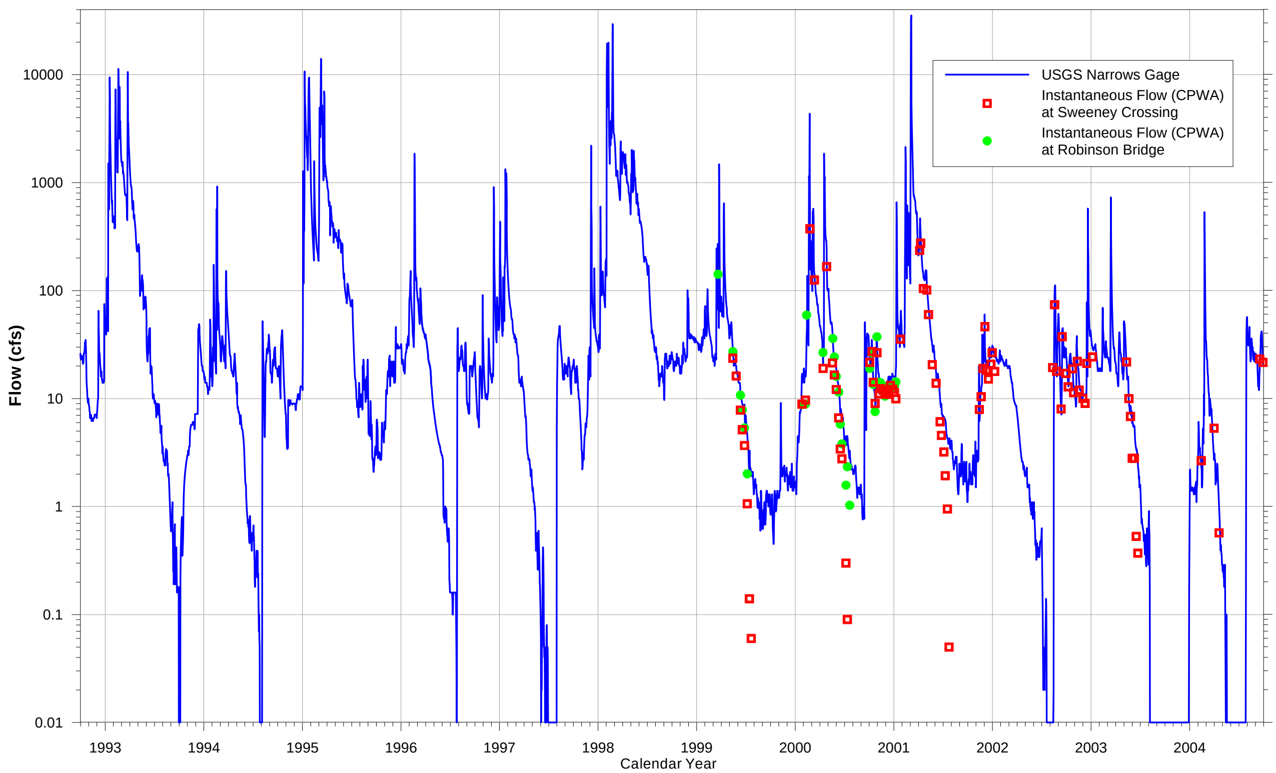


Figure 2-13. Daily flow hydrograph for USGS Gage at Lompoc Narrows (ID No. 11133000) and other flow measurements (Source: USGS 2005; CPWA 2005; Stetson 2005)

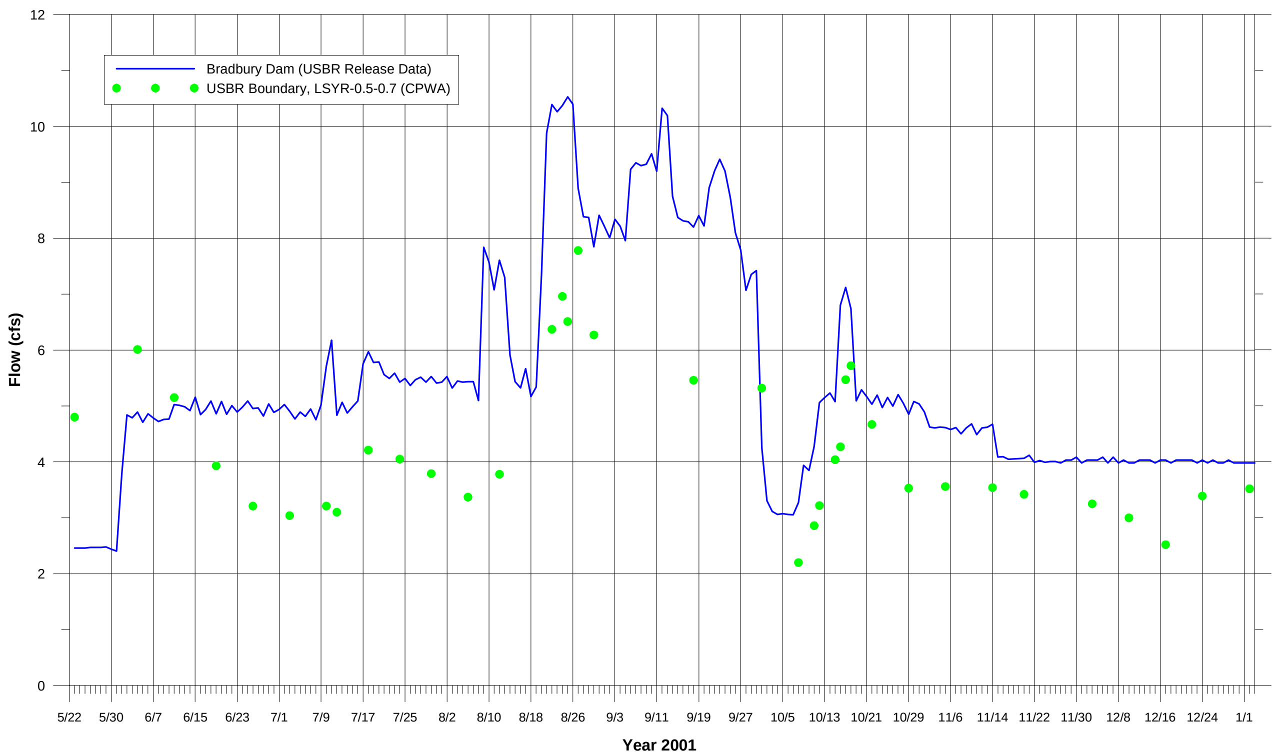


Figure 2-14. Hydrograph of flows in the Santa Ynez River at Reclamation boundary (Source: Reclamation 2005; CPWA 2005; Stetson 2005)

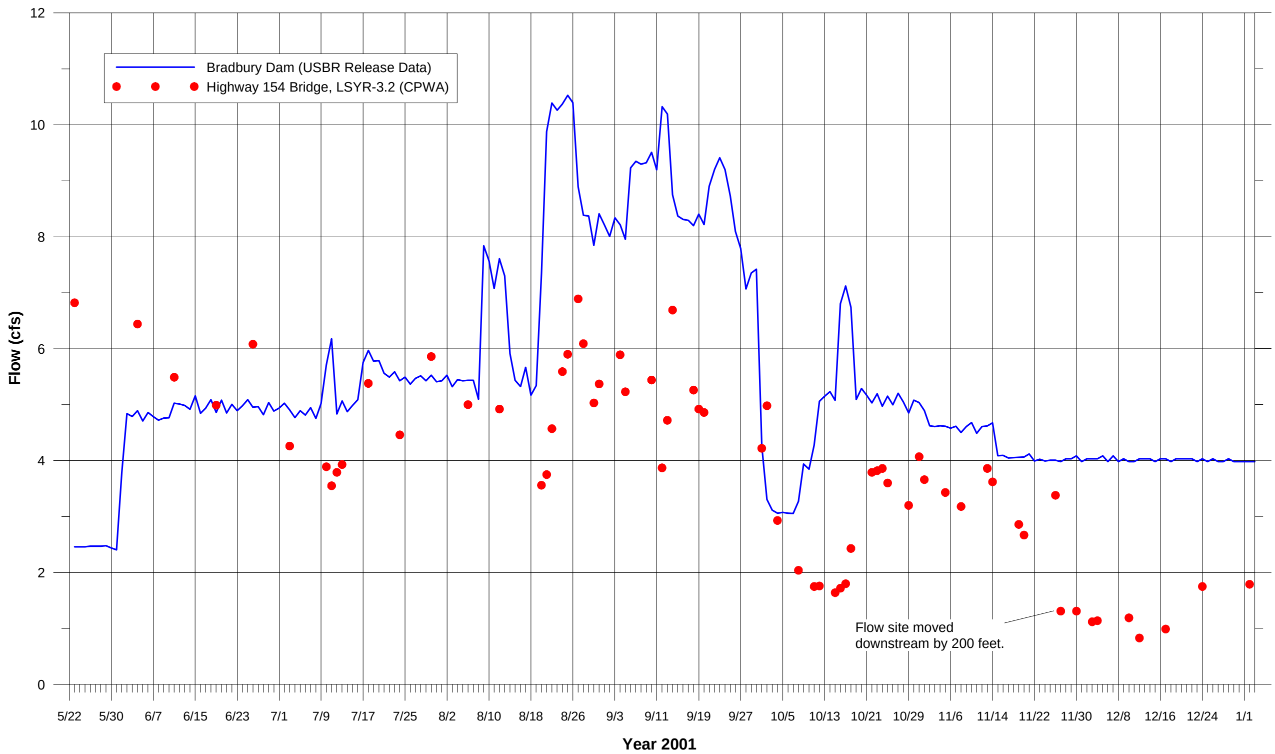


Figure 2-15. Hydrograph of releases at Bradbury Dam and flow measurements in the Santa Ynez River at Highway 154 Bridge (Source: Reclamation 2005; CPWA 2005; Stetson 2005)

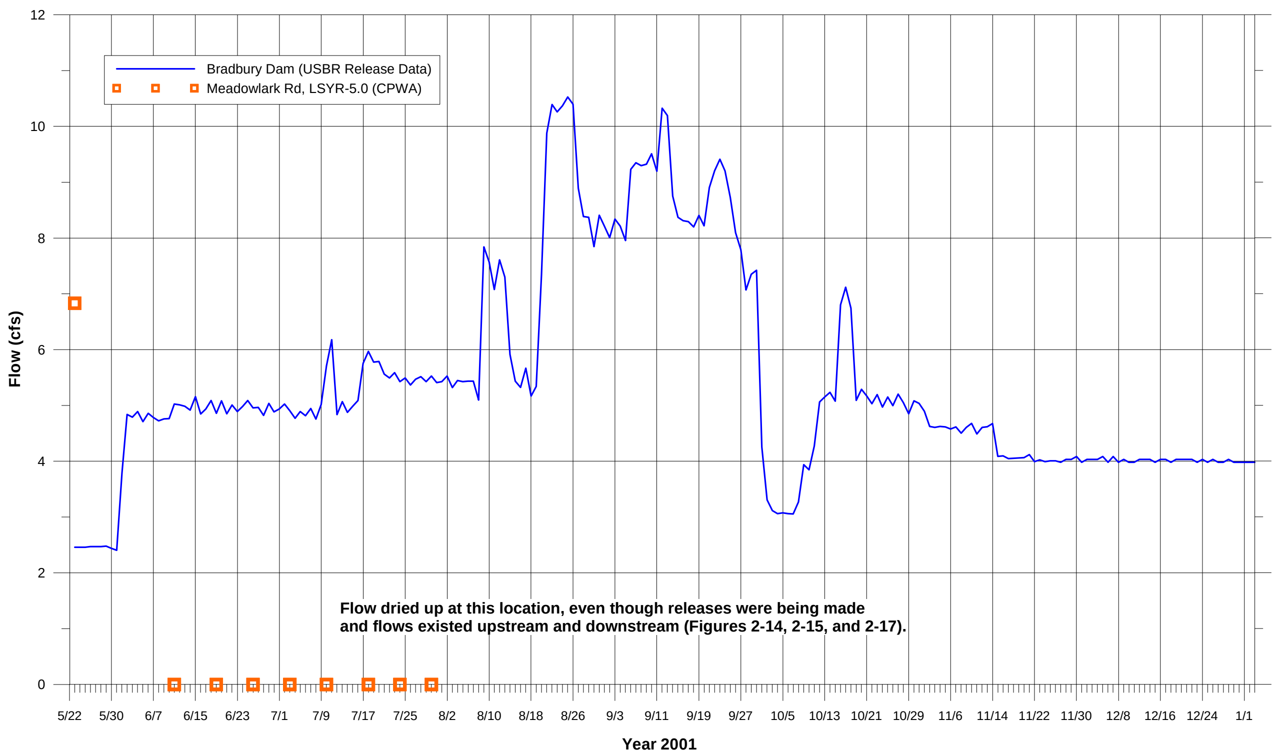


Figure 2-16. Hydrograph of releases at Bradbury Dam and flow measurements in the Santa Ynez River at Meadowlark Road (Source: Reclamation 2005; CPWA 2005; Stetson 2005)

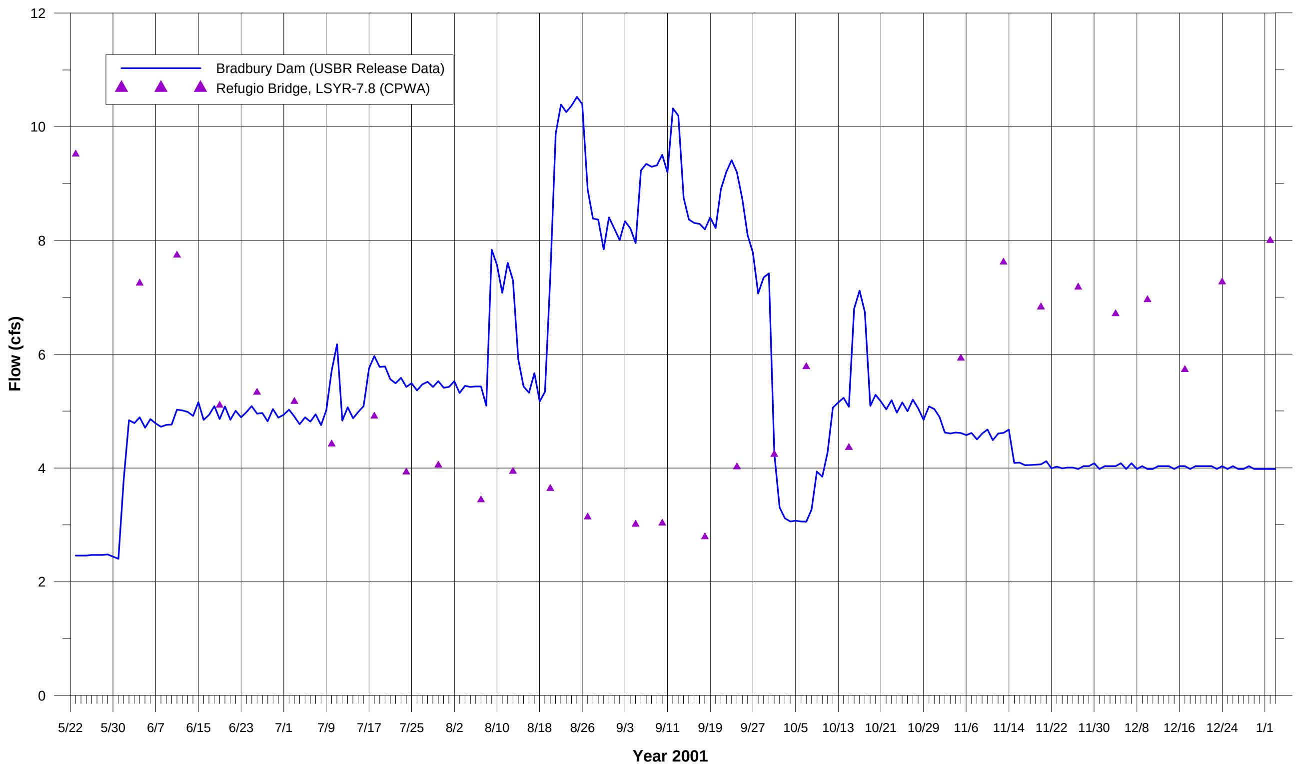


Figure 2-17. Hydrograph of releases at Bradbury Dam and flow measurements in Santa Ynez River at Refugio Bridge (Source: Reclamation 2005; CPWA 2005; Stetson 2005)

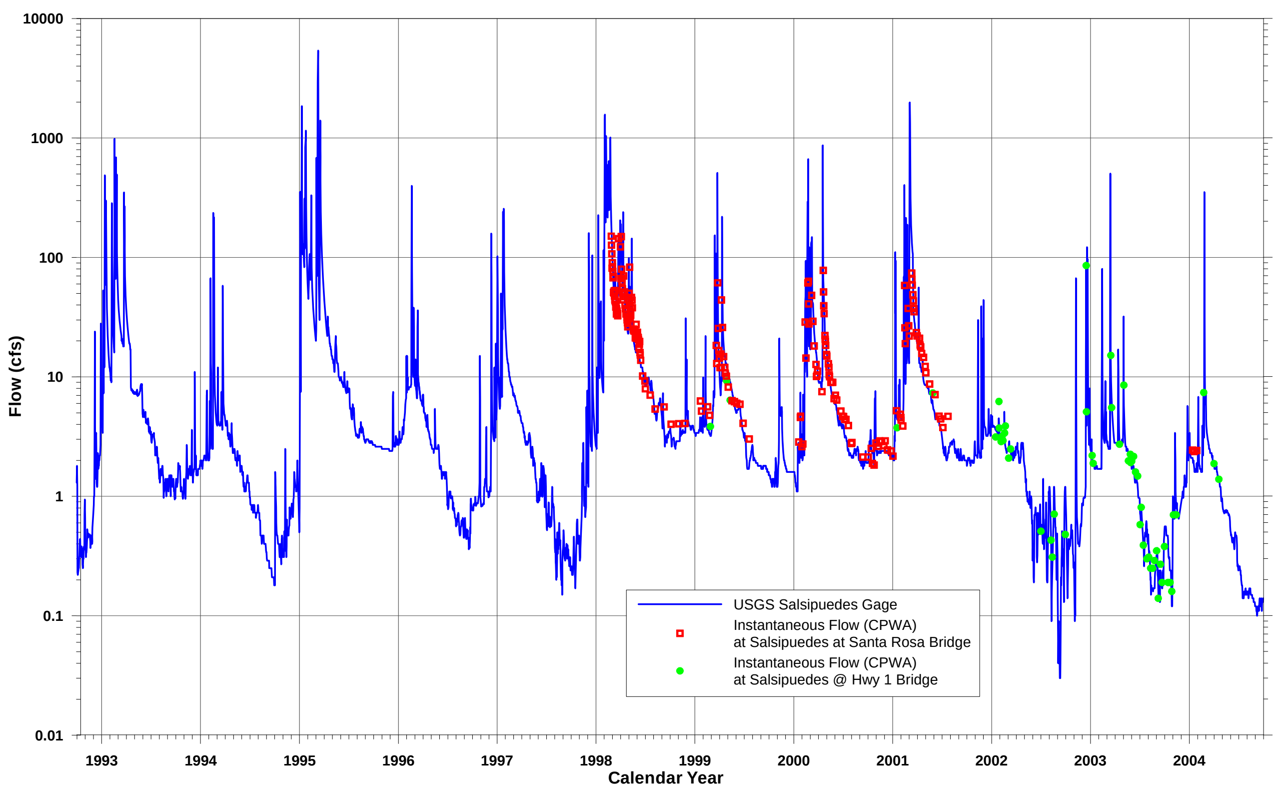


Figure 2-18. Daily flow hydrograph for USGS Gage in Salsipuedes Creek (ID No. 11132500) and other flow measurements (Source: USGS 2005, Stetson 2005; CPWA 2005)

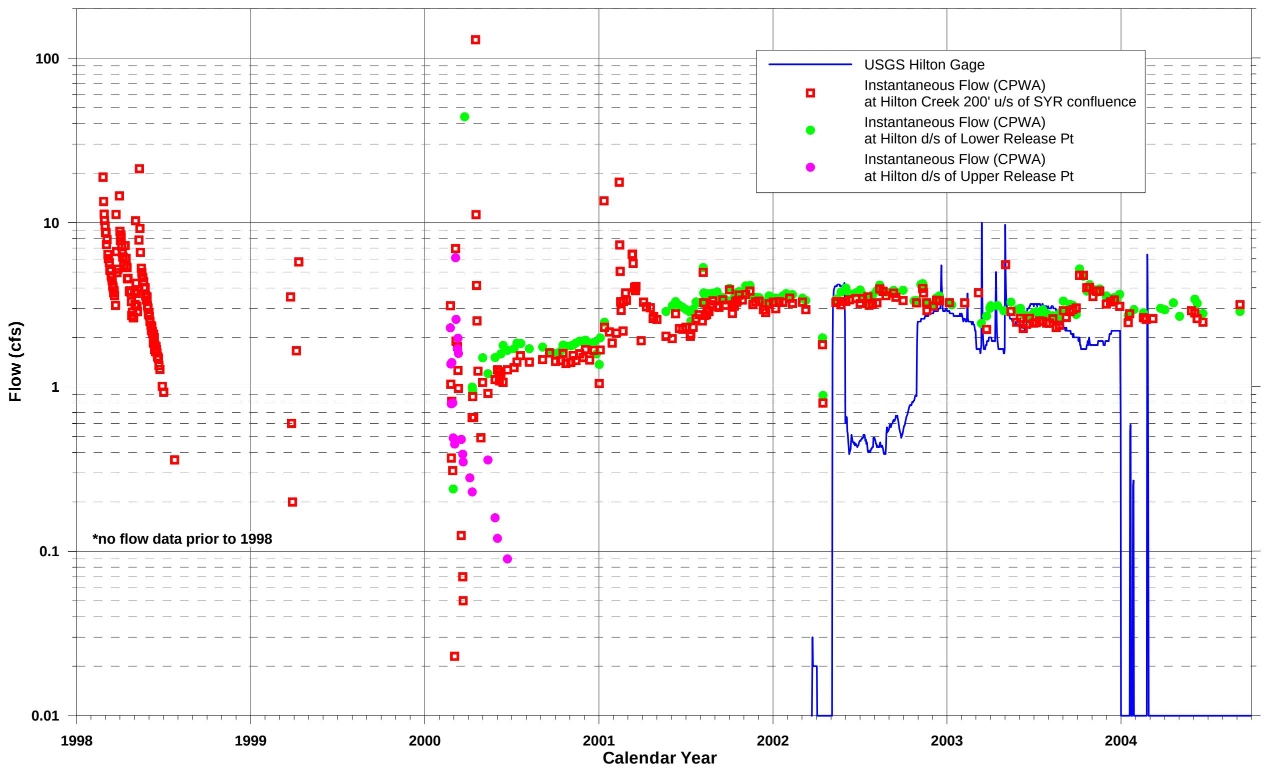


Figure 2-19. Daily flow hydrograph for USGS Gage in Hilton Creek (ID No. 11125600) and other flow measurements (note: HCWS began in April 2000; Source: USGS 2005, Stetson 2005; CPWA 2005)

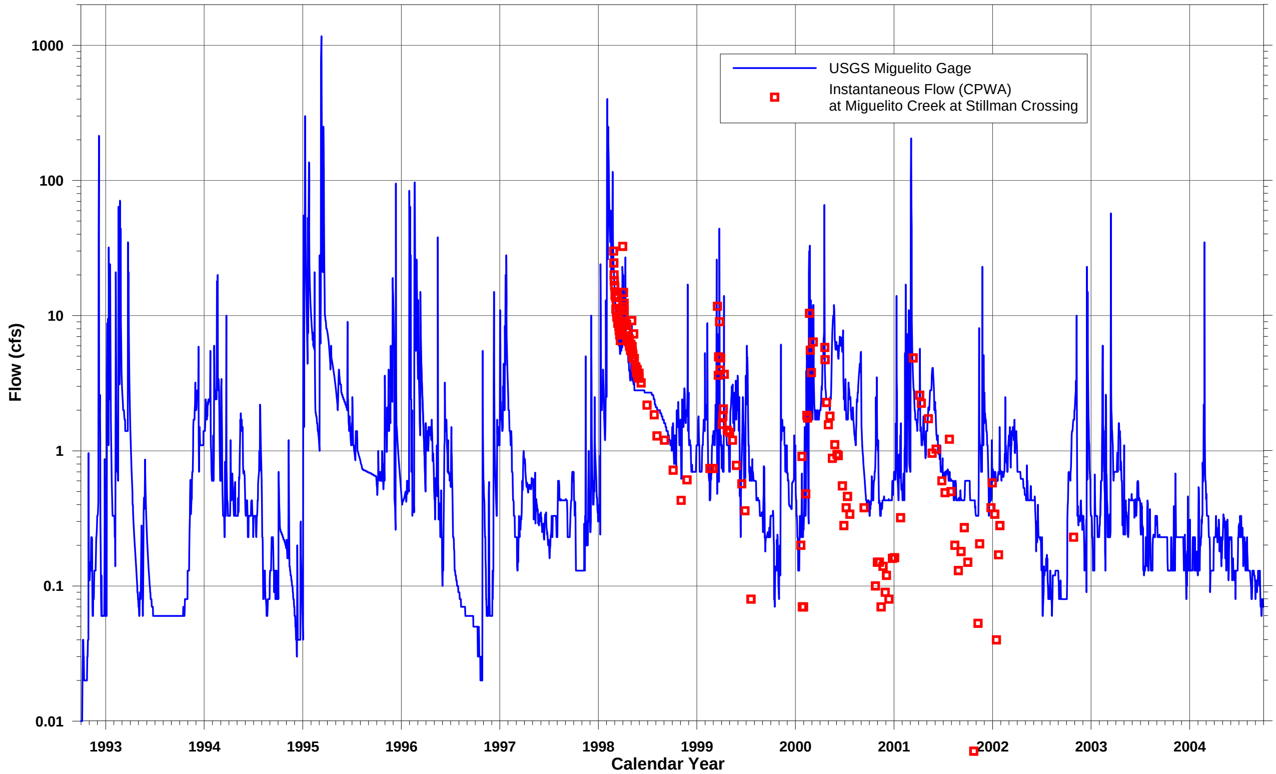


Figure 2-20. Daily flow hydrograph for USGS Gage in San Miguelito Creek (ID No. 11134800) and other flow measurements (Source: USGS 2005, Stetson 2005; CPWA 2005)

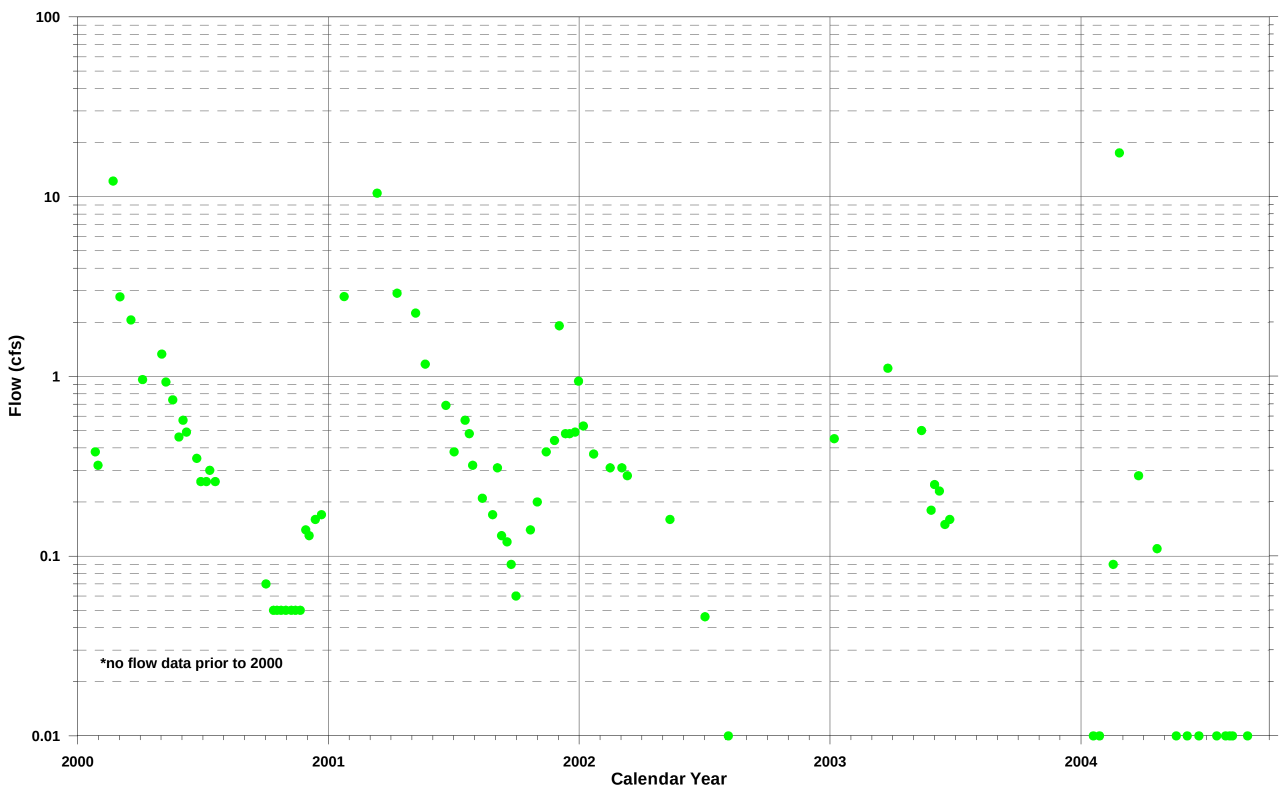


Figure 2-21. Instantaneous flow measurements by CPWA on Quiota Creek upstream of the 7th Road crossing (Source: CPWA 2005)

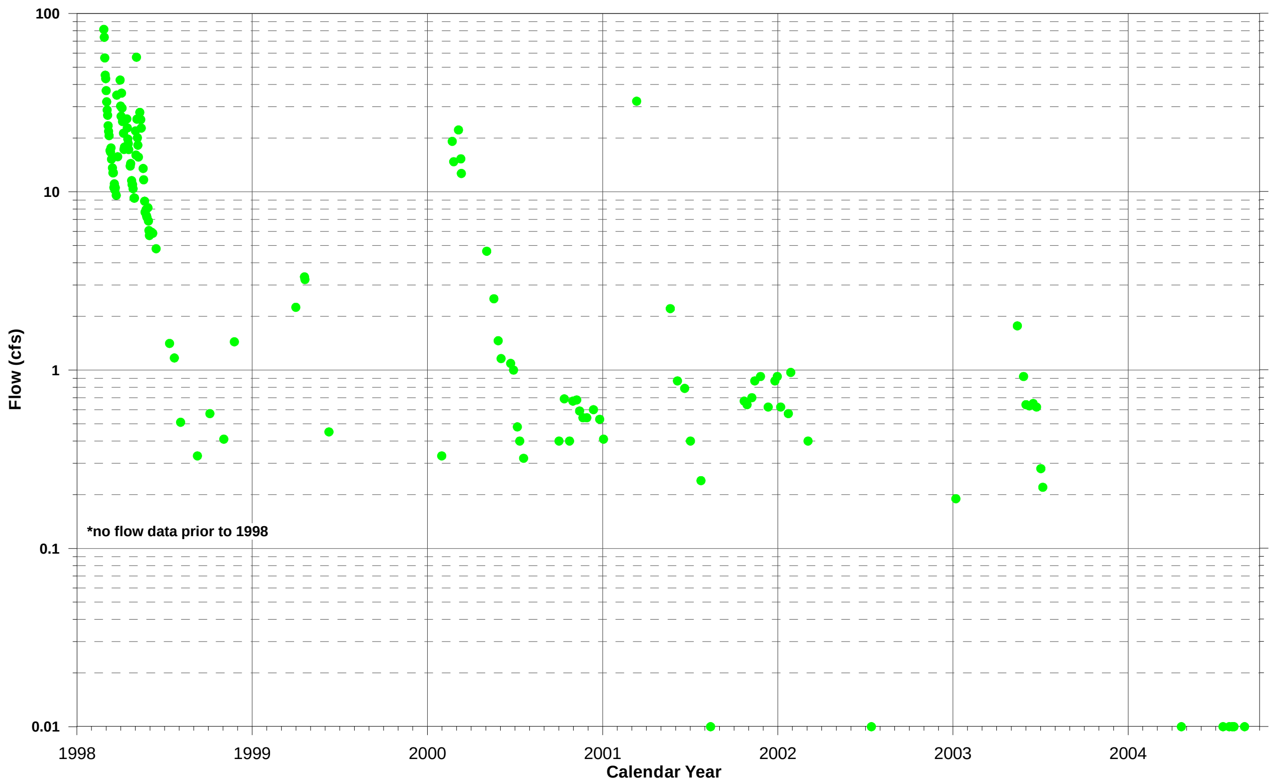


Figure 2-22. Instantaneous flow measurements by CPWA on Nojoqui Creek (4th HWY 101 Bridge from Buellton (Source: CPWA 2005)

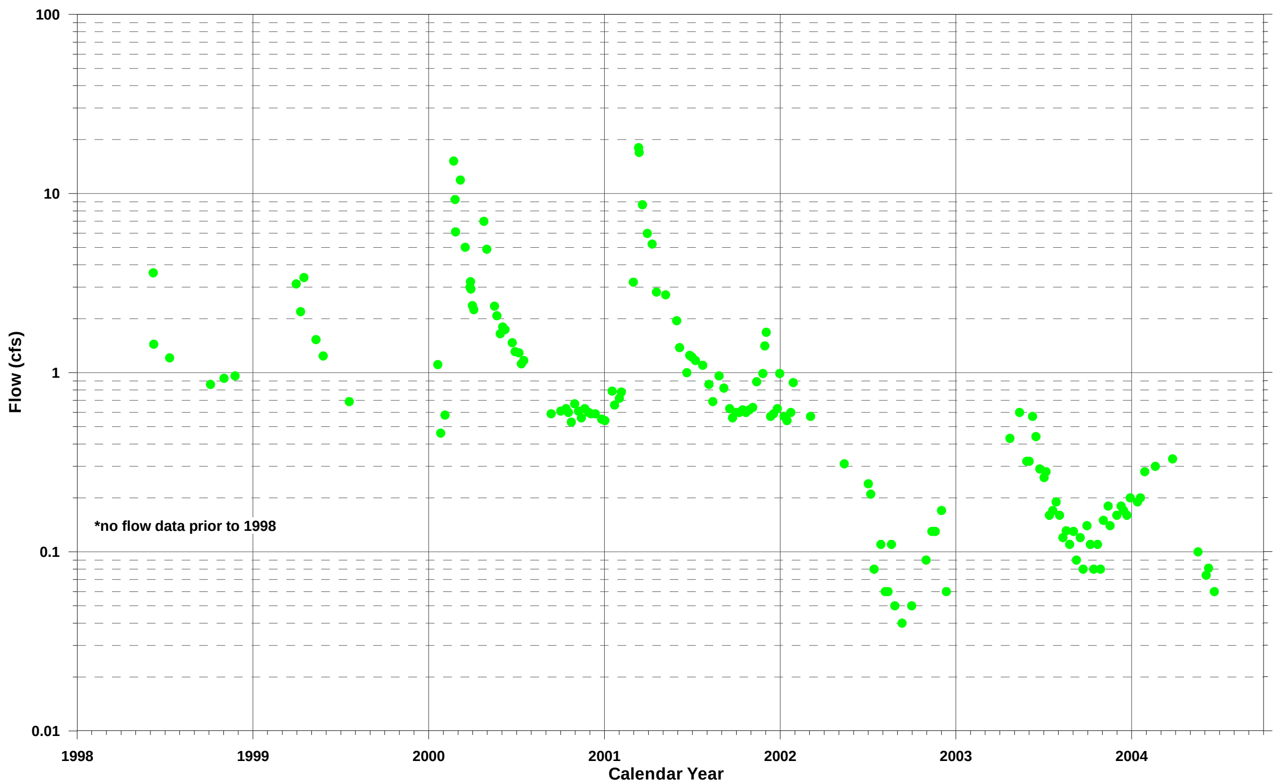


Figure 2-23. Instantaneous flow measurements by CPWA on Upper Salsipuedes Creek about 50 feet upstream of the confluence with El Jaro Creek (Source: CPWA 2005)

Figure 2-24. Instantaneous flow measurements by CPWA on El Jaro Creek about 50 feet upstream of the confluence with Salsipuedes Creek (Source: CPWA 2005)

Table 2-1. Inventory of USGS gaging stations in the Lower Santa Ynez River Watershed

USGS ID	Site Description	CPWA ID[1]	Internet Real Time	Date Flow Data Began	Date Flow Data Ended	Data Gaps 1993 – 2004	Comments
11125500	Lake Cachuma	LSYR-0	Yes (Reclamation)	1953	---		Reclamation data
11125600	Hilton Creek near Santa Ynez River	HC-0.5	Yes	March 2002	---	1993 through March 2002	New; located between upper and lower release points
11126000	Santa Ynez River below Bradbury Dam	LSYR-0.5	Yes	January 1929	---	Seasonal, December through March	December through March available on real-time but not published
11128250	Alamo Pintado Creek near Solvang	APC-3	Yes	October 1970	---	---	---
11128300	Alisal Reservoir near Solvang	AC-3	No	December 1971	---	---	---
11128500	Santa Ynez River at Solvang	LSYR-10.5	Yes	October 1928	---	November 1999 through July 2002	---
11129800	Zaca Creek	ZC-4	No	October 1963	---	---	---
11132500	Salsipuedes Creek near Lompoc	SC-3.7	Yes	April 1941	---	---	---
11133000	Santa Ynez River at Narrows near Lompoc	LSYR-36.1	Yes	May 1952	---	---	---
11133500	Santa Ynez River near Lompoc	LSYR-36.7	No	November 1906	June 1998	High flow gage only	---
11134000	Santa Ynez River at H Street near Lompoc	LSYR-37	Yes	October 1946	---	1993 through September 1998	---
11134800	San Miguelito Creek at Lompoc	SMC-3	No	October 1970	---	Varies; records poor	---
11135250	Santa Ynez River at 13th Street Bridge	LSYR-45	Yes	June 2004	---	1993 through June 2004	New

Notes:
[1]CPWA ID indicates location and river mile (see CPWA ID naming conventions in Section 1)

Table 2-2. Inventory of CPWA flow measurement sites in the Lower Santa Ynez River watershed

CPWA ID [1]	Site Description	Measured Spot Flows - Range of Dates		Number of Days Measured
		First	Last	
LSYR-0.5 – 0.7	Santa Ynez River at Reclamation boundary	March 1999	February 2004	146
LSYR-3.2	Santa Ynez River at 154 Bridge overpass; target flow area	May 2001	November 2002	81
LSYR-5.0	Santa Ynez River at the Meadowlark Crossing	January 2000	October 2004	77
LSYR-6.4	Santa Ynez River at the Lower Gainey Crossing within the Refugio Reach	March 1999	July 1999	11
LSYR-7.8	Refugio Bridge – Santa Ynez River	February 1997	December 2004	170
LSYR-10.5	Alisal Bridge - Santa Ynez River	January 1997	December 2004	151
LSYR-13.9	Santa Ynez River at Avenue of the Flags in Buellton	February 1999	December 2004	104
LSYR-26.7	Santa Ynez River at the Sweeney Road Crossing	May 1999	December 2004	93
LSYR-36.7	Robinson Bridge at Hwy 246 – Santa Ynez River	March 1999	January 2001	34
LSYR-37	Santa Ynez River at the H-Street Bridge in Lompoc	January 2003	December 2003	8
HC-0.12	Hilton Creek flow transect approximately 200' upstream of the confluence with the Santa Ynez River	February 1998	October 2004	315
HC-0.3	Hilton Creek at the Lower Release Point outlet pipe	March 2000	September 2004	168
HC-0.54	Upper release point / thermograph pool – Hilton Creek	February 2000	June 2000	21
QC-2.6	Quiota Creek at the 5th road crossing	January 2000	April 2004	85
NC-2	Nojoqui Creek at the 4th Highway 101 bridge from the City of Buellton	February 1998	July 2003	144
SC-1.2	Salsipuedes Creek at Santa Rosa Bridge; old trapping site	February 1998	January 2004	223
SC-3	Salsipuedes Creek at the Highway 1 Bridge; new trap site and fish ladder project	February 1999	April 2004	56
SC-3.8	Upper Salsipuedes Creek approximately 100 feet upstream of the El Jaro Creek confluence	June 1998	June 2004	156
EJC-4	El Jaro Creek approximately 100 feet upstream of the confluence of Upper Salsipuedes Creek	June 1998	June 2004	151
SMC-4	San Miguelito Creek at the Stillman Crossing, trapping location	February 1998	January 2003	163

Notes:
[1]CPWA ID indicates location and river mile (see CPWA ID naming conventions in Section 1)

Table 2-3. Monthly Totals of Rainfall Measurements (inches) at Bradbury Dam, 1993 – 2004 (Source: Cachuma Project, Annual Progress Reports, Reclamation)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total[1]	Year Type[2]
1993	0.79	0	5.47	11.85	12.09	6.08	0.02	0	0.41	0	0	0	36.7	Wet
1994	0.26	1.06	2.21	1.65	7.52	2.9	0.82	0.9	0	0	0	0.06	17.4	Normal
1995	1.03	1.39	1.01	25.13	1.96	12.34	0.46	1.78	0.48	0	0	0	45.6	Wet
1996	0	0.3	1.35	2.16	6.92	1.92	0.57	0.19	0	0.02	0	0	13.4	Dry
1997	4.15	2.42	4.29	4.39	0.18	0.02	0	0	0	0.05	0	0.18	15.7	Normal
1998	0	4	10.11	6.09	23.3	3.4	2.9	3.36	0.03	0	0	0.46	53.7	Wet
1999	0.12	1.38	1.31	3.19	1.54	5.71	3.23	0.02	0.07	0.05	0.02	0.03	16.7	Normal
2000	0	1.62	0	1.94	10.37	2.76	4.73	0.01	0.04	0	0	0	21.5	Normal
2001	2.64	0	0.09	8.4	5.71	13.44	1.35	0.06	0	0.06	0	0	31.8	Wet
2002	0.62	3.27	2.66	0.87	0.24	0.79	0.13	0.12	0	0	0	0.08	8.8	Dry
2003	0	2.5	6.73	0.06	3.56	2.4	2.15	2.33	0.02	0.01	0	0	19.8	Normal
2004	0	1.2	2.03	0.32	6.52	0.48	0	0	0	0	0	0	10.6	Dry
Avg	0.8	1.6	3.1	5.5	6.7	4.4	1.4	0.7	0.1	0.0	0.0	0.1	24.3	

Notes:
[1]Water year (October 1 – September 30)

[2]Water year classifications are as follows:
dry years = <15" of rainfall
normal years = 15" – 22" of rainfall
wet years = >22" of rainfall

Long-term average: 20.3" (1953 – 2004)

Table 2-4. Summary of Cachuma Project operations 1993 – 2004 (12 years) in acre-feet (Source: Reclamation 2005)

Water Year	Inflow Computed[1]	End of Water Year Storage	Gross Evapo-ration	Precipi-tation on Lake	SWP Inflow	Releases from Lake Storage							Total Downstream[4]
						Direct Diversions TO PARK	Tecolote Tunnel	SYRWCD ID# 1[2]	WR 89-18[3]	Fishery	Spills	Leakage	
1993	333,387	177,479	13,428	8,875	0	79	22,582	2,042	1,518	1,429	280,698	73	283,718
1994	16,729	151,046	12,561	4,144	0	73	22,821	1,819	9,192	494	0	345	10,031
1995	365,092	134,855	10,321	10,063	0	64	23,887	109	1,547	740	354,402	276	356,965
1996	33,243	120,503	11,627	2,653	0	76	24,721	2,109	9,313	2,012	0	390	11,715
1997	56,552	124,771	11,861	2,911	148	83	26,785	1,785	12,791	1,623	0	414	14,828
1998	475,175	185,500	11,350	12,071	1,354	60	24,473	0	1,684	1,976	386,055	2,272	391,987
1999	21,562	168,772	12,341	4,077	323	70	26,397	0	0	2,999	0	883	3,882
2000	51,895	170,840	12,435	4,972	2,156	79	30,365	0	4,423	2,037	6,067	1,549	14,076
2001	152,773	173,479[5]	11,995	7,712	818	78	26,089	0	1,795	2,157	112,313	1,707	117,972
2002	5,508	129,370	11,004	2,040	4,627	90	30,976	0	11,466	2,253	0	495	14,214
2003	18,822	115,449	9,402	3,707	6,816	99	28,781	0	2,000	2,692	0	292	4,984
2004	5,752	71,378	8,829	1,782	5,924	83	32,269	0	14,193	2,134	0	22	16,349
Maximum	475,175	185,500	13,428	12,071	6,816	99	32,269	2,109	14,193	2,999	386,055	2,272	391,987
Minimum	5,508	71,378	8,829	1,782	0	60	22,582	0	0	494	0	22	3,882
Average	128,041	143,620	11,430	5,417	1,847	78	26,679	655	5,827	1,879	94,961	727	103,393

Notes:

1 Computed inflow is the change in storage plus the sum of all outflows minus precipitation on the lake and SWP inflow.

2 Starting in year 1997, ID#1 is no longer delivered water from Lake Cachuma directly but receives Cachuma Project water via a SWP water exchange with South Coast Member Units.

3 Because WR89-18 water rights releases typically extend from summer through fall and new water year starts each October 1, a single total release can be assigned to two different water years. See Table 2-6 for a description of WR89-18 releases by calendar year.

4 Total discharge downstream is the sum of the columns of WR89-18, fishery, spills, and leakage.

5 The storage for 2001 was reduced by 2,530 acre-feet based on the reservoir capacity survey in that year.

Table 2-5. Summary of Lake Cachuma spills: 1993 – 2004 (Source: Reclamation annual progress reports)

Year	Start Date	End Date	Spill Volume (acre-feet)	Number of Days
1993	16-Jan	25-Jun	280,698	157
1994	*No spill*	-	-	-
1995	10-Jan	8-Jul	354,402	180
1996	*No spill*	-	-	-
1997	*No spill*	-	-	-
1998	4-Feb	20-Jul	386,055	167
1999	*No spill*	-	-	-
2000	18-Apr	10-May	6,067	23
2001	5-Mar	21-May	112,313	78
1994	*No spill*	-	-	-
2002	*No spill*	-	-	-
2003	*No spill*	-	-	-

- = not applicable

Table 2-6. WR 89-18 water rights releases. (Source: Reclamation annual progress reports)

Calendar Year	Releases (Acre-Feet/Year)			Number of Days
	Above Narrows Account (ANA)	Below Narrows Account (BNA)	Total	
1993	0	0	0	0
1994	6,727	4,012	10,739	100
1995	0	0	0	0
1996	7,319	3,459	10,778	105
1997	9,572	3,438	13,010	126
1998	0	0	0	0
1999	0	0	0	0
2000	4,360	1,858	6,218	73
2001	0	0	0	0
2002	9,054	4,412	13,466	126
2003	0	0	0	0
2004	11,494	4,512	16,006	101

Table 2-7a. Interim mainstem Santa Ynez River rearing target flows based on the Proposed Action and FMP

Lake Cachuma Storage	Reservoir Spill	Target Flow	Target Site
> 120,000 AF	Spill > 20,000 AF	5 cfs	Highway 154 Bridge
> 120,000 AF	Spill <20,000 AF or No Spill	2.5 cfs	Highway 154 Bridge
< 120,000 AF	No Spill	1.5 cfs	Highway 154 Bridge
<30,000 AF	No Spill	Periodic Release; ≤30AF per month	Stilling Basin and Long Pool

Table 2-7b. Long-term mainstem Santa Ynez River rearing target flows based on the Proposed Action and FMP

Lake Cachuma Storage	Reservoir Spill	Target Flow	Target Site
> 120,000 AF	Spill > 20,000 AF	10 cfs	Highway 154 Bridge
> 120,000 AF	Spill <20,000 AF or No Spill	5 cfs	Highway 154 Bridge
< 120,000 AF	No Spill	2.5 cfs	Highway 154 Bridge
>30,000 AF	Spill > 20,000 AF and Year immediately after	1.5 cfs*	Alisal Road Bridge
<30,000 AF	No Spill	Periodic Release; ≤30AF per month	Stilling Basin and Long Pool

Table 2-8. Breaches of Santa Ynez Lagoon: 1993 – 2004

Year	Assumed Duration of Breaching	Basis for Finding
1993	No breaching in August	Observation made in August; inflow was 1 cfs or less
1994	March through May 20	Observed to be 30 ft wide and flowing one foot deep in March; on May 20, aerial photographs show that the breach was closed. In July, the breach was observed as closed and the inflow was 1 cfs or less
1995	Early- to mid- January through May	No observations were recorded but the lagoon was probably breached in early or mid January as the dam spilled 354,102 AF from January to July
1996	February, exact dates unknown	No observations, although 6.92" of rainfall on record more than likely caused the lagoon to breach, and in addition, lampreys were caught in February in the Alisal Reach
1997	January through mid-March	Flow rates in excess of 100 cfs
1998	January through May	Flow rates (peak in excess of 30,000 cfs)
1999	March 12 (closed on March 16)	Observation; one-day spot check
2000	February 14 through unknown	Observation; one day spot check. Lagoon mouth was closed when re-surveyed on May 26
2001	Jan 22 through March 5; possibly into May	Observation on Jan 22; flow rates in excess of 100 cfs through March 5
2002	No breaching	No observations and flows were below 100 cfs
2003	January 13; April 7-16, May 12 – 19	Observations
2004	February 26 to March 22	Observations following a 3.47" storm event

SECTION 3

WATER QUALITY CONDITIONS

Section 3: Water Quality Conditions

3.1 Introduction

This section focuses primarily on two water quality parameters: water temperature and DO. Results of water quality monitoring presented in the 1997 Synthesis Report (SYRTAC 1997) showed that water temperature and/or DO are often unsuitable for steelhead and resident rainbow trout at various stream locations, and as noted in Section 2, portions of the mainstem Santa Ynez River and lower reaches of tributaries may dry completely during summer months. During the winter and early spring, water temperatures are seasonally cool and generally within the range considered to be suitable. Juvenile steelhead, however, rear within the river and tributaries throughout the year and elevated summer water temperatures may result in stressful or unsuitable habitat conditions.

For steelhead, stresses related to water temperature exposure and DO concentrations are interrelated (Deas and Orlob 1999) because higher temperatures increase metabolic rates and thus demand for oxygen. In addition, warmer water holds less oxygen. Potential stresses related to water temperature and DO concentration are also complex in that, although warmer water holds less oxygen, water at or near the surface and during the daytime typically will be warmer but hold more DO than during the night and early morning due to both physical and biological processes. Conversely, water near the bottom of reservoirs and pools may be cooler but have less DO. Deas et al. (2004) also suggest that as water temperatures and DO concentrations approach lethal thresholds, their stress effects increase exponentially rather than linearly.

The majority of information available on the water temperatures that are within the optimal, suboptimal, and incipient lethal levels has been derived from laboratory and/or field observations made on salmon and steelhead inhabiting more northerly watersheds (e.g., Oregon, Washington, British Columbia; EPA 2003; McCullough et al. 2001; Sullivan et al. 2001; Brett et al. 1982; Brett 1952). It has been hypothesized that steelhead inhabiting the LSYR, located in the southerly part of the species geographic distribution, have been exposed to elevated seasonal water temperatures and may have adapted to have higher thermal tolerance. Although there is a growing body of scientific information on thermal tolerance of steelhead/rainbow trout and other salmonids in California (Marine and Cech 2004, Myrick and Cech 2000a and 2000b, Cech and Myrick 1999, Baker et al. 1995, Boles 1988), uncertainty remains regarding the behavioral and physiological response of southern steelhead to elevated temperatures. As a result of this uncertainty, general water temperature guidelines have been developed for use in assessing habitat conditions.

The general temperature guidelines for steelhead include an indicator of potentially stressful conditions using average daily temperatures above 20 °C and an indicator of high stress conditions using a maximum daily temperature above 24 °C (Cech and Myrick 1999, Myrick and Cech 2000a and 2000b). Similarly, DO concentrations less than approximately 6 mg/L represent potentially stressful conditions for steelhead with DO less than 3 mg/L associated with high stress conditions (Deas and Orlob 1999, Deas et al. 2004). These guidelines provide a basis for evaluating the effects of temperature and DO on rearing habitat conditions for steelhead/rainbow trout inhabiting the LSYR and its tributaries during the summer and early fall months, recognizing that variation in thermal tolerance, availability of thermal refugia, food supply, species interactions, and a variety of other factors may affect the response of steelhead to temperature or water quality conditions within the LSYR and its tributaries.

Results of water temperature and water quality monitoring conducted within the LSYR are briefly summarized below. Locations of water temperature and water quality measurements are shown in Table 1-1 and Figure 3-1. Section 3.2 briefly outlines factors affecting water quality. Section 3.3 presents water quality monitoring methods. Results of water quality monitoring within the reservoir, mainstem river, tributaries and lagoon are summarized in Sections 3.4, 3.5, and 3.6, respectively. Section 3.7 provides a summary of findings.

3.2 Factors Affecting Temperature and Water Quality

Successful spawning and subsequent rearing of steelhead/rainbow trout depends on (a) intermittent periods of high flow for migration and spawning, and (b) the availability of cool and well-oxygenated water in the mainstem and tributary reaches during the hot summer and fall months. Summer rearing habitat may be associated with upwelling of cold sub-surface flows providing localized thermal refugia. An understanding of seasonal water quality conditions within various reaches of the mainstem and tributaries, and the factors that affect water quality, is therefore an important element in the effective management of the LSYR mainstem and its tributaries. Factors affecting water quality and temperatures in the LSYR include:

- **Air Temperature.** Because the Santa Ynez River is influenced by coastal conditions and highly variable topography, air temperature varies significantly within the basin. During the summertime, maximum daily temperatures above 35°C can occur for several days, also described as heat waves, which are typical for the Southern California area;
- **Reservoir Stratification.** Lake Cachuma stratifies in the late spring and turns over in the fall. Stratification generally results in high water temperatures/high DO in the upper strata (epilimnion) and low water temperatures/low DO in the lower strata (hypolimnion) with the transition zone referred to as the thermocline;
- **Reservoir Releases.** Although reservoir releases are cool, water warms in response to high air temperatures as flows travel downstream. The rate of warming varies in response to a number of factors including the rate of release, solar radiation, shading, and air temperatures;
- **Upwelling of Groundwater.** Subflow (flow below ground as sub-surface flows) is forced to surface (welling up) at points where geologic barriers cause groundwater to rise. Sub-surface flows are also intercepted by deeper pools in the streambed. Localized upwelling may create pockets or pools of colder water that serve as thermal refuges for juvenile steelhead/rainbow trout, however DO may be depressed in upwelling sub-surface flows;
- **Pool Dynamics.** In the summer, upwelling and high water levels in pools may create temporary stratified conditions, with areas of low temperature along the bottom of the pools and/or localized along the banks of the pools. Stratification in isolated pools may also result in a diel cycle of depressed DO concentrations near the pool bottom during the night and early morning hours associated with algal respiration and reduced mixing. The diel photosynthesis-respiration cycle of submerged and emergent aquatic plants and algae may create low DO levels following nightfall as a result of algal respiration and high DO levels during the day as a result of photosynthesis. The life cycle of algae including rapid growth in biomass followed by senescence and decay is also an important factor and process affecting

water quality conditions. Higher water temperatures and low DO levels interact to stress aquatic organisms directly (Deas and Orlob 1999, Deas et al. 2004) including an increase in susceptibility to fungal infections and vulnerability and severity of disease;

- **Riparian Shading.** The distribution and quality of riparian habitat along the river and tributaries varies in the basin (Section 4). Riparian shading generally tends to reduce water temperatures by reducing direct solar heating (shading the stream); and
- **Nutrient Loading.** Nutrient loading affects water temperature and DO by increasing turbidity and promoting algal growth. Shallow turbid waters absorb sunlight, promoting warming. Elevated nutrient concentrations can increase algal production, contributing to greater diel variation in DO.

3.3 Water Quality Monitoring Methods

Water quality measurements have been made at various locations within the reservoir, lower river, and tributaries as part of the 1993 – 2004 fishery habitat monitoring program (Table 1-1 and Tables 3-1 through 3-4; Figure 3-1). Locations of water quality monitoring in the lower river and tributaries are shown in Figure 3-1. Water quality data were routinely collected at a number of mainstem river sites (Figure 3-1) that included: Long Pool (LSYR-0.5); Refugio Reach at Meadowlark Crossing and Lower Gainey Crossing (LSYR-5.0 and LSYR-6.4, respectively); Alisal Reach at Below Refugio Bridge and at Alisal Bridge (LSYR-7.8 and LSYR-10.5, respectively). Note that all sampling locations are identified by a two part site-code including an alphanumeric code indicating the mainstem of the LSYR or a tributary (e.g., EJ for El Jaro Creek) and a distance measurement downstream of Bradbury Dam in the mainstem river or upstream from the confluence of the mainstem river with a tributary (e.g., LSYR-0.5 is located 0.5 mile downstream of the dam on the mainstem river; or HC-0.14 is located on Hilton Creek 0.14 mile upstream of the confluence with the mainstem).

3.3.1 Lake Cachuma Temperature and Dissolved Oxygen Profiles

Temperature and DO vertical profile measurements have been collected within Lake Cachuma to characterize the seasonal and annual variability in reservoir conditions affecting water quality in releases to the lower river. Temperature and DO profile measurements were made using a Yellow Springs Instrument (YSI) Model 57 Oxygen and Temperature Meter. Prior to a survey, the meter was air calibrated for DO in accordance with manufacturer specifications and protocols. When properly calibrated and maintained, the YSI Model 57 meter is expected to have an accuracy of +/- 0.1 °C temperature and +/- 0.1 mg/L DO. Measurements were taken by boat at 1-meter depth intervals at three locations within the lake during the period 1994 – 2004 (Table 3-1):

- Station 1 (LC-0.1): At the Bradbury Dam buoy line, roughly 600 feet upstream of the dam;
- Station 2 (LC-1.2): Within the deep channel of Tequipas Point; and
- Station 3 (LC-3.2): Within the deep river channel off Tecolote Tunnel.

3.3.2 Santa Ynez River Mainstem and Tributaries Water Temperatures

Optic StowAway temperature loggers (recording thermographs) have been used routinely to measure water temperatures within the mainstem river and tributaries. The loggers are programmed to record temperatures hourly. The loggers were deployed at selected locations (Table 3-2; Figure 3-1) along the river and tributaries, and at selected depths within deeper pools (e.g., surface and bottom to measure potential stratification). Monitoring was limited in some cases due to lack of access to sites on private property and intermittent drying of the channel. The loggers were recovered and the temperature data downloaded approximately monthly. The data were then transferred to a computer where daily maximum, average, and minimum temperatures were tabulated. Graphic and tabular data displays were used as part of the water temperature database quality control to identify and eliminate outlying data points that may result from temperature recording before and after deployment in the field, loggers that may be dewatered, and logger malfunctions. After examination of the dataset and initial quality control review, temperature data were appended to the ongoing dataset for each specific monitoring location. The data set is archived in the CPWA offices.

When new thermographs were received from the factory they were tested for accuracy as recommended by the manufacturer. New thermographs were activated at a 1-second interval and placed into an insulated container filled with crushed ice and water. The container was then placed in a refrigerator with the thermographs and left for approximately 15 minutes. Data were then downloaded and checked for accuracy. If the recorded temperatures were within +/- 0.1 °C of 0 °C the instrument was considered to be reliable and accurate. The same procedure was used on a routine basis to validate the performance and accuracy of temperature loggers used in the monitoring program. Temperature logger performance was tested on an annual basis. Thermographs are removed from the mainstem river and tributaries during the winter to prevent loss during high storm flows, as well as during spill events from Bradbury Dam. Note that high temperature measurements, such as those greater than 30°C, typically reflect an instrument exposed to air rather than a maximum water temperatures.

3.3.3 Diel Water Quality Measurements

A YSI Model 650 multi-parameter water quality instrument was used to collect 24-hour diel measurements, beginning in 2003 to evaluate seven mainstem pools. The parameters measured included temperature, DO, pH, turbidity (NTU), specific conductance, and oxidation-reduction potential (ORP). Total dissolved solids (TDS) were determined indirectly from specific conductance measured by the instrument. The instrument was manually calibrated on a monthly basis in accordance with manufacturer protocols and specifications.

3.3.4 USGS Water Quality Measurements

The USGS reports on two different types of water quality measurements including: 1) data from a probe in the field which measures parameters like temperature or DO on a 15-minute or hourly basis and 2) data from a grab sample which is analyzed in a laboratory. Table 3-3 and Figure 3-1 summarizes the available data from the USGS. Quality control for instrument calibration and data summaries are the responsibility of USGS.

3.3.5 Lagoon Water Quality Measurements

Lagoon water quality monitoring was conducted between 1995 and 2004 at varying times and frequencies within each year depending on monitoring plan priorities (Table 3-4). Several different water quality meters were used in the lagoon over the study period, including a Hydrolab Datasonde 3 Water Quality Meter (provided by the USFWS), a Horiba Model U-22, and a YSI Model 55 DO/temperature meter. The Horiba Model U-22 meter (first used in 2000) expanded the number of parameters measured to include turbidity, specific conductance, ORP, and specific gravity. Water quality parameters included: temperature (°C), DO (mg/L), salinity (ppt and %), pH, specific conductance (mhos or S/m), turbidity (Nephelometric Turbidity Units, NTU), specific gravity, and oxygen-reduction potential (ORP, Redox, mV). At each site, a visual transect was established across the lagoon channel. Soundings were made to determine the area of maximum depth and measurements were taken at the deepest area along each transect. Each measurement was made at one-foot depth intervals.

3.4 Results

3.4.1 Air Temperatures

As a result of the strong influence of air temperature on water temperature within the lower river and tributaries, hourly air temperature data were compiled from a monitoring station located near Santa Ynez using the California Irrigation Management Information System (CIMIS). Figure 3-2 shows a good example of the influence of air temperature on the oscillating pattern of water temperature in a pool near the Lower Gainey Crossing (LSYR-6.4). Both the maximum and minimum water temperatures follow within one to two hours of the maximum and minimum air temperatures. Note that water temperatures are much more stable than air temperatures. Figure 3-2 also shows the influence of a "heat wave", in which the air temperatures can exceed 100 °F (37.8 °C). Starting on June 11, 2000 through June 16, 2000, the maximum hourly air temperatures exceeded the average monthly maximum of 24.2 °C for June (Table 3-5). Figure 3-2 shows that the surface water temperature was elevated above 30°C and the bottom water temperature was above 25 °C due to the increase in air temperatures during the heat wave.

Air temperatures at the inland Santa Ynez Airport were routinely higher than at the Lompoc site, located approximately 25 miles downstream where there is a greater coastal influence (Tables 3-5 and 3-6). Although average maximum daily temperatures at the inland Santa Ynez Airport location were only slightly higher than those recorded at Lompoc during the winter months, summer temperatures at the inland location were considerably higher than near the coast. For example, at the Santa Ynez Airport (Table 3-5) the average maximum temperature in August 1998 was 30.7 °C and average minimum temperature was 13.2 °C, a difference of 17.5 °C. During the same period at Lompoc (Table 3-6), average maximum temperature was 22.5 °C and average minimum temperature was 14.9 °C, a difference of only 7.6 °C. Higher inland air temperatures in the upper watershed contribute to elevated water temperatures in the river and tributaries and potentially stressful conditions for over summering steelhead/rainbow trout.

3.4.2 Water Quality within Lake Cachuma

Water temperatures (Figures 3-3 to 3-10) and DO levels (Table 3-7) within Lake Cachuma were found to vary predictably on a seasonal basis, reflecting (a) the influence of seasonal air temperatures, and (b) summer-fall lake stratification. Differences in temperatures and DO concentrations between the epilimnion (upper stratum) and hypolimnion (lower stratum) were greatest during the summer and early fall when stratification was significant. In the late fall, winter, and early spring when the reservoir was vertically mixed, stratification was minimal. The lake typically becomes destratified in the late fall (e.g., November) when water temperatures are uniform from the surface to bottom and the lake undergoes turnover resulting from wind across the water surface and cooler air temperatures.

Temperatures in the upper stratum of the lake (epilimnion) typically rose from 21 °C – 24 °C in May to 22 °C – 26 °C in August and then declined to 16 °C – 21 °C by November. The lower stratum of the lake (hypolimnion) showed relatively constant (low) temperatures from month-to-month (Figures 3-3 to 3-10). The general seasonal patterns of lake stratification and water temperatures were similar among the years (Figures 3-3 to 3-10). In general, the data collected (Figures 3-3 to 3-10) indicate the same conclusion as the 1997 Synthesis Report in that vertical thermal profiles measured during the summer indicate that water should be taken from a minimum depth of 65 feet (20 meters) below the lake's surface in order to obtain water of 18 °C or cooler (SYRTAC 1997). Figures 3-3 to 3-10 indicate that the minimum depth to obtain water cooler than 18°C in the summertime could be 60 feet. Figure 3-7 shows that for some years like 2001 the minimum depth to obtain water cooler than 18 °C in the summertime could be even 45 feet.

DO concentrations (Table 3-7) also followed a reasonably predictable seasonal and depth related pattern. DO concentrations in May generally exceeded 6.0 mg/L in all but the deepest portions of the lake. Except in the warm upper stratum, DO levels declined rapidly as the lake stratified, and by late July or early August, DO concentrations levels of less than 5.0 mg/L were common at depths greater than about 50 feet. By October, DO levels in the thermocline and hypolimnion were often below 2.0 mg/L (Table 3-7). The DO concentrations are not as great a concern as temperature in regards to the effects of releasing or spilling water downstream into the LSYR because each outlet type from Bradbury Dam (spillway, outlet works, HCWS) provides large exposure to air and oxygenation before discharging into the LSYR.

In general, water temperatures and DO levels within Lake Cachuma followed a predictable seasonal pattern. Variations in the seasonal pattern were, however, observed on several occasions. First, measured DO levels in May of 1996 and 1997 (Table 3-7) were unusually low compared to other years of record during the same month, falling below 4.0 mg/L at a depth of approximately 80 feet. This may have been an indication of early stratification, or an instrument calibration problem. Second, August 1998 epilimnion water temperatures were unusually high (26 °C). This may have been related to the extended period of reservoir inflow and the associated thermal heating of river water entering the lake, or the unusually high maximum air temperatures in this month. In short, while there is a generally predictable seasonal pattern of water temperatures and DO levels in Lake Cachuma, annual and seasonal variation in precipitation and air temperatures may affect these parameters resulting in occasional variations from the predicted patterns.

3.4.3 Water Quality within the Mainstem Lower Santa Ynez River

3.4.3.1 General

Figures 3-11 to 3-14 show the available USGS temperature probe data at four locations along the LSYR at miles 0.5, 3.2, 10.5, and 36.1 downstream of Bradbury Dam, respectively for the period 1997 – 2004. Water temperatures in the mainstem LSYR followed a predictable seasonal and geographic pattern. Water temperatures remained well below 20 °C throughout the winter and spring in all reaches, reflecting low temperatures in releases from Bradbury Dam and low air temperatures. As summer progressed, water temperatures increased at all monitoring locations in response to higher air temperatures (Figure 3-2). Water temperatures were lowest at upstream locations near the dam and increased at downstream locations until a dynamic equilibrium was reached. In the reach immediately downstream of Bradbury Dam at the Long Pool (Figure 3-11, LSYR-0.5), maximum surface temperatures generally reached 22 °C – 24 °C during the day, but were generally below 20 °C at night, except for the years 1999 and 2000. Near the Highway 154 Bridge (Figure 3-12; LSYR-3.2), water temperatures are very similar to the Long Pool. For example, in the years 2002, 2003, and 2004, the maximum water temperature recorded by the USGS was below 25 °C at both the Long Pool (Figure 3-11) and the Highway 154 Bridge (Figure 3-12). At further downstream locations at Solvang (Figure 3-13; LSYR-10.5) and the Lompoc Narrows (Figure 3-14; LSYR-36.1), the effects of high air temperatures, low flows, lack of riparian vegetation, and pool isolation routinely resulted in summer and early fall surface water temperatures in the 24 °C – 28 °C range, with spikes above this range during periods of particularly high air temperatures. Variation in general seasonal and geographic trends in mainstem water temperatures also occurred in response to spills and releases from Bradbury Dam. For example, during the water rights releases in 2002, Figure 3-11 shows that the maximum water temperatures dropped from 20-21 °C to 17-18 °C at the Long Pool (LSYR-0.5).

Figures 3-15 to 3-27 show temperature data collected by the CPWA, which include data in pool habitats with probes placed at both surface and bottom locations within a particular pool. Figures 3-15 to 3-27 also show that there was seasonal and year-to-year variation in mainstem water temperatures. Bottom temperatures, depending upon the particular pool, time of year, and other factors could be cooler than surface temperatures in pool habitats, but were in excess of 20 °C on numerous occasions (Figures 3-18, 3-20, 3-22, and 3-27). Near the dam (LSYR-0.5) diel temperature variation was substantially greater near the surface (Figure 3-17) when compared to the bottom (Figure 3-18). Thermal equilibrium was typically reached within a reach approximately 3 to 5 miles downstream of the dam (e.g., Figure 3-19 and 3-20; LSYR-5.0), depending on factors such as the rate of release (e.g., spills, target flows, WR 89-18 releases) and seasonal air temperatures. However, local groundwater seepage can result in localized areas of reduced water temperatures regardless of thermal heating, particularly in deeper pools.

Figures 3-15 to 3-27 indicate that average daily water temperature is in excess of 20 °C and/or maximum daily temperatures is in excess of 24 °C (considered to be an indicator of stressful habitat conditions for juvenile and adult life history stages of steelhead: EPA 2003, McCullough et al. 2001, Sullivan et al. 2001, Myrick and Cech 2000a) often during the dry summer and early fall months in habitat units located in the LSYR. Water temperatures near the dam, within the Highway 154 reach, provide more suitable habitat for over summering steelhead/rainbow trout. Daily maximum temperatures above 24 °C occur frequently in most habitat units (see Figures 3-17 to 3-27). These spikes in stressful temperatures may be above the incipient lethal temperature for steelhead/rainbow trout (about 24 °C) (e.g., Figures 3-17, 3-19, 3-20, 3-21, 3-22, 3-23, 3-24, and 3-25). Although exposure to elevated average daily temperatures and/or daily maximum temperatures reduce habitat quality for steelhead/rainbow trout, the response of individual fish to these conditions varies based on a number of factors such as the magnitude and duration of temperature exposure (dose), food supplies, individual tolerance, combined effects of temperature and DO, and other conditions (Deas and Orlob 1999, Deas et al. 2004, EPA 2003, McCullough et al. 2001, Sullivan et al. 2001). As part of the fishery monitoring program, steelhead/rainbow trout have been observed successfully inhabiting pools where water temperatures were within the range considered to be highly stressful and potentially lethal. The fact that these fish were able to survive exposure to elevated temperatures and in some cases depressed DO concentrations as well reflects both the tolerance of steelhead/rainbow trout to highly varying environmental conditions and the complexity of factors interacting within southern California streams that influence the biological response to habitat conditions.

3.4.3.2 Diel Temperature and DO Fluctuations

Diel surface and bottom water temperatures in the LSYR mainstem varied seasonally and among locations (see Figures 3-15 to 3-27). Fluctuations were greater during the summer months with lesser diel variation during the winter, fall, and early spring period.

Measurements of daily (diel) temperature and DO were made in June, August, and October (the end of September – beginning of October) of 2003 at five to seven pool locations (Figure 3-28). Monitoring results showed that daily temperature and DO peaks between 1500 and 1800 hours, and daily temperature and DO lows occurring between 0500 and 0900 hours (Figures 3-29 to 3-31). As a general criterion for assessing habitat quality for steelhead/rainbow trout, DO concentrations above 6 mg/L are considered to be suitable (Deas and Orlob 1999). DO concentrations less than 6 mg/L result in increased stress with exposure to DO concentrations less than approximately 3 mg/L considered to be highly stressful and potentially lethal (Deas and Orlob 1999). Daily low DO levels of less than 6 mg/L were recorded at all pool sites monitored during June and August and at all pool sites in October (Figures 3-29 to 3-31). High diel temperature variation also was recorded within the pools. The diel variability in both DO and water temperatures observed during the summer in mainstem pools reflects effects of both physical (e.g., daily air temperature cycles) and biological (photosynthesis during the day and algal respiration at night) processes. Groundwater upwelling with relatively low temperatures and low DO concentrations was detected in several pools (e.g., LSYR-3.2, LSYR-7.8, and LYSR-8.6).

The general trends in diel temperature and DO (Figures 3-29 to 3-31) in the summer and early fall are consistent with expectations. Daylight conditions were characterized by a slow rise in water temperatures and DO levels, reflecting solar radiation influence on oxygen production by aquatic plants and both solar and high air temperature influences on water temperatures. DO conditions were suitable (>6 mg/L) for steelhead/rainbow trout and other aquatic species in the early to mid-evening, at approximately the same time that temperature conditions were least optimal for salmonids. The opposite pattern occurred during the night, when temperatures fell generally into the suitable range for salmonids, but DO levels uniformly declined to concentrations that are considered to be highly stressful or lethal to salmonids (<3 mg/L). DO levels below 1 mg/L were recorded on numerous occasions, particularly at site N154 (LSYR-3.2). Figures 3-32 and 3-33 show the DO concentrations as measured by the USGS at the

Highway 154 Bridge, LSYR-3.2 (USGS ID No. 11126400) and the Solvang Bridge, LSYR-10.5 (USGS ID No. 11128500) for the period 2002-04. The data from the CPWA 2003 study is plotted on these graphs as well for comparison. The year 2003 had the lowest DO concentrations out of the three years 2002, 2003, and 2004. The USGS DO concentrations agreed with the CPWA 2003 data which showed that DO concentrations at the Highway 154 Bridge (Figure 3-32) were much lower than at the lower half of the Alisal Reach (Figure 3-33).

Temperatures in excess of 20 °C, considered an upper threshold for suitable/optimal conditions for salmonids, and frequently in excess of 22 °C, occurred in June, July, and August. Daily temperature ranges (difference between daily minimum and maximum) varied by as little as 1 °C and by as much as 6.6 °C. Over the full period of this study, variation in diel temperatures was somewhat greater, with a daily variation of up to about 9 °C. The magnitude of diel temperature variation is important for rearing steelhead/rainbow trout in several ways. Maximum daily temperatures that approach or exceed the incipient lethal threshold temperature, even for relatively short exposure durations, may contribute to increased stress, increased risk of disease, reduced growth, and under severe conditions direct mortality (EPA 2003, McCullough et al. 2001, Sullivan et al. 2001). Steelhead/rainbow trout have also been observed to be more tolerant of higher average daily temperatures and maximum daily temperatures under conditions in which diel variation provides cooler temperatures at night when compared to fish exposed to elevated temperatures over an extended period (EPA 2003, McCullough et al. 2001, Sullivan et al. 2001).

Early observations of habitat conditions in the mainstem river during the summer months showed an accumulation of filamentous algae, particularly in pools and low velocity habitats in the Refugio Reach that were thought to adversely affect habitat for oversummering steelhead (obstruction of habitat, diel variation in DO). In 1994, an algal flush release test was made at 3.5 and 20 cfs. Algae was not substantially removed in response to a flow release of 3.5 cfs; however, the higher release met with limited success. WR 89-18 releases have been observed to remove much of the algae from pool habitats and produce enough mixing to raise DO concentrations in most of the mainstem habitat units receiving surface water flows.

3.4.3.3 Cold Water Refugia

Vertical thermograph arrays were deployed in deep pool habitats at several mainstem river pool habitats including the Long Pool (LSYR-0.5), Refugio Reach (LSYR-3.4), Sycamore Pool (LSYR-5.8), Alisal Reach at Refugio Bridge (LSYR-7.8), and the pool located downstream of Refugio Bridge (LSYR-8) suspected of providing cool water refuges. Several of the vertical array locations monitored before 1997 were subsequently abandoned (e.g., LSYR-7.8) and relocated to adjacent pools due to changes in the course of the river during high flow events that occurred in the winter of 1997 – 1998 (February 1998 flood event) and contributed to geomorphic changes to the river channel at a number of sites. Additionally, the pool location at Refugio Bridge (LSYR-7.8) was filled in during the storms of 2001; the vertical temperature monitoring array was moved to the next large pool habitat immediately upstream (LSYR-7.3). The new vertical array locations correspond to habitats where young-of-the-year (YOY) juvenile and adult steelhead/rainbow trout were observed during routine snorkel surveys (Section 5).

The cool temperatures observed near the bottom in a number of mainstem pools (Table 3-8) were likely from the influences of cool water upwelling at those sites. However, there appears to be multiple factors affecting temperature within any given pool and at any given time. Results of vertical water temperature profile measurements within the pools, as well as observations during snorkel surveys, indicated the occurrence of localized microhabitat areas where cool groundwater upwelling may result in thermal refugia. However, some of the temperature monitoring results did not support stratification in the pools (Table 3-8).

Measurements within many of the pools showed a pattern of depressed DO concentrations near the bottom associated with areas where cool groundwater upwelling occurred (i.e. pool at LSYR-3.2 as shown in Figures 3-29 to 3-31). Based on these observations, it was concluded that although thermal refuges were identified within some of the deeper pool habitats, the area of reduced temperature was frequently limited to a small area where DO levels may be depressed to the point of limiting the availability and quality of summer rearing habitat for steelhead/rainbow trout supported by the thermal refugia. Steelhead/rainbow trout have been observed to survive stressful conditions associated with exposure to elevated water temperatures, depressed DO concentrations, and exposure to predators within isolated pools on the LSYR. Although providing suboptimal habitat conditions, thermal refugia are thought to be an important habitat feature that warrant further monitoring and investigation.

3.5 Tributary Water Temperatures

Tributary flow and water temperature were highly variable among years, seasons, and tributary locations (Figures 3-34 to 3-44 and Section 2.0 for a discussion of flows). Upon reaching the floodplain of the mainstem river, tributary flow is also subject to the same high percolation conditions that result in extended periods of dry surface conditions during the spring, summer, and fall. Hilton Creek received flows from the HCWS beginning in 2000 that directly affected seasonal water temperatures, and suitability of habitat for juvenile steelhead/rainbow trout rearing in lower Hilton Creek (Section 2). The other tributaries do not have regulated flow and low summer flows have been identified as one of the factors contributing to elevated water temperatures during the late spring, summer, and early fall months. Tributary water temperatures are also influenced by a riparian canopy that provides increased shading along reaches of several of the tributaries and thereby reduces the effects of solar radiation on increasing water temperatures. In general, water temperatures within the tributaries followed a predictable pattern of lower average daily and maximum daily temperatures in the upstream reaches with increasing temperatures as a function of distance downstream until thermal equilibrium with atmospheric conditions is reached. The general geographic distributional patterns observed in water temperature monitoring were reflected in observations of the geographic distribution and habitat use within tributaries by steelhead/rainbow trout (Section 5). Results of the study also demonstrated substantial differences in water temperature affecting habitat suitability for steelhead/rainbow trout not only as a function of location within a tributary but also among tributaries.

Locations and time periods when water temperatures have been monitored in the tributaries are presented in Table 3-2. Results of water temperature monitoring within the tributaries where access to private lands was available are briefly discussed below.

3.5.1 Hilton Creek

For analysis purposes, water temperature monitoring results for Hilton Creek (watershed area 3.2 square miles) are presented separately for upper (HC-0.54), middle (HC-0.25), and lower

(HC-0.12) reaches (Figures 3-34 through 3-37). The watering system has two release points on Hilton Creek, one in the upper reach (HC-0.54) and one in the lower reach (HC-0.3)[1]. The lower release point began operation in 2000. The upper release point was not operated continuously until after 2004 (Figures 3-34 and 3-35). In the absence of the watering system operation within the upper reaches of the creek channel, water temperatures varied substantially. Following 2004, upper reach releases resulted in virtually constant flow that would be expected to substantially improve habitat conditions for steelhead/rainbow trout in the upper reaches of the creek. The shift towards more consistent habitat conditions is also evident in the middle (HC-0.25) and lower (HC-0.12) reaches of Hilton Creek following activation of the HCWS (Figures 3-36 and 3-37). In these figures, note also the lower range of diel water temperature variation following activation of the watering system. Suitable habitat conditions for steelhead/rainbow trout rearing during the summer and early fall within Hilton Creek, based on seasonal water temperatures, were improved substantially as a result of operation of the watering system.

3.5.2 Quiota Creek

Quiota Creek has a drainage area of 7.6 square miles. During the five years of water temperature monitoring within Quiota Creek (Crossing 6 QC-2.71), recorded temperatures seldom exceeded 20 °C (Figure 3-38), indicating excellent habitat conditions for oversummering salmonids. Water temperature monitoring results showed a consistent seasonal pattern in temperature variation; diel temperature variation was typically 4 °C to 6 °C in the summer and 1 °C to 4 °C in the fall, winter, and spring (Figure 3-38). The seasonal water temperatures measured within Quiota Creek were within the general range considered to be suitable for steelhead/rainbow trout. These results are consistent with fishery observations demonstrating that juvenile (<6 inches) and older (>6 inches in length) steelhead/rainbow trout inhabit the creek (Section 5).

3.5.3 Nojoqui Creek

Nojoqui Creek has a drainage area of 15.9 square miles. During the three years of record (1998 -2000; Figure 3-39), average daily stream temperatures were above 20 °C from late spring to early fall during two years, and there were extended periods of maximum daily temperatures in excess of 24 °C in 1998. Temperature monitoring was discontinued in 2000 due to the absence of steelhead/rainbow trout inhabiting the creek. Temperature monitoring within Nojoqui Creek was affected by equipment failure during a storm that exposed the temperature unit to the air in early 1998.

3.5.4 Salsipuedes Creek

As noted in Section 2, Salsipuedes Creek drains a large watershed (52.4 square miles) and is capable of generating high seasonal flows and can breach the sand bar at the mouth of the LSYR. As a result, there is more consistent baseflow in the creek during the summer months and a consistent seasonal pattern of instream temperatures at all three temperature sampling sites (Figures 3-40 through 3-43).

[1] There is a third release point of the HCWS into the Stilling Basin.

Water temperatures were lowest at the upper Salsipuedes Creek site (SC-3.8, Figure 3-41) where they exceeded 24 °C for only short intervals during the summer in four of the nine years of record. In the upper creek, diel temperatures varied by 2 °C to 8 °C which is thought to be the result of the excellent canopy cover. Minimum daily temperatures below 18 °C were common in upper Salsipuedes Creek. Water temperatures measured within the upper reach of Salsipuedes Creek were within the general range considered to be suitable for steelhead/rainbow trout during a majority of the time. Although short periods of elevated temperature stress may occur, habitat within the upper reaches would be expected to support steelhead/rainbow trout (refer to Section 5).

In general, water temperatures at the lower creek monitoring site (SC-3, Figure 3-40) were higher during the summer when compared to water temperatures measured in the upstream reach. Summer water temperatures in the lower reach experienced extended periods with maximum daily temperatures in excess of 24 °C in nine of the ten years of record. Elevated summer water temperatures within the lower reach of Salsipuedes Creek indicate that rearing conditions would be highly stressful and/or unsuitable for steelhead/rainbow trout in most years. Despite the observed high summer water temperatures, steelhead/rainbow trout have been observed inhabiting the lower reaches of the creek, however their growth and survival through the summer months is unknown. Therefore it is thought that the lower reaches of the tributaries function as an upstream and downstream migratory corridor in most years.

3.5.5 El Jaro Creek

El Jaro Creek has a watershed area of 33 square miles, representing 63 percent of the Salsipuedes Creek watershed. Recorded temperatures in El Jaro Creek (Figure 3-43) reflect highly variable flow conditions, with low winter temperatures and consistently high summer temperatures (maximum daily temperatures exceeded 24 °C in all nine years of record, and reached 28 °C in four of the nine years of record). Diel variation was 2.5 °C to 8 °C. Based on the observed maximum daily water temperatures within the 24 to 28 °C range, summer habitat conditions were expected to be highly stressful and/or unsuitable for steelhead/rainbow trout. These conclusions are in conflict with results of fishery monitoring that have documented the presence of both juvenile (<6 inches in length) and older (>6 inches in length) steelhead/rainbow trout every year within El Jaro Creek (Section 5). Steelhead/rainbow trout may be taking advantage of microhabitat thermal refugia to reduce exposure to maximum temperatures within the creek. High water temperatures within El Jaro Creek during the summer months contribute to elevated water temperatures within the lower reaches of Salsipuedes Creek downstream of the confluence with El Jaro Creek.

3.5.6 San Miguelito Creek

San Miguelito Creek has a watershed area of 10.8 square miles. Temperatures were recorded within San Miguelito Creek (SMC-4) over the period 1997 – 2000 (Figure 3-44). For 1999 - 2000, the recorded temperatures showed a normal seasonal distribution, except for an anomalous spike in daily maximum temperatures above 20 °C in December of 1999. Results of water temperature monitoring indicate that suitable habitat conditions occurred within the creek for steelhead/rainbow trout. These results are consistent with fishery observations documenting that steelhead/rainbow trout inhabit San Miguelito Creek (Section 5).

3.6 Lagoon Water Quality

The Santa Ynez River lagoon is located approximately 46 – 48 miles downstream from Bradbury Dam (Figure 3-1), and the lagoon is entirely under the jurisdiction of Vandenberg Air Force Base (VAFB); the public access point to the lagoon is at Ocean Park. Access to the lagoon for water quality monitoring was limited by VAFB regulations and by nesting populations of the federally-listed endangered western snowy plover.

Tidal fluctuation, variation in salinity, and water depth complicate both sampling and the interpretation of measurements within the Santa Ynez River lagoon. The large numbers of interacting physical and biological components within the lagoon make the ecosystem complex and varied. In addition, the Lompoc Wastewater Reclamation Facility discharges treated effluent (regulated by the California Regional Water Quality Control Board) directly into the river at a point approximately 8.5 miles upstream from the ocean. Depending on hydrologic circumstances, river flow contributed by this discharge contributes to increased water levels in the lagoon. Finally, seasonal flows from the mainstem and tributaries can periodically breach the sandbar at its mouth, usually during winter and spring after storms have saturated the watershed.

Water quality monitoring data provide insight into the variability of water quality parameters of interest for steelhead/rainbow trout in the Santa Ynez River lagoon (Table 3-9). It should be noted that the habitat suitability guidelines used in Table 3-9 are general thresholds at which steelhead/rainbow trout may exhibit stress, disruption, behavioral response, or potentially death given that the water quality conditions persist and/or act with one another to create unsuitable habitat conditions. However, steelhead/rainbow trout can survive in conditions outside of those defined by these environmental thresholds (general guidelines for assessing habitat conditions). Furthermore, Table 3-9 includes the depths of the profile at which the water quality parameter fell above or below the guideline threshold; in most cases, suitable water quality for steelhead/rainbow trout was found at some depth within the vertical profile. In addition, simultaneous unsuitable conditions for temperature DO, pH, and redox potential occurred infrequently (Table 3-9).

Several general patterns were observed during monitoring within the lagoon. First, elevated water temperatures appear to be more frequent in the upstream portion of the lagoon, probably reflecting high water temperatures in freshwater inflow and the shallow depth of the sampling station at 1 to 2 feet (LSYR-46.6). At the upstream sampling site (LSYR-46.6), temperatures often exceeded suitability thresholds throughout the (shallow) water column. More typically, water temperatures in the lagoon ranged from 15 °C to 20 °C, with only a few instances of temperatures in excess of 20 °C recorded in any year. Based on results of water temperature monitoring it appears that habitat would be suitable for steelhead/rainbow trout within the lagoon.

Second, DO conditions are more frequently unsuitable for steelhead/rainbow trout in the lower two reaches of the Lagoon (LSYR- 47.2 and LSYR-47.75), particularly in the lower quarter of the water column. Redox potential appears to correspond to DO levels, as would be expected (EBMUD unpubl. data). The DO and redox potential data probably reflect stratification of the pool in the downstream portion of the lagoon and/or low DO levels in inflows late in the year. Unsuitable DO levels were found at or near the surface on only two occasions: August of 2001 (LSYR-47.2) and November 2002 (LSYR-46.6).

Third, high pH is only occasionally a problem, and this condition tends to occur in the upper portion (upper third) of the water column or in shallow water at the upstream sampling site (LSYR-46.6). In almost all cases, the threshold value of pH 9.5, when exceeded, was exceeded by a small amount, probably within the measurement error for the instruments used. The year 1997 was an exception to this general trend: pH readings exceeded 10 on several occasions and at several sites in April; a pH in excess of 11 was also recorded at all three sites and follow-up sampling found high pH (> 9) at all three sites in July. An extended period of pH above 11 would, however, cause significant mortality for fish and benthic invertebrates (Colt et al. 1979; MacDonald et al. 1991), and there is no record of such a fish kill during April or July of 1997. The high recorded pH may have been the result of measurement problems associated with equipment calibration.

Turbidity was greater than 70 NTUs in several surveys, primarily in the mid-lagoon and upper-lagoon sites (LSYR 47.2 and LSYR 46.6). Higher turbidity readings generally occurred in deeper portions of the water column. Higher turbidity measurements were not coincident with obvious environmental conditions such as a storm event or heavy tidal influence. These data on turbidity suggest a highly variable aquatic environment within the lagoon, but do not shed light on the mechanism for episodes of high turbidity. Turbidity measurements within the lagoon may reflect algal production and/or sediment resuspension. The levels of turbidity observed in the lagoon, however, are within the range expected to be suitable for steelhead/rainbow trout habitat (Hanson et al. 2004).

The lagoon functions as an estuarine zone with a salinity gradient extending from freshwater at the inflow from the mainstem river to more saline conditions near the coast when the sand bar is closed. When the sand bar is open freshwater flows extend further downstream through the breach in the bar reducing the salinity gradient within the lagoon. Salinity within the lagoon was observed to increase when the tide was high, reflecting greater salinity intrusion from the ocean when the bar was open.

3.7 Findings of the Water Quality Monitoring Program

3.7.1 Lake Cachuma

Results of 1993 – 2004 water temperature and DO monitoring within Lake Cachuma are consistent with results and findings presented in the 1997 Synthesis Report in showing that Lake Cachuma becomes thermally stratified during the late spring through early fall and destratified (relatively uniform temperatures from the surface to the bottom) during the late fall and winter.

During the period of stratification, water temperature and DO concentrations are greatest in the upper part of the water column (epilimnion), with the coolest water temperatures and DO concentrations decreasing below 2 mg/L within the lower part of the water column (hypolimnion). After fall turnover, water temperature and DO concentrations (6-8 mg/L) were relatively uniform throughout the water column of the reservoir. Water quality stratification and limnologic conditions within Lake Cachuma are important in the design and management of the HCWS. This report's findings agree with the 1997 Synthesis Report in that vertical thermal profiles measured during the summer indicate that water releases for fish should be taken from a minimum depth of 65 feet (20 meters) below the lake's surface in order to obtain water measuring 18 °C or cooler (SYRTAC 1997).

3.7.2 Mainstem Water Temperature

Results of 1993 – 2004 water temperature monitoring on the LSYR are consistent with results and findings presented in the 1997 Synthesis Report in showing:

Water temperature follows a general seasonal pattern, with increasing temperatures during the spring and summer, and decreasing temperatures during the fall and winter, coincident with the seasonal pattern in air temperature;

Water temperature, particularly during summer, is lowest near Bradbury Dam, with a longitudinal gradient of increasing temperature moving downstream until thermal equilibrium between air and water temperatures is reached. Thermal equilibrium with atmospheric conditions has been observed to occur within approximately 3 to 5 miles of the dam depending on factors such as the water temperature released from the dam, release rate, air temperature, and solar radiation;

Daily variation in water temperature, particularly during the summer, is generally lowest near Bradbury Dam, with a longitudinal gradient of increasing daily variation in water temperature at locations further downstream. For example, daily variation during the summer near the dam in the Stilling Basin (LSYR-0.2) was typically +/- 0.5 °C, compared to daily variation downstream of the dam within the Refugio Reach (LSYR-5.0 – 7.8) during the same period which was typically +/- 2 °C;

Seasonal patterns of water temperature within the Santa Ynez River lagoon are typically cooler, particularly during the summer, than water temperatures occurring at locations further upstream, with the exception of those immediately below Bradbury Dam. Lower summer water temperatures within the lagoon reflect the influence of the marine climate and fog on temperatures within the lagoon;

Evaluation of average daily and maximum daily water temperatures, with respect to thermal tolerance for steelhead/rainbow trout, showed water temperatures are within acceptable ranges at all locations downstream of Bradbury Dam during the late fall, winter, and early spring;

Water temperatures at a number of mainstem pool monitoring sites exceeded temperature guidelines (average daily water temperature greater than 20 °C, or maximum daily temperature greater than 24 °C) for steelhead/rainbow trout during the summer. Steelhead/rainbow trout have been observed to survive exposure to seasonal water temperatures greater than the indices of habitat suitability;

The frequency and magnitude of average daily temperatures that exceed 20 °C and/or maximum daily temperatures above 24 °C increased as a function of distance downstream from Bradbury Dam, with the exception of temperature conditions occurring within the lagoon and localized areas influenced by cool upwelling of sub-surface flows; and

Maximum water temperatures recorded from surface thermographs on one or more days during the summer months exceeded the incipient lethal threshold (>25 C) at the Refugio Reach (LSYR-5.0 – 7.8 miles downstream of Bradbury Dam), and at all habitat units (for a short period of time) monitored further downstream, with the exception of the lagoon. Bottom temperatures in pools generally ranged from having lower to having the same temperatures as the surface during the low-flow summer period.

3.7.3 Mainstem Dissolved Oxygen

Results of 1993 – 2004 DO monitoring on the LSYR are consistent with results and findings presented in the 1997 Synthesis Report in showing:

- High algal production between late spring and early fall contributes to substantial diel variation in DO concentrations and adversely affects habitat quality for steelhead/rainbow trout;
- Early morning DO concentrations during the fall were substantially higher than those during the summer, coincident with a seasonal decline in algal cover and decreased temperatures; and
- DO concentrations at night (measured during pre-dawn surveys) showed concentrations within many habitats ranging from 1 to 3 mg/L;
- Low diel DO concentrations, measured at several habitat units, would be expected to result in severe physiological stress and/or mortality to many fish species (less than 3 mg/L); and
- River flow provided by the WR 89-18 releases was sufficient to remove much of the algae from pool habitats and create sufficient mixing to sustain higher DO concentrations (>7 mg/L) during the critical morning hours in most, but not all, mainstem habitat units receiving surface water flows. The relationship between river flows, pool stratification, and thermal refugia warrants further investigation.

3.7.4 Santa Ynez River Lagoon

Results of 1993 – 2004 lagoon water quality monitoring are consistent with results and findings presented in the 1997 Synthesis Report in showing:

- No substantial differences were observed in water quality measurements (water temperature, DO, and salinity) across transects within the lagoon. However, when the lagoon was both open and closed, water quality differences were observed between upstream and downstream monitoring locations indicating tidal prism influences;
- The lagoon water depth increases after the sand bar is closed. Vertical gradients were observed in water temperature, DO, and salinity within deeper areas of the lagoon during periods when the lagoon sandbar was closed. Vertical stratification in water quality parameters varied substantially between locations and survey periods;
- Average daily and maximum daily water temperatures within the lagoon during the summer were consistently lower than water temperatures measured at upstream monitoring locations, with the exception of locations immediately downstream from Bradbury Dam, reflecting the effects of marine climate and fog on summer water temperatures;
- DO concentrations were generally greater than 5 mg/L in the upper three quarters of the water column during months when stratification within the lagoon had developed. The lower one quarter of the water column had DO levels typically less than 4 mg/L, with concentrations less than 1 mg/L developing at the bottom one foot at most sites;

- Salinity levels within the lagoon followed a consistent longitudinal pattern, with salinity near brackish/full strength sea water at Ocean Park (LSYR-47.75), decreasing to freshwater at the upstream location (LSYR-46.6); and
- Salinity level varied between months, reflecting seasonal variation in the balance between freshwater inflow and tidal influence. Higher salinity concentrations were observed at high tide at all three sites, particularly when the lagoon was breached.

3.7.5 Water Temperatures within the Tributaries

Results of 1993 – 2004 water temperature monitoring within tributaries to the LSYR are consistent with results and findings presented in the 1997 Synthesis Report in showing:

3.7.5.1 Hilton Creek

Prior to implementation of the HCWS, seasonal flows and water temperatures within Hilton Creek resulted in highly variable habitat conditions, including exposure to elevated water temperatures and fragmentation of habitats. After the HCWS began operations, flows have been stable and seasonal water temperatures are almost always less than 20 °C (and generally less than 18 °C) in the reach immediately downstream of the water system release points. Water temperatures during the summer increased as a function of distance downstream of the watering system release points. The resulting changes in water temperatures and seasonal stream flows have substantially improved habitat conditions for steelhead/rainbow trout within the habitats downstream of the watering system outlets. Fishery observations confirm that Hilton Creek provides suitable habitat for steelhead/rainbow trout spawning and juvenile rearing (Section 5).

3.7.5.2 Nojoqui Creek

Average daily water temperatures within Nojoqui Creek during the summer months typically exceeded 20 °C, with maximum daily temperatures frequently exceeding 24 °C. Maximum daily temperatures exceeded the potential incipient lethal threshold (25 °C) during summer months throughout the survey period.

3.7.5.3 Salsipuedes Creek

Upper Salsipuedes Creek is characterized by having an intact riparian corridor with abundant canopy where water temperatures were substantially cooler during the low-flow summer season than those observed in either El Jaro or lower Salsipuedes Creek (water temperatures in upper Salsipuedes Creek were typically 2 to 4°C lower than corresponding peak daily temperatures in either El Jaro or lower Salsipuedes creeks). Results of water temperature monitoring within upper Salsipuedes Creek suggest that habitat conditions were suitable for steelhead/rainbow trout. Results of fishery observations document successful spawning and rearing by steelhead/rainbow trout with upper Salsipuedes Creek (Section 5).

Lower Salsipuedes Creek is characterized by a wider streambed and the riparian canopy is less abundant when compared to the upper reaches of Salsipuedes Creek. Water temperatures were higher during the summer months within the lower reaches of the creek. Although results of water temperature monitoring showed maximum daily temperatures frequently above 24 °C and average daily temperatures above 20 °C, results of fishery surveys document that steelhead/rainbow trout inhabit the lower reaches of the creek (Section 5) primarily in pool habitat. The fact that steelhead/rainbow trout have been observed inhabiting lower Salsipuedes Creek where summer water temperatures are elevated is consistent with the hypothesis that southern steelhead/rainbow trout have higher thermal tolerance than more northerly populations and/or that these fish are able to take advantage of microhabitat thermal refugia and successfully oversummer.

3.7.5.4 El Jaro Creek

Inflow during the summer from El Jaro Creek contributes to higher average daily and maximum daily water temperatures within lower Salsipuedes Creek. Water temperatures within Salsipuedes Creek downstream of the confluence with El Jaro Creek frequently exceeded an average daily temperature of 20 °C and a maximum daily temperature of 24 °C during summer months. Average daily water temperatures within El Jaro Creek upstream of the confluence with Salsipuedes Creek exceeded 20 °C over extended periods (weeks or months) in many years (e.g., 1995, 1998, 2000, 2001) representing stressful/potentially unsuitable habitat conditions for steelhead/rainbow trout. Maximum daily temperatures exceeded 27 °C on occasion, representing conditions above the incipient lethal level for steelhead/rainbow trout. The fact that steelhead/rainbow trout have been observed inhabiting El Jaro Creek where summer water temperatures are elevated is consistent with the hypothesis that southern steelhead/rainbow trout have higher thermal tolerance than more northerly populations and/or that these fish are able to take advantage of microhabitat thermal refugia and successfully oversummer.

Water temperature monitoring data during the summer months from El Jaro Creek confirmed higher average daily and maximum daily water temperatures than those observed within upper Salsipuedes Creek.

3.7.5.5 San Miguelito Creek

Results of water temperature monitoring within San Miguelito Creek indicate that suitable habitat conditions occurred for steelhead/rainbow trout. These results are consistent with fishery observations documenting that steelhead/rainbow trout inhabit the creek.

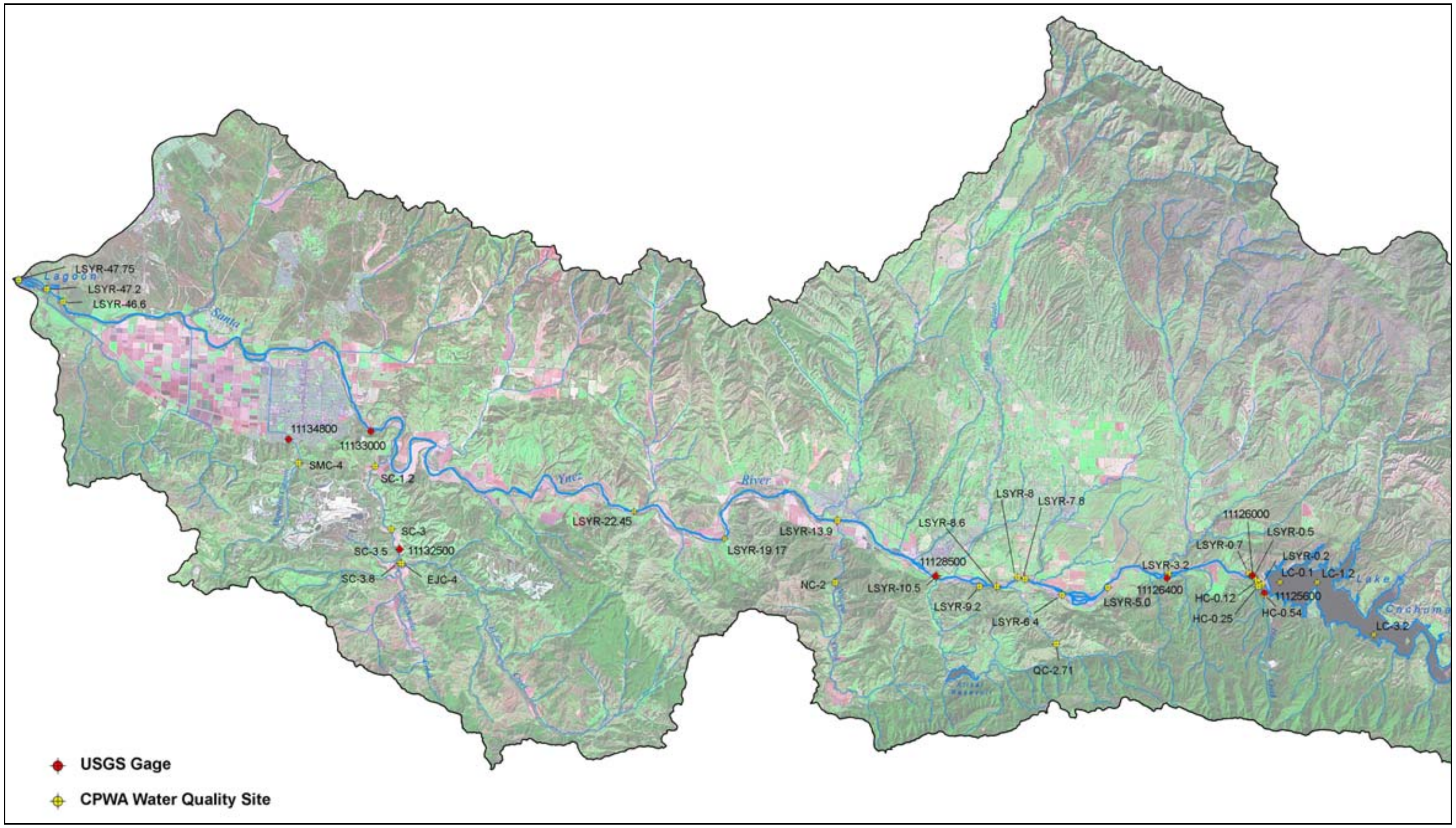


Figure 3-1. Locations of Water Quality Monitoring by CPWA and USGS for the period 1993-2004. (Source: CPWA 2004, Stetson 2008)

THIS PAGE INTENTIONALLY LEFT BLANK

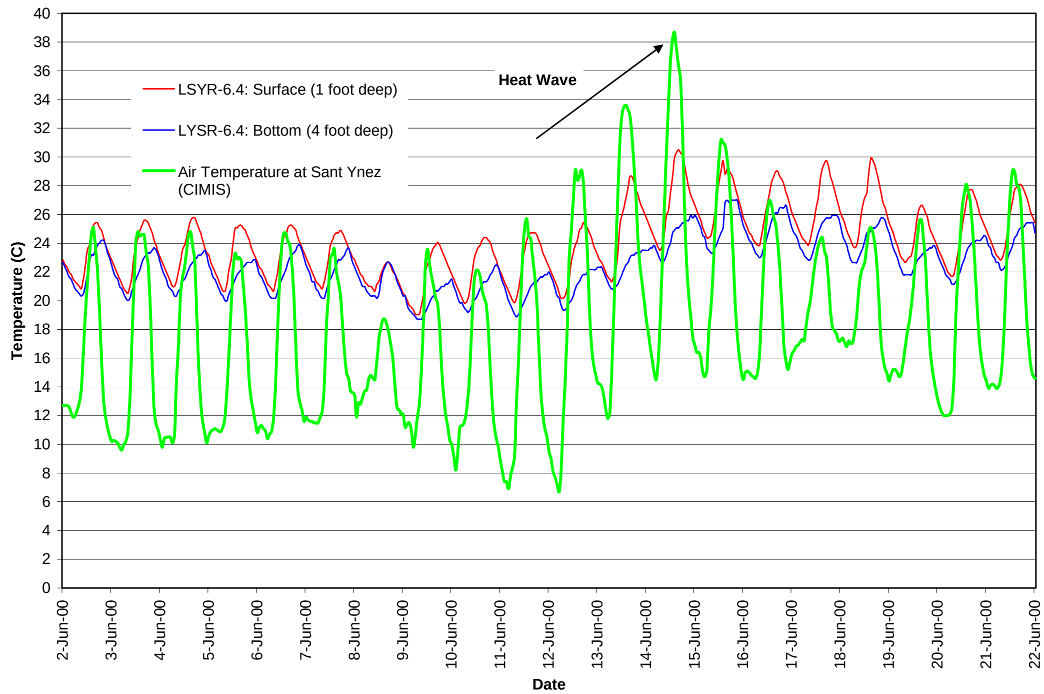


Figure 3-2. Example of Effects of Diel Air Temperatures on Water Temperatures at Pool Located at the Lower Gainey Crossing, LSYR-6.4 (Source: CPWA 2005, Stetson 2008)

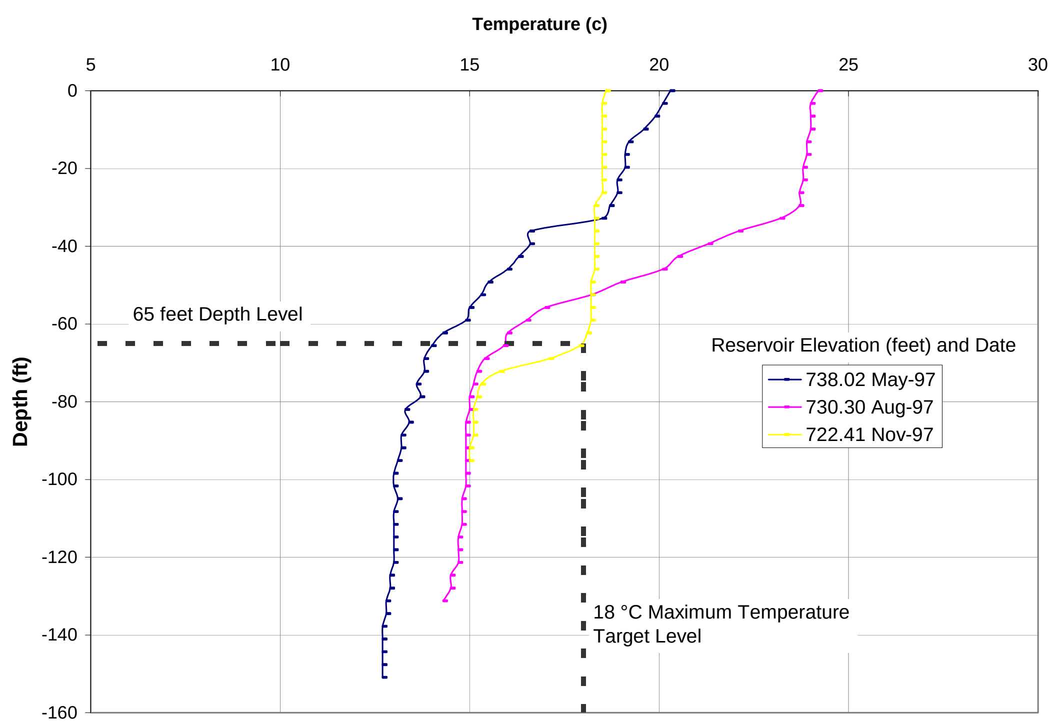


Figure 3-3. 1997 Lake Cachuma Temperature Profiles

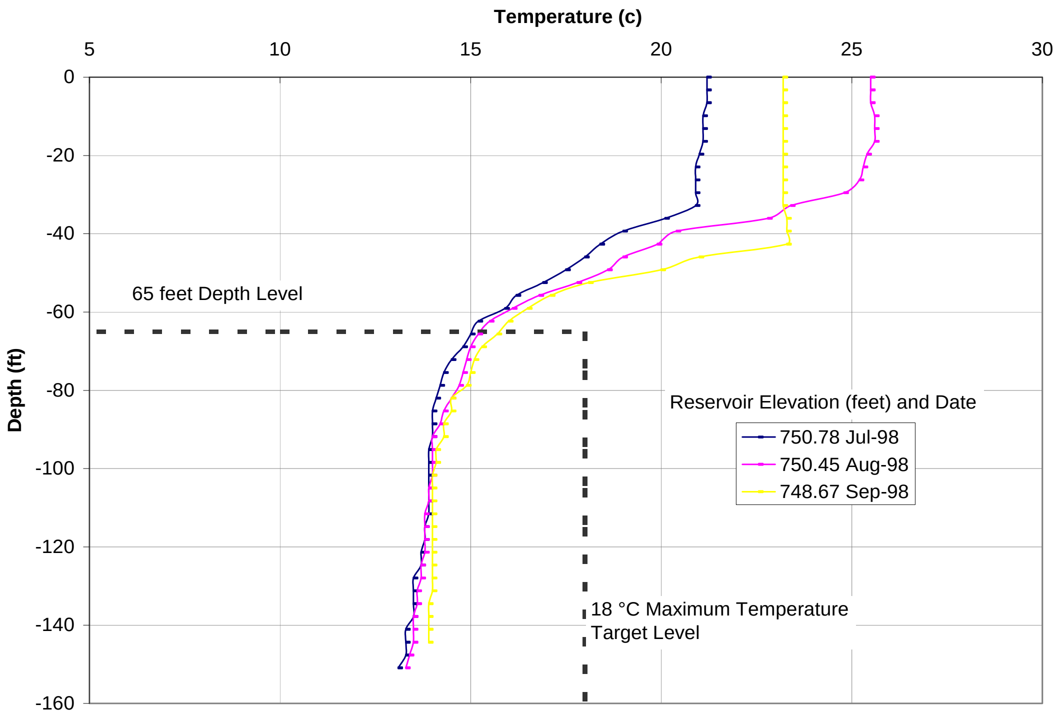


Figure 3-4. 1998 Lake Cachuma Temperature Profiles

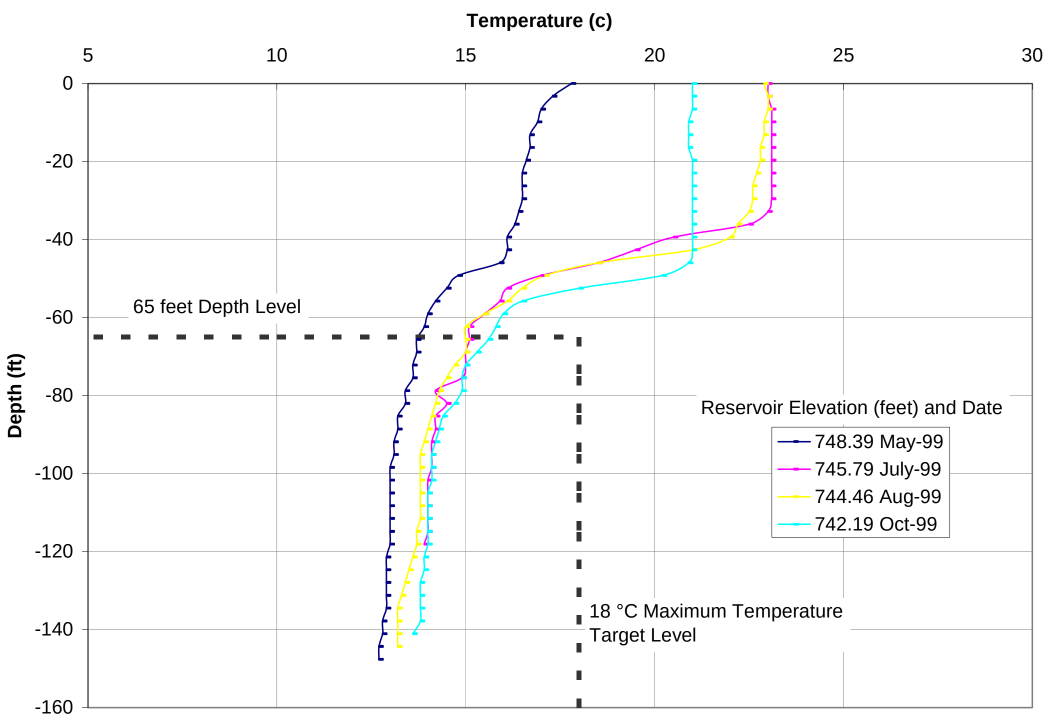


Figure 3-5. 1999 Lake Cachuma Temperature Profiles

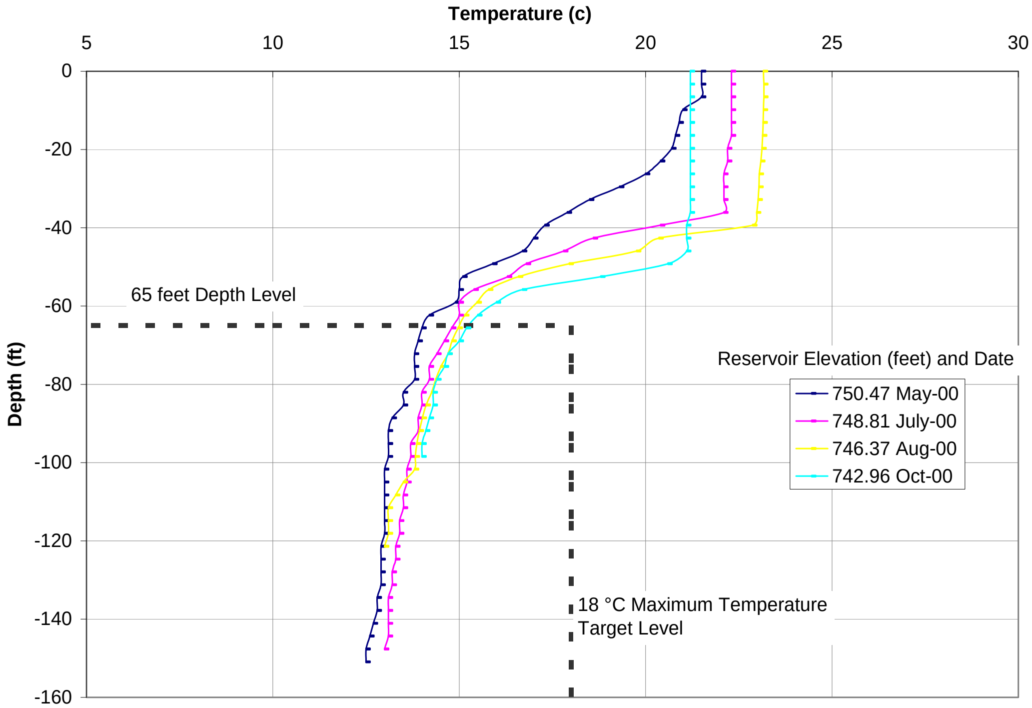


Figure 3-6. 2000 Lake Cachuma Temperature Profiles

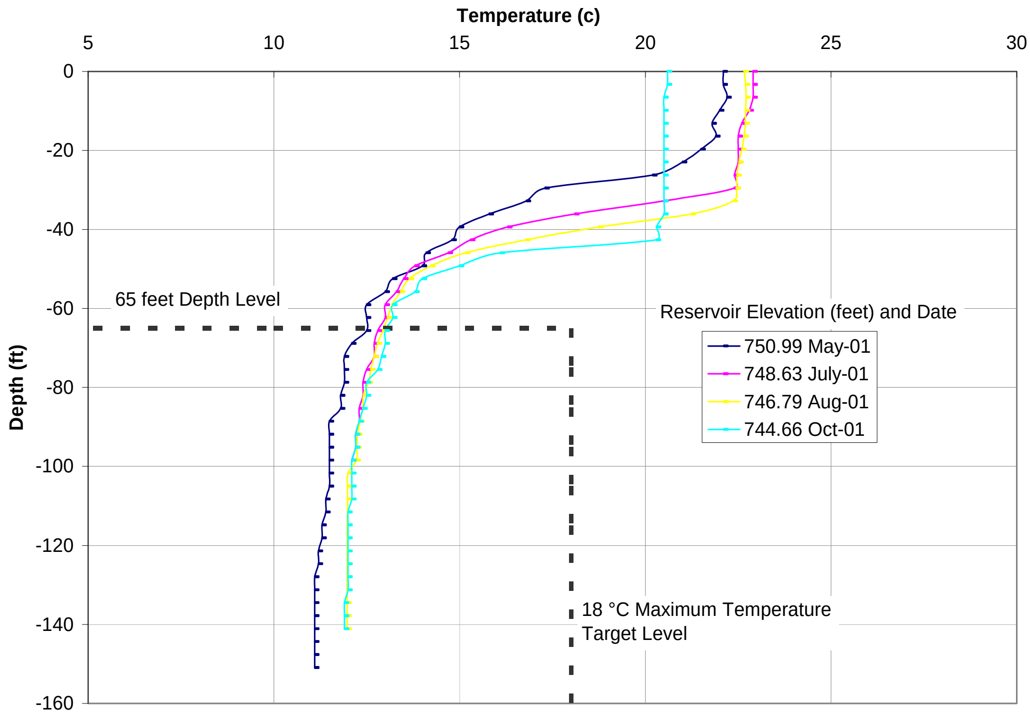


Figure 3-7. 2001 Lake Cachuma Temperature Profiles

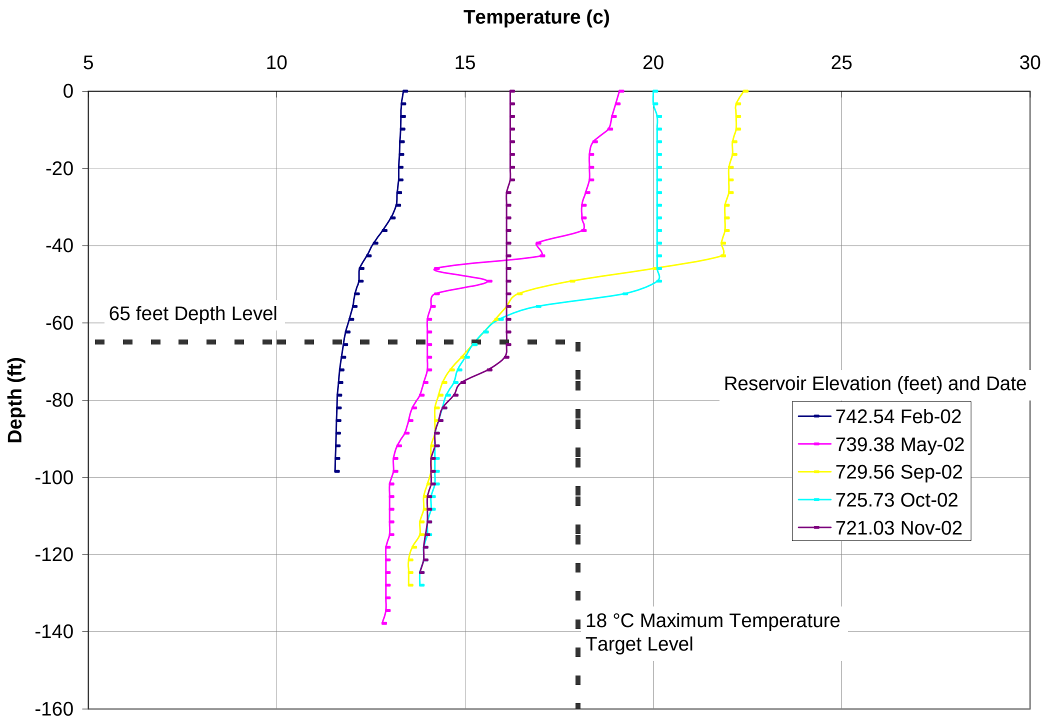


Figure 3-8. 2002 Lake Cachuma Temperature Profiles

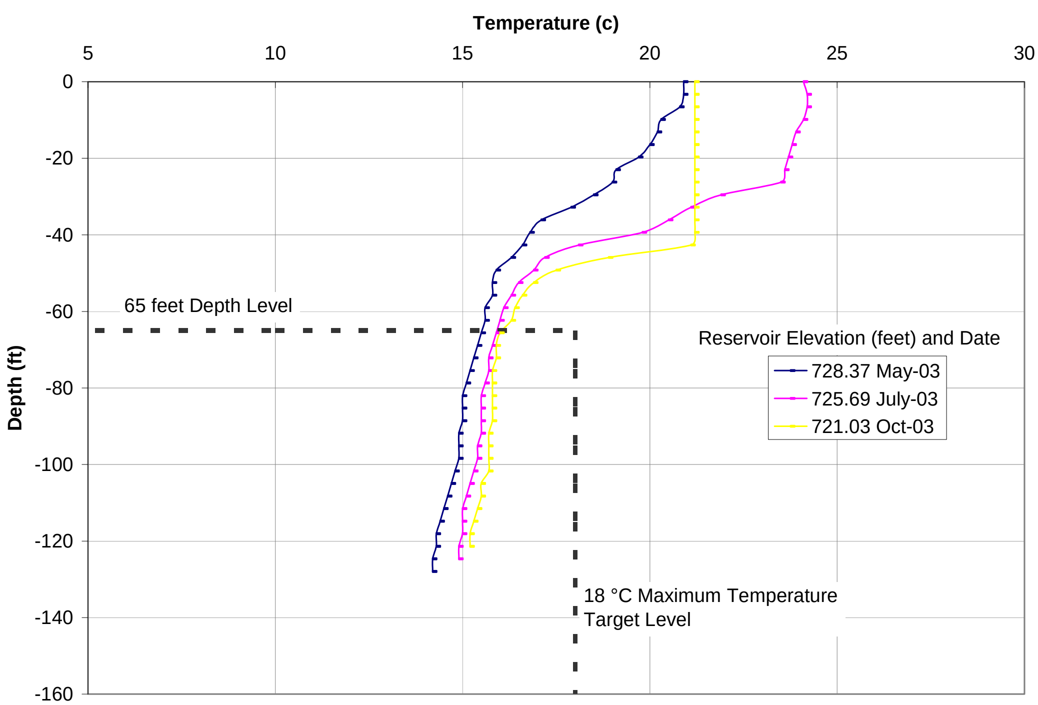


Figure 3-9. 2003 Lake Cachuma Temperature Profiles

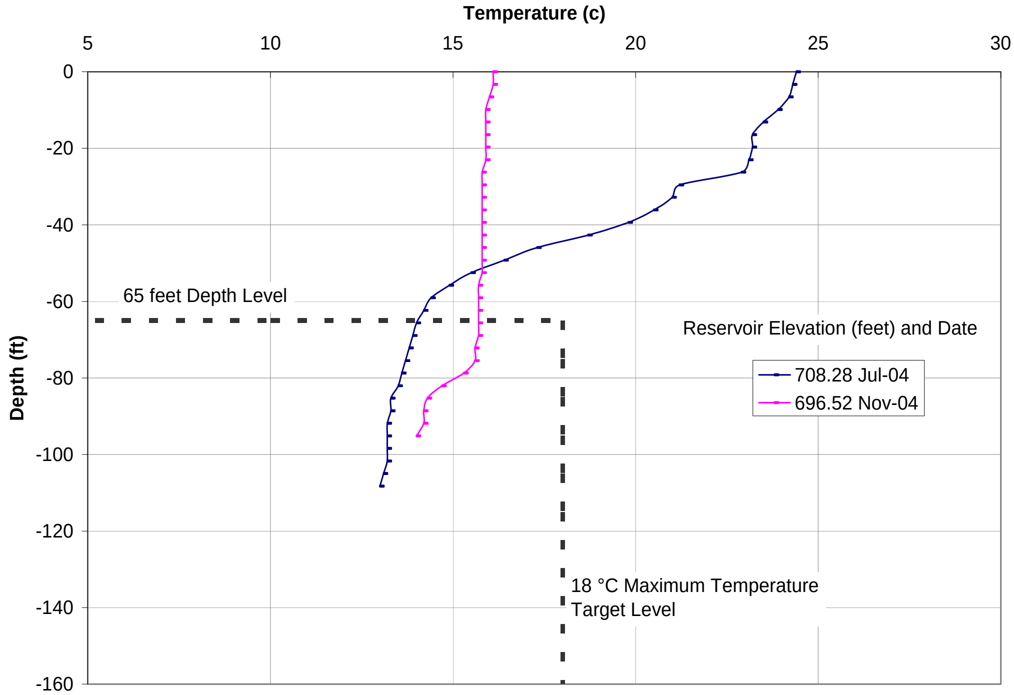


Figure 3-10. 2004 Lake Cachuma Temperature Profiles

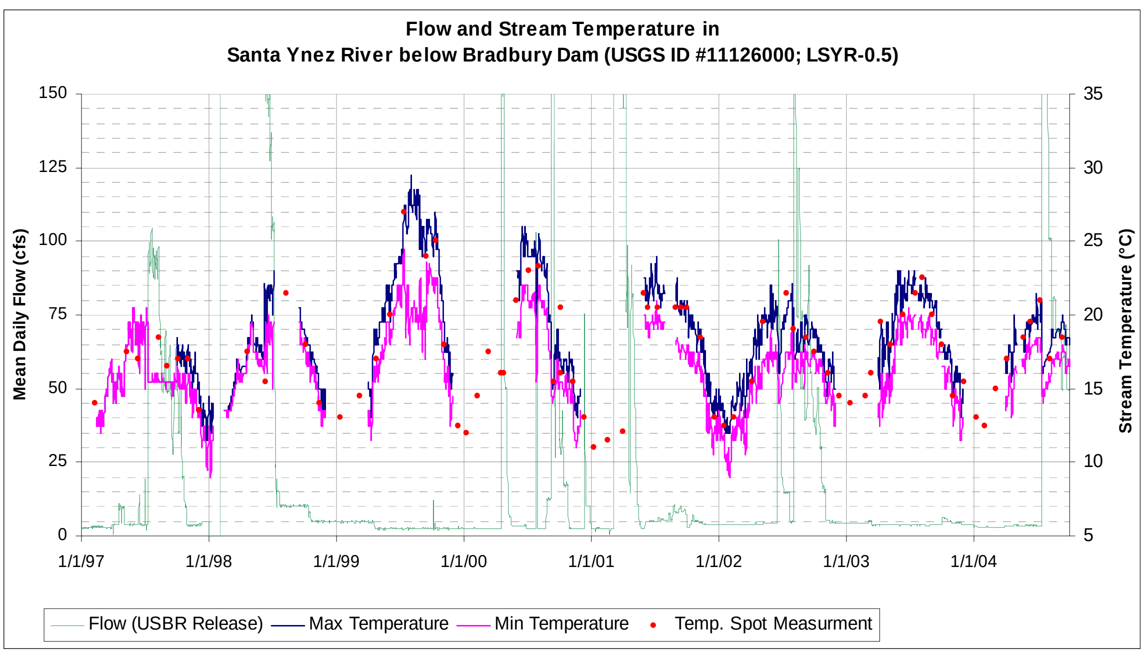


Figure 3-11. Flow and USGS Stream Temperature in Santa Ynez River below Bradbury Dam; LSYR-0.5 (Source: USGS 2008, Stetson 2008)

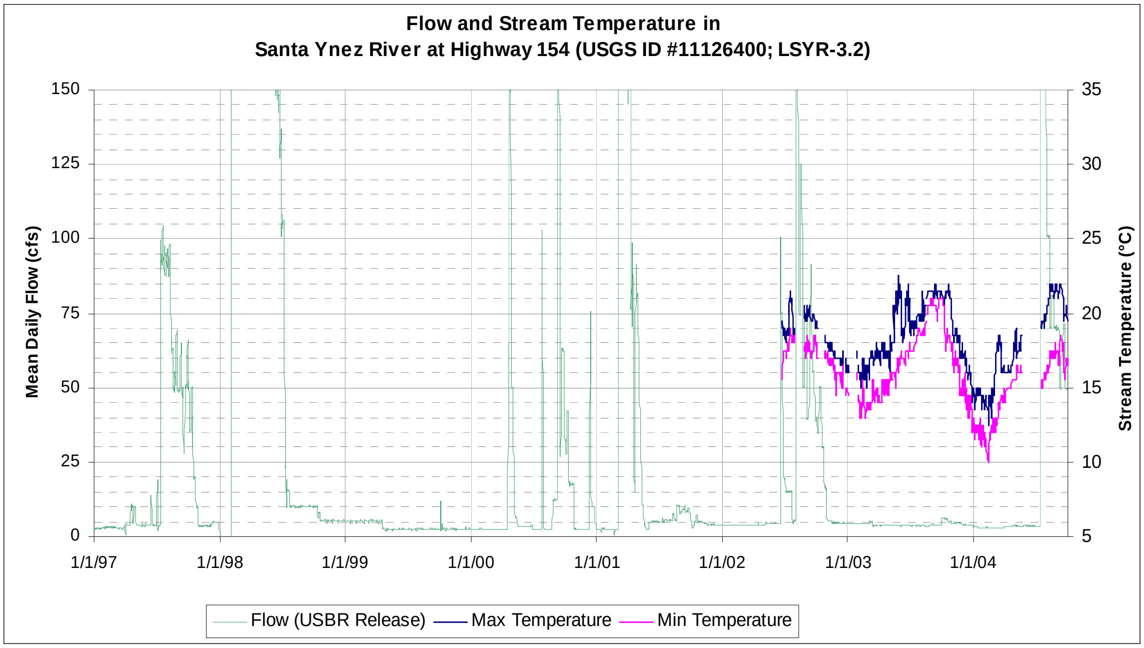


Figure 3-12. Flow and USGS Stream Temperature in Santa Ynez River at 154 Bridge, LSYR-3.2 (Source: USGS 2008, Stetson 2008)

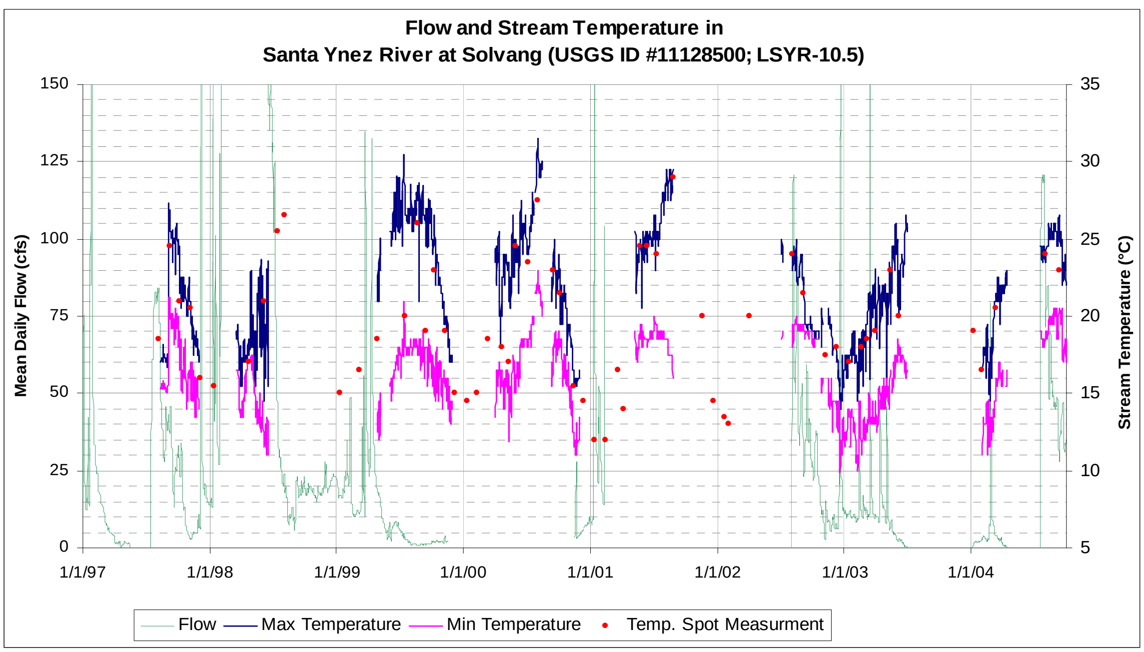


Figure 3-13. Flow and USGS Stream Temperature in Santa Ynez River at Solvang, LSYR-10.5 (Source: USGS 2008, Stetson 2008)

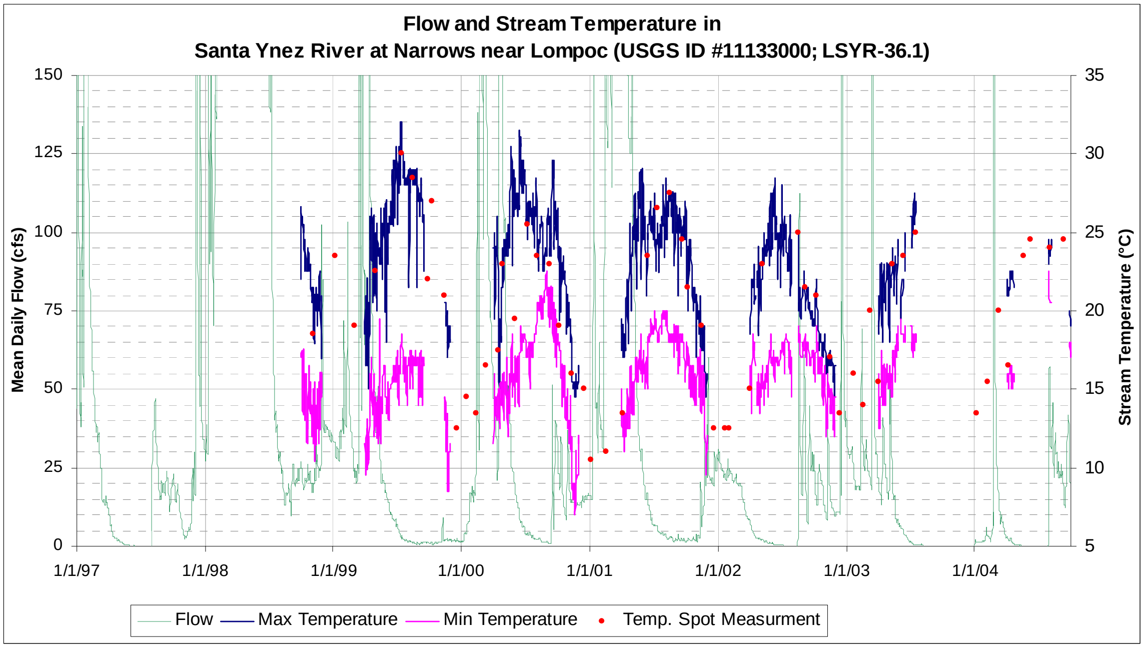


Figure 3-14. Flow and USGS Stream Temperature in Santa Ynez River at Lompoc Narrows, LSYR-36.1 (Source: USGS 2008, Stetson 2008)

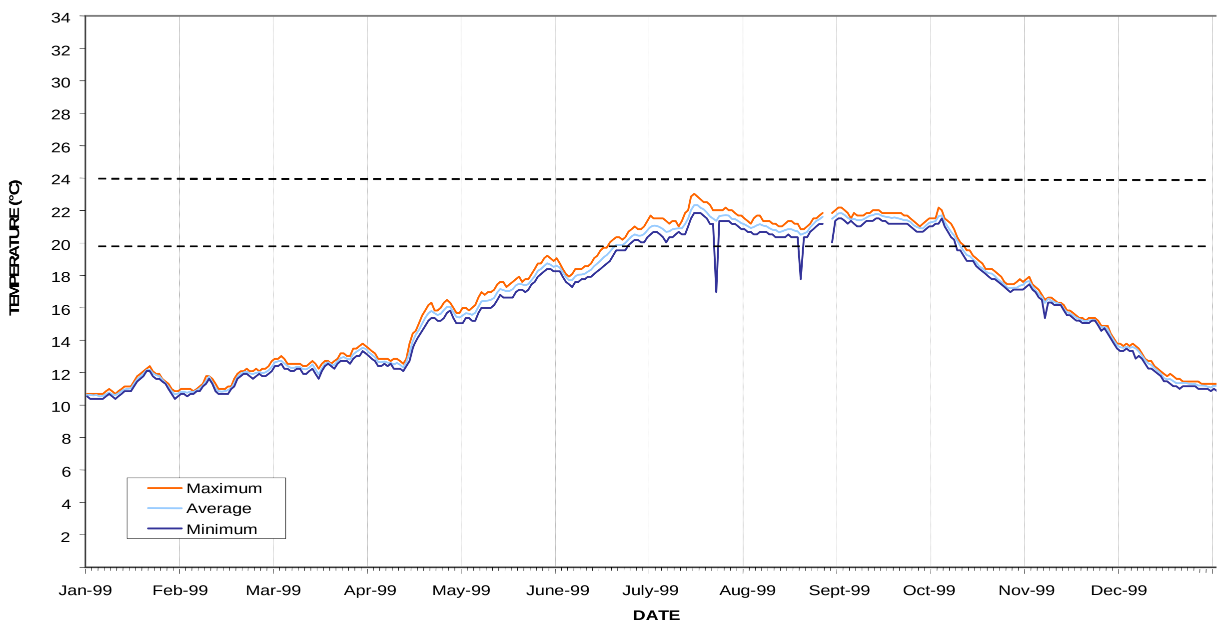


Figure 3-15. Water temperatures at the Stilling Basin (LSYR-0.2), 1999, at a depth of 3 feet (Note: This was exploratory monitoring that confirmed that water temperatures are not much different at this location than at the Long Pool (LSYR-0.5); Source: CPWA 2004)

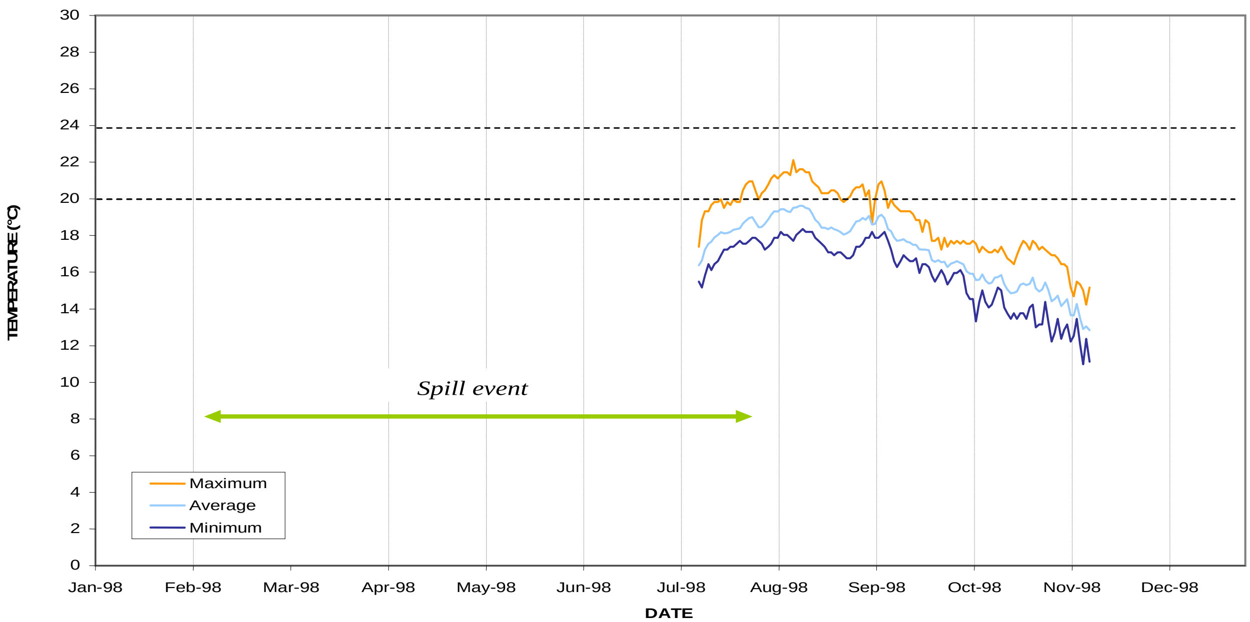


Figure 3-16. Water temperatures between the Stilling Basin and Long Pool (LSYR-0.2–0.4), 1998, measured during the Hilton Creek fish rescue where fish were released (Source: CPWA 2005)

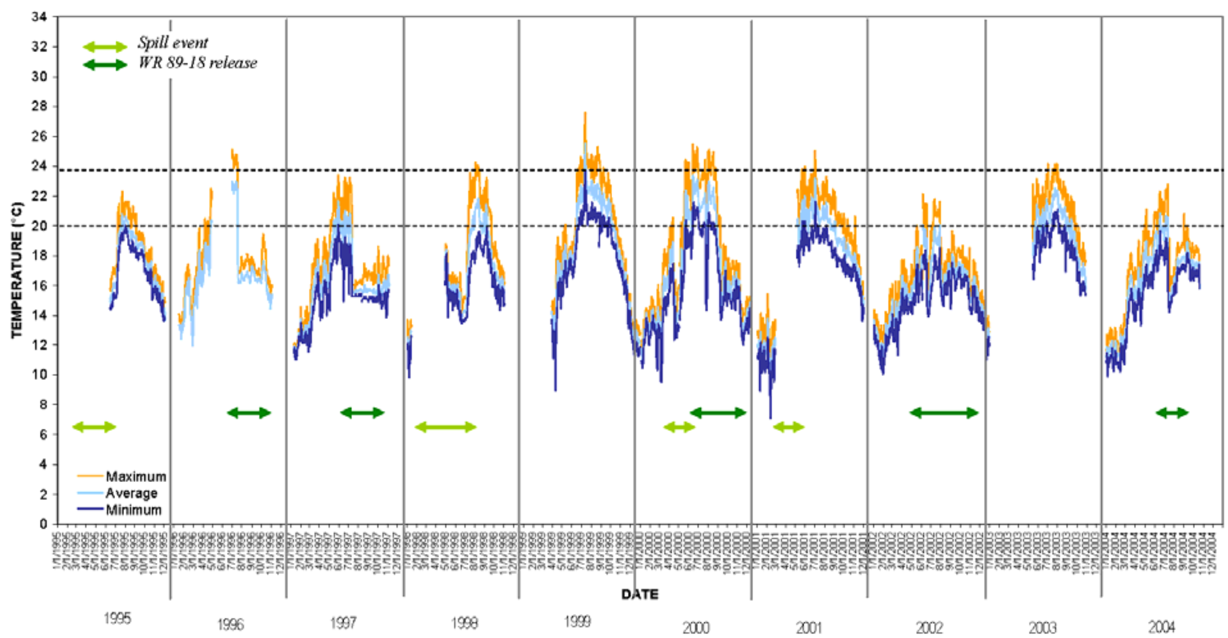


Figure 3-17. 1995 – 2004 Santa Ynez River water temperatures at Long Pool (LSYR-0.5), 0.5 miles downstream of Bradbury Dam, Surface Unit thermograph – 1 foot below surface (Note: Data gaps in the temperature record are the result of removing units during the winter, unit dewatering, or instrument failure (Source: CPWA 2005))

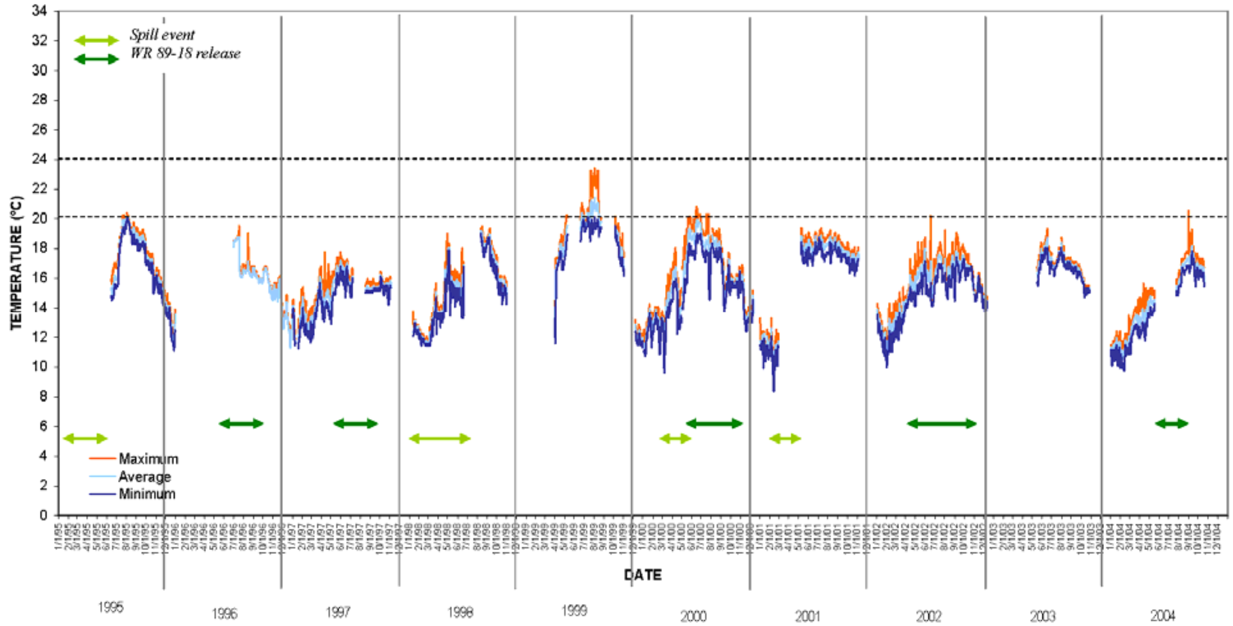


Figure 3-18. 1995 – 2004 Santa Ynez River water temperatures at Long Pool (LSYR-0.5), 0.5 miles downstream of Bradbury Dam, Bottom Unit thermograph, 9 feet below surface (Note: Data gaps in the temperature record are the result of removing units during the winter, unit dewatering, or instrument failure (Source: CPWA 2005))

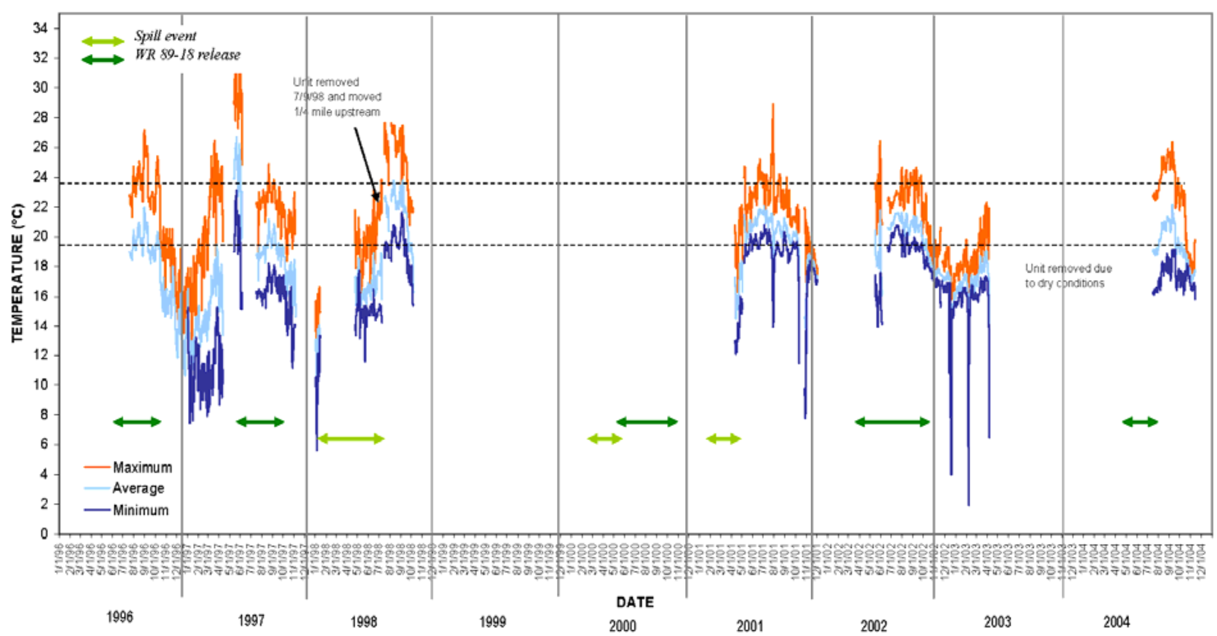


Figure 3-19. 1996 – 2004 Santa Ynez River water temperatures, Refugio Reach (LSYR-5.0), 5.0 miles downstream of Bradbury Dam, Surface Unit thermograph – 1 foot below surface (Note: Data gaps in the temperature record are the result of removing units during the winter, unit dewatering, or instrument failure. No monitoring was performed between 1999 and mid-2001. (Source: CPWA 2005))

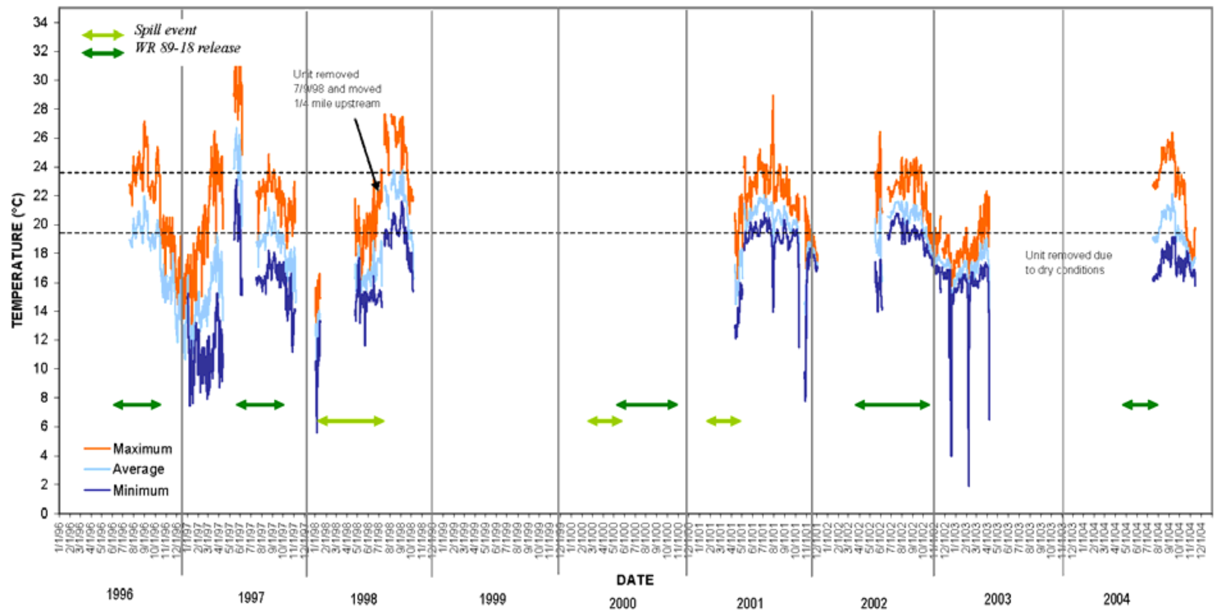


Figure 3-20. 1995 – 2004 Santa Ynez River water temperatures, Refugio Reach (LSYR-5.0), 5.0 miles downstream of Bradbury Dam, Bottom Unit (Note: Data gaps in the temperature record are the result of removing units during the winter, unit dewatering, or instrument failure. No monitoring was performed between 1999 and mid-2001. (Source: CPWA 2005))

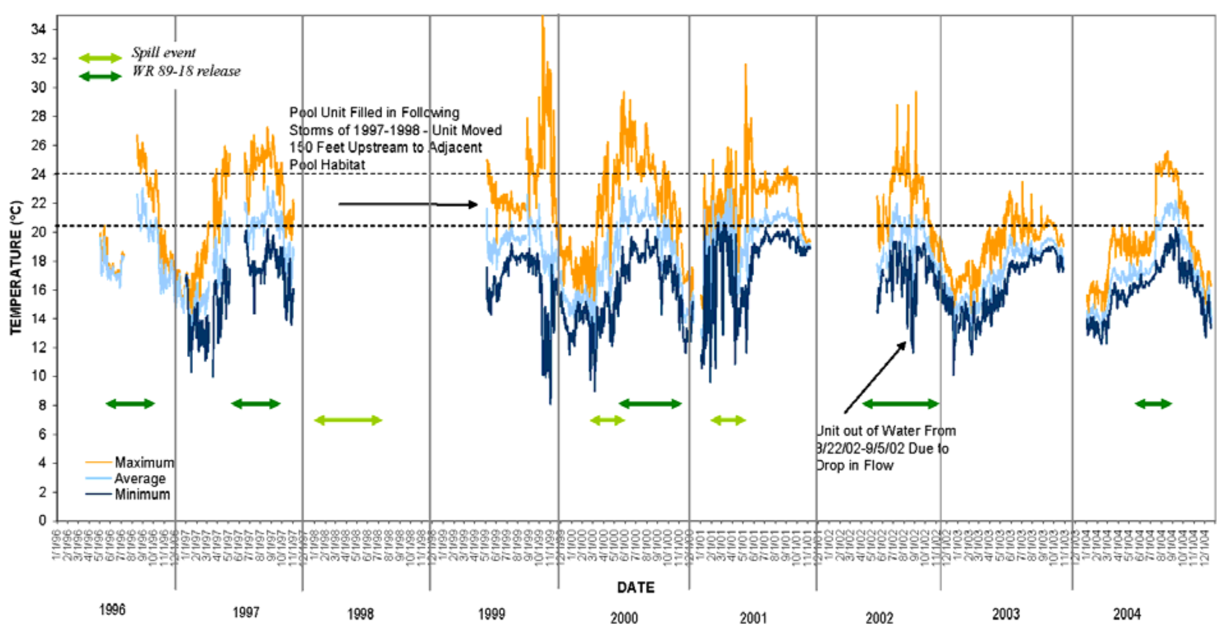


Figure 3-21. 1996 – 2004 Santa Ynez River water temperatures, Alisal Reach (LSYR-7.8), 7.8 miles downstream of Bradbury Dam, surface unit 1 foot below the surface (Note: Data gaps in the temperature record are the result of removing units during the winter, unit dewatering, or instrument failure (Source: CPWA 2005))

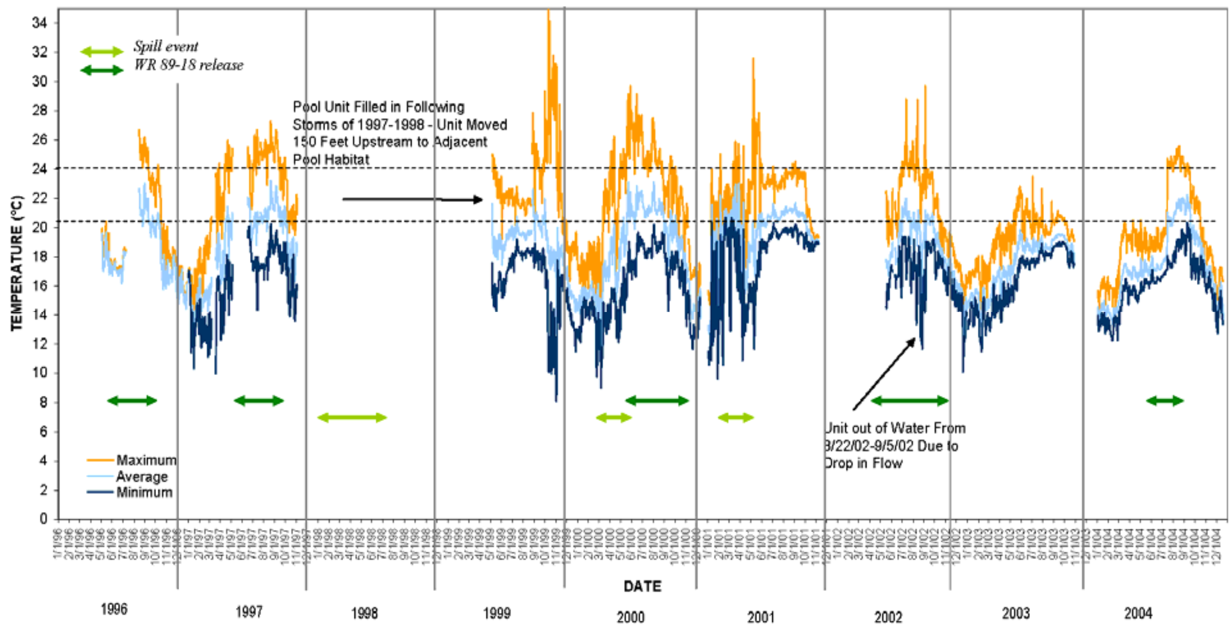


Figure 3-22. 1996 – 2004 Santa Ynez River water temperatures, Alisal Reach (LSYR-7.8), 7.8 miles downstream of Bradbury Dam, Bottom Unit, 4 feet below surface (Note: Data gaps in the temperature record are the result of removing units during the winter, unit dewatering, or instrument failure (Source: CPWA 2005))

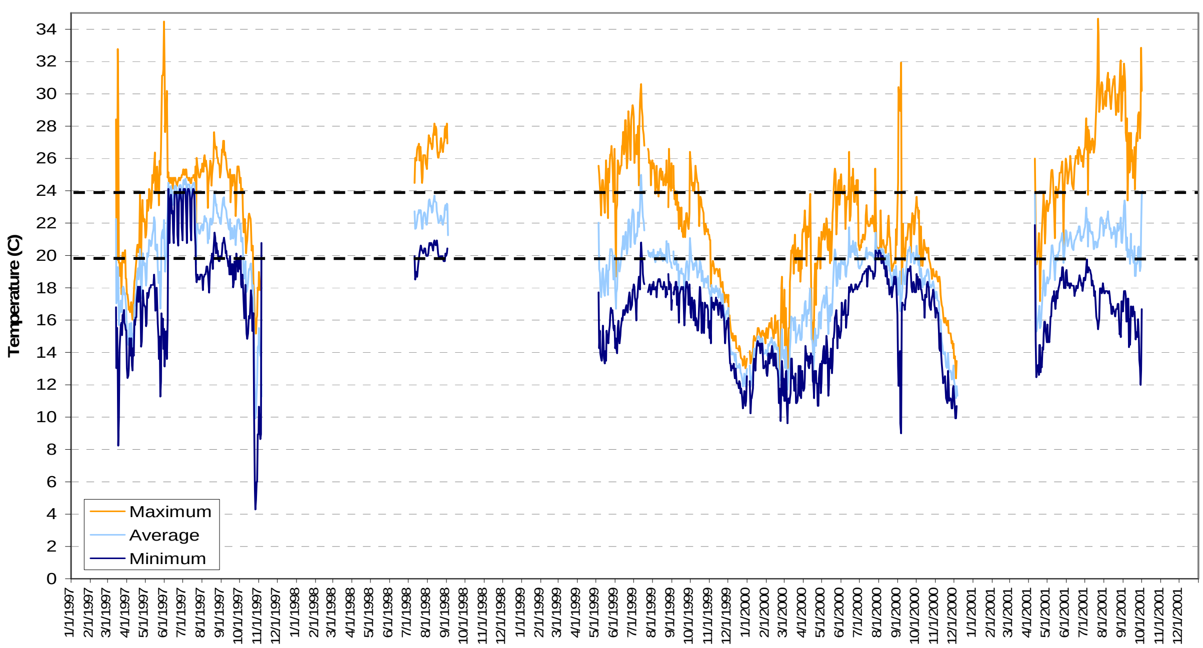


Figure 3-23. 1997 – 2001 Santa Ynez River water temperatures, Alisal Reach at Alisal Bridge (LSYR-10.5) (Note: Data gaps in the temperature record are the result of removing units during the winter; unit dewatering, or instrument failure (Source CPWA 2005))

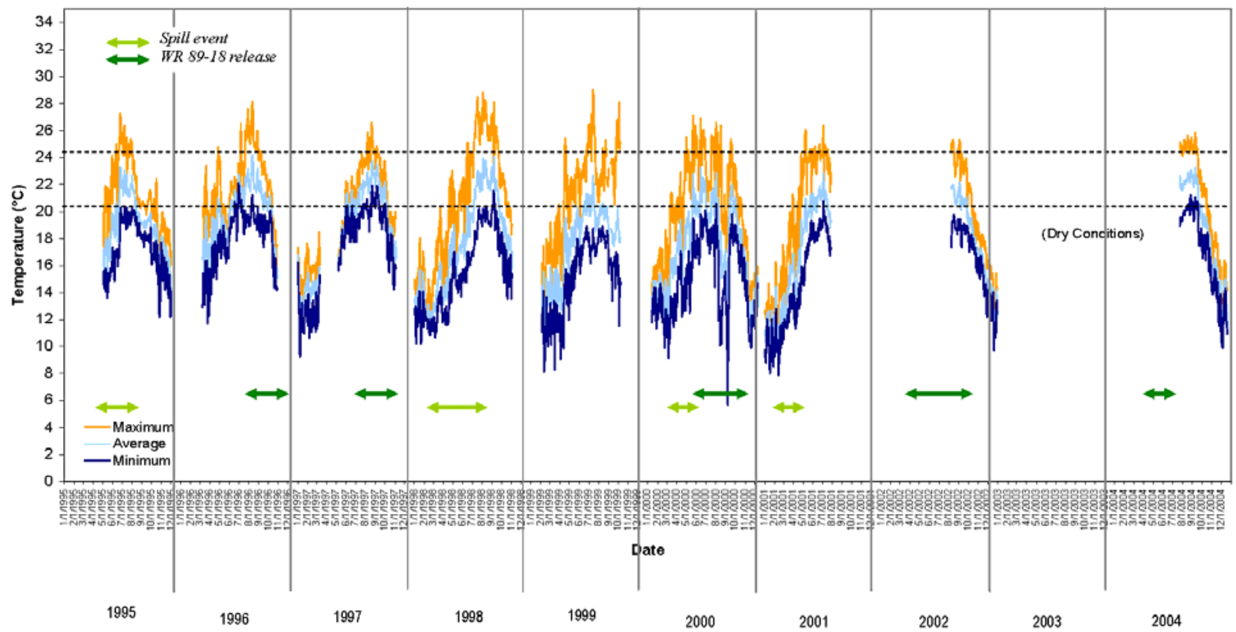


Figure 3-24. 1995 – 2004 Santa Ynez River water temperatures, Buellton Reach at Avenue of the Flags Bridge (LSYR-13.9), 13.9 miles downstream of Bradbury Dam (Note: Data gaps in the temperature record are the result of removing units during the winter, unit dewatering, or instrument failure (Source: CPWA 2005))

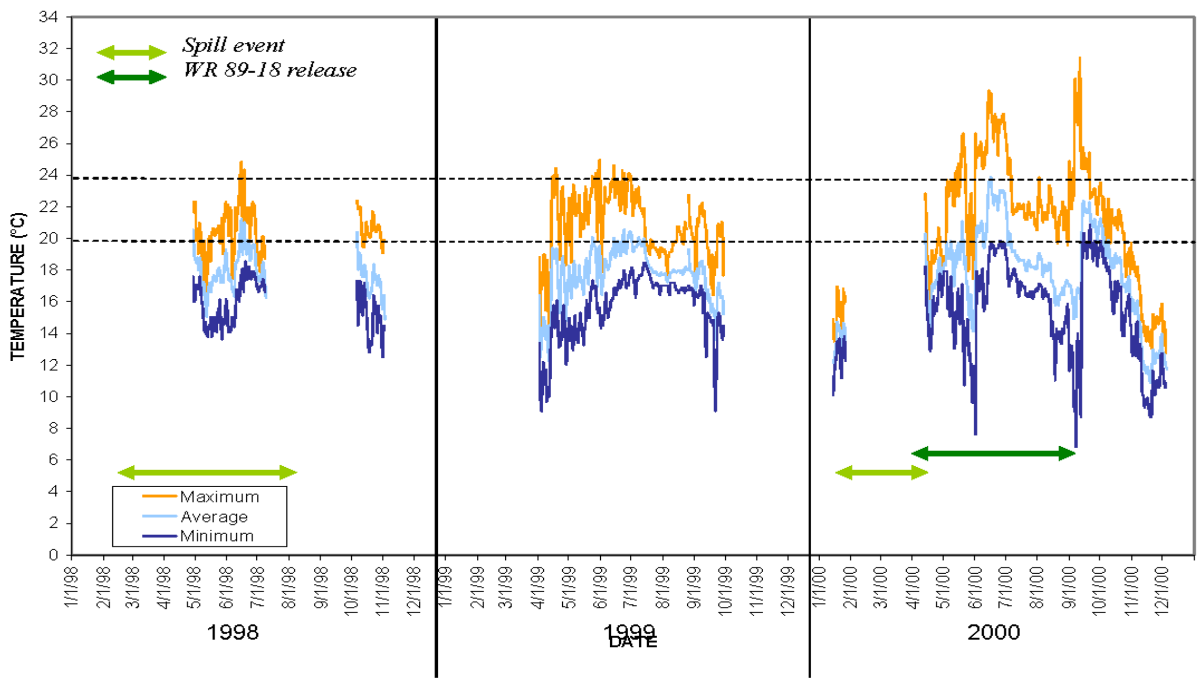


Figure 3-25. 1998 – 2000 Santa Ynez River water temperatures, Cargasacchi Reach, LSYR-22.45; Surface Unit, 1 foot below the surface; Note: Private landowner restricted access in 2000 which prevented further monitoring (Note: Data gaps in the temperature record are the result of removing units during the winter, unit dewatering, or instrument failure (Source: CPWA 2005))

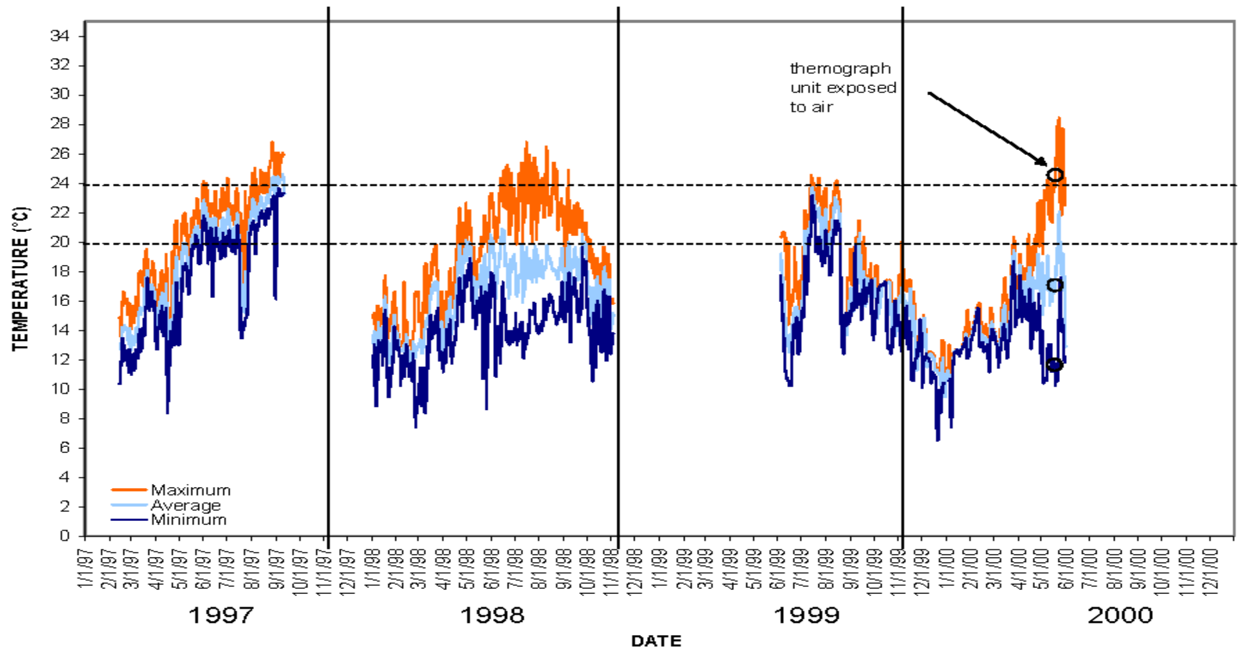


Figure 3-26. 1997 – 2000 Santa Ynez River water temperatures, Santa Ynez Lagoon at Ocean Park (LSYR-47.75), Surface unit, 1 foot below the surface (Note: Data gaps in the temperature record are the result of removing units during the winter, unit dewatering, or instrument failure (Source: CPWA 2005))

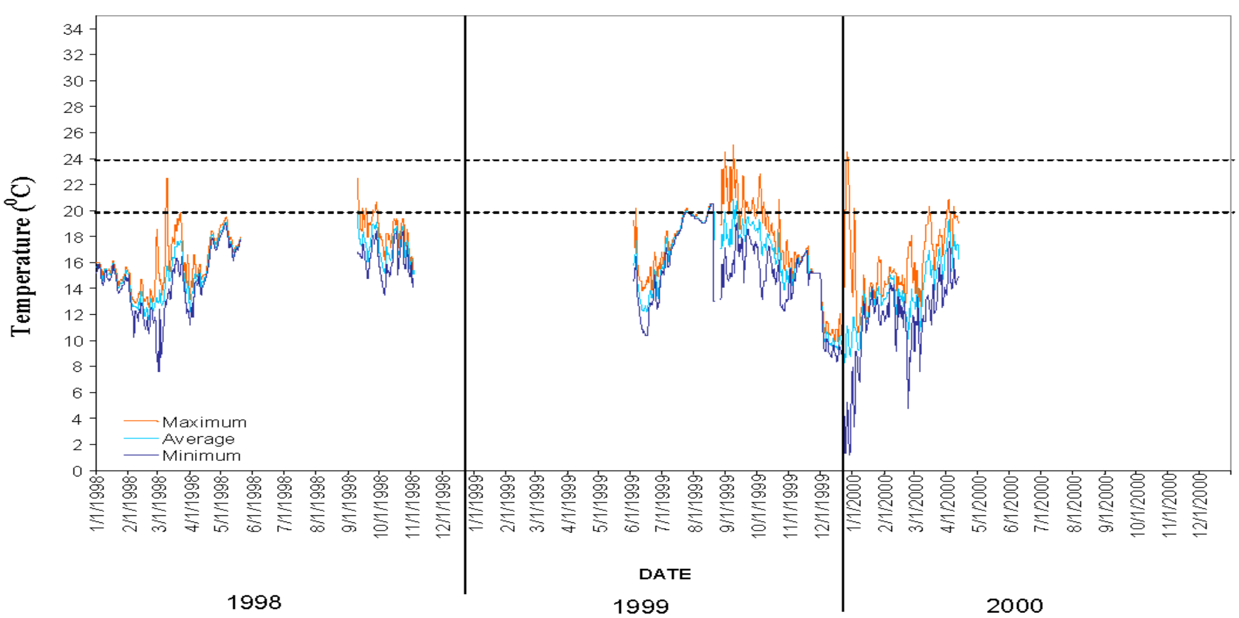


Figure 3-27. 1998 – 2000 Santa Ynez River water temperatures, Santa Ynez Lagoon at Ocean Park (LSYR-47.75), Bottom Unit 6 feet below surface (Note: Data gaps in the temperature record are the result of removing units during the winter, unit dewatering, or instrument failure (Source: CPWA 2005))

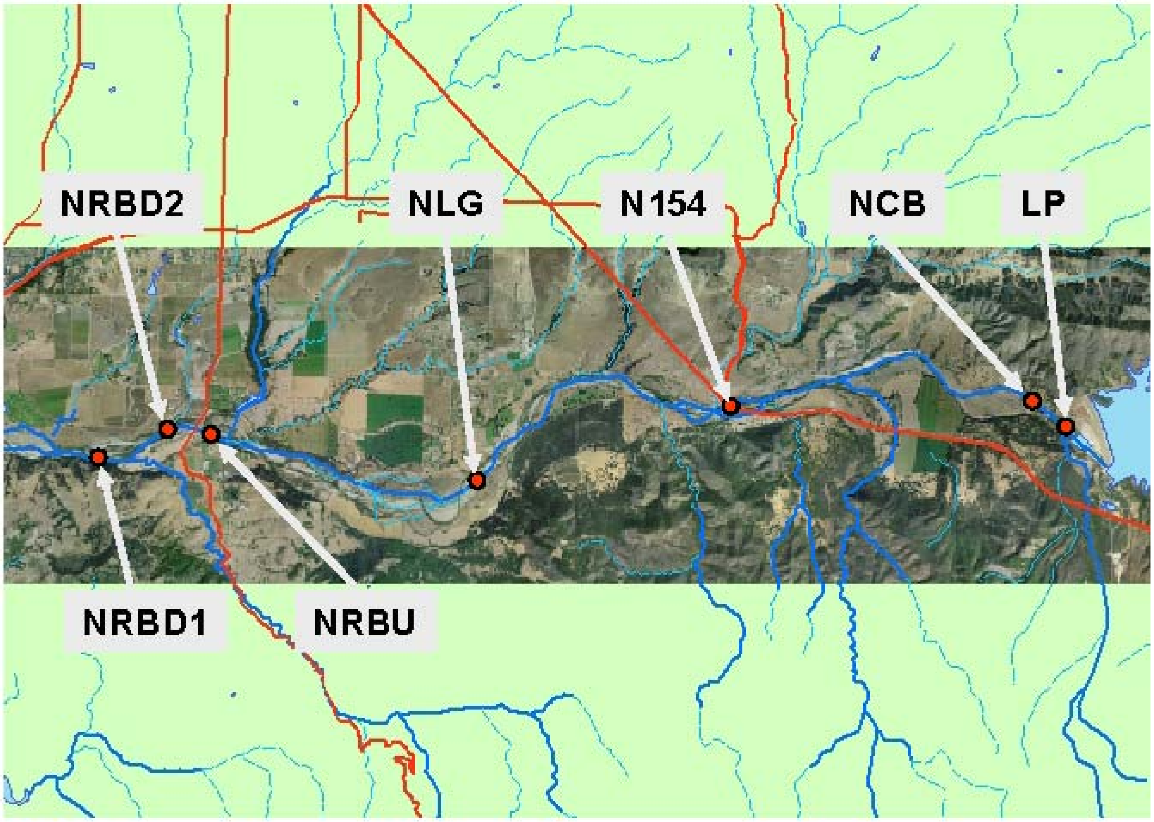


Figure 3-28. Seven pools monitored for water quality during the summer of 2003 on the mainstem of the LSYR. Sites are from the dam down past the Town of Santa Ynez (Source: CPWA 2005)

LEGEND[1]

LP	=	Long Pool (first site below the dam): LSYR-0.5
NCB	=	near the Reclamation property boundaries: LSYR-0.7
N154	=	near Highway 154 Bridge: LSYR-3.2
NLG	=	near lower Gainey Crossing: LSYR-6.4
NRBU	=	upstream of Refugio Road Bridge: LSYR-7.8
NRBD[1]	=	200 yards downstream of Refugio Road Bridge: LSYR-8.0
NRBD[2]	=	one mile downstream of Refugio Road Bridge: LSYR-8.6

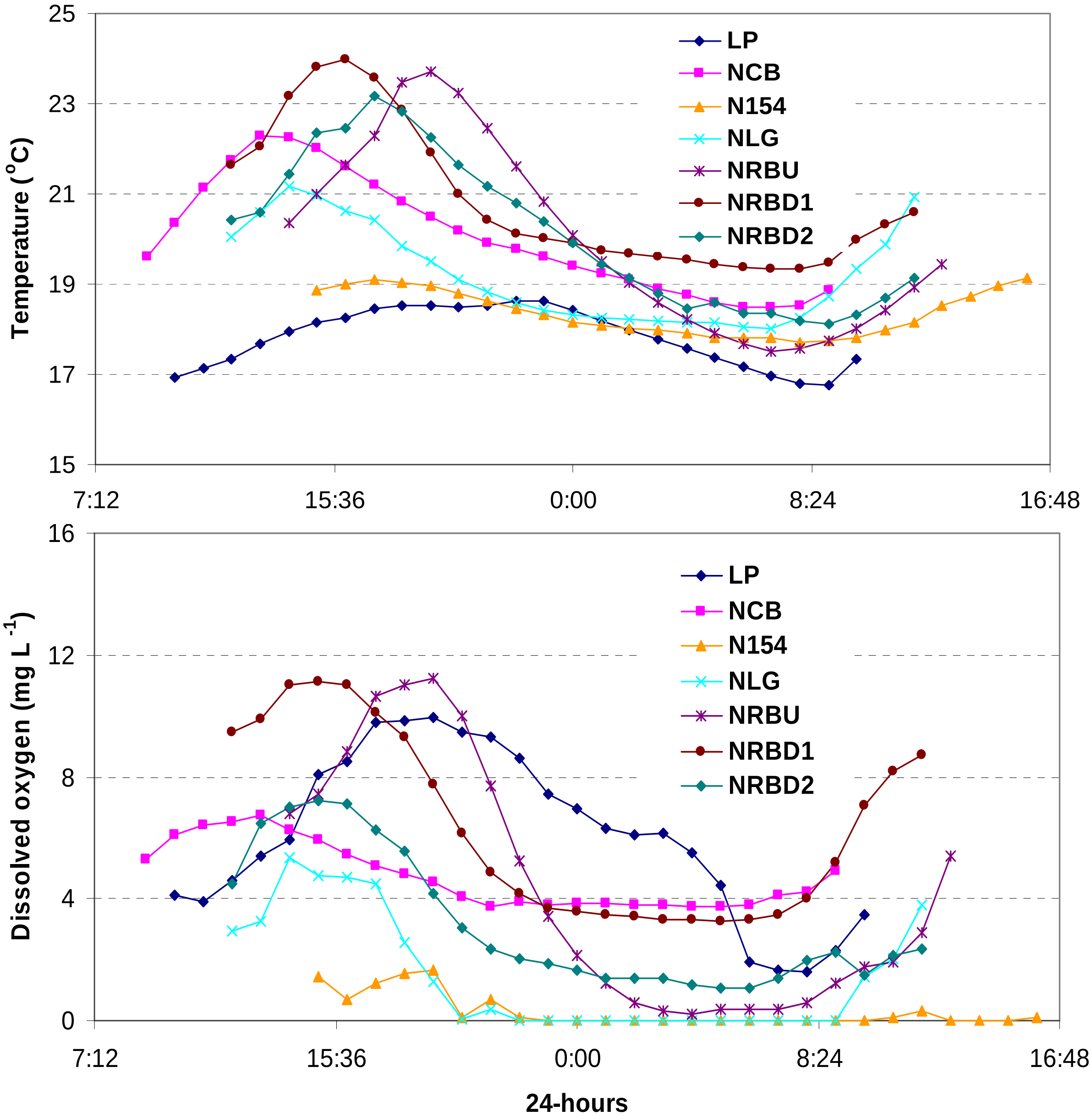


Figure 3-29. Pool water quality conditions, temperature and DO at the end of June for all of the seven pools monitored on the mainstem of the Santa Ynez River during the summer of 2003 (see Figure 3-28 for pool locations) Source: CPWA 2005))

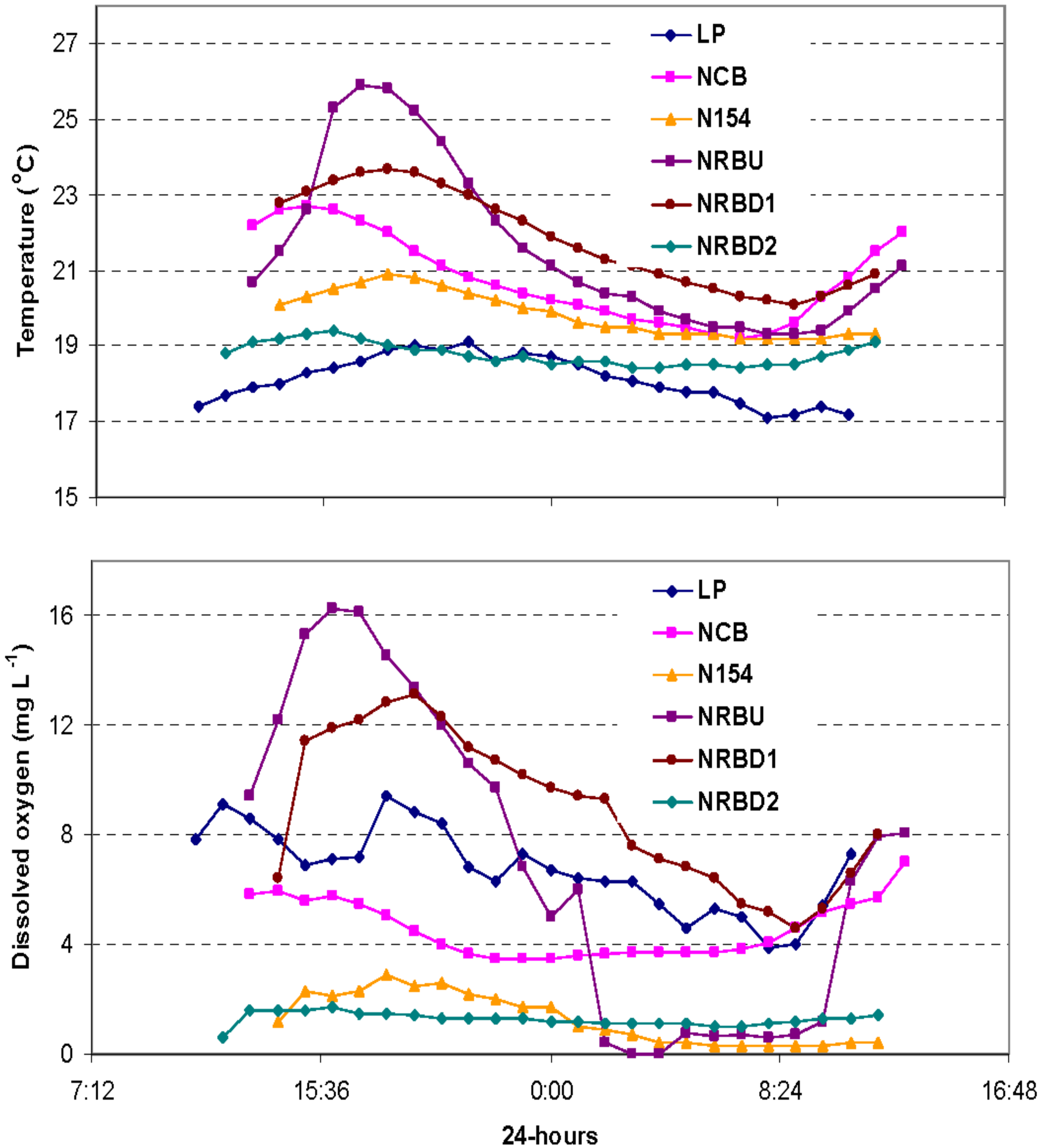


Figure 3-30. Pool water quality conditions, temperature and DO during August for all of the five to seven pools monitored on the mainstem of the Santa Ynez River during the summer of 2003 (See Figure 3-28 for pool locations (Source: CPWA 2005))

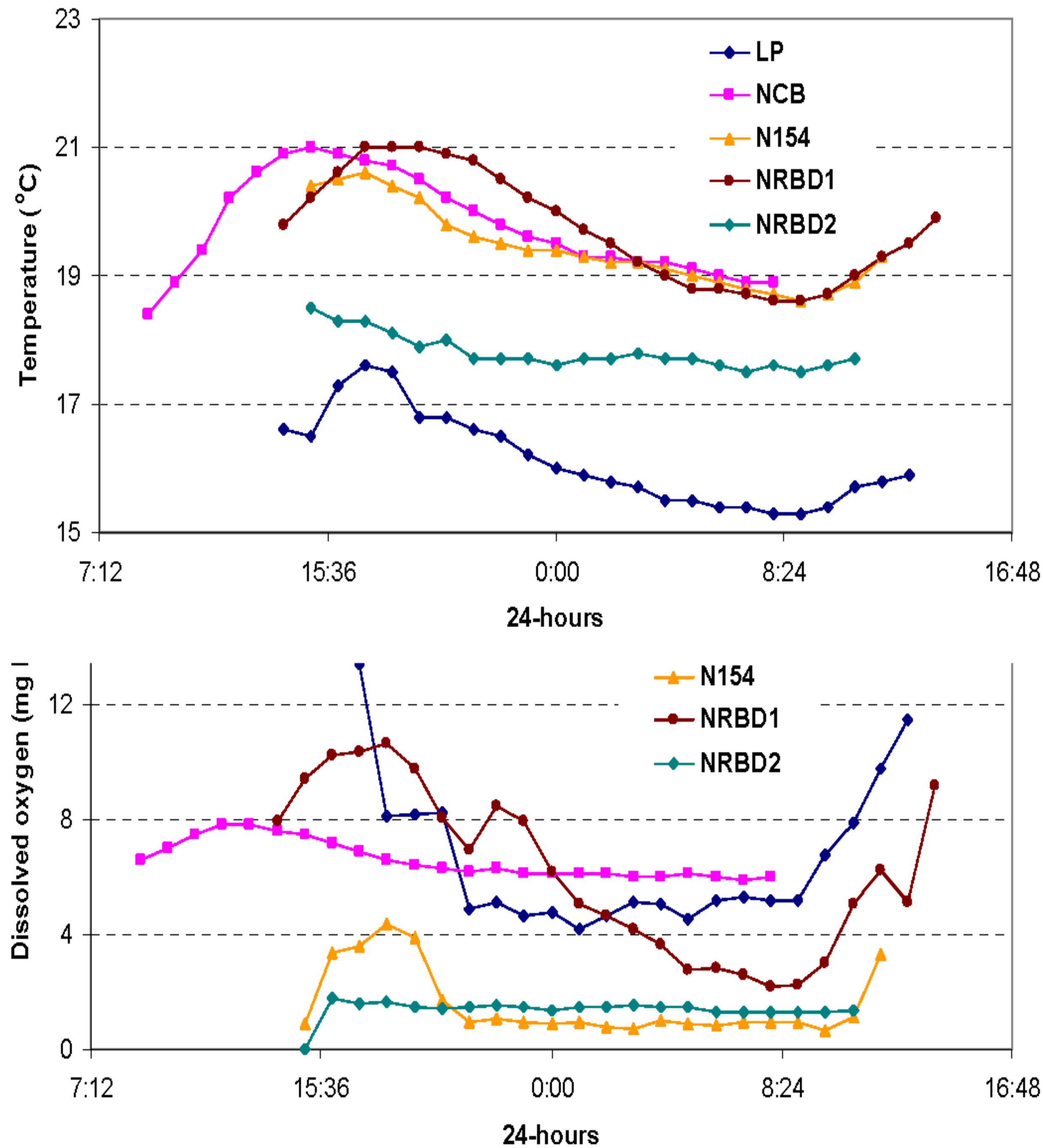


Figure 3-31. Pool water quality conditions, temperature and DO, at the end of September and beginning of October for all of the five to seven pools monitored on the mainstem of the Santa Ynez River during the summer of 2003 (See Figure 3-28 for pool locations (Source: CPWA 2005))

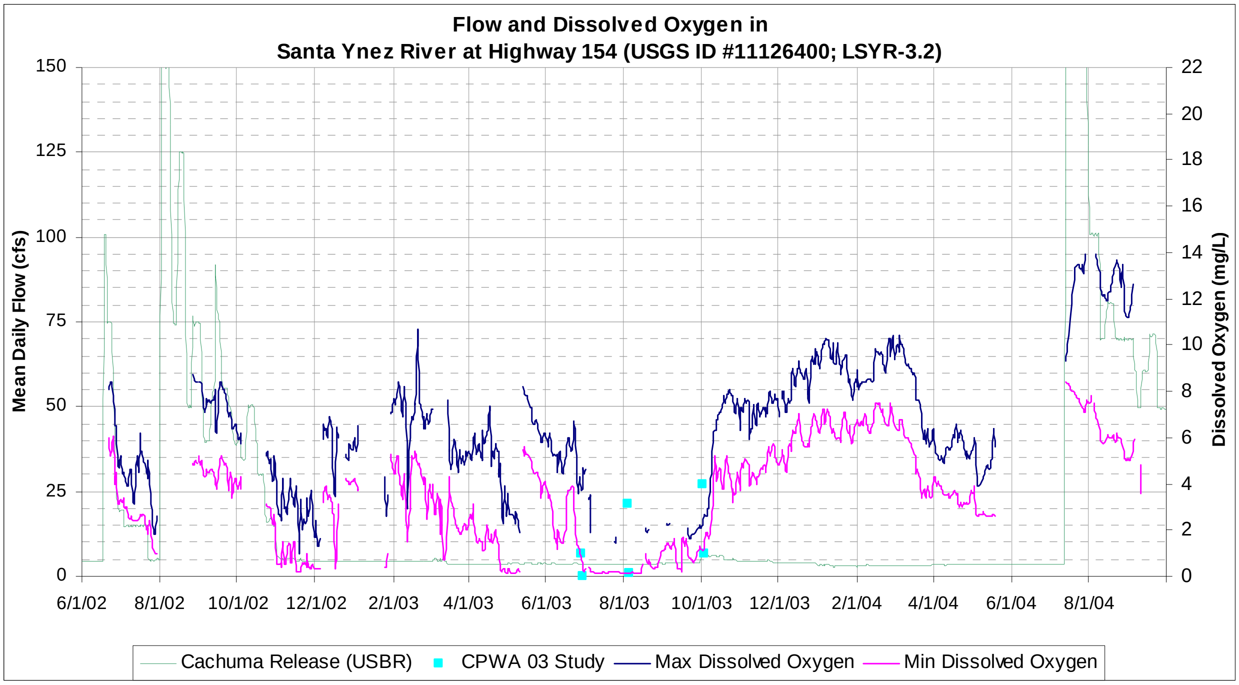


Figure 3-32. USGS Flow and DO Concentration Measurements in Santa Ynez River at Highway 154 Bridge, LSYR-3.2 (Source: USGS 2008, Stetson 2008, CPWA 2005)

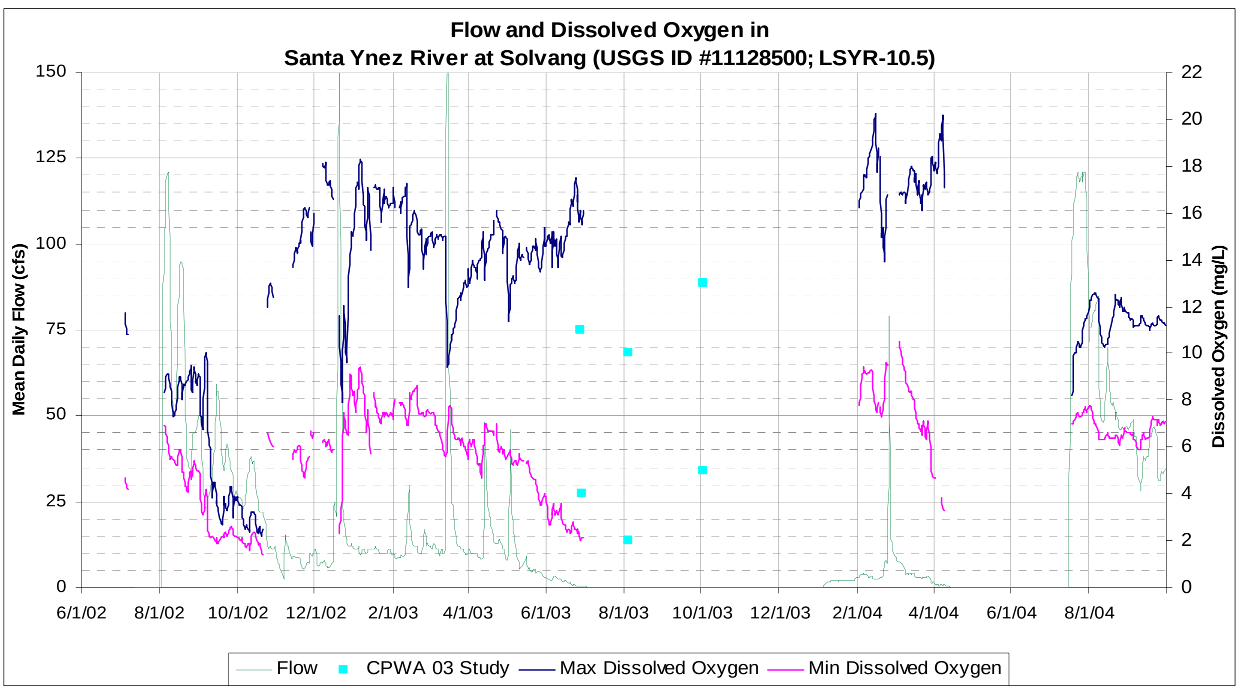


Figure 3-33. USGS Flow and DO Concentration Measurements in Santa Ynez River at Solvang, LSYR-10.5 (Source: USGS 2008, Stetson 2008, CPWA 2005)

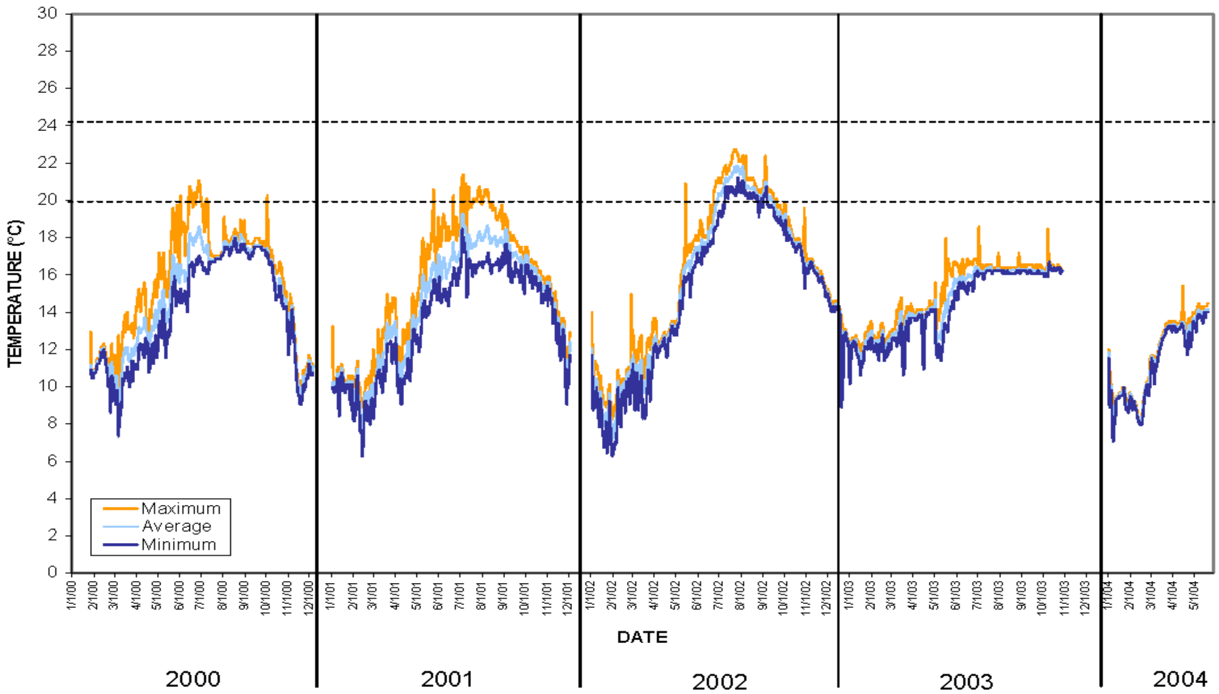


Figure 3-34. Upper Hilton Creek (HC-0.54) water temperatures, 2000 – 2004, after the water system began operation in April 2000 (Note: Data gaps in the temperature record are the result of removing units during the winter, unit dewatering, or instrument failure. Additionally, the upper reach of the creek went dry in May 2004 (Source: CPWA 2005)). Water temperatures observed from 2000 through 2003 reflect natural streamflows. The HCWS upper release point was not operated continuously until 2004.

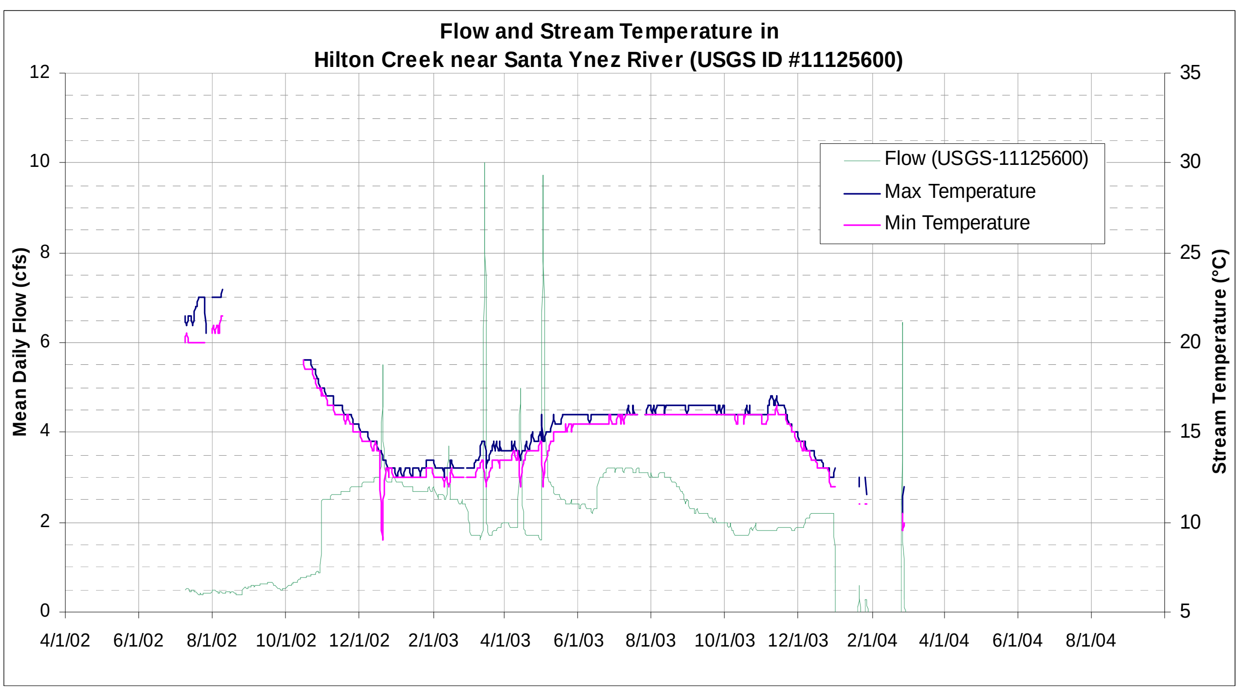


Figure 3-35. USGS Flow and Stream Temperature in Hilton Creek below Upper Release Point; HC-0.5 (Source: USGS 2008, Stetson 2008)

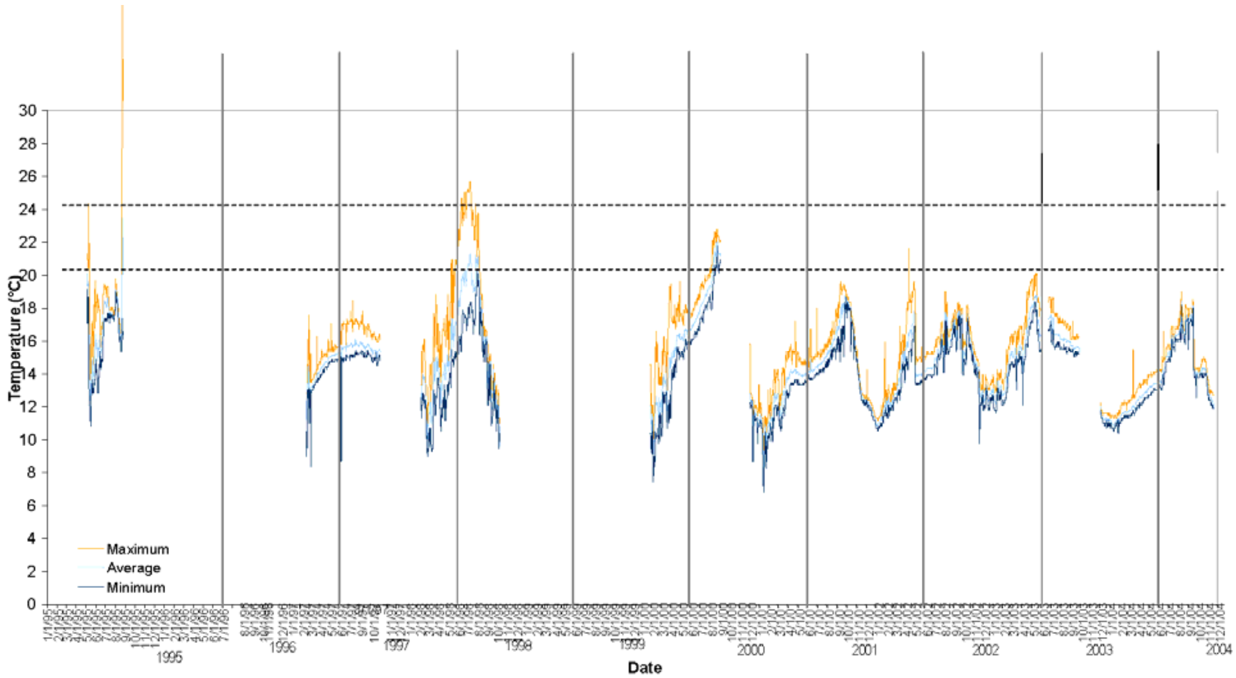


Figure 3-36. Middle Hilton Creek (HC-0.25) water temperatures, 1995 – 2004 (approximately 1,200 feet upstream of Santa Ynez River confluence (Note: Data gaps in the temperature record are the result of removing units during the winter, unit dewatering, or instrument failure (Source: CPWA 2005)). Water temperatures observed from 1995 - 2000 reflect natural stream flows. The HCWS lower release point began operation in 2000.

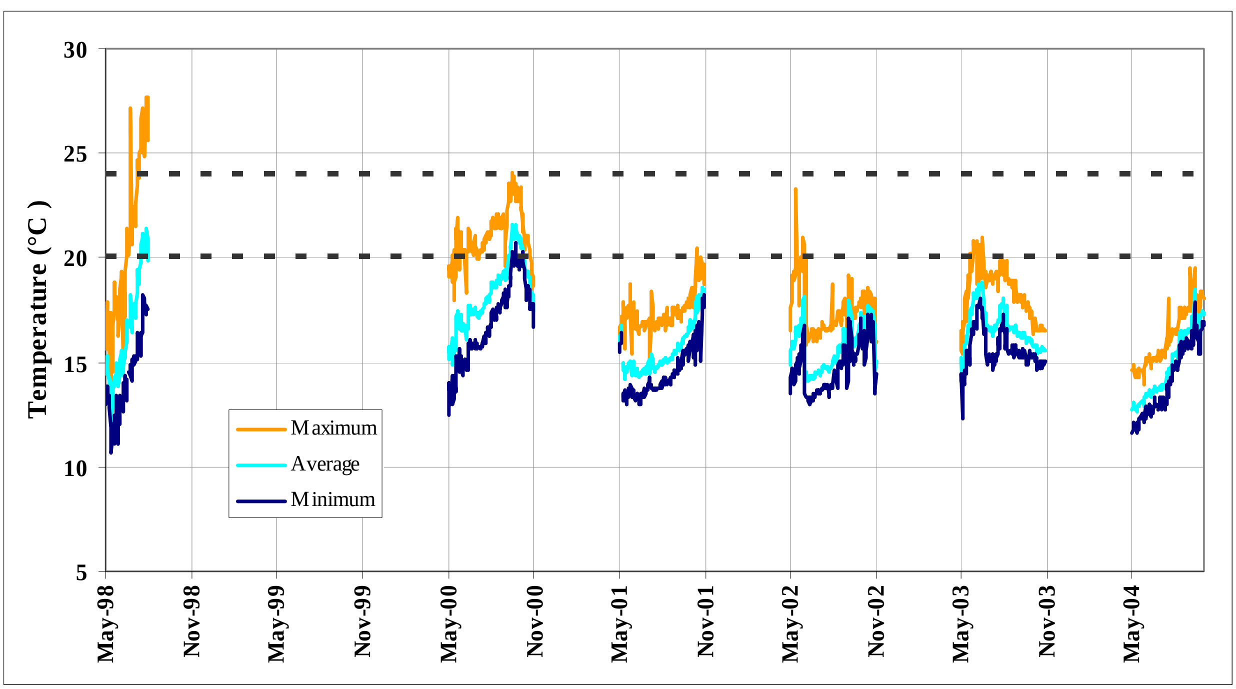


Figure 3-37. Lower Hilton Creek (HC-0.12) water temperatures, 1995 – 2004 (Note: Data gaps in the temperature record are the result of removing units during the winter, unit dewatering, or instrument failure (Source: CPWA 2005))

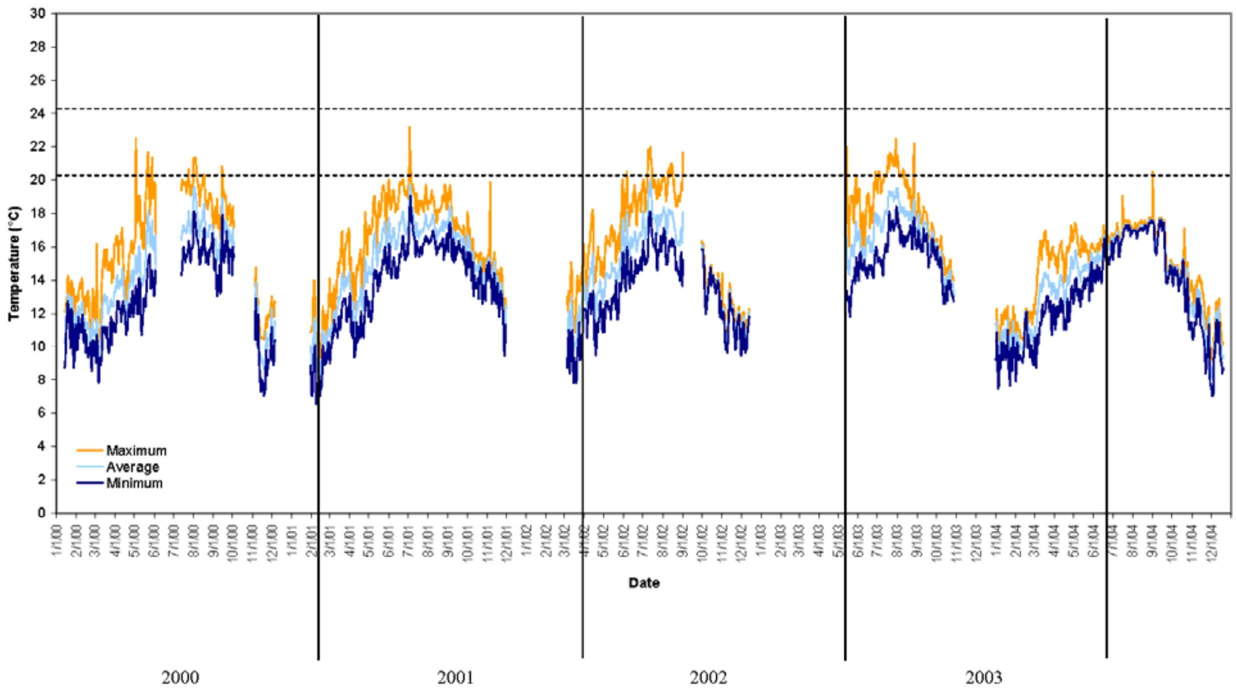


Figure 3-38. Quiota Creek (QC-2.71) water temperatures, 2000 – 2004 (Note: Data gaps in the temperature record are the result of removing units during the winter, unit dewatering, or instrument failure (Source: CPWA 2005))

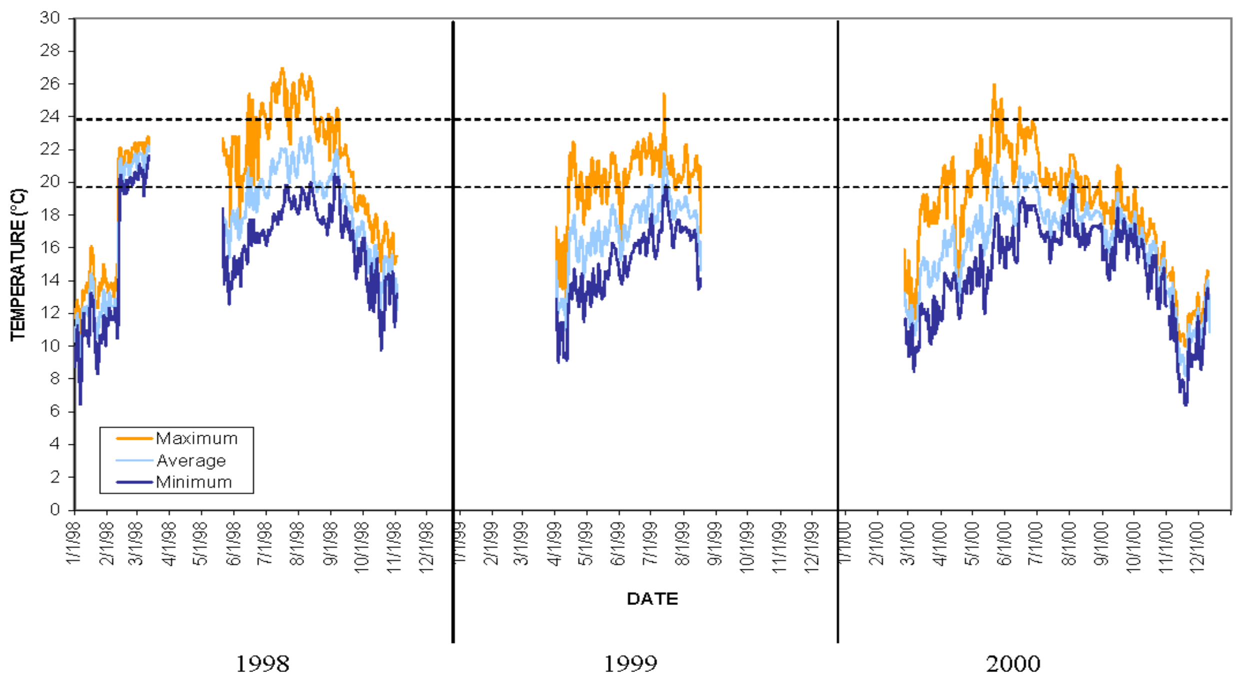


Figure 3-39. Nojoqui Creek (NC-2) water temperatures, 1998 – 2000 (Note: these reconnaissance level surveys were conducted when habitat appeared suitable for steelhead/rainbow trout in winter, characterized by deep pools. Since no steelhead/rainbow trout population has been observed inhabiting the creek, monitoring ceased in 2000. Data gaps were due to winter flows or equipment failure. (Source: CPWA 2005))

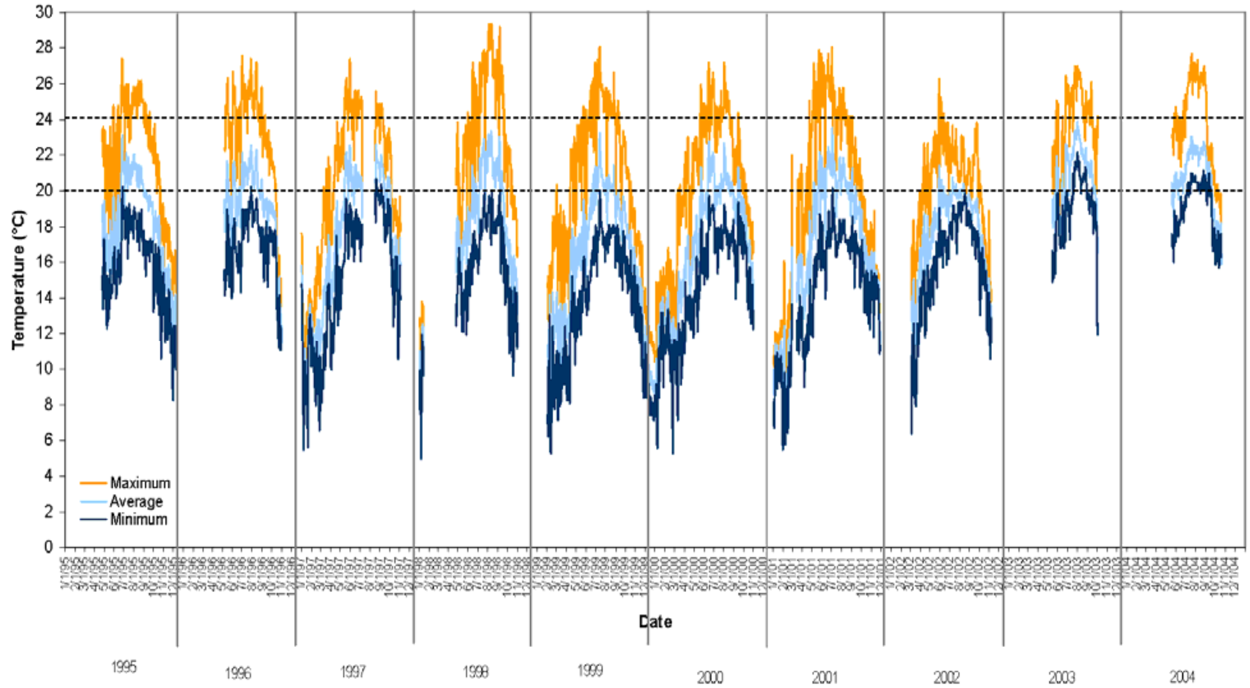


Figure 3-40. Lower Salsipuedes Creek temperatures 1995 – 2004; SC-1.2 (Note: Data gaps in the temperature record are the result of removing units during the winter, unit dewatering, or instrument failure (Source: CPWA 2005))

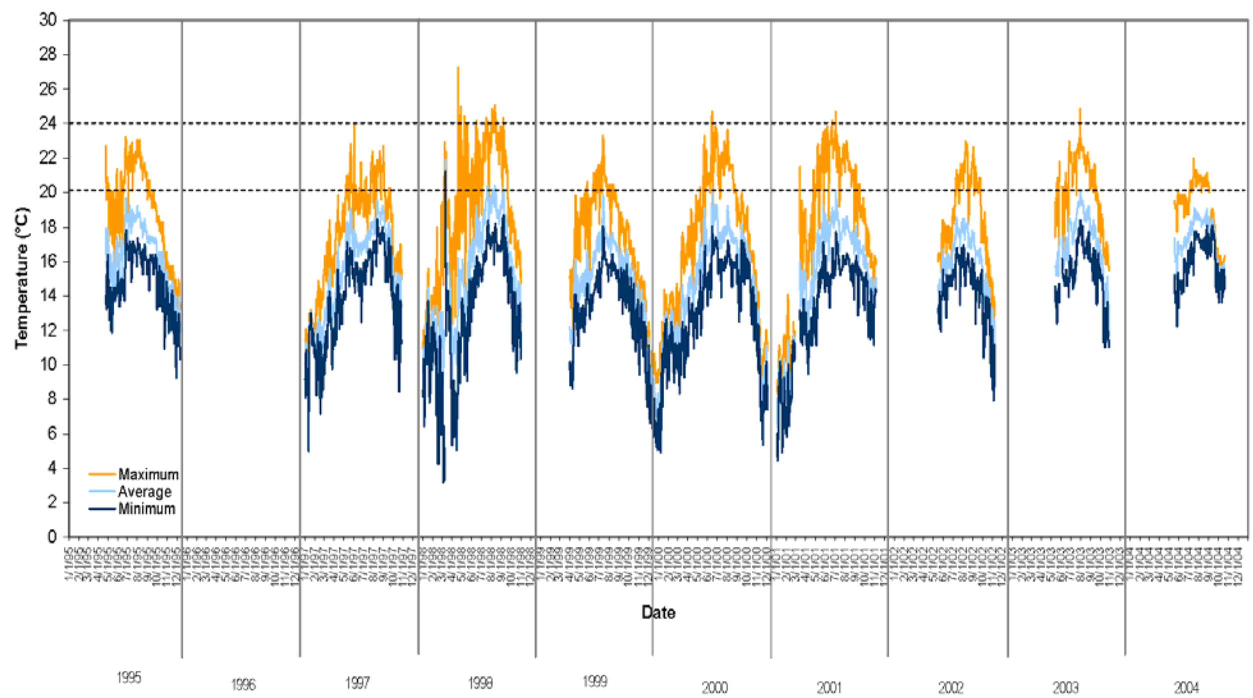


Figure 3-41. Upper Salsipuedes Creek (SC-3.8) water temperatures, 1995 – 2004 measured 3.8 miles upstream of the Santa Ynez river confluence-50 feet upstream of El Jaro confluence (Note: Data gaps in the temperature record are the result of removing units during the winter, unit dewatering, or instrument failure (Source: CPWA 2004))

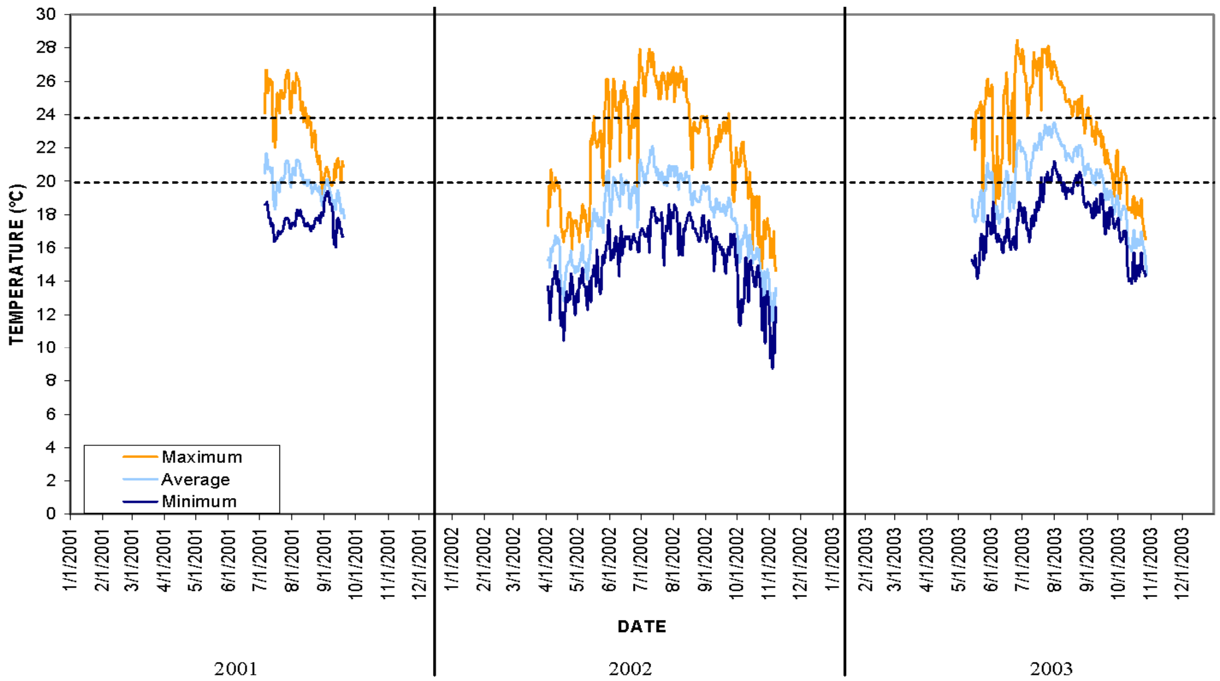


Figure 3-42. Middle Salsipuedes Creek (SC-3) water temperatures, 2001 – 2003 (Note: Data gaps in the temperature record are the result of removing units during the winter, unit dewatering, or instrument failure. Surveying was conducted to monitor conditions surrounding the time when the Highway 1 Fish Passage Project was completed in 2002 (Source: CPWA 2005))

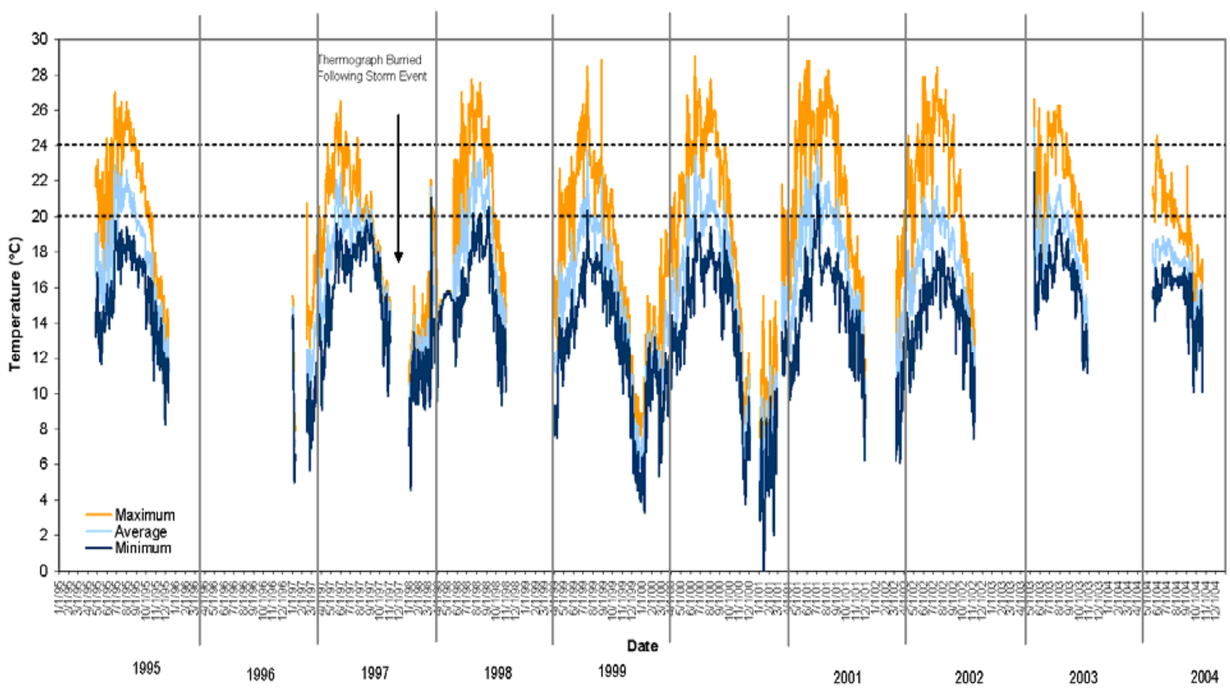


Figure 3-43. El Jaro Creek (EJC-4) water temperatures, 150 ft upstream of the Salsipuedes Creek confluence, 1995 – 2004 (Note: Data gaps in the temperature record are the result of removing units during the winter, unit dewatering, or instrument failure (Source: CPWA 2005))

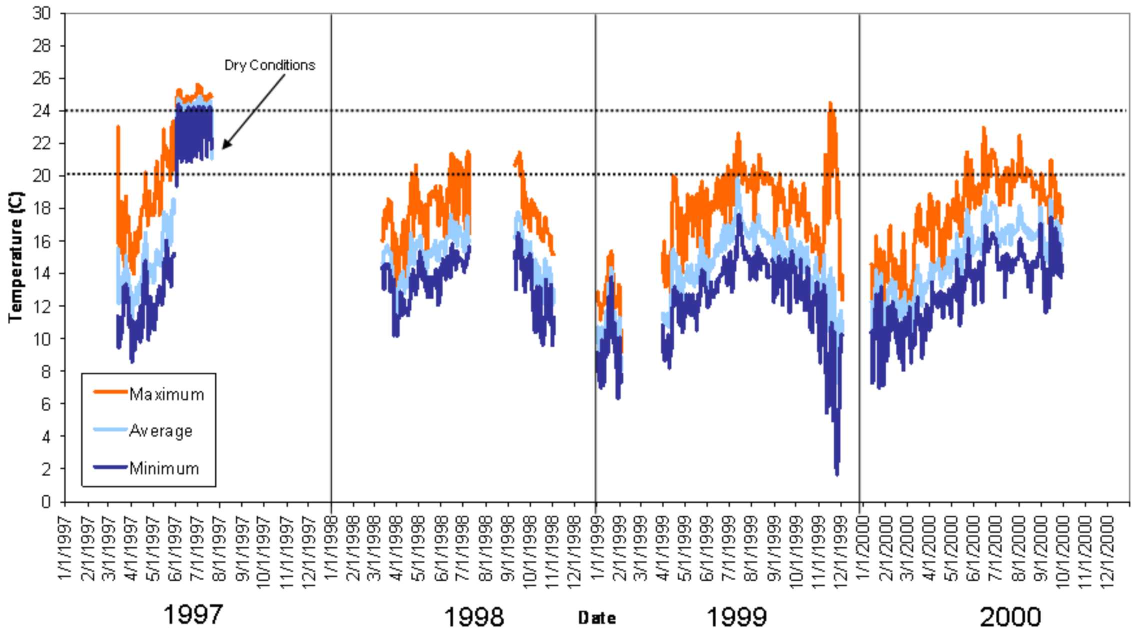


Figure 3-44. San Miguelito Creek (SMC-4) water temperatures, 1997 – 2000 (Note: Data gaps in the temperature record are the result of removing units during the winter, unit dewatering, or instrument failure (Source: CPWA 2005))

Table 3-1. Water Temperature and DO Sampling at Site 1 (Bradbury Dam; LC-0.1), Site 2 (Tequipas Point; LC-1.2), and Site 3 (Tecolote Tunnel; LC-3.2), Cachuma Reservoir, 1994 -2004

Site 1: Bradbury Dam, (LC-0.1)											
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
January											
February									2/27		
March											
April		X									
May			X	X		X	X	X	X	X	
June		X									
July			X		X	X	X	X		X	X
August				X	X	X	X	X			
September		X			X				X		
October	X					X	X	X	X	X	
November	X	X		X						X	X
December	X										
Site 2: Tequipas Point, (LC-1.2)											
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
January											
February											
March											
April		X									
May			X								
June		X									
July			X								X
August			X								
September	X	X									
October											
November	X	X									
December	X										X
Site 3: Tecolote Tunnel, (LC-3.2)											
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
January											
February											
March											
April		X									
May			X								
June		X									
July			X								X
August			X								
September	X	X									
October											
November	X	X									X
December	X										

X = Dates not available, but sampling occurred during these months.
Source: CPWA 2005

Table 3-2. Locations and Years of Temperature Data Collected by CPWA in 1993 – 2004

Location	CPWA Site Id's[1]	Years Temperature Data Recorded											
		1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Lake Cachuma/Bradbury Dam	LC-0.1		X	X	X								
Lake Cachuma/Tequipas Point	LC-1.2		X	X	X								
Lake Cachuma/Tecolote Tunnel	LC-3.2		X	X	X								
Bradbury Dam – Mile 0		X	X	X									
Stilling basin – SYR	LSYR-0.2	X		X	X			X					
Reach between Stilling basin + Long Pool – SYR	LSYR-0.2 – 0.4						X						
Long Pool – Snorkel Site – SYR	LSYR-0.5	X	X	X	X	X	X	X	X	X	X	X	X
Reclamation Boundary - SYR	LSYR-0.7											X	
Santa Ynez River/Highway 154	LSYR-3.2 (2.9[2])	X	X										
Refugio Reach – Meadowlark Crossing	LSYR-5.0 (3.4[2])			X	X	X	X	X	X	X	X	X	
Lower Gainey Crossing – SYR	LSYR-6.4 (6.0[2])						X	X	X		X	X	
Refugio Bridge	LSYR-7.8			X				X	X	X	X	X	X
Pool down from Refugio Bridge	LSYR-8 (7.9[2])				X			X	X	X	X	X	
Alisal Unit Downstream of Quiota Creek confluence	LSYR-8.6 (8.7[2])			X									
Mid-Alisal Deep Pool	LSYR-9.2 (9.5[2])			X	X								
Alisal Bridge – SYR	LSYR-10.5		X	X		X	X	X	X	X			
Avenue of t he Flags Bridge – SYR	LSYR-13.9 (13.6[2])		X	X	X	X	X	X	X	X	X	X	
Weister Ranch	LSYR-19.17 (16[2])				X								
Cargasacchi Reach	LSYR-22.45 (24[2])						X	X	X				
Upper Outlet Lagoon – SYR	LSYR-46.6		X	X	X		X	X					
Mid-Outlet Lagoon – SYR	LSYR-47.2 (46.5[2])			X	X								
Lower Outlet Lagoon – SYR	LSYR-47.75 (47.1[2])					X	X	X	X	X	X	X	X
Lower Thermograph – Hilton Creek	HC-0.12			X	X	X	X	X	X	X	X	X	X
Mid Thermograph/spawning pool – Hilton Creek	HC-0.25			X		X	X		X	X	X	X	X
Upper Release Point/Thermograph Pool – Hilton Creek	HC-0.54								X	X	X	X	X
Upper Hilton Creek at Reclamation property boundary	HC-0.56						X						
Crossing 7 – Quiota Creek	QC-2.71								X	X	X	X	X
4th Bridge from Buellton at Highway 101 – Nojoqui Creek	NC-2						X	X	X				
Lower Salsipuedes Creek	SC-1.2			X	X	X	X	X	X	X	X	X	X
Highway 1 Bridge – Salsipuedes Creek	SC-3									X	X	X	
Jalama Bridge – Salsipuedes Creek	SC-3.5	X											
Upper Salsipuedes Reach – Salsipuedes Creek	SC-3.8					X	X	X	X	X	X	X	X

Table 3-2. Locations and Years of Temperature Data Collected by CPWA in 1993 – 2004

Location	CPWA Site Id's[1]	Years Temperature Data Recorded											
		1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Big Bend Ranch – El Jaro Creek	EJC-4			X		X	X	X	X	X	X	X	X
Stillman Creek Crossing – San Miguelito Creek	SMC-4					X	X	X	X				

[1]CPWA ID indicates location and river mile (see CPWA ID naming conventions in Section 1)
[2]River miles used in 1997 Synthesis Report (these miles have been revised)

Table 3-3. Inventory of USGS Water Quality Data for Lower Santa Ynez River Watershed

USGS ID	Site Description	CPWA ID 1	DO Probe Record2	Temperature Probe Record2	Grab Samples (Water Year)	Number of Samples
11125600	Hilton Creek near Santa Ynez River	HC-0.5	n/a	7/9/02 - 9/30/04	---	0
11126000	Santa Ynez River below Bradbury Dam	LSYR-0.5	n/a	7/26/1994 - 9/30/04	1992 – 2008	148
11126400	Santa Ynez River at Highway 154	LSYR-3.2	6/22/02 - 9/30/04	6/21/02 - 9/30/04	1993 – 1994	4
11128500	Santa Ynez River at Solvang	LSYR-10.5	7/25/02 - 9/30/04	7/13/97 - 9/30/04	1997 – 2008	103
11132500	Salsipuedes Creek near Lompoc	SC-3.7	n/a	n/a	1958 – 2008	377
11133000	Santa Ynez River at Narrows near Lompoc	LSYR-36.1	n/a	10/1/98 - 9/30/04	1978 – 2008	187
11134800	San Miguelito Creek at Lompoc	SMC-3	n/a	n/a	1980 – 1997	154

[1]CPWA ID indicates location and river mile (see CPWA ID naming conventions in Section 1)

[2]Data gaps in the probe record vary for each year

Table 3-4. Water Quality Sampling of Santa Ynez Lagoon for Period 1995 – 2004

Year	January	February	March	April	May	June	July	August	September	October	November	December
1995								X	X	X		X
1996	X	X	X	X		X	X					
1997				X			X				X	
1998								X			X	X
1999					X	X				X		
2000								X		X		
2001							X	X			X	
2002					X					X	X	
2003						X		X		X		
2004							X				X	

Source: CPWA 2004; Hanson Environmental 2005

Table 3-5. Monthly Air Temperatures at Santa Ynez Airport, 1993 – 2004

	Monthly Average Maximum (°C)												
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Average
January	16	19.4	15	18	17.5	16.6	18.5	18	18.4	16.3	21.1	17.4	17.7
February	15.8	15.9	22.2	17.6	19.7	14.6	17.6	16.8	16.5	20.5	17.3	16.1	17.6
March	20.3	19.5	17.9	19.1	23.9	17.5	17.6	19.5	18	18.1	20.4	23.5	19.6
April	21.7	19	19.8	23.4	22.9	18.2	18	21.9	17.3	19.9	18.1	23.1	20.3
May	23.3	20.1	19.2	24.4	27.6	17.9	19.9	24.3	25.6	21.5	22.9	25	22.6
June	26.8	26.2	23.5	26.5	24.7	21.1	22.9	26.6	28.3	14.1	24.1	25	24.2
July	24.8	25.5	27.9	31.2	26.9	27.1	26.6	25.7	27.6	27.9	31	29	27.6
August	27	29.2	29.4	31.3	28.7	30.7	26.3	30.1	28.9	26.9	28.9	28.6	28.8
September	26.9	27.1	27.3	28.4	30.4	26	26	29.2	27.6	29	28.7	29.4	28
October	24.7	24.1	25.9	28.4	25.7	23.8	27.7	23.3	24.6	21.8	28.5	22.8	25.1
November	12.6	17.5	24	21.1	21.4	19.3	21.2	21.3	19.6	22.4	18.8	18.2	19.8
December	9.4	17.1	18.3	18.5	17	17.4	20	22.4	16.1	16.3	17	17.6	17.3
	Monthly Average Minimum (°C)												
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Average
January	4.9	2.8	7.3	4.8	5.8	5.4	4.1	5.7	2.1	2.2	6.7	3.1	4.6
February	5.5	4.1	7.8	7.8	3.5	5.9	3.5	6.8	4.2	3.6	4.9	4.1	5.1
March	7.6	6.9	7	6.1	4.9	6.9	3.9	5.4	7.7	4	5.5	8.1	6.2
April	6.3	7.3	6.7	7.6	6.2	5.6	5.2	7.6	5.8	7.1	6.2	7.4	6.6
May	8.6	8.7	8.9	8.7	9.7	8.7	6.8	9.1	10	7.9	8.6	8.8	8.7
June	10.2	8.7	9.8	9.4	10.3	11	8.6	11.4	10.5	10	11.6	11	10.2
July	11.9	10.8	12	11.8	11.5	12.4	11.5	10.9	12.3	11.5	12.3	12.2	11.8
August	12.5	11.7	11	11.8	13.4	13.2	11.2	11.7	11.3	11	12.7	12.7	12
September	10.8	10.5	10.5	10.4	13.2	12.6	10.5	10.8	10.7	11.1	12.3	11.3	11.2
October	10.1	8.3	8.9	8.5	8.5	7.4	8.8	9.7	9.2	8.3	9.7	8.7	8.8
November	5.8	2.9	7.5	6.9	7.5	4.5	6.7	2.7	7.6	6.9	4.9	4.7	5.7
December	3.3	3	5.5	5.2	2.9	1.4	3.1	4	4.7	5.1	4.1	3.5	3.8

Source: Santa Barbara County Air Pollution Control District 2005, 2006

Table 3-6. Monthly Air Temperatures in Lompoc, 1993 – 2004

	Monthly Average Maximum (°C)												
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Average
January	16	18.3	15.6	17.5	16.5	16.6	19	16.8	16.3	16	21	16	17.1
February	16.2	16.2	19.4	17.8	17.6	15.7	18	17	15.6	19.7	17.8	15.8	17.2
March	19.1	18.5	18.1	18.2	19.5	17.4	16.3	17.7	16.8	17.5	19.2	20	18.2
April	19.4	17.5	18.4	21.6	22	17.2	16.4	18.2	15.8	17.9	17.3	18.9	18.4
May	20.5	17.5	17.1	20.5	19.7	18	16.2	19.4	20.6	17.9	18.4	19.6	18.8
June	21.8	19.5	18.8	19.5	20.7	19.2	17.1	20.3	21.1	19.5	18.8	18.9	19.6
July	20.5	18.8	21.7	21.2	23	20.8	19.9	19.2	20.1	21.3	21.3	20.8	20.7
August	21.2	21	20.8	21.1	23	22.5	19.5	20.6	19.7	20.5	21.4	21.4	21.1
September	21.1	21.2	21.1	21.3	25	21.9	19.9	22.1	20.5	22.1	21.4	23.4	21.8
October	22.1	21.7	22.9	21	23.4	23	22	19.3	20.7	18.9	22.2	19.9	21.4
November	20.4	16.6	20.6	19.6	20.7	19.6	18.7	17.5	18.6	21.7	18.1	17.9	19.2
December	17.2	16.1	17.3	17.8	17	17.6	18.9	19	16.3	16.8	16.4	17.5	17.3
	Monthly Average Minimum (°C)												
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Average
January	7.1	5.2	9.4	4.8	9.2	8.6	4.9	9.2	4.2	4	8.2	5.2	6.7
February	7.5	6.5	9.5	7.8	7.2	8.9	5.2	10.5	6.1	5.7	7.1	6.3	7.4
March	9.9	8.7	9.5	6.1	8	9.2	5.5	8.2	9.6	6.4	8.2	9.5	8.2
April	9.6	9.5	9.2	7.6	12.5	8.2	7.9	9.9	8	8.9	8.4	8.6	9
May	10.7	10.5	10.8	8.7	13.2	10.9	9.5	10.8	11.5	9.9	10.2	10.3	10.6
June	11.9	10.5	11.4	9.4	13.9	12.9	10.8	13	11.8	11.2	12.3	11.9	11.8
July	13.9	12.6	13.3	11.8	16	13.8	13.1	12.7	13.5	12.7	12.4	13.4	13.3
August	14.1	13.2	12.6	11.8	16	14.9	13.3	12.7	12.8	12.6	13.9	13.9	13.5
September	12.4	12.4	12.7	10.4	15.5	14.2	12.6	12.5	12.4	11.7	12.9	12.5	12.7
October	11.3	9.9	10.9	10.3	11.4	8.5	11	11.6	10.9	9.9	10.4	10.1	10.5
November	7.7	4.7	9.7	9.6	10.7	6.6	9	5.1	9.6	8.5	6.9	6.5	7.9
December	5.4	5.2	8.3	8.5	5.7	1.4	5	6	6.7	7.1	6.1	5.6	5.9

Source: Santa Barbara County Air Pollution Control District 2005, 2006

Table 3-7. DO Concentrations (mg/L) at Site 1 (Bradbury Dam; LC-0.1) in Lake Cachuma April – May, 1995 – 2004

		DO mg/L															
		April	May							June	July						
Meters	Feet	1995	1996	1997	1999	2000	2001	2002	2003	1995	1996	1998	1999	2000	2001	2003	2004
0	0	8.9	8.3	9.7	9.6	8.9	9.4	9.7	9.1	8.4	10	8.6	8.2	8	8.3	8.5	7.7
-5	-16	7.7	7.4	10.4	10	9.3	9.3	9.9	10	0	10	8.7	8.2	8	8.3	8.6	7.9
-10	-33	7.3	6.6	10.1	10	9.7	8.2	9.7	10	8.4	4.3	8.4	8.4	7.9	4.5	6.6	7.8
-12	-39	7.3	6.5	9.5	10	9.4	7.9	9.2	9.7	7.4	2.1	7.3	8.1	7.8	3.2	5.3	4.1
-14	-46	6.8	5.5	8.4	10	8.8	8.1	7.9	8.7	6.6	1.3	6.5	7.5	6.4	3.6	4.4	2.4
-16	-52	6.5	4.6	7.6	9.7	8.4	8.1	7.6	8.1	6.2	1.3	5.9	6.5	5.2	4.4	4.3	2.2
-18	-59	6.3	4.2	6.8	9.6	8.1	7.7	7.4	7.8	5.9	1.6	5.9	6.4	5.2	4.8	4.3	1.9
-20	-66	6	3.7	5.8	9.4	7.9	7.7	7.3	7.6	5.6	1.7	5.8	6.3	5.3	4.5	4.3	2
-22	-72	5.8	3.5	4.2	9.4	7.9	7.6	7.3	7.3	5.5	1.6	5.8	6.2	5.3	4.5	4.3	2
-24	-79	5.6	3.3	3.9	9.3	7.8	7.6	7.1	6.8	5	1.6	5.7	6.5	5.5	4.9	4.2	1.9
-26	-85	5.6	3.2	3.7	9.2	7.8	7.6	7.1	6.7	4.8	1.6	5.8	6.6	5.5	4.9	4.1	2
-28	-92	5.5	3.1	3.7	9.2	7.7	7.6	6.9	6.5	4.8	1.6	5.8	6.5	5.6	4.5	3.9	1.9
-30	-98	5.4	3	3.7	9.1	7.6	7.5	6.9	6.3	4.7	1.4	5.8	6.4	5.7	4.9	3.7	1.5
-32	-105	4.1	3	3.7	9	7.6	7.6	6.8	6.3	4.7	1.6	5.7	6.4	5.4	NA	3.5	0.7
-34	-112	3.7	2.9	3.6	9	7.5	7.4	6.7	6.1	4.6	1.6	5.6	5.9	5.4	NA	2.9	NA
-36	-118	3.7	2.9	3.5	9	7.5	7.6	6.6	5.8	4.5	1.6	5.6	5.6	5.3	NA	2.3	NA
-38	-125	3.7	2.9	3.4	8.9	7.5	7.4	6.6	5.4	4.5	1.4	5.6	NA	5.1	NA	0.6	NA
-40	-131	3.7	2.8	3.4	8.9	7.4	7.4	6.6	4.4	4.5	1.3	5.4	NA	5	NA	NA	NA

Table 3-7.a DO Concentrations (mg/L) at Site 1 (Bradbury Dam; LC-0.1) in Lake Cachuma August – November, 1995 – 2004

		DO mg/L																
		August						September				October			November			
Meters	Feet	1996	1997	1998	1999	2000	2001	1994	1995	1998	2002	1999	2000	2003	1994	1995	1997	2004
0	0	8.4	9.2	8	8.7	9.1	8	7.9	10	8	8.2	8.4	8.6	7.9	8.6	14	13.4	8
-5	-16	7.9	9.7	7.9	8.9	9.1	8	8.1	9.7	8	9	8.7	8.6	8	8.6	12.5	11.1	9.5
-10	-33	8.1	7.3	7.2	8.8	9.1	7.6	8.1	9.5	8	9	8.8	8.6	8.1	8.6	11.4	10.4	7.8
-12	-39	2.2	2.6	5.6	8.4	9.1	2.2	8	2.1	8	8.8	8.8	8.6	8	8.6	10.2	10.3	7.4
-14	-46	1.3	1.5	4.3	6.4	6.3	2.2	7.7	1.3	2.8	4.2	8.6	8.5	0.3	8.6	3.7	9.6	7.1
-16	-52	1.2	0.9	3.7	5.6	4.2	3.4	1.2	1.3	1.8	2.5	4	2.4	0.2	8.5	2.2	9.5	6.7
-18	-59	1	1.2	3.9	5.4	4.2	4	1.3	1.8	2.4	2.8	3.8	1.9	0.3	0.2	2.1	8.3	6.5
-20	-66	0.9	1.7	4.7	5.2	4.2	4	1.3	2	3.2	2.8	3.6	2.3	0.7	0.2	2.1	6.5	6.4
-22	-72	0.9	1.9	4.7	5.4	4.3	4.1	1.4	2.5	3.5	3.2	3.7	2.6	0.7	0.4	2.2	0.2	5.9
-24	-79	1.2	2.1	4.5	5.5	4.7	4.2	1.3	2.4	4	3.3	4.2	2.9	0.6	0.1	2.2	0.1	4.6
-26	-85	1.1	2	5.1	5.1	4.7	4.4	1	1.7	3.9	3	4.3	3.1	0.6	0	2.1	0.1	0.8
-28	-92	0.9	1.9	5	5.4	4.8	4.5	0.8	1.6	4.2	2.8	4.3	3.2	0.7	0	1.7	0.1	0.7
-30	-98	0.7	1.8	4.9	5.3	4.6	4.5	0.7	1.7	3.8	2.8	4.1	3.3	0.6	0	1.7	NA	NA
-32	-105	0.7	1.8	4.7	5.2	4	4.6	0.4	1.6	4	2.7	3.8	NA	0.4	0	1.5	NA	NA
-34	-112	0.7	1.8	4.6	5.1	3.6	4.5	0.7	1.6	3.8	2.2	3.7	NA	0.1	0	NA	NA	NA
-36	-118	0.6	1.7	4.4	4.7	3.2	4.5	0.5	1.3	3.5	1.1	3.8	NA	0.1	0	NA	NA	NA
-38	-125	0.5	1	4.2	4.3	NA	4.3	0.5	0.8	3.3	0.3	2.6	NA	NA	0	NA	NA	NA
-40	-131	NA	0.2	4.2	4.1	NA	4.2	0.1	0.5	3.5	NA	2.9	NA	NA	0	NA	NA	NA

Source: CPWA 2004; Hanson Environmental 2005

Table 3-8. Results of 1995 – 2004 Studies of Potential Cold-water Refugia

Pool Site	Year	Observations Regarding Coldwater Upwelling
LSYR-0.5	1995 – 2004	Bottom temperatures ranged from the same or only slightly cooler than surface temperatures to 3 – 6° C cooler compared to surface temperatures.
LSYR-5.0 (3.4[1])	1996 – 97; 1999 – 2004	Bottom temperatures ranged from the same or only slightly cooler than surface temperatures to 2 – 4° C cooler compared to surface temperatures.
LSYR-6.4 (6.0[1])	1998 – 2003	Bottom temperatures ranged from the same or only slightly cooler than surface temperatures to 1 – 2° C cooler compared to surface temperatures.
LSYR-7.8	1995 – 2004	'Bottom temperatures ranged from the same or only slightly cooler than surface temperatures to 3 – 6° C cooler compared to surface temperatures.
LSYR-8.6 (8.7[1])	1995	Bottom temperatures ranged from the same or only slightly cooler than surface temperatures to 1 – 2° C cooler compared to surface temperatures.
LSYR-9.2 (9.5[1])	1995 – 1996	Bottom temperatures ranged from the same or only slightly cooler than surface temperatures to 3 – 6° C cooler compared to surface temperatures.

[1]River miles used in 1997 Synthesis Report (these miles have been revised)
Source: CPWA 2005

Table 3-9. Suitability of Santa Ynez Lagoon Temperature, Dissolved Oxygen, pH, and Redox Potential for Steelhead/Rainbow Trout, 1993 – 2004 Surveys, by Year, Site, and Depth

		Depths (in feet) at which Parameter Exceeds Steelhead Suitability Standards			
		Temperature	Dissolved Oxygen		Redox
Year	Month	>20 C (68 F)	<5.0 mg/L	pH >9.5	>0 m/V
Site 1: Ocean park RR Bridge (Lagoon/Ocean Interface; LYSR-47.75)					
1997	April		7-9	0-8	7-9
	July	0-2	7-7.8	1-2	
1998	All				
1999	All				
2000	August		3-7		6-7
2001	October		7-10		0-2; 5-10
	July		3-8.5		
2002	November		10-14.5		10-14.5
	May		5-11	1	6-11
	October		11-14		12-14
2003	November		4-12		
	June		6-12	0	
	August	0-6			
	October		8-17	N/A	8-9
35th Street Bridge (Mid Lagoon; LSYR-47.2)					
1997	April	0-1	6-7	2; 5-7	
	July	0-7	4-7	0-2	
	November		8		
1998	August	0-1			
1999					
2000	August	2-4	2-4	0	2-4
	October		4-5		0-5
2001	July	1	3		
	August		1-2		2
2002	November		4		
2003	June				
	August				
	September				
½ Mile Upstream of the 35th Street Bridge (Lagoon Inflow Site; LSYR-46.6)					
1997	April	0-2		0-4	
	July	0-5	5	0-3	
	November		6		
1998	August	0-1			
1999	May				
	June				
	October				
2000	August				
	October				0-3
2001	July	0-1			
	August	0-1.5			
	November				
2002	May	0-1			
	October				

Table 3-9. Suitability of Santa Ynez Lagoon Temperature, Dissolved Oxygen, pH, and Redox Potential for Steelhead/Rainbow Trout, 1993 – 2004 Surveys, by Year, Site, and Depth

Year	Month	Depths (in feet) at which Parameter Exceeds Steelhead Suitability Standards			
		Temperature >20 C (68 F)	Dissolved Oxygen <5.0 mg/L	pH >9.5	Redox >0 m/V
	November		0-1; 3-4		
2003	June	2.5		2	
	August	0-3.5	3.5		
	October		4-5		

Source: CPWA 2005, Hanson Environmental 2005

SECTION 4

HABITAT CHARACTERISTICS

Section 4: Habitat Characteristics

4.1 Introduction

Steelhead/rainbow trout inhabit relatively cool stream and river environments with suitable size gravels for use as spawning and egg incubation habitat. Other factors that affect habitat quality for juvenile and adult salmonids include, but are not limited to, water depth, water velocity, availability of pool and riffle habitats, availability of instream and riparian cover, seasonal flow patterns, water temperature, DO concentrations, availability of macroinvertebrates as a prey resource, as well as biological interactions affecting competition for suitable habitat, and vulnerability to predation (Bjornn and Reiser 1991, Healey 1991, Mason and Chapman 1965, Moyle 2002, Smith 1990). Steelhead, which migrate from spawning and juvenile rearing habitats downstream through a river system to coastal marine waters, and subsequently migrate back upstream as adults prior to spawning, are affected by the presence of passage barriers and impediments to migration within a watershed. Impediments and barriers to migration may preclude successful upstream migration by adults to otherwise suitable spawning and juvenile rearing habitat. Impediments and barriers to migration also affect the rate of upstream and downstream migration, resulting in delays in migration that may adversely affect spawning and subsequent reproductive success, increase vulnerability to predation, poaching, and other sources of mortality, and restrict access to potentially suitable instream habitat (Groot and Margolis 1991, Meehan 1991, Williams 2006).

An understanding of the relationship between physical habitat features and processes affecting habitat quality and availability for steelhead/rainbow trout, their geographic distribution within the watershed, suitability of habitats for meeting the life-history requirements, and the identification of management actions that could be prioritized to enhance quality and availability of habitat as part of the LSYR FMP were identified as important elements of the fishery monitoring program. The following section briefly describes a synthesis of results from habitat mapping used to identify the geographic distribution of suitable and unsuitable habitats within the watershed for steelhead/rainbow trout. Habitat surveys also have been used to identify the occurrence of passage barriers and impediments that affect migratory opportunities for steelhead/rainbow trout to successfully pass upstream and downstream (SYRTAC 1997), and the geographic distribution of steelhead/rainbow trout within various portions of a watershed in relationship to habitat conditions. Results also are presented from a pilot-scale study designed to provide information on the aquatic macroinvertebrate community that serves, in part, as the prey base for steelhead/rainbow trout inhabiting both the mainstem LSYR and major tributaries.

4.2 Methods

The surveys and observations made over the 1993-2004 study period to characterize habitat conditions within the LSYR and its tributaries focused primarily on three elements. The first element was an inventory of passage barriers and impediments that affect the ability of steelhead/rainbow trout to migrate upstream to potentially suitable spawning and juvenile rearing habitat, and for juvenile downstream migration. The second element focused on habitat mapping of stream channel characteristics that affect habitat quality and availability for various life-history stages of steelhead/rainbow trout. The third element of the habitat analysis was a pilot-scale study to characterize the species composition and relative abundance of macroinvertebrates, which serve as the prey base for rearing steelhead/rainbow trout within the watershed. The methods and approach used to address each of the three elements of the habitat investigations are briefly described below.

4.2.1 Inventory of Passage Barriers and Impediments

The ability of adult and juvenile steelhead/rainbow trout to successfully migrate upstream or downstream within a watershed may be affected by both naturally occurring physical structures such as bedrock outcroppings as well as man-made structures such as bridge and road crossings, culverts, and impoundments (NMFS 2000b, Bates and Fuller 1992, Clay 1995, Evans and Johnston 1980, Katopodis 1992). In addition, structures such as beaver dams and the sand bar at the mouth of the river represent temporary impediments or barriers to steelhead/rainbow trout migration. Physical structures, both natural and man-made, may result in a temporary delay (impediments to migration) for either upstream or downstream migrating steelhead or may result in a complete blockage (passage barrier; keystone barrier) to upstream and/or downstream migration. Factors that influence the degree of severity of a structure on steelhead migration include, but are not limited to, the jump height of the structure, the depth of the pool immediately downstream of the structure and the relative depth of the plunge pool to the jump height, the water velocity, the water depth, the distance to be traversed (e.g., length and width of a structure), availability of resting pools, water turbulence, and the physical characteristics of the structure. The physical characteristics of a structure may result in a complete barrier to steelhead migration at low flows (e.g., as a result of shallow water depths across a structure or a shallow pool and greater height of the structure at low water levels) and an impediment to migration at higher flows when water depths are greater. In contrast, a structure may be a complete barrier to upstream steelhead migration at high flows as a result of high water velocities, and an impediment to migration at lower flows. Bates and Fuller (1992), Clay (1995), Katopodis (1992), and others provide information on the specific physical features and criteria used to assess the potential effects and severity of a structure on salmonid upstream or downstream passage. Much of the information available on salmonid passage criteria has been developed in the Pacific Northwest for species such as chinook and coho salmon as well as anadromous steelhead.

As part of the fishery monitoring program, CPWA biologists used a combination of published criteria for assessing potential barriers or impediments to steelhead migration and professional judgment in identifying and characterizing physical structures within the watershed that would affect fish passage. During these field observations, the specific location of each passage obstacle was recorded with GPS coordinates in addition to the characteristics of the structure (e.g., jump height; plunge pool depth; distance traversed from the confluence of the mainstem/ocean; water depth, velocity and turbulence; and, if observed, fish passing over the obstacle).

An independent inventory of potential barriers and impediments to steelhead migration within the LSYR watershed was conducted by Stoecker (2004), which provides additional information on barrier type and location to improve passage and access to suitable habitats within the area. Based on information collected through the fishery monitoring program and in combination with results of the passage barrier inventory conducted by Stoecker (2004), the specific locations and characteristics of passage barriers/impediments have been identified. Migration barriers/impediments have been classified as follows:

- **Active-complete**: This is an impassable barrier to upstream migration such as Bradbury Dam, Alisal Reservoir, San Miguelito Creek debris basin and concrete channel, etc.
- **Active-complete-natural**: This is an impassable barrier that is natural such as Nojoqui Falls
- **Active-partial**: This is a man-made barrier to upstream migration under certain hydrological conditions such as the low flow crossing at Cross Creek Ranch on El Jaro Creek
- **Active-partial-natural**: This is a natural barrier to upstream migration under certain hydrologic conditions such as the Hilton Creek Chute
- **Active-temporal**: This is a barrier to upstream migration under certain hydrologic conditions such as the sandbar at the LSYR lagoon mouth

Information on the specific location of passage barriers and impediments was used in GIS mapping to relate barrier locations with the length of potentially suitable upstream habitat.

4.2.2 Habitat Mapping of Stream Channel Characteristics

The quantity, quality, and spatial distribution of suitable habitat to meet the various requirements for each lifestage of steelhead (e.g., adult migration, spawning and egg incubation, juvenile rearing, etc.) is an important element in assessing the overall suitable habitat of a watershed as well as identifying enhancement opportunities to either improve existing habitat conditions or provide improved access to suitable habitats. Results of habitat surveys can also provide insight into potentially limiting factors that affect the population dynamics of a species such as steelhead within the LSYR and its tributaries. Limited habitat surveys were conducted as part of the initial phase of fishery investigations on the LSYR and were reported in the 1997 Synthesis Report and subsequently used as part of the technical foundation for the FMP, BA Proposed Action, and NMFS BO. Since much of the LSYR watershed is under private landownership, particularly within the tributary areas, habitat surveys were limited to locations where public access was allowed, Reclamation property, or where private landowners granted access. Although habitat surveys were not conducted on private lands without permission, aerial photography provided limited information on general habitat conditions in inaccessible areas. Tributary surveys were conducted, where access was available, to characterize available steelhead/rainbow trout habitat and to identify pool habitats for over-summering steelhead/rainbow trout. Lack of access through private property limited the tributary areas that could be surveyed, particularly in the upper portions of Hilton Creek and a large portion of Salsipuedes Creek (after 2001).

4.2.2.1 Habitat Mapping

The amount and quality of physical habitat within the LSYR and its tributaries plays an important role in determining the potential of the river to support fish populations. Aquatic habitat measurements help to predict biological responses such as the impacts of habitat alterations, potential fish production, limiting factors, and the success or failure of different species interacting with one another. Habitat characteristics also make it possible to classify aquatic areas into similar groups so that research and management results may be generalized. Physical habitat consists of available space, including channel width and depth, stream habitat types (e.g., pools, riffles, runs, etc.), channel gradient, substrate size and the occurrence of fine sediments (e.g., clay, silt, and sand), instream and overhead cover, bank type and vegetation, water temperature, water chemistry characteristics (e.g., DO concentrations), and current velocity (see Bjornn and Reiser 1991, Healey 1991, Mason and Chapman 1965, Moyle 2002, Smith 1990, and the CDFG 1998 Salmonid Stream Habitat Restoration Manual for additional information on the criteria used to assess stream habitat quality for various lifestages of steelhead). Streams were also classified as perennial or intermittent based on USGS quadrangle maps. The USGS defines a perennial stream as one which flows continuously throughout the year. An intermittent stream is defined as one which flows only at certain times of the year when it receives water from springs or from some surface source such as melting snow in mountainous areas (Restrepo and Waisanen, 2004).

Habitat surveys were conducted at a number of locations within the mainstem LSYR and tributaries between 1994 and 2001 (Figure 4-1, Table 4-1). In 1994, habitat mapping was preliminary and limited in extent. The habitat mapping in 1995 was conducted in the mainstem and selected tributaries immediately after the January 10 to July 8, 1995 spill event that altered channel conditions. Surveys also were conducted in 1996 and 1997 to provide additional information on habitat characteristics at various locations within the watershed. Other spill events that affected the channel and habitat conditions occurred in 1998 and 2001. Although a variety of habitat observations have been made in recent years, systematic habitat mapping has not been conducted since May of 2001 based on program priorities established by the FMP, NMFS BA Proposed Action, and in consultation with the AMC.

Habitat mapping of stream channel characteristics conducted as part of the fishery monitoring program followed the general protocols and guidance used for characterizing fishery habitat conditions developed by the CDFG (Flosi and Reynolds 1998). Habitat mapping survey reaches began at the downstream end of a particular reach (bridges, access points, property lines, and confluences) with an associated flow measurement taken at a convenient transect location (see Section 2 for methods on spot-flow measurements). At least two CPWA staff participated in conducting a habitat survey, one person recording the data and the other making the desired measurements/observations. A hip chain was tied onto a branch or rock where each survey began, and the length of streambed reach, and each specific habitat unit surveyed was measured (in feet). Habitat characteristics were measured and recorded for each specific habitat unit (e.g., pool, riffle, run, glide, etc.) encountered as the crew moved upstream through the reach (Table 4-2). A surveyor's tape was used to measure 5 to 10 representative channel widths of each habitat unit depending on stream width within the habitat unit, and a stadia rod was used to estimate average and maximum depths of each habitat unit. Multiple width measurements were taken within habitat units (3-5 normally and 8-10 in complex habitats) units to characterize varying wetted widths and depths. The types of instream cover recorded included undercut banks, small and large woody debris; root mass, terrestrial and aquatic vegetation, white water and bubble curtains, boulders, and bedrock ledges. Habitat zone designations included flat-water, bar complex, or off-channel. The types of bank composition recorded included bedrock/rock, boulder, cobble/gravel, bare soil, grass, brush, and trees. Each side of the habitat unit was characterized for bank composition and the percent (in quartiles) of vegetation growing within the floodplain and on channel banks. The percent (in quartiles) of canopy cover associated with each habitat unit was also recorded.

4.2.2.2 Habitat Quality Classification

In drafting the BA (Reclamation 1999) and the 2000 LSYR FMP (2000), a Tributary Working Group was formed from the SYRTAC that evaluated habitat quality for steelhead/rainbow trout within the tributaries of the LSYR. A habitat quality classification was generated by that sub-committee and approved by the SYRTAC that applied the collective professional judgment of the biologists working on the BA and FMP and was not strictly quantitative. The classification included three categories; Good, Fair, and Poor. The criteria for each category are described in Table 4-3 and were applied to all reaches where access was permitted up to 2004. The presence of steelhead/rainbow trout was an important consideration in determining habitat quality as fish are the final integrator of habitat parameters. A fourth category, Potential, was assigned to stream reaches that had good potential habitat but field verification could not be conducted due to access limitations. The Potential classification was predicated on observed flow, slope, and aerial photographs.

GIS mapping was used to estimate the linear stream distance (miles) of habitat within a specific tributary or river reach for each of the categories in the classification to assess habitat quality for steelhead/rainbow trout. Impediments for steelhead/rainbow trout migration also were included in the analysis to quantitatively evaluate the benefit of removing a migration barrier and the quality of habitat that would be made available.

4.2.3 Aquatic Macroinvertebrate Reconnaissance Survey

Benthic macroinvertebrates/aquatic insects (BMI) play an important role as prey of juvenile and adult steelhead/rainbow trout. Macroinvertebrates also serve as a biological indicator of aquatic habitat conditions, including substrate and water quality within a stream. As one element of the fishery and aquatic habitat surveys, a pilot-scale survey was conducted in 2002 to characterize the macroinvertebrate communities inhabiting riffles within the mainstem river and Hilton Creek. CDFG and others have established protocols and experience in designing, conducting, and analyzing results of stream macroinvertebrate surveys conducted in California and other waters supporting salmonid populations (Andonaegui 1999, Bauer and Ralph 1999, Harrington 1999, Bacey and Spurlock 2007, Uyehara 2006, Pacific EcoRisk 2007, Aquatic Bioassay & Consulting Laboratory 2004, 2005, 2006, 2007, Luce 2003, Reed 2005, Rehn et al. 2007, Buchan 2003, Maas-Baldwin et al. 2007). Many of these studies used results of BMI investigations to develop an indicator of habitat and water quality conditions within a stream. Results of these previous studies have shown, however, that a number of factors can influence the characteristics of a stream macroinvertebrate community and that interpretation of cause-effect relationships based on macroinvertebrate survey results is difficult. Based on these considerations, a pilot-scale exploratory study was designed and implemented as part of the LSYR habitat investigations to provide information on the general characteristics of the macroinvertebrate community inhabiting specific reaches of the mainstem river and Hilton Creek (on Reclamation property) where access was allowed.

As specified in the CDFG BMI sampling protocol (Harrington 1999), a series of riffles were selected within designated reaches of the mainstem of the LSYR (Highway 154 Reach, Refugio Reach, and Alisal Reach; Figure 4-1) and Hilton Creek to be sampled for BMI. Within the three mainstem river reaches selected for investigation, two riffles within each reach were chosen for macroinvertebrate sampling. Three riffles were selected for sampling within Hilton Creek. At each of the selected riffles, a tape measure was positioned length-wise along the riffle; a random number was then selected from a random number table to identify a transect location within the upper 1/3 of the riffle. Three representative locations across each transect were chosen to collect samples. Each benthic sampling area was two square feet. A D-shaped kick-net was placed on the substrate, perpendicular to the flow. CPWA biologists then scrubbed the surrounding cobble, gravel, boulders, and leaf litter on the upstream side of the net. A consistent effort of 1-2 minutes was used to collect each sample. The contents of the kick-net were then placed in a 0.5-mm mesh sieve. A squirt bottle filled with ethanol and forceps were used to wash the net. Larger rocks, twigs, and leaves were removed from the sieve by hand and carefully inspected for clinging organisms. The sampled material was then placed in a Whirl-Pak bag containing 95 percent ethanol.

Data collected to characterize each selected riffle included riffle length, average width, average depth, average velocity, and percent canopy cover. Canopy cover was estimated using a densiometer. Substrate composition was characterized as the percentage of fines, gravel, cobble, boulder, and bedrock present within the riffle. Water quality measurements at each site included water temperature, specific conductance, pH, and DO. A California Bioassessment Worksheet (CBW) (Harrington 1999) including 10 specific habitat parameters was completed for each sampling location.

BMI collected during these surveys were identified to the family level of taxonomy (Level 2 Bioassessment). Each sample was spread out in a plastic tray with numbered grids. Several grids were chosen from a random-numbers table. The contents of each grid was placed in a Petri dish, counted, and taxonomically identified to family. Approximately 100 macroinvertebrates from each sub-sampled grid cell were identified until a total of 300 individual macroinvertebrates were identified from each sample. Sample processing and family identifications used standard taxonomic references and protocols (Barbour et al. 1999; EPA 2002).

4.3 Results and Discussion

The results of migration barrier evaluation, habitat characterization, and benthic macroinvertebrate sampling conducted between 1994 and 2004 are summarized below.

4.3.1 Passage Barrier Assessment

Results of the inventory of passage barriers/impediments on the mainstem river and tributaries are summarized in Table 4-4. Other than Bradbury Dam, which has been identified as a complete and permanent passage barrier, the other identified mainstem impediment was the sand bar at the lagoon mouth, which was characterized as temporary/partial impediments to steelhead migration (Figure 4-2). Beaver dams and low-flow passage riffles, although temporary/partial impediments to steelhead migration, were not included in Figure 4-2 due to their changing location. However, a number of physical structures exist, both natural and constructed structures, within the LSYR tributaries that adversely affect steelhead migration within various portions of the watershed (Figures 4-2 through 4-5). These have been described in detail and prioritized for action through a consensus process by the SYRTAC Tributaries Working Group in the FMP and many have been included as management actions within the BA Proposed Action. Results of the passage and habitat surveys have served as the fundamental technical basis for successfully designing modifications to passage structures and obtaining grant funding to assist CPWA staff in completing the implementation of these passage projects.

Several of the passage barriers/impediments that were identified as part of the 1997 Synthesis Report and subsequently verified as part of more recent habitat surveys have been modified as part of the fishery management program between 2000 and 2004 to improve steelhead migration and rearing potential to suitable upstream habitat (Table 4-4). For example, Salsipuedes Creek Highway 1 Bridge apron (2002), Salsipuedes Creek-Jalama Road Bridge apron (2004), and Hilton Creek cascade/chute (2005) have been modified as actions implemented through the FMP and BA Proposed Action. Additional barriers/impediments remain within the tributaries, particularly Quiota Creek. A number of passage improvement projects are currently in the design, funding, and implementation phase of the program.

The locations of passage barriers/impediments on San Miguelito, Salsipuedes, and El Jaro Creeks are shown in Figure 4-3. In addition to the location of passage barriers/impediments, results of the BA related to habitat suitability for steelhead/rainbow trout within the creeks upstream and downstream of passage barriers/impediments are also shown in the figure and discussed in more detail in Section 4.2.2, Habitat Characterization, below. Results of the passage barrier and habitat assessment for the Salsipuedes, El Jaro, and San Miguelito Creek watersheds show habitat classified as Fair to Good (Table 4-3) for steelhead/rainbow trout exists at locations above and below passage barriers/impediments. The linear extent of the habitat within these watersheds affected by passage barriers/impediments is summarized in Table 4-5. Some reaches were classified as Potential (Table 4-3) and were cut off at the upper extent at either USGS perennial stream designation or excessive slope (greater than 8 percent). There are two tributaries in the middle section of the El Jaro Creek drainage that were thought in 2004 to not have potential habitat but will be surveyed in future years. Results of these analyses showed that passage barriers/impediments affected the ability of steelhead/rainbow trout to migrate into potentially suitable habitat areas for spawning and/or juvenile rearing. Impacts of passage barriers/impediments within the tributaries were identified in the 1997 Synthesis Report (SYRTAC 1997), the FMP (SYRTAC 2000), BA (Reclamation 1999), and BO (NMFS 2000a) as an important factor affecting steelhead/rainbow trout geographic distribution and habitat usage within tributaries to the mainstem LSYR. As a result of these findings, the FMP and BA Proposed Action identified physical improvements to facilitate upstream and downstream passage by steelhead/rainbow trout within selected tributaries where suitable upstream habitat exists as a high priority action for enhancing habitat conditions within the LSYR watershed. The FMP evaluated and ranked the tributary actions based on their biological benefits and project feasibility. Of the two watersheds in Figure 4-3, Salsipuedes Creek provides the most potential habitat and feasible impediment improvements.

Passage barriers/impediments and the associated quality of instream habitat for steelhead/rainbow trout within the Nojoqui and Alisal creek watersheds are shown in Figure 4-4. The culvert at Highway 101 serves as a complete passage barrier to upstream migration within Nojoqui Creek. The 5.6 miles of habitat upstream of the confluence to the culvert has been classified as having Poor habitat quality and no classification was assigned to the area above the Highway 101 culvert (4.1 miles) due to no fish observed and the intermittent nature of the stream flow above the culvert passage barrier. Actions on Nojoqui Creek were given a low priority in the FMP, due to the low apparent use of Nojoqui Creek by steelhead/rainbow trout and the speculation that this creek does not have a remnant steelhead/rainbow trout population. In 2003, ENTRIX performed a feasibility study for providing passage around the Highway 101 culvert. Due to the low biological benefit and the high cost of providing passage, this project was not recommended for further consideration (ENTRIX 2003).

Within Alisal Creek, a dam/reservoir forms a complete barrier to upstream steelhead passage (Figure 4-4). Approximately 3.7 miles of habitat classified as Poor or Fair exists on Alisal Creek downstream of the passage barrier (Table 4-5). Although no habitat surveys have been performed above the reservoir as a result of access limitations, observations based on inspection of aerial photographs and a one-time electrofishing survey by the CPWA biologist in 1996, suggests that the creek habitat upstream of the reservoir may provide good habitat but has been classified as Potential. Until habitat surveys can confirm the suitability of upstream habitat for steelhead spawning and juvenile rearing, actions on Alisal Creek to improve upstream passage (which would have a high cost based on the existing physical characteristics of the structure and site) have been given a low priority in the FMP.

The locations of passage barriers/impediments within Quiota and Hilton creeks are shown in Figure 4-5. Quiota Creek has a total of 10 migration barriers/impediments (Table 4-4), nine of which are associated with road crossings. Road Crossings 2 and 6 (QC I-2 and QC I-6) are classified as complete barriers to migration while the remaining seven road crossings are identified as partial impediments to migration. Conditions within the lower reaches of Quiota Creek (downstream of road Crossing 2; QC I-2) have been characterized as having Poor habitat quality for steelhead/rainbow trout. From Crossings 1 (QC I-1) to 2 (QC I-2), the habitat quality improves to Fair and Good from Crossings 2 (QC I-2) to 9 (QC I-9) due to greater habitat complexity and perennial flow. Habitat conditions in the upper part of the watershed above Crossing 9 have been identified as being Poor along the mainstem where the flood plain widens and Good in the northern aspect tributaries where continuous canopy cover and perennial flows provide for good pool habitat that is ideal for over summer rearing. Hence, providing improved passage opportunities to allow upstream migration of adult steelhead/rainbow trout into the higher-quality habitat in the upper portions of the watershed has been identified as a high priority for habitat enhancement within Quiota Creek.

Two passage barriers/impediments have been identified within Hilton Creek: (1) a naturally occurring cascade/chute bedrock outcrop, and (2) the culvert at Highway 154 that was identified as a complete barrier to upstream steelhead migration (Figure 4-5 and Table 4-5). The bedrock cascade/chute was modified in 2005 to allow steelhead/rainbow trout improved access to a stream reach extending approximately 0.5 miles upstream to the Highway 154 culvert. Hilton Creek now provides approximately 0.8 miles of Good habitat between the confluence with the LSYR and the Highway 154 culvert, particularly once the HCWS was put into operation in 2000 from its upper most discharge point downstream. The HCWS now provides consistent streamflow that supports improved instream habitat and riparian cover. This can be seen in the increased riparian vegetation growth in density and height of the canopy and the subsequent and associated lowering of the stream water temperatures during the hotter months of the year, May through October from pre-HCWS to 2004 (Figure 4-6). Above the Highway 154 culvert up to the first tributary confluence, good habitat quality has been observed. Access to the reach above that tributary confluence was prohibited but appears to have potential hence was classified as Potential.

4.3.2 Habitat Characteristics

Two large rain years during the study period had the potential to make significant alterations to the streambed, in 1998 and in 2001 (Section 2). In 1998, 53.7 inches of rain was recorded at Bradbury Dam (Table 2-3). Spill releases totaled 386,055 acre-ft in a six-month period (Table 2-4), nearly twice the capacity of Lake Cachuma. The mainstem LSYR shifted alignment in response to localized sediment accretions and depletions in many areas in response to the spill event which peaked at 22,613 cfs (changes in stream geomorphology and the physical processes of sediment movement within and through a watershed), particularly in the Alisal Reach (mile 7.8-10.5). In 2001, 31.4 inches of rain was recorded at Bradbury Dam. With an already high water elevation in the lake, one particular rainfall event resulted in a significant spill release from the reservoir. On March 5, 2001, 10.4 inches of rain fell within the Santa Ynez River watershed, and Bradbury Dam released nearly 40,000 acre-ft in a 24-hour period with a spill peak of 21,791 cfs. Visual observations of the height (stage) of the water surface and recorded data by the USGS gauge within Salsipuedes Creek on March 5 showed that the stream had reached the third highest instantaneous peak flows observed during the 12-year study period at 5,810 cfs behind 1995 at 7,850 cfs on March 10 and 1998 at 7,470 cfs on February 3.

River flow is an important factor determining stream habitat characteristics for steelhead/rainbow trout, considering that streamflow conditions during the habitat surveys and recent high flow events can result in entirely different habitat conditions from year- to-year. In a flashy drainage such as the LSYR, stream habitats and channel morphology are dynamic and change in response to high flows and geomorphic processes.

Since the greatest change during the 12-year period covered by this report occurred to the mainstem LSYR and its tributaries in 2001, habitat mapping in 2001 reflects the basic morphology of the system through 2004. This conclusion has been confirmed by examination of annual field monitoring data and observations related to channel type, riparian growth, and instream cover from year-to-year during field surveys. As part of the routine fishery and habitat monitoring elements of the program, photo-points (photographs of the stream habitat from specific fixed observation locations that allow comparisons in stream changes over time) are taken several times a year at each mainstem bridge location and at several additional locations where access is allowed on the mainstem LSYR and major tributaries. Photo points help to confirm the change over time in the mainstem and tributary reaches and are useful in determining the necessity of future habitat mapping.

Habitat quality within the mainstem LSYR and tributaries is shown in Figures 4-2 through 4-5 and summarized in Table 4-6. Based on results of habitat surveys and field observations during routine fishery surveys conducted over the 12-year study period, it has been estimated that the LSYR mainstem and south side tributaries include over 100 miles of instream habitat potentially available to steelhead/rainbow trout (Table 4-6). Of the instream habitat potentially available to steelhead/rainbow trout in the LSYR mainstem and tributaries, an estimated 8.9 miles (9 percent) has been classified as supporting good habitat conditions for steelhead/rainbow trout that encompass areas with perennial flow and suitable summer water quality conditions, predominantly in the tributaries. Within the mainstem LSYR extending from Bradbury Dam downstream to the ocean (49.5 miles) only 3.1 miles (6 percent of the mainstem only; 3 percent overall) has been classified as having good habitat conditions for steelhead/rainbow trout which is located below Bradbury Dam on Reclamation property (LSYR 0-0.75) and on the adjacent downstream property to the Highway 154 bridge. Although the majority of the Highway 154 Reach is located on private property where access to conduct fishery or habitat surveys has been very limited, approximately 2.5 miles of continually wetted habitat are assumed to provide suitable spawning and rearing habitat between miles 0.75 and 3.2 and were classified as good.

The majority of higher-quality habitat totaling approximately 28.6 miles (Good and Fair for the tributaries only) of stream length is located within the tributaries (Table 4-6). The findings of the more recent habitat surveys are consistent with the general conclusions of the 1997 Synthesis Report in showing that the majority of higher-quality steelhead/rainbow trout spawning and juvenile rearing habitat exists on the major tributaries rather than the mainstem LSYR. Results of these analyses support a high priority within the FMP and BA Proposed Action for improving upstream and downstream migration to allow steelhead/rainbow trout enhanced access to the higher-quality habitats within the tributaries.

The availability of suitable gravel substrate within a stream channel is an important element of habitat quality that supports a variety of ecological functions including spawning and egg incubation habitat for steelhead/rainbow trout, as well as substrate providing habitat for aquatic insects and other macroinvertebrates. Substrate quality is a function of the gravel size distribution and the percentage of fines (small-grained silts, clay, and sand) that impede water flow through the gravel and obstruct open spaces within the gravel matrix. Gravels within the mainstem LSYR are characterized by a larger size distribution near the dam (e.g., imbedded cobbles) with a decrease in particle size to sand and smaller materials further downstream (approximately from Cadwell downstream). A similar pattern in sediment size distribution occurs within many of the tributaries with gravels predominantly in the upper reaches and finer-grained substrates in the lower reaches. The geomorphic characteristics of a stream channel, such as higher gradient and bedrock outcroppings with chutes and pools, such as that in the lower reaches of Hilton Creek, also affect the distribution of gravels with deposits of larger gravel primarily in pools, and scour of gravel from areas of higher velocity and bedrock. Observations of gravel deposits within Hilton Creek have shown that gravels suitable for steelhead/rainbow trout spawning and egg incubation are limited to relatively small areas, primarily at the tail of pools. Land use activities that result in an increase in sediment erosion contribute to an increase in fine-sediment loading and a reduction in stream substrate quality for salmonids. As part of habitat surveys several areas were observed where changes in erosion patterns would improve stream conditions and were the subject of demonstration projects to help inform local landowners of management actions that could be implemented to protect and improve habitat within the LSYR and tributaries (see Section 6). Observations during the 12-year study have also documented scour, erosion, sediment deposition, and changes in channel form and alignment resulting from winter high-flow events (storm runoff and reservoir spill) on gravel characteristics in the mainstem LSYR and tributaries.

Based on geologic conditions and hydrogeology within the basin, a number of pools exist within the Highway 154, Refugio, and Alisal reaches where steelhead/rainbow trout greater than 6 inches in length have been observed to oversummer. Habitat conditions within these pools are influenced by a number of factors including cool groundwater upwelling creating thermal refugia as well as the production and accumulation of filamentous algae that contributes to severely depressed diel DO conditions (Section 3). During the summer months dense accumulations of filamentous algae occur in many of the mainstem pools that has been observed to serve as cover for steelhead/rainbow trout but also contributes to substantial diel variation in DO concentrations within the residual pools during the summer months (low diel DO levels discussed in Section 3 contribute to localized habitat conditions that are thought to be stressful or unsuitable for steelhead/rainbow trout). Residual pools within the Refugio and Alisal reaches have been identified as an important habitat feature in those years when the geographic distribution of steelhead/rainbow trout extends further downstream within the mainstem river. Monitoring and management activities have been designed in collaboration with the AMC to improve oversummering conditions within these downstream pool refugia areas.

Habitat typing was conducted on the mainstem river during the spring of 2001 following a wet winter when Bradbury Dam spilled (Section 2) resulting in changes to channel characteristics downstream of the dam (Table 4-1). The primary reaches surveyed included the Highway 154 Reach (mile 0.2-0.7; habitats within the Highway 154 reach located between Reclamation property and the Highway 154 Bridge have not been surveyed or included in this analysis as a result of limitations on access to private property), Refugio Reach (mile 5.0-7.8), and Alisal Reach (mile 7.8-10.5). Habitat surveys were used to identify likely pool habitat within each reach where potential over summering by steelhead/rainbow trout was thought to occur. The Highway 154 reach was characterized by an intact riparian zone; canopy and bank vegetation was also highest within the Highway 154 Reach when compared to reaches located further downstream. Within the Highway 154 Reach, seven habitat types were identified of which three pools made up the majority of habitat with the Long Pool (LSYR 0.5) dominating the proportion of pool habitat within the survey area.

During the 2001 surveys, 59 habitat units were identified in the Refugio Reach, with 64 percent of the reach length comprised of run habitats. Pools comprise 9 percent of the total length, glides 11 percent, and riffle habitat 16 percent. In total, there were 10 pools identified with an average maximum depth of 4.7 feet. Cobble/gravel was the dominant bank type found in 92 percent of the habitats. At high flow rates ranging from 59 to 91 cfs during the habitat surveys, aquatic vegetation (algae) was the dominant shelter component of the Refugio Reach. During the 2001 surveys, a total of 47 habitat units were identified in the Alisal reach, 10 were pools that comprised 8 percent of the total reach length. The majority of reach (72 percent of length) was run habitat. Cobble/gravel was the dominant bank type found in 86 percent of the habitats in the Alisal Reach.

Other than the reach extending downstream between the Reclamation property and Highway 154 Bridge that has a well developed riparian canopy, the current riparian canopy along the mainstem of the LSYR downstream of the Highway 154 Bridge is not well developed, and does not provide significant shading or cover for aquatic habitats. The spill from Bradbury Dam that occurred in March, 2001 (Section 2) resulted in significant scour and geomorphic changes to the lower river channel and associated riparian vegetation. Results of recent qualitative riparian vegetation surveys have indicated that riparian stream bank vegetation has increased in many reaches located downstream of the Highway 154 Bridge since the 2001 spill event.

Habitat surveys conducted in Nojoqui Creek during the summer of 1998 identified 112 habitat units within the 3.3 mile reach surveyed, of which run habitat accounted for 62 percent of the length, while only 3 percent of the length surveyed was identified as pool habitat. The dominant shelter components were aquatic and terrestrial vegetation, however other shelter components such as boulders, large woody debris, and undercut banks were all observed within the survey reach.

The most recent systematic habitat surveys within Hilton Creek were performed in August 2001 following initiation of the HCWS operations in April 2000. More recent observations of habitat conditions and riparian vegetation along Hilton Creek have been made in conjunction with routine fishery and water quality monitoring. Observations over the past 12 years within Hilton Creek reflect a substantial change in the growth of riparian vegetation in response to the increase in perennial flows. A total of 39 habitat units were identified within the stream reach surveyed between the confluence with the LSYR and lower release point (mile 0.32). More than half the length of the habitat surveyed was characterized by run habitat with riffles and pools each representing approximately 25 percent of the habitat area. A total of approximately 6 percent of the reach was classified as pools greater than 3 feet in depth. The primary shelter components were identified as whitewater and bubble curtains in addition to undercut banks, small and large woody debris, root mass, terrestrial, and aquatic vegetation, boulders, and bedrock ledges. Qualitative observations since the 2001 surveys show substantial increases in stream bank vegetation, canopy, and instream shelter components have been observed in the creek, which contribute to increased habitat diversity and quality for steelhead/rainbow trout and other aquatic and terrestrial wildlife (see Section 6).

Salsipuedes Creek extends approximately 4 miles from the confluence with the LSYR to the confluence of El Jaro and Upper Salsipuedes creeks. During the spring of 2001, approximately 3.4 miles of the creek were surveyed extending from Santa Rosa Bridge upstream to the confluence of the tributaries. A total of 78 habitat units were observed in lower Salsipuedes Creek, comprised of 81 percent (by length) run habitat, and 6 percent pool habitat of which approximately 5 percent had depths greater than 3 feet.

Upper Salsipuedes Creek was surveyed during May 2001. Upper Salsipuedes Creek has been identified as an area characterized by suitable stream habitat conditions that consistently produces steelhead/rainbow trout (Section 5). Spawning activity and oversummer rearing by steelhead/rainbow trout has been documented in Upper Salsipuedes Creek (Section 5). Of the 26 habitat units mapped, 89 percent (by length) of the surveyed reach was characterized as run habitat, with 7 percent pool, of which approximately 5 percent had depths greater than 3 feet. The creek habitat was characterized as having substantial cover in the form of riparian vegetation, large and small woody debris, boulders, and other cover features.

El Jaro Creek is the primary tributary to Salsipuedes Creek. As a result of limitations on access to the stream on private lands, a stream reach limited to approximately 0.6 miles was available for habitat surveys in June 2001. A total of 39 habitat units were identified including 43 percent (by length) run habitat, 27 percent riffle, 23 percent glide, and 7 percent pool habitat. None of the pool habitat had depths greater than 3 feet at the time of the survey. The dominant bank type was cobble/gravel and bare soil, comprising 69 percent of the bank coverage in the reach of El Jaro Creek surveyed. Instream cover occurred throughout the survey reach including large and small woody debris, riparian vegetation, boulders, and other cover features.

Quiota Creek has its confluence with the LYSR 8.5 miles downstream Bradbury Dam. As a result of limitations on access to private property, habitat surveys were restricted to a public easement located approximately 2.7 miles upstream of the confluence with the LSYR. The limited survey reach where access was allowed was 0.13 miles in length. The reach, which was surveyed in September 2001, was comprised of 11 habitat units with approximately 56 percent (by length) of the reach characterized as pool habitat, 16 percent of the reach was pools greater than 3 feet in depth. The creek reach was characterized by a diversity of shelter components contributing to habitat complexity and diversity. Steelhead/rainbow trout were relatively abundant in the surveyed reach, as reflected in results of the 2000-2003 snorkel surveys (Section 5).

4.3.3 Aquatic Macroinvertebrate Survey

BMI are one of the bases of the aquatic food web, and are an essential component of the diet of rearing steelhead/rainbow trout. Benthic macroinvertebrates forage and grow within the stream environment prior to emergence and dispersal as terrestrial adults. Depending upon the species and the environmental conditions, maturation of aquatic insects and other macroinvertebrates can take as little as two weeks or as long as several years (Harrington 1999). Each macroinvertebrate goes through a number of distinct periods of growth until it finally emerges in adult form. The emergence of BMI into the adult life stage peaks in the spring and fall months. At this point the primary function of the adults is to mate and deposit eggs in a suitable area of the stream to insure survival of the next generation. All life stages of BMI form the food base (prey) for steelhead/rainbow trout and other fish within the LSYR and its tributaries. The EPT Ratio of *Ephemeroptera* (mayfly), *Plecoptera* (stoneflies) and *Tricoptera* (caddisfly) taxa present in a stream is commonly used as an index of BMI composition and tolerance to environmental conditions as they form the fundamental base of the food chain in a healthy, cool, clean and well oxygenated stream (Harrington 1999). All three EPT orders contain species that are relatively sensitive to environmental stress. *Ephemeroptera* occur naturally in many different types of habitats and are usually abundant and easy to find. *Plecoptera*, in comparison, do not occur naturally in very high densities and their natural habitat requirements usually restrict them to small, cool, swift streams. Therefore, the absence of *Plecoptera* in large, warm rivers does not necessarily indicate an unhealthy system. *Tricoptera*, like *Plecoptera*, are less abundant in large, warm rivers (Voshell 2002). In 2002, a pilot study of the BMI community in portions of the LSYR (two riffle within each of the Highway 154, Refugio, and Alisal reaches) and Hilton Creek (three riffles within the lower reach of the creek) was conducted (Table 4-7). Abundance and population structure of BMI in the LSYR and its tributaries may help identify potential limiting factors affecting steelhead/rainbow trout.

Two riffles were sampled for BMIs within the Highway 154 Reach of the mainstem in October of 2002 (Table 4-7). The first riffle was located at the tail-out of the Stilling Basin (LSYR- 0.20). This riffle was 60 feet in length and had an average width of 125 feet. Average depth and velocity was 0.65 feet and 1.47 ft/sec, respectively. Thirteen different taxa were identified, including one *Ephemeroptera* (mayfly), no *Plecoptera* (stoneflies), and two *Tricoptera* (caddisfly). The majority of BMI used for family identification were in the order *Diptera* (true flies), from the family *Simulidae*. The density of invertebrates collected within the 6 square foot area sampled was estimated to be 46,065 individuals (82,259/m^2). The second riffle site within the Highway 154 Reach was located underneath the Highway 154 Bridge (LSYR- 3.0). This riffle was 75 feet in length and had an average width of 22 feet. Average depth and velocity was 0.65 feet and 0.65 ft/sec, respectively. Seventeen different taxa were identified, including one *Ephemeroptera*, no *Plecoptera*, and two *Tricoptera*. Of the 300 BMI used for family identification, 45 percent of the organisms were from the order *Diptera*. Once again, the *Simulidae* family encompassed the majority of the *Diptera* order. The total number of organisms collected was 18,255 within a 6 ft^2 area (35,598/m^2) at the Highway 154 Bridge.

In the Refugio Reach, results are available from one riffle site sampled in October 2002; the second site was sampled but not processed due to time constraints. The site was located 200 yards upstream of the Lower Gainey Crossing. This riffle was 80 feet in length and had an average width of 24 feet. Average depth and velocity was 0.57 feet and 0.95 ft/sec, respectively. Thirteen different taxa were identified, including two *Ephemeroptera*, no *Plecoptera*, and two *Tricoptera*. The single most abundant taxon was from the order *Ephemeroptera*, specifically the *Baetidae* family. The *Baetidae* family comprised 59 percent of the 300 BMI examined from the riffle site. The estimated density of organisms collected at the site was 9,195 within the 6 ft^2 area (16,420/m^2) sampled.

Two riffle sites within the Alisal Reach were surveyed in October of 2002. The first site was located ¼ mile downstream of Refugio Bridge (mile 7.8). The riffle was 60 feet in length and had an average width of 94 feet. Average depth and velocity was 0.29 feet and 1.35 ft/sec, respectively. Fourteen different taxa were found in this riffle, including one *Ephemeroptera*, no *Plecoptera*, and three *Tricoptera*. The family *Baetidae* in the order *Ephemeroptera* accounted for 36 percent of the BMI sample. Another 26 percent of the sample was from the family *Hydropsychidae*, from the order *Tricoptera*. The total estimated number of organisms within the 6 ft^2 area was 4,048 (7,229/m^2). The second riffle site within the Alisal Reach was 1/3 mile upstream of Alisal Bridge (mile 10.5). This riffle was 280 feet in length and had an average width of 61 feet. Average depth and velocity was 0.33 feet and 0.54 ft/sec, respectively. Fifteen different taxa were identified, including two *Ephemeroptera*, no *Plecoptera*, and two *Trichoptera*. The single most abundant taxon was from the order *Ephemeroptera*, specifically the *Baetidae* family. Nearly half of the 300 BMI examined from this sample were from this family of mayfly. The total estimated number of organisms collected at this site was 8,874 within the 6 ft^2 area (15,846/m^2) sampled.

In Hilton Creek, three sampling locations encompassing the area between the confluence of the Santa Ynez River (Long Pool) and the Lower Release Point were sampled in July of 2002 (Table 4-7). The first sample site was located approximately 200 feet upstream of the confluence with the LSYR. This riffle was 62 feet in length and had an average width of 19.2 feet. The total number of organisms found in the 6 square foot sample area was 1,500. Nineteen different taxa were identified, including three *Ephemeroptera* (mayflies), one *Plecoptera*, and six *Trichoptera*. The second sample site, located approximately 300 feet upstream of the first riffle, was 29 feet in length and had an average width of 16 feet. The total amount of organisms found was 1,275. Twenty-two different taxa were identified, with the same EPT (*Ephemeroptera, Plecoptera, Trichoptera*) taxa breakdown as the first riffle. The final sample site within Hilton Creek was located another 200 feet upstream within the first bedrock section of the drainage. This riffle was 78 feet in length and had an average width of 20 feet. The total number of organisms collected was 1,408. Twenty-six different taxa were identified, again with the exact same EPT taxa breakdown observed in the first two riffles.

Benthic macroinvertebrate species have varying tolerances and responses to water quality and habitat conditions. Some species are sensitive (intolerant to adverse conditions) to various habitat conditions and are not found in those habitats where conditions exceed the species tolerance. Other species may have a high tolerance (low sensitivity) to various water quality or habitat conditions. CDFG, EPA and others have used the sensitivity of BMI as an indicator of habitat conditions and water quality within a stream (Harrington 1999). As part of the tolerance index for BMI taxa, each family of BMI has been assigned a tolerance value ranging from 0 (highly sensitive) to 10 (highly tolerant). Characterizing BMI's in terms of their relative sensitivity (tolerance and intolerance) to aquatic disturbances has been used in a number of watersheds as a means of quantifying habitat conditions. A community of BMI's dominated by organisms with a high tolerance for the effects of fine particulate organic matter and sedimentation and other environmental stressors, for example, has been used as an indicator of poor aquatic habitat conditions for salmonids such as steelhead. A community of intolerant organisms has been used as an indicator of better aquatic conditions. The quality of stream habitat thus varies inversely to the "tolerance value" of the BMI community. These criteria are derived by Harrington (1999), and should only be used as a general guide on the LSYR and its tributaries (Harrington 1999). As noted above, some orders that are considered sensitive, or indicators of intolerance to environmental stress (e.g. *Plecoptera* and

Tricoptera) do not occur naturally in very high densities and they are generally found in small, cool, swift streams. Therefore, the absence of *Plecoptera* or *Tricoptera* in large, warm rivers like the Santa Ynez mainstem does not necessarily indicate an unhealthy system.

Riffles within Hilton Creek had lower tolerance values reflecting a greater proportion of the sample comprised of more sensitive BMI taxa than riffles within the LSYR mainstem (Table 4-7). No sensitive (intolerant) BMI taxa such as *Plecoptera* were observed in samples collected from the mainstem LSYR. In contrast, samples collected from Hilton Creek included more sensitive taxa (intolerant species) (Table 4-7). Overall, tolerance values for the BMI communities sampled as part of the 2002 pilot study ranged from 4.7 to 6.0 within the mainstem and 3.8 to 4.6 within Hilton Creek reflecting a better functioning stream ecosystem within Hilton Creek but in general, both were identified as moderately disturbed streams.

Results of the 2002 BMI surveys showed that the abundance (density) and tolerances of the BMI community were variable among sampling sites both within the mainstem LSYR and Hilton Creek. The range of tolerance values observed suggest that more sensitive taxa inhabited Hilton Creek (for example *Plecoptera*) when compared to the mainstem river. The actual factors contributing to the observed differences in BMI community composition could not be determined but may be the result of perennial vs. intermittent flow conditions potentially cooler water conditions in Hilton Creek and possibly some seasonal differences between summer (July) and fall (October) surveys. The fact that the tolerance values for the BMI communities inhabiting both Hilton Creek and the mainstem were within the range considered to represent moderately disturbed habitat conditions was consistent with the general characteristics of the lower watershed (e.g., stream gradient, substrate characteristics, adjacent land characteristics, results of hydrologic conditions and water quality measurements, etc.). The observed densities of BMI inhabiting the mainstem river and Hilton Creek were within the general range of densities observed in other lower elevation California rivers and streams.

4.3.4 Illegal Harvest (Poaching)

To provide protection for steelhead/rainbow trout inhabiting the LSYR and tributaries, the California Fish and Game Commission has adopted fishing regulations that are enforced by CDFG and NMFS that prohibit recreational angling within the LSYR watershed. As part of conducting habitat surveys and fishery monitoring, incidental observations have been made of the areas where illegal angling has occurred. In a number of instances, the evidence of the illegal angling activity has been associated with barriers or impediments to steelhead/rainbow trout migration, representing locations where fish are concentrated and more vulnerable to angling and illegal (poaching) activity. Locations within the lower river watershed where evidence of the illegal angling activity has been observed are summarized in Table 4-8. Sites where frequent illegal angling activity has been observed nearly every year include mid-Alisal Pool (LSYR-9.2), Bedrock Pool 1/3 mile above the Alisal Bridge (LSYR-10.2), Alisal Bridge (LSYR-10.5), Salsipuedes Highway 1 Bridge (SC-3), and Salsipuedes Jalama Bridge (SC-3.5).

4.4 Findings of the 1993-2004 Habitat Monitoring Program

Results of 1993-2004 habitat monitoring on the LSYR are consistent with results and findings presented in the 1997 Synthesis Report in showing that:

- The availability of habitat characterized as Good for various life-history stages of steelhead/rainbow trout mainly occurs within the tributaries, with only 6 percent of the mainstem located within the Highway 154 Reach classified as having Good habitat quality for steelhead/rainbow trout spawning and/or juvenile rearing. Approximately 2.5 additional miles of habitat directly downstream of Bradbury Dam appear to have Good habitat conditions based on aerial photographs, but cannot be routinely surveyed due to access restrictions. The most suitable habitat for steelhead/rainbow trout within the mainstem LSYR occurs in the reach located upstream of the Highway 154 Bridge;
- Barriers and impediments to steelhead/rainbow trout migration and access to suitable habitat exist within many of the tributaries and restrict the ability of adult steelhead/rainbow trout to access suitable upstream habitat within several of the tributaries. As a result, improvements to fish passage conditions to facilitate migration within the tributaries have been identified as a high priority management action within the FMP and BA Proposed Action and several passage barriers/impediments that were originally identified in the 1997 Synthesis Report have been modified to improve upstream and downstream migration by adult and juvenile steelhead/rainbow trout (see Section 6);
- The geographic distribution of steelhead/rainbow trout extends further downstream within the mainstem river and tributaries in response to wet hydrologic conditions and is generally limited to upstream tributaries and areas near Bradbury Dam in dry years. Changes in the distribution of steelhead/rainbow trout under wet conditions, such as those during and immediately following spill events, are consistent with field observations and collected data and the interannual variation in streamflows as discussed within the FMP (SYRTAC 2000) and BO (NMFS 2000a);
- Riffle and run habitats dominate the lower mainstem river and tributaries. However, pool habitat exists even at low flow, but the quality of pool habitats is limited for steelhead/rainbow trout by elevated summer water temperature and low DO levels (Section 3);
- Riparian vegetation is poorly developed along portions of the lower mainstem river downstream of the Highway 154 Bridge and does not provide significant shade or cover. However, riparian vegetation is becoming more established throughout the management reaches during the interim target flows. Riparian vegetation along the mainstem river upstream of the Highway 154 Bridge and in many of the tributary reaches is intact and provides cover, shading, and bank protection from erosion;
- Instream vegetation in the mainstem LSYR in the form of “algal mats” can be extensive during summer months. Algae is not usually extensive in the reach immediately downstream of Bradbury Dam to the Reclamation boundary, but can dominate the aquatic habitat in the Refugio and Alisal reaches during summer low flow conditions, as well as further downstream;

- Pools, particularly deep pools greater than 3 feet in depth, provide habitat for juvenile and older age classes of steelhead/rainbow trout, and other fish species inhabiting the river. During low flow conditions these may be the only aquatic habitat available in reaches downstream of the Highway 154 Bridge and within reaches of the various tributaries. Pools in the lower reaches of the mainstem river and tributaries can be thermally stratified during summer periods with relatively cool water at the bottom of deeper pools (thermal stratification can occur in pools as shallow as 3-4 feet). Pools in the Highway 154, Refugio, and Alisal reaches (up to 10.5 miles downstream of Bradbury Dam; Figure 4-1) have supported steelhead/rainbow trout greater than 6 inches in length throughout the summer under conditions of little or no surface streamflow. Pool habitat has been shown to be dynamic in response to high flow events that result in sediment deposition in some pools, sediment scour forming new pools, and movement of the stream channel;
- Substrate in the form of gravel of suitable size for spawning steelhead/rainbow trout is present on the mainstem river within the reach extending from Bradbury Dam downstream to the Refugio and Alisal reaches and within certain sections (predominantly the upper reaches) of the tributaries. As a result of the geomorphic structure of lower reaches of Hilton Creek the availability of suitable sized spawning gravel for steelhead/rainbow trout is limited primarily to gravel deposits near the tail of pools. Quality of spawning substrate in the mainstem LSYR in the Lompoc reach and further downstream was poor due to the transition from a gravel bed to a sand-bedded channel;
- Information on the macroinvertebrate communities inhabiting portions of the mainstem river and Hilton Creek, which had not been surveyed as part of the 1997 Synthesis Report, is now available. Results of the initial survey showed in general a BMI community assemblage of moderately tolerant taxa in both the mainstem and Hilton Creek. Initial survey results showed relatively high variability in the macroinvertebrate communities occupying various habitats, particularly within the mainstem LSYR, which has less sensitive BMI species than Hilton Creek.

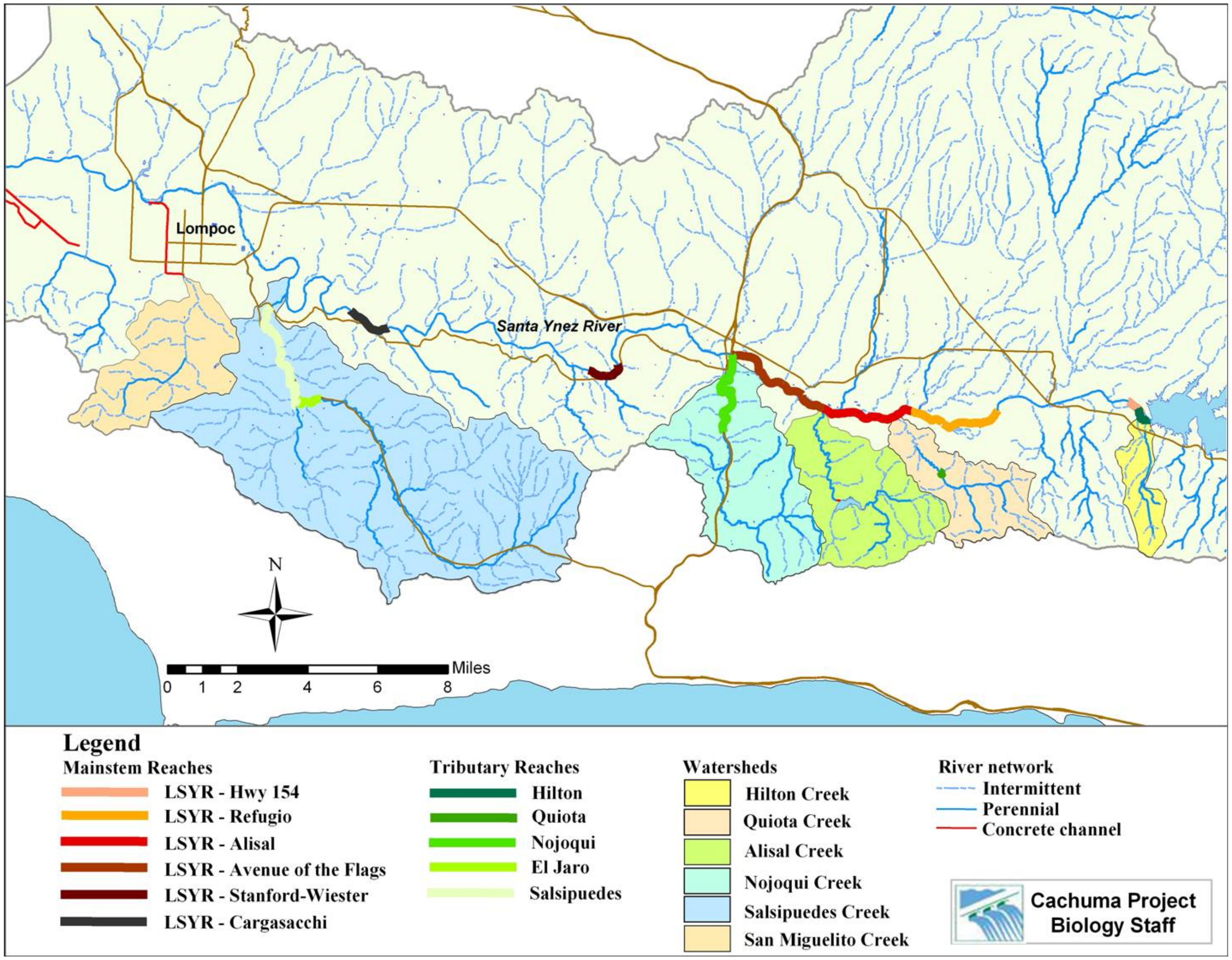


Figure 4-1. Habitat mapping in the LSYR reaches surveyed in 1995-1997 and 2001 (Sources: CPWA 2006; Stetson 2005)

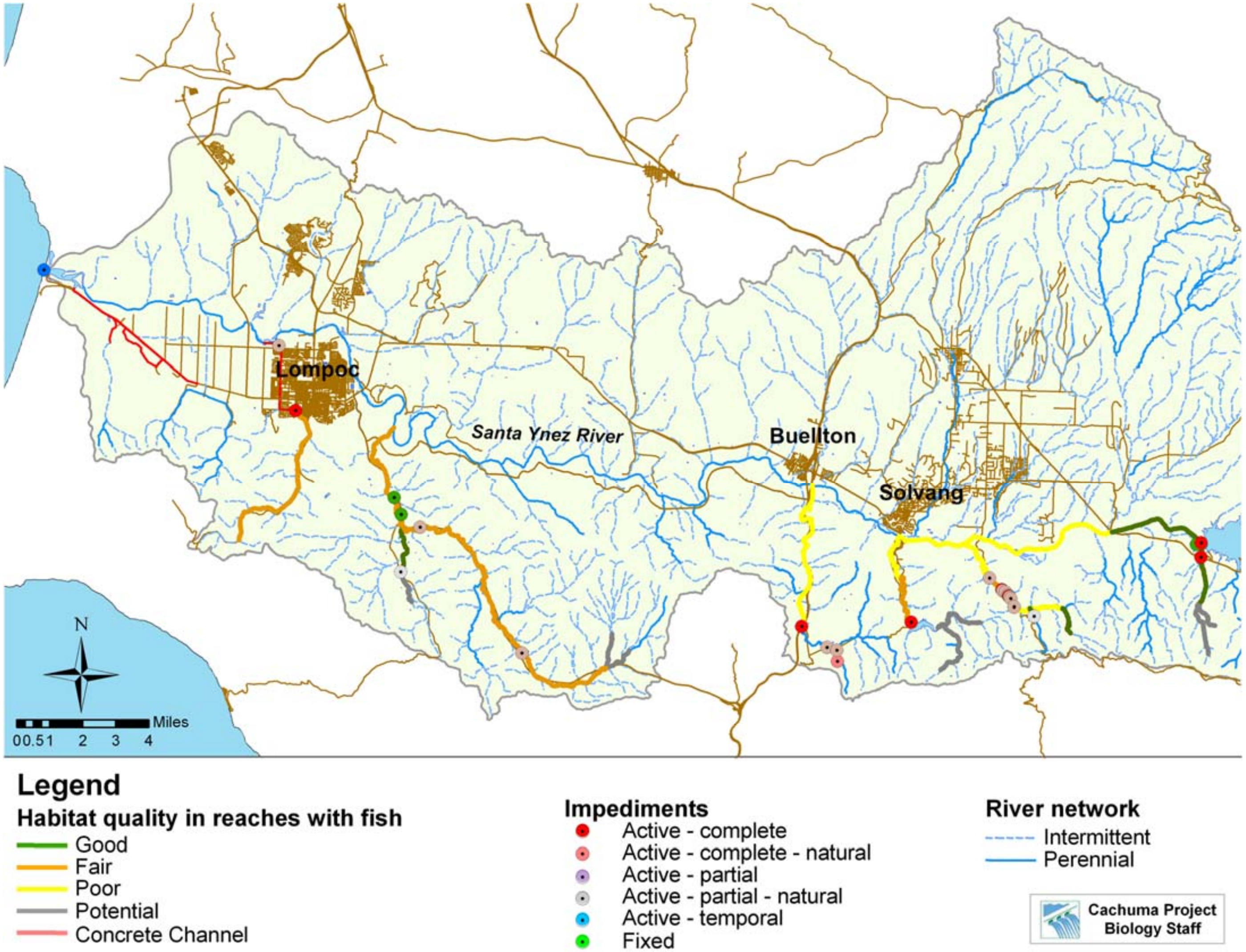


Figure 4-2. LSYR reaches by habitat quality for steelhead/rainbow trout and fish migration impediments (Source: CPWA 2006) Habitat quality categories are defined in Table 4-3.

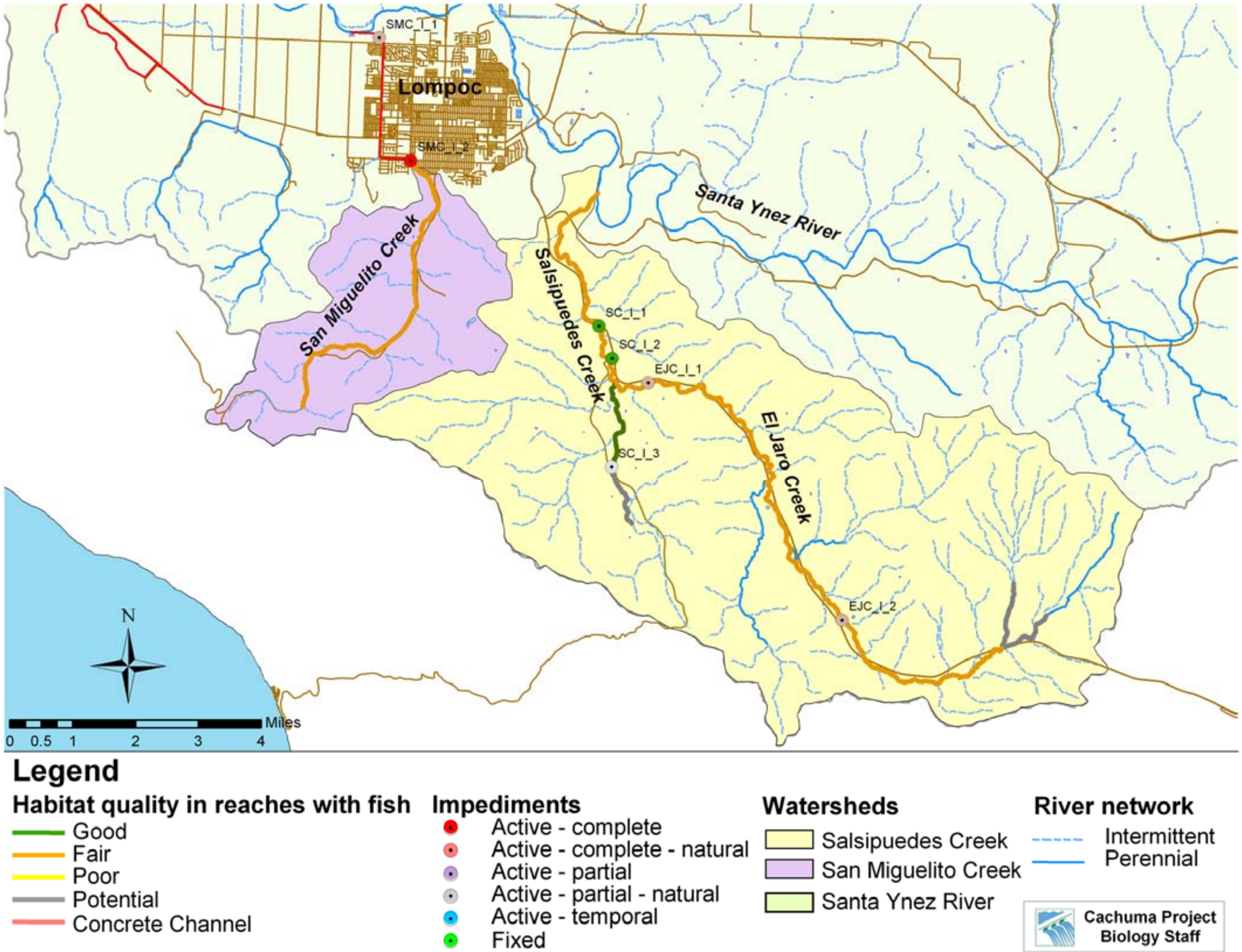


Figure 4-3. Steelhead migration impediments in San Miguelito and Salsipuedes creeks with habitat quality for steelhead/rainbow trout (Source: CPWA 2006). Habitat quality categories are defined in Table 4-3.

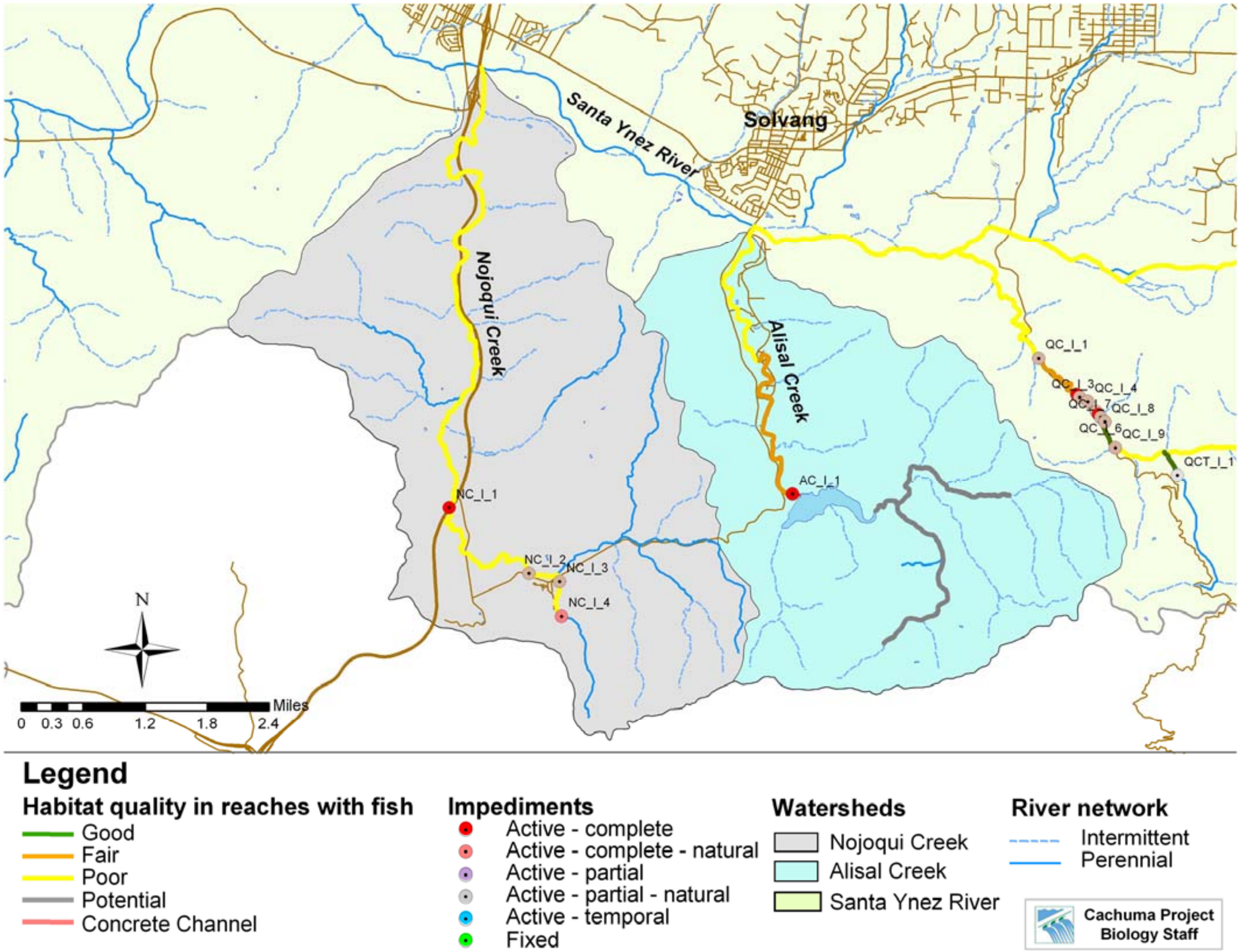


Figure 4-4. Steelhead migration impediments in Nojoqui and Alisal creeks with habitat quality for steelhead/rainbow trout (Source: CPWA 2006). Habitat quality categories are defined in Table 4-3.

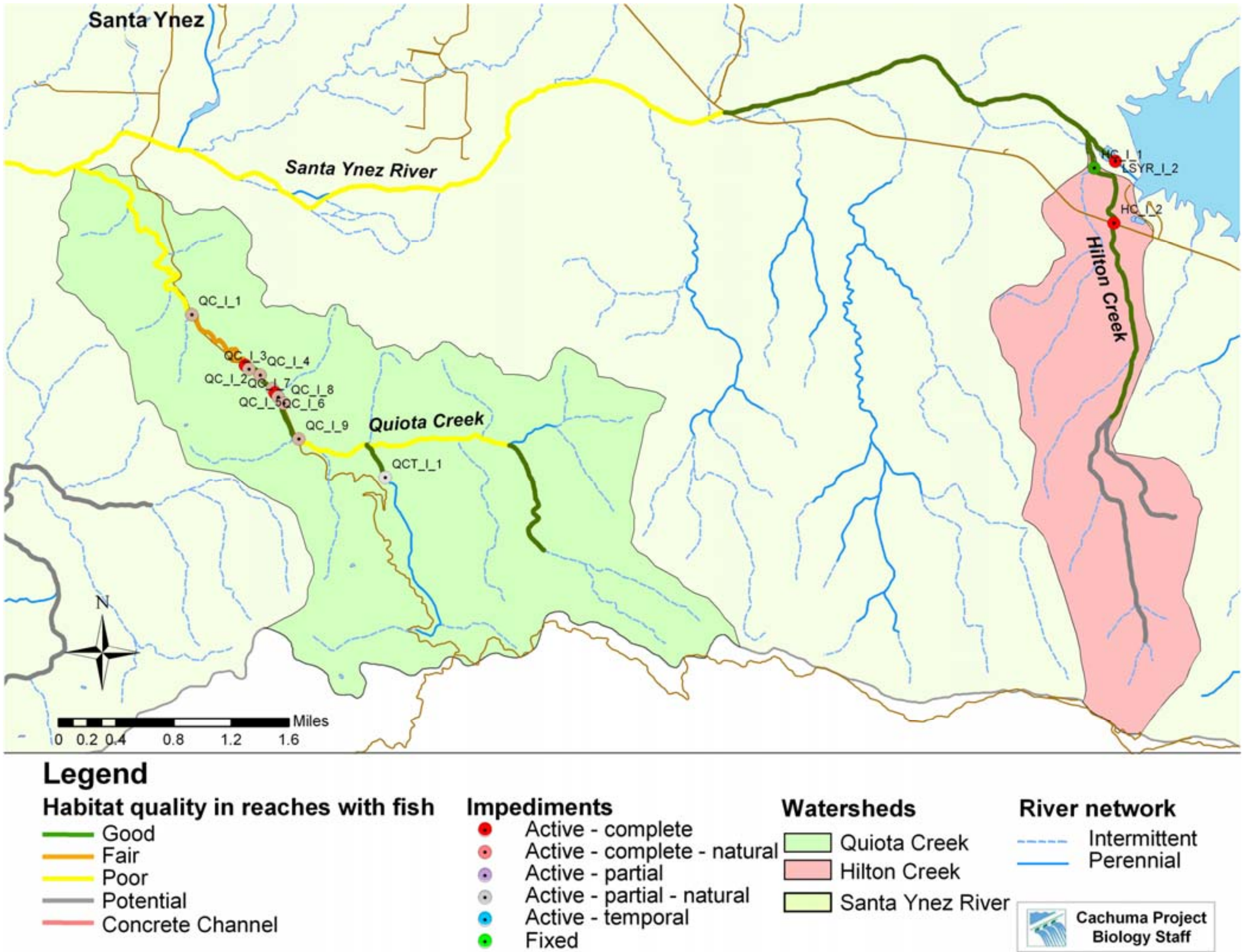


Figure 4-5. Steelhead migration impediments in Quiota and Hilton creeks with habitat quality for steelhead/rainbow trout (Source: CPWA 2006). Habitat quality categories are defined in Table 4-3.

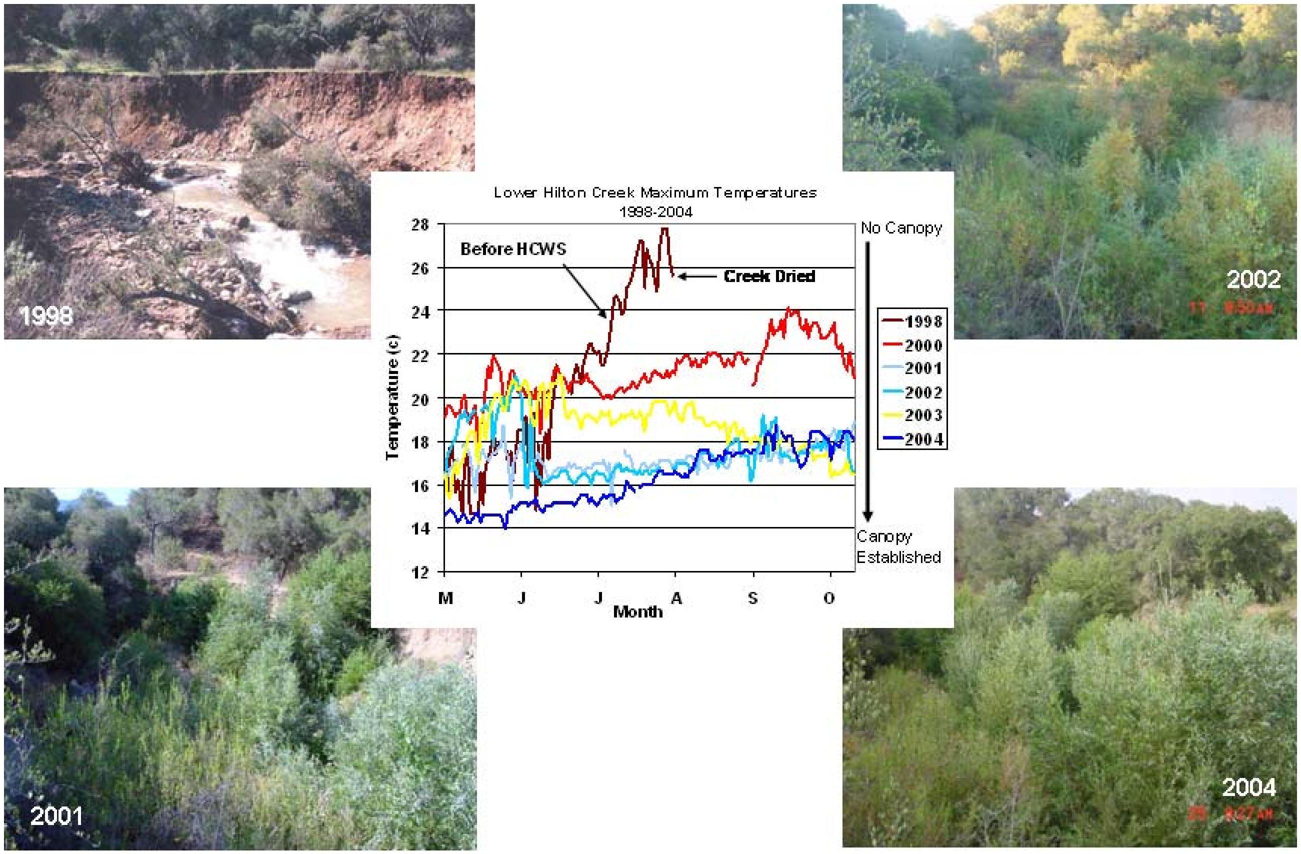


Figure 4-6. Hilton Creek riparian growth and stream temperature change near the confluence with the LSYR mainstem from May through October 1998-2004 (Source: CPWA 2006)

Table 4-1. Lower Santa Ynez River Mainstem and Tributary Habitat Survey Data

Mainstem/Tributary	Reach/Creek	Miles Below Bradbury Dam	Survey Dates	Dominant Habitat Type (% of reach by length)
1995 Mapping				
Mainstem	Highway 154	0.2 to 0.7 (0.5)	July 27-October 19	Pool
	Refugio	3.4 to 7.8 (4.4)	August 17-December 20	Pool, Run
	Alisal	7.8-10.5 (2.7)	July 18-Dec 18	Pool
	Cargasacchi	26.7 - 27.7 (1)	August 20 - December 27	--
1996 Mapping				
Mainstem	Highway 154	0.2 to 0.7 (0.5)	January 16 - August 17	Pool
	Refugio	3.4 to 7.8 (4.4)	January 23 - August 19	Pool, Run
	Alisal	7.8-10.5 (2.7)	January 17 - August 13	Pool, Run
	Cargasacchi	26.7 - 27.7 (1)	January 26 - July 29	--
1997 Mapping				
Mainstem	Avenue of the Flags	10.5 - 14.1 (3.6)	July 23-31	Glide, Run
	Weister/Sanford	17.5 - 18.7 (1.2)	July 23-31	Glide, Run
	Cargasacchi	26.7 - 27.7 (1)	July 23-31	Glide, Run
Tributary	Hilton	0.0 to 0.28	July 29 - December 16	Riffle, Run
1998 Mapping				
Tributary	Hilton	0.0 - 0.56	June 2 - 3	Riffle, Run
	Nojoqui	0.0 - 3.30	June 5 - 16	Run, Riffle
	Salsipuedes	0.64 - 5.78	June 22 - July 2	Run
	Upper Salsipuedes	5.78 - 6.01	July 2	Run
	El Jaro	0.0 to 0.73	July 7	Run, Riffle
2000 Mapping				
Tributary	Salsipuedes	0.64 - 5.78	June 30 - August 16	Run
	Upper Salsipuedes	5.78 - 6.01	August 16	Run
	El Jaro	0.0 - 0.21	August 18	Run
2001 Mapping				
Mainstem	Highway 154	0.2 to 0.7 (0.5)	March 5 - May 22	Pool
	Refugio	3.4 to 7.8 (4.4)	March 5 - May 22	Run (64)
	Alisal	7.8-10.5 (2.7)	March 5 - May 22	Run (72)
Tributary	Upper Salsipuedes	5.78 - 7.37	May 30 - 31	Run
	Salsipuedes	0.64 - 5.78	May 17 - 30	Run
	El Jaro	0.0 - 0.21	June 30	Run, Riffle
	Hilton	0.0 - 0.28	August 16 - 28	Run, Riffle
	Quiota	3.21 - 3.39	September 4	Pool

Table 4-2. Habitat mapping variables (Source: CPWA 2004)

Stream Type
Pool
Run
Glide
Riffle
Secondary Characterizations
Riparian canopy
Riparian vegetation
Aquatic vegetation type and cover
Channel complexity (bars, white water, boulders, woody debris, root mass, cobble substrate)
Bank composition
Secondary Metrics
Percent cover
Vegetation community
Percent cover, wetted area
Other data collected
Unit size (length, width, depth)
Algal growth
Groundwater upwelling
Benthic macroinvertebrates

Table 4-3. Habitat ranking criteria for the LSYR. (Note: A fourth category, Potential, was applied to areas with potential habitat but were unsurveyed due to access limitations (Source: SYRTAC 2000))

Habitat Component	Good	Fair	Poor
Flow	Perennial and sustained	Perennial, but minimal	Intermittent, fragmented
Temperature	Mean Daily < 21°C	Mean Daily > 21°C and < 23°C	Mean Daily 23°C to < 25°C
Habitat Structure	Mix of different habitat types, spawning habitat available, mix of substrates, cover available	Predominantly pool, some riffle, some spawning habitat, substrate dominated by sand, limited cover	Mainly pool, little riffle, no spawning habitat, substrate nearly all sand, little or no cover
DO	> 6 ppt	< 6 and > 4 ppt	< 4 ppt
Steelhead/Rainbow Trout Presence	Always	Usually	Rarely
Potential Refugia[1]	Extensive	Common	Limited
Gradient[1]	2-8%	0-2%	>8%

Notes:

[1]Component not explicitly considered in the evaluation but recommended for future evaluation

Table 4-4. Steelhead migration impediments (Impediment ID) and their status within the Lower Santa Ynez River and south-side tributaries that provide potential steelhead/rainbow trout habitat. (Note: Sites are listed from the lagoon upstream to the dam. (Source: CPWA 2004))

Stream/River	Impediment Name	Status	Impediment ID
LSYR	Bradbury Dam (dam, spillway)	Active – complete	LSYR I-2
Hilton	Cascade Chute @ 1380' upstream (natural cascade)	Fixed – 2005	HC I-1
	Highway 154 culvert 4200' downstream (culvert)	Active – complete	HC 1-2
Quiota	Quiota Creek Crossing – 1 (low flow crossing)	Active – partial	QC I-1
	Quiota Creek Crossing – 2 (low flow crossing)	Active – complete	QC I-2
	Quiota Creek Crossing - 3 (low flow crossing)	Active – partial	QC I-3
	Quiota Creek Crossing - 4 (low flow crossing)	Active – partial	QC I-4
	Quiota Creek Crossing - 5 (low flow crossing)	Active – partial	QC I-5
	Quiota Creek Crossing - 6 (low flow crossing)	Active – complete	QC I-6
	Quiota Creek Crossing - 7 (low flow crossing)	Active – partial	QC I-7
	Quiota Creek Crossing - 8 (low flow crossing)	Active – partial	QC I-8
	Quiota Creek Crossing - 9 (low flow crossing)	Active – partial	QC I-9
	Upper Quiota Creek natural barrier (natural cascade)	Active – partial – natural	QCT I-10
Alisal	Alisal Creek Reservoir, 1972 (dam, spillway)	Active – complete	AC I-1
Nojoqui	Nojoqui Creek – Highway 101 Culvert (culvert)	Active – complete	NC I-1
	Nojoqui Creek – Folded Hills Ranch Bridge (concrete apron)	Active – partial	NC I-2
	Nojoqui Creek (culvert)	Active – partial	NC I-3
	Nojoqui Falls (natural, waterfall)	Active – complete – natural	NC I-4
Salsipuedes	Highway 1 Bridge (concrete apron)	Fixed - 2002	SC I-1
	Jalama Bridge (concrete apron)	Fixed – 2004	SC I-2
	Upper Salsipuedes (natural cascade)	Active – partial – natural	SC I-3
El Jaro	Cross Creek Ranch (low flow crossing)	Active – partial	EJC I-1
	San Julian Ranch entrance bridge (concrete apron)	Active – partial	EJC I-2
San Miguelito	San Miguelito Creek (concrete channel)	Active – partial	SMC I-1
	San Miguelito Creek (debris basin, dam, spillway)	Active – complete	SMC 1-2
LSYR	Outlet of Santa Ynez River (sand bar)	Active – temporal	LSYR I-1

Table 4-5. Stream-river distances, downstream to upstream, in relation to migration impediments within the Lower Santa Ynez River and south-side tributaries that provide potential steelhead/rainbow trout habitat

Stream – River	Reaches	Distance (miles)
Hilton Creek	Confluence to Cascade Chute	0.28
	Cascade Chute to Highway 154 culvert	0.53
	Above the Highway 154 culvert – observed and potential-ND	4.19
Quiota Creek	LSYR confluence to Crossing 1	1.82
	Crossing 1 to Crossing 2	0.66
	Crossing 2 to Crossing 3	0.05
	Crossing 3 to Crossing 4	0.1
	Crossing 4 to Crossing 5	0.13
	Crossing 5 to Crossing 6	0.03
	Crossing 6 to Crossing 7	0.05
	Crossing 7 to Crossing 8	0.08
	Crossing 8 to Crossing 9	0.29
	Above Crossing 9	2.46
	Quiota Creek confluence to natural barrier (QCT_I_1) on unnamed tributary	0.27
Alisal Creek	LSYR confluence to Alisal Reservoir	3.66
	Above Alisal Reservoir	3.86
Nojoqui Creek	LSYR confluence to Highway 101 culvert	5.62
	Highway 101 culvert to Folded Ranch Bridge	1.54
	Folded Ranch Bridge to Nojoqui Creek culvert	0.36
	Nojoqui Creek culvert to Nojoqui Creek Falls	0.36
Salsipuedes Creek	LSYR confluence to Highway 1 Bridge	2.99
	Highway 1 Bridge to Jalama Road Bridge	0.74
	Jalama Road Bridge to Upper Salsipuedes cascade	2.06
	Above the upper Salsipuedes cascade	1.06
El Jaro Creek	Salsipuedes Creek confluence to Cross Creek Ranch low-flow crossing	0.73
	Cross Creek Ranch low-flow crossing to Rancho San Julian Bridge	6.29
	Above Rancho San Julian Bridge	5.52
San Miguelito Creek	LSYR confluence to concrete channel	0.49
	Concrete channel (beginning to end)	2.43
	Above concrete channel to debris basin	5.68
LSYR	Ocean to Bradbury Dam	49.54

Table 4-6. Stream-river miles and percentages of potential steelhead/rainbow trout habitat quality within the Lower Santa Ynez River mainstem and south-side tributaries that provide potential steelhead/rainbow trout habitat

Stream-River	Good	Fair	Poor	Potential	Not-Classed	Total	Good	Fair	Poor	Potential	Not-Classed
	(mi)	(mi)	(mi)	(mi)	(mi)	(mi)	(%)	(%)	(%)	(%)	(%)
Hilton Creek	2.24	0	0	2.76	0	5.00	45%	0%	0%	55%	0%
Quiota Creek	1.91	0.66	3.38	0	1.39	7.73	25%	9%	43%	0%	23%
Alisal Creek	0	1.92	1.74	3.86	0	7.52	0%	26%	23%	51%	0%
Nojoqui Creek	0	0	7.88	0	2.26	9.75	0%	0%	71%	0%	29%
El Jaro Creek	0	10.44	0	2.1	0	12.54	0%	83%	0%	17%	0%
Salsipuedes Creek	1.59	4.19	0	1.06	0	6.84	23%	61%	0%	16%	0%
San Miguelito Creek	0	5.68	0	0	2.92	8.60	0%	66%	0%	0%	34%
Lower Santa Ynez River	3.12	0	7.48	0	38.95	49.55	6%	0%	15%	0%	79%
Mainstem and Tributary total:	8.9	22.9	20.5	9.8	45.5	107.6	8%	21%	19%	9%	42%

Table 4-7. Characteristics of the benthic macroinvertebrate community surveyed in 2002 within the mainstem Lower Santa Ynez River and Hilton Creek (Source: CPWA 2004)

Sample Site	Hilton			Highway 154		Refugio	Alisal	
	Riffle #1	Riffle #2	Riffle #3	Riffle #1	Riffle #2	Riffle #1	Riffle #1	Riffle #2
Site Characteristics	62' x 19' Located near trap site	29' x 16' Located near 1st boulder bend	78' x 20' Located in reach 2	125' x 60' Located at the tail-out of the Stilling Basin	22' x 75' Located underneath the Hwy 154 Bridge	24' x 80' 200 yards upstream of lower Gainey Crossing	60' x 94' Located ¼ mile downstream of Refugio Bridge	280' x 61' Located ½ mile upstream of Alisal Bridge
Number of EPT[1] Taxa	3-1-6	3-1-6	3-1-6	1-0-2	1-0-2	2-0-2	1-0-3	2-0-2
Total Number of Organisms Collected within 6 sq ft	1,500	1,275	1,408	46,065	18,255	9,195	4,048	8,874
Tolerance Value[2]	3.8	4	4.6	6	5.5	4.9	4.9	4.7

[1]Ephemeroptera-Plecoptera-Tricoptera – numbers represent the number of taxa for each order

[2]Tolerance values from 0-3 reflect well-functioning streams; 3-7 reflect moderately disturbed streams; 8-10 reflect highly disturbed streams (Barbour et al. 1999)

Table 4-8. Poaching sites within the Lower Santa Ynez River and south-side tributaries that provide potential steelhead/rainbow trout habitat. (Note: Site identification codes (Site-Ids) are listed in Table 1-1 (Source: CPWA 2004))

Site Id's	Location	Frequency	Comments:	Signage
LSYR-0.2	Stilling Basin	Infrequent	Less angling with security measures in 2001	None
LSYR-0.5	Long Pool	Infrequent	Less angling with security measures taken in 2001 although poachers were found in 2004	None
LSYR-6.4	Lower Gainey Crossing	Infrequent	Angling observed in 2001; none since	None
LSYR-8	Pool below Refugio Bridge	Infrequent	Gear found on several occasions from 1995-2001	Yes
LSYR-8.6	Beaver Pool 1 mile below Refugio Bridge	Infrequent	Gear found on several occasions from 1995-2001	Yes
LSYR-9.2	Mid-Alisal Pool	Frequent	Gear found nearly every year	Yes
LSYR-10.2	Bedrock Pool 1/3 mile above Alisal Bridge	Frequent	Gear found nearly every year	Yes
LSYR-10.5	Alisal Bridge	Frequent	Gear found nearly every year	Yes
LSYR-13.7	Highway 101 Bridge/Nojoqui Confluence	Infrequent	Gear found on several occasions from 1995-2004	None
SC-3	Salsipuedes Highway 1 Bridge	Frequent	Gear and poachers found nearly every year	Yes
SC-3.5	Salsipuedes Jalama Bridge	Frequent	Gear and poachers found nearly every year	Yes

SECTION 5

FISHERY RESOURCES

Section 5: Fishery Resources

5.1 Introduction

The LSYR and its tributaries provide habitat for a variety of native and introduced fish and other aquatic resources (SYRTAC 1997). Among the fish species inhabiting the river downstream of Bradbury Dam are the federally listed endangered Southern California DPS of anadromous steelhead (*Oncorhynchus mykiss*). Since both the anadromous form of *O. mykiss* (steelhead) and the resident form (rainbow trout) inhabit the LSYR and its tributaries and cannot be distinguished from each other based on morphology except as smolts or recent ocean returnees, the fishery monitoring and FMP have focused collectively on both the resident and anadromous forms of *O. mykiss*. This section briefly describes the fishery monitoring program methods and results. Results of the fishery monitoring program have been used in forming the scientific foundation for identifying management actions designed to protect and enhance habitat conditions and survival of steelhead/rainbow trout presented in the FMP and BA Proposed Action to comply with monitoring and reporting requirements identified in the BO.

Objectives of the fishery monitoring program that began in 1993 reflect the importance of developing an understanding of the abundance, reproductive success, and the seasonal and geographic distribution of steelhead/rainbow trout in the lower mainstem river and tributaries. It also is important to monitor changes in abundance and distribution (a) related to habitat conditions as described in Sections 2 through 4, and/or (b) in response to management actions as described in Section 6. To gain an overall perspective on how the steelhead/rainbow trout population functions in the highly variable environment of the LSYR and its tributaries and how they may respond to management actions, it is important to understand:

- The timing and conditions under which the adult migration may occur;
- The conditions under which spawning is successful;
- The distribution and conditions at spawning (redd) sites;
- The survival of juveniles and factors that may affect this survival;
- The timing and factors that trigger juvenile emigration to the ocean;
- The factors which affect survival of juveniles during emigration;
- The distribution of young fish and associated habitat conditions for juvenile rearing;
- How management actions may affect any or all of these conditions; and
- The distribution and abundance of other aquatic species and the potential to interact (e.g., competition, predation, etc.) with steelhead/rainbow trout.

Steelhead/rainbow trout in the LSYR have several life-history strategies. Both resident and anadromous fish contribute to the gene pool, and resident populations of rainbow trout within the mainstem river and tributaries account for a portion of redd building activity. For the purposes of this study, juvenile steelhead/rainbow trout are defined as *O. mykiss* that have not reached the age of reproduction and are less than six inches in length. This criterion is based on observations by CPWA fisheries biologists that spawning fish in the LSYR are greater than 6 inches. This is consistent with Meeham and Murphy (1991) who define juvenile steelhead as 6-7.9 inches. This criterion is within the range of Moyle (2002), who defines non-anadromous adult rainbow trout as 5.1 inches or greater, Spina (2006) who defines juvenile steelhead in the range of 4-11 inches, and Spina, Allen and Clark (2005) define juvenile steelhead as less than 11.8 inches. For the purposes of this study, juvenile bass are defined as les than 6 inches in length. This is consistent with Moyle (2002) who states that male largemouth bass spawn for the first time at approximately 7 inches total length.

Given the depleted numbers of ocean-run (anadromous) steelhead and highly variable streamflow documented within the river and its tributaries (Section 2) affecting access and adult migration, resident rainbow trout may account for 100 percent of spawning when the sandbar at the lagoon mouth remains closed. Based on observations of the seasonal timing and size of salmonids within the river it is thought that resident rainbow trout may spawn between the months of December and May, characterized as extended season spawners, whereas the seasonal window of opportunity for anadromous steelhead in the basin to spawn is narrower as a result of seasonal limitations on access and upstream passage to spawning areas (e.g., periodic occurrence of higher streamflows from storms, opening of the sand bar, etc.). Rainfall must saturate the ground and stormwater runoff within the tributaries and the river must be sufficient to breach the sandbar at the lagoon and allow fish to migrate up the drainage. Streamflow also must continue in order for fish to move to upstream spawning areas and provide suitable conditions for successful egg incubation within the mainstem river and/or tributaries which depends, in part, on seasonal rainfall events.

Gaining an understanding of these issues requires a systematic monitoring program based on an understanding of steelhead/rainbow trout behavior and life history in the LSYR system. In a system characterized by high seasonal and inter-annual hydrologic variability (Section 2, Table 2-3), a small population of steelhead/rainbow trout, and high levels of historic and on-going disturbance, quantifying long-term trends in steelhead/rainbow trout distribution and recruitment is difficult within the LSYR. This difficulty is compounded by problems associated with limited sampling site access, and constraints associated with equipment function and personnel safety, especially during periods of high streamflow when steelhead/rainbow trout are expected to be migrating.

For the LSYR an initial monitoring program was implemented to develop an adequate understanding of how the system functions and what data collection methods are appropriate and can be successfully employed within the mainstream river and primary tributaries. Using data and experience from the initial monitoring period that culminated in the BA in 1999 and FMP in 2000, a refined monitoring program was developed and is continuing to be refined. Results of fishery surveys and monitoring within the mainstem river and tributaries over the 12-year period from 1993 to 2004 have provided valuable insight into the fishery community and habitat use, with particular focus on steelhead/rainbow trout. These results provide a technical foundation for refining the fishery monitoring activities in the future, but should be reviewed annually, or more often as necessary, as part of the adaptive management element of the FMP and Reasonable and Prudent Measure No. 11 in the BO.

The following sections briefly describe the survey methods and results of the fishery monitoring program consisting of migrant trapping, snorkel surveys (and limited electrofishing surveys prior to the steelhead listing in 1997); redd surveys, and limited trapping within the lagoon (1997-99). Results of the fishery surveys conducted over the 12-year period representing a wide range of hydrologic conditions within the watershed (Section 2, Table 2-3), are then used to re-evaluate the preliminary findings of the fishery surveys presented in the 1997 Synthesis Report. Results of the fishery, water quality (Section 3), and habitat surveys (Section 4) are also used as the technical basis for identifying and implementing management actions to benefit steelhead/rainbow trout and other aquatic resources (Section 6). Information gained through the 12-year fishery surveys on the mainstem river and tributaries are used to identify potential modifications and refinements to the monitoring program in the future (Sections 7 and 8).

5.2 Methods

5.2.1 General

The primary fishery sampling efforts in the LSYR and tributaries from the 12-year period are identified in the FMP and BA Proposed Action and included (a) migrant trapping to determine the seasonal timing and the numbers of adult and juvenile (smolt) steelhead/rainbow trout migrating into and out of the LSYR watershed, (b) snorkel surveys to assess fish utilization of instream habitats through the critical summer rearing period, and (c) redd surveys to determine locations where resident and anadromous steelhead/rainbow trout spawn. The geographic distribution of fishery monitoring sites (trapping and snorkel surveys) within the lower mainstem river and tributaries are shown in Figure 5-1 and in Section 1, Figure 1-3 and Table 1-1. These surveys were performed only on public land or private land where the permission of the landowner was obtained, which limited the spatial extent of the fishery surveys. Locations where field sampling occurred over the 12-year study were affected by changes in access permission and study sites were added or withdrawn through time based on access and channel changes following high flow and spill events. Implementing fishery monitoring activities was also hampered by permitting delays and unhealthy water quality conditions (e.g., high coliform bacteria concentrations as determined by routine laboratory analysis of water samples for *E. coli* collected from the river) for divers.

5.2.2 Migrant Trapping

Migrant trapping was conducted in various tributaries from 1994-2004 (Figure 5-1) with the primary trapping effort focused on Salsipuedes and Hilton creeks starting in 1994 (Table 5-1). Specific information on the dates that migrant traps were deployed, the duration of the trapping period, and the functional trapping days is summarized in Table 5-2. Both upstream and downstream traps were typically deployed simultaneously with the trap arrangement side-by-side. Migrant traps were typically deployed in January, usually coinciding with rainfall events and increases in tributary flow. Traps were typically maintained through May or June, coinciding with the end of the steelhead migration period. Since migrant trapping occurs during the winter and spring months, the ability to continuously deploy the traps is affected by high flow events and debris loading. Traps were temporarily removed from the stream in anticipation of high flow events that would damage the traps or result in unsafe sampling conditions, or potentially harm steelhead/rainbow trout captured in the traps. The only other times that traps were removed from the stream were due to regulatory issues.

Migrant trap dimensions were 5x6x3 foot PVC fyke traps with a ¾ inch plywood bottom and a plywood top. The top was screwed to the trap and locked to prevent the general public from harassing any captured fish. Attached to the PVC frame was ¼ inch plastic hexigrid poultry netting. On either side of the trap, panels were used to block migration and direct fish into the trap. Every panel consisted of two 8-foot long sections of steel channeling (each piece of channeling with 48 1¾-inch holes) separated by a two or three foot piece of PVC pipe. The number of panels used depended on stream width with the trap deployment tailored for each specific stream site sampled. Once panels were deployed on either side of the trap, five-foot long pieces of 1-inch diameter electrical conduit were placed vertically through the holes in the channeling. Width between each piece of channeling was approximately 1¼ inches. Poultry netting was placed against the upstream panels and conduit to insure capture of small downstream migrating steelhead/rainbow trout. The netting described above was used in Salsipuedes Creek trapping. Two traps were typically positioned in each creek with the fykes pointing both upstream and downstream to capture migrating fish.

Prior to 2000, traps were checked one or two times daily for migrating fish and cleaned of debris. Beginning in 2000 all migrant traps were checked every 4 to 6 hours during the migration period to minimize the duration that any captured steelhead was held in the trap. Trapped fish were removed and measured to the nearest millimeter (fork length). Scales were collected from steelhead/rainbow trout for age analysis from the right side of each fish, directly above the lateral line and directly below the posterior end of the dorsal fin. If scales were embedded at this location, an attempt was made to collect scales from the caudal peduncle. This secondary scale removal location was typically not as embedded and allowed for the removal of some scales for analysis. A small one-centimeter piece of tissue was removed from the upper lobe of the caudal fin for genetic analysis and also to mark the fish to determine if it had been previously captured. All tissue samples collected were delivered to NMFS for genetic analysis. Each captured steelhead/rainbow trout was photographed and described and any blemishes or wounds recorded for future identification before being released into the creek.

5.2.3 Snorkel Surveys

During the period from 1993 to 1997 electrofishing was used as one of the fishery sampling techniques to count steelhead/rainbow trout and other fish species. With the listing of steelhead under the Federal ESA as endangered in 1997, electrofishing was deemed to be an unacceptable method according to NMFS due to its potential to harm fish, and snorkel surveys replaced electrofishing. Direct observations during snorkel surveys allow a non-invasive method of count with minimal stress or risk to the species.

Since 1995, snorkel surveys have been conducted within various reaches of the LSYR mainstem and tributaries (Figure 5-1) to provide information on the relative abundance, geographic distribution and habitat use by steelhead/rainbow trout. Survey locations were limited to where access to private lands was available. Locations where snorkel surveys have been performed in the mainstem river and tributaries are presented in Table 5-3 and Figure 5-1 as well as in Figures 1-3 and 1-4 in Section 1.

Snorkel surveys initially were conducted twice a year, late spring or early summer and late summer or early fall. Beginning in 2001, following the issuance of the BO, snorkel surveys were conducted three times a year. Spring snorkel surveys were conducted between May and June to assess the number of adults and juveniles, particularly young-of-the-year (YOY) steelhead/rainbow trout produced during the spawning season (January through April), and to assess the baseline population abundance and distribution at the beginning of the summer dry season. Summer snorkel surveys were conducted between July and August and fall surveys between September and November and were focused on locations within the mainstem river and tributaries where steelhead/rainbow trout had been observed during the spring surveys, as well as where steelhead/rainbow trout had been observed in previous years. Snorkel surveys during the summer and fall frequently occurred in isolated residual pools, particularly in the mainstem river in habitats downstream of the Highway 154 Bridge within the Refugio and Alisal reaches.

Snorkel surveys typically were conducted by two divers in the mainstem (one diver in the tributaries) on a single-pass basis with sufficient time to thoroughly observe the habitat. Up to six divers were used in surveys of the Long Pool (LSYR-0.5) because it is a large and complex habitat. The number of passes through a habitat unit varied, depending on the visibility, size, and complexity of the habitat being surveyed. When multiple divers made observations, the divers separated themselves to cover the entire habitat. Surveyors swam upstream side by side so that fish numbers were not duplicated. Surveys began at the downstream end of the habitat unit to ensure turbidity from snorkeling activity was displaced downstream, and because salmonids generally orient upstream and were less likely to be aware of divers and seek cover. Fish observed during each survey were identified by species, counted, and length estimated within three-inch length classes (e.g. 0-3, 3-6, 6-9 inches, etc). Information on habitat type, habitat unit length, maximum depth, and water clarity were also recorded. Underwater observations were recorded on a palette during each survey and subsequently transferred to data sheets for input into the database.

5.2.4 Redd Surveys

Redd surveys were conducted in the LSYR and tributaries to document the presence, numbers, timing and geographic location of spawning sites within the lower basin. Furthermore, the presence of redds assisted in other monitoring activities such as snorkel surveys where divers can revisit spawning sites to document successful recruitment later in the year. Redd surveys in the LSYR and tributaries were conducted between 1996 and 2004. The redd surveys were conducted periodically between November and May depending on streamflow and water clarity. As a result, surveys varied by year with respect to location and seasonal timing. When water clarity was suitable for visual observations redd surveys focused on areas with suitable gravel and tail-outs of pools. Limitations on access to private property affected the reaches of the mainstem river and tributaries where redd surveys could be conducted. Sites where adult steelhead/rainbow trout spawning activity (e.g., adult fish showing mating behavior, redd construction as indicated by removal of algae and substrate disturbance) were observed, were then flagged and a GPS location was recorded so that the site could be documented and revisited with a snorkel survey later in the season. Data recorded during each redd survey included: survey date, stream reach, redd location, redd length, redd width, water depth, five current velocity measurements in and around the redd, substrate size and composition, associated cover and habitat conditions, fish observations, water quality, and photographs of the site.

Steelhead/rainbow trout were observed on several occasions to “test” areas before choosing one specific site to construct a redd or to use several sites for spawning within a localized section of creek. Test sites can be difficult to distinguish from actual redds. Based on the characteristics of the observed sites and over ten years of field observations, CPWA biologists used professional judgment in identifying areas as salmonid redds. Given the inherent difficulties and uncertainty associated with redd surveys, results of the surveys are considered to be an indicator of salmonid spawning activity with respect to timing and geographic location. Snorkel surveys were subsequently performed in areas where evidence of spawning was observed to verify the occurrence of YOY steelhead/rainbow trout demonstrating successful reproduction.

5.2.5 Lagoon Trapping

A pilot study was conducted within the lagoon during 1993 and 1994 using a 50-foot beach seine (Table 5-4). During 1997-1999, traps of various types were placed in the Santa Ynez River lagoon to determine if steelhead/rainbow trout utilize the lagoon for juvenile rearing. Three one-week sampling periods were originally scheduled during April-May, September-October, and December-January.

To provide for sampling in different salinity zones, sampling was proposed for locations in the lower, middle, and upper lagoon (Ocean Park – LSYR-47.8; 35th Street Bridge-LSYR-47.2. and Santa Ynez River inflow-LSYR-46.6, respectively). Various passive sampling trap designs/locations were used during sampling in attempts to minimize impacts to tidewater gobies and grebes (Table 5-4). In 1997, small fyke nets, hoop traps, and two-box traps were placed at various locations, perpendicular to the shore, with one lead line attached to shore debris or vegetation and the other lead line attached to an anchor in the lagoon. Traps were placed approximately 50 feet offshore in the lagoon. Each trap was checked once per day in the morning; fish were counted and identified to species and released into the lagoon. In 1998 and 1999, large Onieda traps with ½-inch mesh were used to sample within the lagoon.

The lagoon sampling program was complicated by trapping and captures of tidewater gobies and migratory western grebes, both of which are protected species. In the summer of 1997 and winter of 1998, there were repeated captures of various migratory bird species and the endangered tidewater goby. As a result, trapping activities within the lagoon were discontinued early in both 1997 and 1998. No tidewater gobies or grebes were captured during the 1999 sampling, when large Onieda fyke traps were deployed. Trapping within the Lagoon occurred during August 22 through August 23, 1997; December 12 through December 20, 1998; and May 30 through June 4, and October 26 through October 31, 1999.

No trapping has been conducted in the lagoon since 1999 due to take concerns of USFWS regarding the presence of the federally endangered tidewater goby.

5.3 Results

Fish populations in the LSYR and its tributaries are composed of both native and introduced exotic species. All of the species reported as native to the river in the 1940s (ENTRIX 1995) are still present (Table 5-5). Native species included steelhead/rainbow trout, threespine stickleback, and prickly sculpin (see Table 5-5 for common and scientific names of fish used in this report). In addition, many introduced species have established reproducing populations in Lake Cachuma and the LSYR and its tributaries. These included largemouth bass, smallmouth bass, green sunfish, redear sunfish, bluegill, channel catfish, bullhead catfish, arroyo chub, and mosquito fish. Many of the introduced fish species, such as largemouth bass, prey on native species such as juvenile steelhead/rainbow trout. In addition to predation, interactions among these species also include competition for food and habitat. Developing information on the characteristics of the fish community inhabiting various geographic regions within the river and tributaries is an important element of the overall fishery monitoring and management plan. The following sections briefly summarize the results of migrant trapping, snorkel surveys, redd surveys, and lagoon trapping, focusing primarily on steelhead/rainbow trout, within the LSYR and its tributaries.

5.3.1 Migrant Trapping

Upstream and downstream migrant trapping was conducted from 1994 to 2004 as part of the fishery monitoring program to assess the seasonal distribution and movement patterns of steelhead/rainbow trout. Limited exploratory migrant trapping was conducted on the mainstem river and in a number of tributaries as part of the early phases of the monitoring program (Table 5-2). Results of the exploratory efforts are reported below. The primary migrant trapping efforts have occurred in Salsipuedes and Hilton creeks (Table 5-1) and are reported in detail in the following sections.

To account for the variation in trapping among years, the results of steelhead/rainbow trout collections within both the upstream and downstream traps has been adjusted to represent the catch-per-unit-effort (CPUE) calculated as the number of fish collected divided by the number of functional trap days within each year. The resulting CPUE then represents a normalized estimate of the number of fish captured per day. Efforts are underway as part of the fishery monitoring program refinements to identify additional collection equipment and methods that would allow continued trapping at higher flow rates than the traps used during the 1996-2004 period.

5.3.1.1 Salsipuedes Creek

Information on deployment of the upstream and downstream migrant trap sampling on Salsipuedes Creek is summarized on Table 5-6. The number of days each year that migrant traps were deployed (“functional trap days”) varied in response to both high river flows (e.g., 2001) and permitting by regulatory agencies (e.g., 1998 and 2000; Table 5-6). “Trapping efficiency” is calculated as the percentage of days each migration season that the migrant traps were operated within the creek. As calculated, trapping efficiency reflects the percentage of time the traps are operational once they are placed in location. Trapping efficiency does not reflect the time of year the traps are deployed. As such, this statistic does not account for late deployment (e.g., in 1998) or early removal of the traps (e.g., in 2000).

During the 1996 to 2004 period, trapping efficiency ranged from lows of 76 percent in 2001 and 84 percent in 1998 (both extremely wet years with frequent high flows), to 89 percent or better in all other years. The notably low trapping efficiency of 53% in 2000 was due to regulatory agency permitting requirements and is not representative of normal trapping efficiency.

Results of trapping, showing the total number of steelhead/rainbow trout collected each year in upstream and downstream migrant traps; trap efficiency, CPUE, and water year type within Salsipuedes Creek are presented in Table 5-7. The total number of steelhead/rainbow collected each year in the upstream trap ranged from 1 to 40 fish. The total numbers of steelhead/rainbow trout collected in the downstream migrant trap each year ranged from 3 to 160 fish. The CPUE for steelhead/rainbow trout in the upstream trap ranged from 0.01 fish captures per day in 1998 and 2000 to 0.25 fish per day in 1999. The CPUE for steelhead/rainbow trout in the downstream trap ranged from 0.02 fish per day in 1996 to 1.76 fish per day in 2001.

The CPUE for steelhead/rainbow trout (Figure 5-2) in the upstream and downstream traps were characterized by high variability among years over the monitoring period. The two wettest years in the monitoring period (1998 and 2001) were characterized by large differences in both number of migrants captured and in CPUE. In 1998, only one upstream migrant was captured, as compared to 22 in 2001. Similarly, 17 downstream migrants were captured in 1998 as compared to 160 in 2001. CPUE values reflected these differences (Table 5-7, Figure 5-2). It was possible that some of these differences were due to trapping efficiency, storm flows, variations in trapping locations and variation in times of the season of trap deployment. The number of functional trap days in 2001 was greater than that in 1998 (91 vs. 79, respectively), and the traps were placed two months later in 1998 than in 2001 (end of March in 1998 compared with end of January in 2001) due to high flows and regulatory issues.

A comparison of normal water years (1997, 1999, 2000, 2003) showed that upstream migrant CPUE was relatively consistent, generally ranging from 0.22 to 0.25 fish captures per day. The year 2000 was a notable exception with an upstream migrant CPUE of 0.01 fish captures per day. This was the year with the lowest trapping efficiency (53 percent) and was due to regulatory agency permitting issues that delayed trapping several months during the critical migration window between January 26 and April 20. In general, CPUE for dry and wet years was lower than for normal years, although 2001 showed CPUE for upstream migrants that was comparable to normal years. The CPUE for downstream migrants showed greater variation within water year type than that seen in the upstream migrant results (Figure 5-2). Downstream migrant CPUE was generally higher in 2001 – 2004 than in previous years, with a decreasing trend that could be associated with water year type or time elapsed since the very wet year in 2001. The exception to this pattern is 2002, where CPUE for downstream migrants was much lower than 2001, 2003 or 2004. The year 2002 was an extremely dry year with no major storms in the Salsipuedes Creek drainage during the critical migration window from February through April (Figure 5-5; Figure 5-6; and Figure 2-18).

More years are needed to determine CPUE trends over time given the high hydrologic variability within the LSYR and tributaries. Many of the management actions identified in the FMP have been implemented since 2000 and others are continuing to be implemented. The response of a fish population such as steelhead/rainbow trout to management actions is expected to occur over multiple generations. Monitoring and evaluating the performance and response of steelhead/rainbow trout to enhancement actions will require a commitment to long-term monitoring over a period of decades to reliably detect trends in population abundance.

Steelhead/rainbow trout ranged in length from 36 to 690 mm (Figure 5-3), reflecting a range of life history stages inhabiting Salsipuedes Creek from YOY to adults. Anadromous steelhead juveniles undergo a physiological transformation as they prepare for their downstream migration from freshwater rearing habitat to coastal marine waters, referred to as smolting. The length-frequency distribution of steelhead/rainbow trout observed in upstream and downstream migrant trapping on Salsipuedes Creek shows a large proportion of juvenile fish collected in the downstream migrant trap, the majority of which were identified as smolts based on size and morphometric characteristics (Figure 5-10). Juvenile steelhead/rainbow trout collected in the migrant traps were classified as juveniles or smolts based on their size, coloration, deciduous nature of scales, and overall body appearance. Over the 1996-2004 sampling period, the majority of downstream migrants in the juvenile size class were classified as smolts.

The occurrence of multiple age classes of steelhead/rainbow trout inhabiting Salsipuedes Creek (Figure 5-3), including the observations of YOY, juveniles, smolts and adults (ranging in size from 450 to 690 mm which likely represent adult anadromous steelhead) collected in downstream migrant traps provide evidence that the creek supports successful spawning and egg incubation, oversummering survival of juvenile steelhead/rainbow trout, and the opportunity for smolts to contribute to the anadromous steelhead population. Although no specific size criterion has been established that conclusively separates anadromous adult steelhead and resident adult rainbow trout, several Central Valley hatcheries use a general size criterion of 18 inches (approximately 460 mm) in length to characterize anadromous steelhead (Barngrover, pers.

com., 1998). Results of migrant trapping showed that Salsipuedes Creek provided suitable habitat and represents an important contribution to the overall population dynamic and abundance of steelhead/rainbow trout inhabiting the LSYR watershed. These results are consistent with earlier findings on the importance of tributary habitat to the successful spawning and rearing of steelhead/rainbow trout and the priority given in the FMP to identifying opportunities to improve passage and access and habitat conditions within the tributaries to enhance the overall quality and availability of habitat supporting the production of steelhead/rainbow trout within the LSYR.

The seasonal distribution of steelhead/rainbow trout collected in the upstream migrant trap (Figure 5-4, Panel a) showed a generally unimodal distribution with the greatest number of fish collected between mid-February and mid-April. The seasonal distribution in downstream migrant trap collections (Figure 5-4, Panel b) showed a unimodal distribution similar to that observed in the upstream trapping results. In general, the greatest numbers of steelhead/rainbow trout collected in downstream migrant trapping occurred from approximately mid-February through late-April coincident with increased streamflows at the end of the runoff season with lengthening photoperiod as shown in Figures 5-5 and 5-6. It should be noted that the information of seasonal patterns in upstream and downstream migration shown in Figure 5-4 reflect the composite results of nine years of trap monitoring. These results are presented to only illustrate general patterns, since results for any specific year will vary in response to hydrologic conditions and a wide variety of other environmental factors.

Comparison of the number of steelhead/rainbow trout collected in the upstream migrant trap on Salsipuedes Creek and corresponding streamflows (Figure 5-5) suggested that at least twice (1997 and 1999) there was an increase in the number fish collected coincident with increasing or decreasing streamflows associated with storm events. In 2001, fish migration also appears coincident with stream flow (Figure 5-5). This is consistent with the suggestion that higher flows in wet years may create more suitable habitat within the creek for spawning, egg incubation and juvenile rearing. As additional years of monitoring data become available more sophisticated and refined statistical analyses may provide greater insight into the migration and abundance of steelhead/rainbow trout.

The comparison between the numbers of steelhead/rainbow trout collected in the downstream migrant trap and corresponding streamflows is shown in Figure 5-6. These results showed a general correspondence between an increase in the numbers of juvenile steelhead/rainbow trout (the majority of which were smolts) collected and the declining limb of a storm flow hydrograph. This pattern was most apparent in the data collected during 1998 and 2001, which were high flow years (Section 2). Exceptions to this general pattern were also evident, such as the fish collected in the downstream migrant trap in 2002 (a dry year when the lagoon did not breach) and in 1999 that did not appear to coincide with changes in streamflow, but did coincide with the seasonal timing of migration when compared to other years. The general observation of higher numbers of steelhead/rainbow trout collected on a descending limb of the storm hydrograph was consistent with the hypothesis that changes in tributary flow during the winter - spring migration period serves as an environmental queue stimulating the downstream migration of juvenile steelhead/rainbow trout. Juvenile salmonid migration corresponding to changes in streamflow has also been observed on other river systems (e.g., Raymond 1979 on the Snake River in Idaho, Berggen and Filardo 1993 within the Columbia River, Giorgi et al. 1997 within the Columbia River). Other cues thought to affect juvenile migration timing include increased turbidity resulting from stormwater runoff, photoperiod, and water quality such as changes in water temperature (Williams 2006; Healey and Groot 1987; Brown and Kimmerer 2001; M Workman pers. comm.).

5.3.1.2 Hilton Creek

Information on deployment of the upstream and downstream migrant trap on Hilton Creek is summarized on Table 5-8. As discussed above for Salsipuedes Creek, Hilton Creek also is characterized by highly variable and flashy flows during the winter and early spring migrant trapping period. As a consequence of the high flow events the traps were periodically removed from the creek to avoid the risk to personnel, migrating fish, and equipment.

The number, direction of movement, trapping efficiency, and CPUE of steelhead/rainbow trout collected in migrant trapping within Hilton Creek is presented in Table 5-9. The Hilton Creek downstream migrant trapping data (Figure 5-7) showed a pronounced increase in the numbers of steelhead/rainbow trout captured in migrant trapping beginning in 2001. Analysis of the CPUE trends over time for steelhead/rainbow trout in upstream and downstream migrant traps showed a positive increasing trend that coincided with the commencement of supplemental instream flows in Hilton Creek in 2000 provided by the Hilton Creek Watering System (HCWS). This trend also coincided with increases in trap efficiency and number of trapping days in more recent years (Table 5-9). Hilton Creek produced few or no juvenile steelhead/rainbow trout during the period from 1996 through 2000 (Figure 5-7), which reflects seasonally adverse and unsuitable habitat conditions prior to operation of the HCWS. The lower reaches of Hilton Creek frequently ran dry in the summer from 1993 to 2000, including the wet years of 1993, 1995 and 1998.

Operation of the HCWS provided more consistent flows throughout the low-flow summer period as well as provided summer water temperatures within the range considered to be suitable for steelhead/rainbow trout (Section 3). The increase in juvenile production over the 2001-2004 monitoring period (Figure 5-7) suggests that suitable habitat conditions have been provided to support juvenile rearing during each of these years, in contrast to the highly variable juvenile production in those years before the watering system began operations.

The length-frequency distribution for steelhead/rainbow trout collected in the upstream and downstream migrant traps from Hilton Creek (Figure 5-8) was bimodal. The bimodality reflected the occurrence of both juvenile and adult resident and/or anadromous steelhead/rainbow trout within the population inhabiting Hilton Creek. As shown in Figure 5-8 the larger sized steelhead/rainbow trout collected in the Hilton Creek migrant trap exceeded 460 mm in length, the estimated minimum size for anadromous steelhead. These results, although not conclusive on the origin of adult steelhead/rainbow trout observed within Hilton Creek, suggest that both resident and anadromous adults migrate upstream and downstream within the creek. Adult steelhead/rainbow trout do not necessarily die after spawning as salmon do and hence adult fish may move upstream into a tributary to spawn and subsequently migrate back downstream after spawning.

The length-frequency distribution observed within Hilton Creek (Figure 5-8) also demonstrates a substantially higher occurrence of juvenile steelhead/rainbow trout in the downstream migrant traps and a greater frequency of larger fish collected in the upstream migrant traps. These results are consistent with the basic life-history characteristics of steelhead/rainbow trout, with adult upstream migration into tributary areas for spawning with subsequent downstream migration of juveniles. Migrant trapping results show that both juveniles and adults migrate upstream and downstream within Hilton Creek. These results also confirm successful reproduction and juvenile rearing within Hilton Creek. The occurrence of multiple age classes of steelhead/rainbow trout inhabiting Hilton Creek, including the observations of YOY, adults, and smolts collected in downstream migrant traps provides evidence that the creek currently supports successful spawning and egg incubation, oversummering survival of juvenile steelhead/rainbow trout, and the opportunity for smolts to contribute to the anadromous steelhead population. Steelhead/rainbow trout collected in the migrant traps on Hilton Creek ranged in length from 25 to 528 mm (Figure 5-8), representing various life history stages including YOY, fish characterized as juvenile smolts, and adults. Some of the juvenile steelhead/rainbow trout collected in Hilton Creek traps showed signs of smolting with increasing numbers between 2001 and 2004, indicating that the Hilton Creek production appears to be contributing to the anadromous population (Figure 5-10). Survival of smolts during their downstream migration to the ocean, and the contribution of these smolts to the adult steelhead population are unknown.

The general seasonal distribution in steelhead/rainbow trout collected in the migrant traps within Hilton Creek is shown in Figure 5-9. It should be noted that the information of seasonal patterns in upstream and downstream migration shown in Figure 5-9 reflect the composite results of trap monitoring for the years 1996-2004. These results are presented to illustrate general patterns, since results for any specific year will vary in response to hydrologic conditions and a wide variety of other environmental factors. The largest numbers of fish collected in the upstream trap (Figure 5-9, Panel a) occurred in early winter (January and February), representing approximately 40 percent of the steelhead/rainbow trout collected in the upstream trap. The January-February peak in migration generally coincided with the onset of winter storms and increased runoff. A second pulse of migration was observed in mid-spring (March and April) which typically coincides with late-season storms. The seasonal distribution in the collection of steelhead/rainbow trout in the downstream migrant trap (Figure 5-9 Panel b) differed from the distribution observed in the upstream migrant trap. The peak period of collection of steelhead/rainbow trout in the downstream migrant trap occurred during April, representing approximately 35 percent of the fish collected. A second smaller peak was observed in collections during February. As in Salsipuedes Creek, the variability in the seasonal distribution of steelhead/rainbow trout migration among years could be in response to a number of factors including the seasonal timing and magnitude of storms and runoff affecting instream flows within tributaries such as Hilton Creek. In the absence of a continuously recording streamflow gage on Hilton Creek the actual relationship between seasonal flows and upstream and downstream migration cannot be quantified. In 2002, the U.S. Geological Survey (USGS) installed a real-time stream gage (11125600) below the upper release point of the HCWS in Hilton Creek allowing for future flow/response analyses (Section 2, Figure 2-19).

5.3.1.3 Examination of Migrant Trapping in Salsipuedes and Hilton Creeks

Salsipuedes Creek is the largest tributary (52.4 square miles) downstream of Lake Cachuma, contains perennial flow (Figure 2-18), consistently produces downstream smolts and is located a short distance upstream from the ocean. For these reasons, there is a potential for greater numbers of steelhead to be attracted to Salsipuedes Creek than other tributaries further upstream. The numbers of steelhead/rainbow trout collected in Salsipuedes Creek from 2001-2004 is more variable than that observed in Hilton Creek after initiating operation of the HCWS. The number of upstream migrants collected in Hilton Creek appears to be higher than that collected in Salsipuedes Creek after initiating operation of the HCWS. However, the number of downstream migrants collected in Salsipuedes Creek in some years (e.g., 2001 and 2003) has been substantially higher than the numbers collected in Hilton Creek (Tables 5-7 and 5-9, respectively). In drier year types (2002 and 2004), the number of downstream migrants collected in Hilton Creek has been higher than Salsipuedes Creek after initiating operation of the HCWS. Variability in CPUE for steelhead/rainbow trout CPUE between Hilton and Salsipuedes creeks among years reflects a variety of factors including, variation in natural hydrologic conditions, the effects of the HCWS in providing year-round flow, differences in trapping effort and timing, the time it takes for high flows to recede within each watershed, and the typical waxing and waning of the already depleted steelhead/rainbow trout population that has had very few years to reap the benefits of the recently implemented management actions. Results of the monitoring show that steelhead/rainbow trout production and habitat use has increased within Hilton Creek after initiating operation of the HCWS (Figure 5-7). Results of the migrant trapping within both Salsipuedes and Hilton creeks have shown that habitat use and production of steelhead/rainbow trout within the tributary habitats is an important part of the population dynamics of steelhead/rainbow trout within the LSYR watershed.

Variation in abundance and migration of upstream adults within the tributaries is thought to reflect a number of factors including the seasonal timing and magnitude of rainfall events that generate enough flow to breach the sandbar at the lagoon and to generate enough runoff to allow steelhead/rainbow trout the opportunity to move upstream from the ocean to spawning areas within the mainstem river and tributaries. As mentioned previously, during 1998 and 2000, migrant trapping did not begin until late March of each year because of the timing associated with NMFS and USWFS endangered species permits. Trapping efficiency (number of days the traps were deployed over the migration season) within Hilton Creek and Salsipuedes Creek averaged 79 percent with a range of 24 percent (2000) in Hilton Creek to 100 percent in Hilton and Salsipuedes creeks. Trapping efficiencies within the LSYR watershed were comparable or higher than other migrant salmonid monitoring in many other coastal tributaries. Although these trapping efficiencies are high, efforts are continuing to be made to improve migrant trap design and deployment to further improve trap efficiency.

The length-frequency distribution for larger sized steelhead/rainbow trout observed in Salsipuedes Creek (Figure 5-3) shows a different distribution pattern than that observed in Hilton Creek (Figure 5-8). Within Hilton Creek no steelhead/rainbow trout greater than 528 mm were observed, while in Salsipuedes Creek large migrants ranging in length from approximately 542 to 690 mm were collected, although in low numbers (Figure 5-3). Preliminary scale analysis, in combination with the size, morphological characteristics, and seasonal timing of migration is strong evidence that these larger adults (>460 mm) from Salsipuedes Creek were anadromous steelhead.

The capture of juvenile steelhead/rainbow trout, including fish characterized as smolts, in traps on both Hilton and Salsipuedes creeks confirmed successful reproduction within the tributaries, indicating that Hilton Creek and Salsipuedes Creek both appeared to provide suitable spawning and incubation habitats. Smolt production in the two creeks is different over the sampling period and especially in the period prior to the operation of the HCWS (Figure 5-10). In general, Salsipuedes Creek produces more smolts than Hilton Creek, especially in wet and normal water years. With the initiation of the HCWS, the number of smolts migrating out of Hilton Creek has generally increased. The lower smolt production in Hilton Creek in 2003 (Figure 5-10) could be associated with a critically dry water year in 2002 with no anadromous adult steelhead captured in the upstream traps. As monitoring of Hilton Creek under the operations with the HCWS increases, temporal trends in smolt production will become more apparent.

The overall seasonal distribution in upstream collections from Salsipuedes Creek (Figure 5-4) varied somewhat from the seasonal distribution observed in the upstream migrant trap on Hilton Creek (Figure 5-9) for the entire survey period (1996-2004). The migration of steelhead/rainbow trout upstream migrants in Hilton Creek occurred, typically one month earlier in the migration season than that observed on Salsipuedes Creek (mid-January vs. mid-February). Both creeks had upstream migrants through the middle of May. Similarly, the overall downstream migrant results demonstrate a shorter migration window for Salsipuedes Creek (generally, mid-February through end of April) as compared to Hilton Creek with an overall downstream migration window extending from mid-January through mid-May.

It has been hypothesized that the earlier migration of adults observed in Hilton Creek may reflect the presence of oversummering steelhead/rainbow trout adults occupying the mainstem river downstream of Hilton Creek, specifically the Long Pool (LSYR-0.5), and the relative ease in which the HCWS allows migration through the upper river reach (Highway 154) year-round.

In both the upstream and downstream migrant trapping data, interannual variability in CPUE was high (Tables 5-7 and 5-9). It is possible that streamflows within both Hilton and Salsipuedes creeks, particularly after implementation of the HCWS, are an important factor affecting habitat use and production within these tributaries, although a variety of environmental conditions such as the occurrence of unsuitable or stressful summer water temperatures (particularly before the HCWS), were likely to contribute to interannual variability in the production and habitat use of various tributaries within the LSYR watershed. Many of these factors varied among tributaries and therefore successful reproduction and juvenile rearing within one tributary may not be reflected in similar success in other tributaries within the watershed. To examine the potential relationship of abundance within Salsipuedes and Hilton creeks, an exploratory correlation analysis was performed on the CPUE between the two creeks using upstream and downstream trapping data over the sampling period. Results of the correlation analysis were not statistically significant ($P>0.05$). These results were consistent with the hypothesis that various environmental factors are affecting populations within the two creeks differently. One major difference is operation of the HCWS that provides a consistent baseflow throughout the year of cool water, where steelhead/rainbow trout can move upstream and downstream within the lower reaches of Hilton Creek year-round. Future analyses will include longer time trends and will control for hydrologic year types, factors that were not accounted for in the preliminary analysis.

Tissue samples are collected from steelhead/rainbow trout prior to release from the migrant traps. Laboratory analysis results of scale samples and DNA analysis are not available for use in evaluating the frequency of resident rainbow trout and anadromous steelhead entering either Hilton Creek or Salsipuedes Creek at the time of this report.

5.3.1.4 Exploratory Migrant Trapping on the Mainstem and Tributaries

As described above, limited exploratory migrant trapping was conducted on the mainstem river and in a number of tributaries as part of the early phases of the monitoring program (Table 5-2). In general, trapping results from these early surveys were very low:

- two adult upstream migrants in the mainstem (1996: 250 mm ; 1997: 406 mm);
- two upstream migrants and one downstream migrant in Nojoqui Creek (1998; 214-385 mm);
- two upstream migrants in Alisal Creek (1995: 377 mm and 387 mm);

- two downstream migrants in San Miguelito Creek (1997: 147 mm; 1999: 140 mm; neither fish showed smolting characteristics); and
- no fish captured in Alamo Pintado or Quiota Creeks.

Trapping in these locations was discontinued for a variety of reasons, including few steelhead/rainbow trout captured or observed, restrictions on access, high flows, high sediment and debris loading, and staffing priorities. These results, although considered to be qualitative, are consistent with snorkel surveys and other observations suggesting that there is limited habitat use by steelhead/rainbow trout within other tributaries to the LSYR. Low utilization may be the result of passage impediments, no summer flow, and stressful/unsuitable summer rearing habitat (Section 4). Migrant trapping has continued on both Salsipuedes and Hilton creeks.

5.3.2 Snorkel Surveys

5.3.2.1 Steelhead/Rainbow Trout

Snorkel surveys have focused on pool habitat (as compared to run habitat), where the majority of steelhead/rainbow trout have been observed during the dry months of the year. The initial years of snorkel surveys demonstrated that run habitats were generally too shallow for effective fish observation by snorkeling and that few if any steelhead/rainbow trout were observed.

Results of snorkel surveys provide useful information on the presence, relative abundance and size distribution of steelhead/rainbow trout among habitats and across years. The indices of abundance are based on the numbers of fish observed and have not been adjusted to account for variation in the level of survey effort.

Lower Santa Ynez River Mainstem

The distribution and relative abundance of adult and juvenile steelhead/rainbow trout observed in the mainstem river during snorkel surveys are shown in Table 5-10. Results of the snorkel surveys conducted within the mainstem river typically show larger numbers of fish inhabiting the upstream reaches, especially the Highway 154 reach. In the years when Lake Cachuma spilled (Section 2) such as 1995, 1998, and 2001 greater numbers of steelhead/rainbow trout were observed downstream within the Refugio and Alisal reaches, when compared to surveys conducted during non-spill years. The change in steelhead/rainbow trout distribution within the mainstem river was presumably in response to the higher flow conditions occurring in a wet year, which allowed the sandbar to remain open for an extended period of time creating favorable migration and spawning conditions. Spill years also are typically wet years which provide more water in the mainstem during the summer period, and extend the amount of suitable habitat further downstream (Sections 2 and 4). For example, 1998 was a spill year with high flows from Cachuma Reservoir extending to July 20. Trout were found in relatively high numbers through July in Refugio and Alisal reaches and some into the Cadwell Reach.

There were some general trends observed from the mainstem data:

- The summer distribution of both juvenile and adult steelhead/rainbow trout was varied by reach, by year, and by season in response to the ambient hydrologic conditions affecting the basin;

- During wet/spill years, more steelhead/rainbow trout were observed in the mainstem river than in dry or normal years (Table 5-10);
- In the mainstem, steelhead/rainbow trout used pool habitat in above mile 10.5 (Alisal Reach), especially in the Highway 154 Reach;
- Adult steelhead/rainbow trout were seldom found in Refugio and Alisal reaches except in years when Lake Cachuma spilled (Table 5-10);
- In summer, most juvenile and adult distribution was associated with pool habitat that offered cooler water;
- High water temperature and low DO were challenges for juvenile distribution and relative abundance (Sections 3.4.3 and 3.5);
- Juveniles were found in pool habitats when the habitat was occupied by predators such as largemouth bass (see Section 5.3.2.2);
- Snorkel surveys for both adult and juvenile steelhead/rainbow trout were sometimes complicated by coliform bacterial levels that exceed human health standards within the mainstem river and tributaries that limited the snorkel surveys as a result of diver health and safety concerns, specifically the dry season of 2002; and
- Shallow water depths, rooted aquatic vegetation, surface algae, and turbidity in mainstem habitat units constrained the ability to conduct snorkel surveys in some habitats (including run habitats) during dry years. However, most, if not all mainstem habitats below mile 5.0 (Refugio Reach) became dry in below average rain years.

Tributaries

The abundance and distribution of steelhead /rainbow trout recorded in the tributaries snorkel surveys are presented in Table 5-11. Snorkel surveys found steelhead/rainbow trout greater than six inches (152 mm, which is thought to be an adult) in length within the tributaries (Table 5-11) including Salsipuedes Creek, Hilton Creek, Quiota Creek, and El Jaro Creek. Fewer large (>6 inches) steelhead/rainbow trout appeared in the limited surveys conducted in Upper Salsipuedes Creek (upstream of the El Jaro Creek confluence) as compared to survey results from Lower Salsipuedes Creek (downstream of the El Jaro Creek confluence). Steelhead/rainbow trout juveniles (<6 inches) were observed in all tributaries except Nojoqui (Table 5-11).

The numbers and length frequency for steelhead/rainbow trout observed in snorkel surveys conducted in Hilton Creek following the commencement of instream flows from the HCWS in 2000 are shown in Figure 5-11. Results of the Hilton Creek snorkel surveys have shown the occurrence of a range of life history stages and size classes inhabiting the creek. The occurrence of juvenile fish ranging from zero to three inches in length demonstrates successful reproduction within the creek.

Although a reduction in abundance has been observed between spring and fall surveys in every year except 2004, likely due to natural attrition dispersal, results of snorkel surveys within Hilton Creek during 2002 showed a substantial reduction (80-85 percent) in the numbers of steelhead/rainbow trout between the May and September surveys (Figure 5-11). A similar decrease (85 percent) was seen in 2000 in the 0-3 inch size class, but this decrease was accompanied by a 273 percent increase in 3-6 inch fish, suggesting fish growth occurred during summer rather than a population decrease. The reduction in the number of steelhead/rainbow trout was greatest in the smaller size classes (0-3 and 3-6 inches; Figure 5-11). Given the small size of Hilton Creek and the effectiveness of direct observations during snorkel surveys to detect and count fish (snorkel surveys conducted in a small creek have an anticipated accuracy of approximately plus or minus 10 percent; Kennedy pers. com., 2004) the observed reduction in abundance between the May and September 2002 surveys appears to be an actual change in the population inhabiting Hilton Creek during the summer of 2002. Review of results of water temperature monitoring and operation of the watering system provided no evidence that the reduction was the result of a failure of the watering system. Although the cause of the reduction in the numbers of steelhead/rainbow trout observed is unknown, it is hypothesized that avian predation and/or predatory mammals such as raccoons may have been an important source of mortality for steelhead/rainbow trout inhabiting the creek. The fact that large numbers of juvenile steelhead/rainbow trout were not subsequently observed downstream in the Long Pool (LSYR-0.5) supports the suggestion that predation mortality may have been a significant factor in the observed decline in the numbers of juveniles rearing within Hilton Creek. In 2002, the watering system had been in operation for two years and the riparian canopy was just becoming well established. Increases in the height and density of riparian vegetation providing overhead cover for juvenile steelhead/rainbow trout in response to the baseflows provided by the watering system (Section 6) have been observed and is expected to reduce avian predation. Results of snorkel surveys conducted in 2003 and 2004 appear to support this suggestion since large reductions in juvenile (<6 inch) steelhead/rainbow trout were not detected in either of these two years, and 2004 showed a small increase in the 0 to 3-inch size class.

5.3.2.2 Other Aquatic Species

During snorkel surveys all species incidentally observed within the LSYR and its tributaries have been documented (Table 5-12). Largemouth bass, smallmouth bass, green sunfish, redear sunfish, bluegill, crappie, channel catfish, and bullhead catfish were observed during snorkel surveys within the mainstem river and/or tributaries; but very few of these species were observed in the tributaries. Sculpin were observed within both the mainstem river and tributaries (Hilton and Salsipuedes creeks) during snorkel surveys. Other fish species observed were three-spine stickleback, arroyo chub, fathead minnow and mosquitofish. Southwestern pond turtles, California red-legged frogs, bullfrogs, crayfish, and beaver were present (Table 5-12). Results of these incidental observations of other fish and wildlife species inhabiting the mainstem river and tributaries provided general insight into the diversity, habitat use, and species composition of the aquatic community inhabiting the LSYR and its tributaries. The observations of species in addition to steelhead/rainbow trout are of interest from a management perspective. Fish species that may prey on steelhead/rainbow trout include channel catfish, largemouth and smallmouth bass, sunfish, and crappie. Predation mortality on juvenile salmon and steelhead by species such as largemouth and smallmouth bass, channel catfish, pikeminnow, and other picivorous fish has been identified as a significant factor affecting population abundance and survival in other river systems (Poe et al., 1991; Rieman et al., 1991; Beamesderfer 2000). Bullfrogs also prey on juvenile steelhead as confirmed by CPWA biologists conducting a stomach content analysis on an adult bullfrog inhabiting Hilton Creek in 2004. Crayfish may incidentally prey on eggs or YOY steelhead/rainbow trout.

Predatory Fish (Largemouth Bass)

Incidental observations of largemouth bass are presented in Table 5-13. The number of adult and juvenile bass observed varied substantially among years and locations within the river. Largemouth bass, which are predators on juvenile steelhead/rainbow trout, (Nobriga and Feyrer 2007) were introduced into Lake Cachuma as a game fish and established a reproducing population in the reservoir. It is not known to what extent bass inhabiting the lower river may have been produced in the reservoir and escaped downstream during reservoir spillway releases or may have successfully spawned and maintained an independent population in the lower river. Largemouth bass are generally restricted to habitats with little flow such as lakes, ponds and backwater areas of larger rivers. They prefer warm water, and tolerate wider temperature fluctuations and low DO levels (Tidwell et al., 2003; Moyle 2002) compared to steelhead/rainbow trout. Although largemouth bass are an important piscivorous predator (Howick and O'Brien 1983, Maezono and Miyashita 2002, Savino and Stein 1982) the impact of predation on rearing and migrating juvenile steelhead population dynamics and abundance has not been documented.

In 1997, prior to dewatering the Stilling Basin for a seismic retrofit of Bradbury Dam, a fish rescue was conducted within the Stilling Basin (LSYR-0.2), which had been dewatered to a pool approximately 200 feet by 100 feet with a uniform depth of two feet. A total of 1,028 fish, including 11 steelhead/rainbow trout, were captured and relocated. Of these rescued fish, 947 were warm-water species, which notably included 493 channel catfish, 237 largemouth bass, 61 smallmouth bass, 78 bluegill, and 62 redear sunfish. Only 1 percent of the fish rescued within the Stilling Basin consisted of steelhead/rainbow trout.

Largemouth bass have been observed during snorkel surveys in many reaches of the mainstem river (Table 5-13). They have been observed in the Highway 154 Reach (Stilling Basin; LSYR-0.2) and Long Pool (LSYR-0.5), Refugio, and Alisal reaches (Table 5-13; Section 1, Figure 1-2), the same reaches where juvenile steelhead/rainbow trout are present (Table 5-10), but they also are found further downstream. The presence of largemouth bass further downstream within the mainstem river observed in the snorkel surveys is thought to reflect their higher thermal tolerance and ability to oversummer in habitat areas that would be considered unsuitable for steelhead/rainbow trout. Relatively large numbers of largemouth bass observed throughout the river in 1995 could have escaped from the reservoir during the reservoir drawdown for seismic safety remediation of the dam at that time.

During water rights releases, CPWA biologists observed bass fry following the leading edge of water as it moved downstream through the Highway 154, Refugio and Alisal reaches (field observation not presented in tables or figures). The observation that the abundance of adult and juvenile bass in the lower reaches of the mainstem river varies substantially among years, and the absence of a sustained adult bass population in the lower reaches of the river suggests that dispersal of bass downstream in response to flow events does not result in the accumulation or maintenance of a large predator population inhabiting the lower reaches of the mainstem river.

Information on the numbers of largemouth bass less than six inches in length observed in Hilton Creek and Salsipuedes Creek are summarized in Table 5-14. Only three juvenile largemouth bass were observed in Lower Salsipuedes Creek in 1999 (Table 5-14); no largemouth bass have been observed in Salsipuedes Creek in more recent years. Juvenile largemouth bass were observed in a few pools and run habitats in lower Hilton Creek following the initiation of sustained flows in 2000 (Table 5-14), however, none have been observed since 2002. Cool water temperatures maintained within Hilton Creek resulting from operation of the watering system and/or increased water velocities within the creek channel may be excluding largemouth bass from Hilton Creek in recent years.

During 1995-2004 snorkel surveys, CPWA biological staff observed the co-occurrence of adult and steelhead/rainbow trout at a number of sites within the mainstem river. These observations are described briefly below:

- In July 1999, 30 adult largemouth bass (three > 12 inches in length) shared a pool ¼ mile downstream of Refugio Bridge (LSYR-8) with 24 steelhead/rainbow trout in the 6 to 9-inch size range (one individual >12 inches). The bass and trout occupied separate areas of the pool, with the bass in the deeper, downstream side of the habitat and the trout concentrated at the head of the pool;
- In 2000, the number of juvenile bass in the Alisal Reach increased from 37 to 98 (between January and July) and remained high through September of 2000. Juvenile steelhead/rainbow trout were observed inhabiting these habitat areas within the Alisal reach during the summer of 2000 but the number observed declined between July and September (Table 5-10). Although predation by largemouth bass may have been a factor contributing to the decline in steelhead/rainbow trout observed, the contribution of predation mortality by largemouth bass to changes in juvenile steelhead/rainbow trout abundance, although suspected, is unknown. Other predatory species, such as sunfish, bluegill, catfish, and predatory birds also inhabit the area and may have contributed to reductions in steelhead/rainbow trout abundance, particularly within shallow isolated pool habitats; The decrease in numbers of steelhead/rainbow trout particularly within isolated pool habitats also could be the result of low DO and high temperatures; and
- From June to October 2001 the number of juvenile bass observed more than doubled in the Highway 154 Reach increasing from 165 to 409 juvenile bass observed in five habitats located adjacent to the Stilling Basin (LSYR-0.2) and Long Pool (LSYR-0.5).). The observed increase in bass abundance may reflect successful spawning within the river and/or possible recruitment from the lake during the 2001 spill event (Section 2). The numbers of juvenile steelhead/rainbow trout observed within the Highway 154 Reach in 2001 showed little change in abundance through the summer months with 29 steelhead/rainbow trout observed in June, 37 in August, and 30 in October. These observations suggest that predation by juvenile largemouth bass was not a significant factor affecting steelhead/rainbow trout abundance during 2001 within the Highway 154 Reach.

Non-Predatory Species

American beaver were not native to the Santa Ynez River or other drainages in southern California (CDFG, California Interagency Wildlife Task Group 2005). A population of beaver inhabits the LSYR, with beaver dams found from the Stilling Basin (mile 0.2) to the Cargasacchi reach (LSYR- 28.0-30.0; Section 1, Figure 1-2). Beaver activity was focused around areas with perennial flows and deep pools such as the Highway 154 reach, and pools within the Refugio, Alisal, Avenue of the Flags, Weister and Cargasacchi reaches (Figure 1-2). Families of beavers also migrated into the Salsipuedes Creek drainage, including Upper Salsipuedes and El Jaro creeks. Beaver dams may be impediments or barriers to upstream and downstream steelhead migration, change local erosion and deposition patterns, alter channel velocities, modify instream habitats, remove riparian vegetation, and increase the occurrence of large woody debris and cover habitat within a stream. The beneficial or detrimental effects of beaver dams on the abundance and distribution of steelhead/rainbow trout and other species are not known.

The California red-legged frog, a federally listed threatened species, is a native species within the Santa Ynez River drainage, and inhabits wetlands and streams across the coastal drainages of central California. California red-legged frogs were not found in the mainstem river or within Hilton Creek, but were observed within Salsipuedes, Upper Salsipuedes, El Jaro, San Miguelito, Quiota, and Nojoqui creeks during the study period (see Table 5-12). The presence of California red-legged frog in the tributaries has been taken into consideration in the design and implementation of the fishery and habitat monitoring program. In addition, the presence of protected red-legged frogs within the watershed is recognized as a factor to address in developing plans for fishery habitat enhancement actions, passage barrier removal, and other actions as part of implementing the FMP.

5.3.3 Redd Surveys

The results of redd surveys shown on Table 5-15 provide general information on the distribution and seasonal timing of steelhead/rainbow trout spawning in the tributaries and LSYR mainstem. The results of these surveys are considered to be qualitative in nature due to the following reasons: varying flow and turbidity conditions, varying levels of sampling effort, and limited access to private lands prohibiting systematic sampling. Redd surveys were conducted periodically, and not systematically. Although qualitative, these surveys provide information on the occurrence and distribution of potential steelhead/rainbow trout spawning within the system. Results of these redd surveys suggest that spawning activity is occurring in a variety of locations including the mainstem river and a number of tributaries with the majority of the redds observed in the tributaries.

Steelhead/rainbow trout spawn in the LSYR and tributaries from December through May, with the majority of spawning activity in March through May coincident with increased runoff and flow; the majority of redds (88 percent) were observed between March 11 and May 12. Although the majority of redds observed appeared to be from resident trout inhabiting the basin (particularly in dry and normal years), the March through May spawning time frame suggested that high flow events generated in late winter and early spring by precipitation and runoff were the primary factors associated with initiation of spawning. The ability of personnel to observe spawning sites with continuous reaches of the mainstem and tributaries was affected by (a) large storm events (especially within the Salsipuedes Creek drainage) which moves substrate and can destroy all evidence of spawning sites; (b) inability to access portions of the watershed during high flows; (c) turbid water following storm events; and (d) limited access to private property.

Results of the redd surveys were consistent with the observations of YOY steelhead/rainbow trout collected in both migrant trapping and observed during snorkel surveys confirming successful reproduction within the watershed.

During redd surveys; observations were made of specific spawning areas and conditions, which might affect spawning success. These observations are summarized below:

- In Lower Salsipuedes Creek, spawning repeatedly occurred about 100-150 feet downstream of the El Jaro confluence;
- The flashy nature of flow in the Salsipuedes Creek watershed, as well as other tributaries below the dam, resulted in redds constructed early in the spawning season being subject to

very high and potentially scouring flows. Redds constructed following the last major precipitation events (late March through May) may have had a greater chance of successful egg incubation, hatching, and emergence;

- Redds were consistently found in Upper Salsipuedes Creek. Many of these redds were larger than those redds observed that were associated with resident steelhead/rainbow trout, suggesting spawning by anadromous steelhead. This reach appeared to be generally suitable for adult migration and spawning in normal-to-wet year types;
- Redds in San Miguelito Creek were small, typical of resident trout spawning. Numerous and significant barriers prevent anadromous steelhead from accessing this creek;
- Land use within the tributary watersheds, especially the Salsipuedes and El Jaro drainages, has affected the quality of spawning gravel as a result of local erosion and fine sediment deposition. Erosion and sediment deposition within the creeks reduces gravel permeability and interstitial space and may directly affect gravel quality for steelhead/rainbow trout egg incubation and macroinvertebrate production. Quantitative gravel sediment-size analyses have not been made to assess the percentage of fines within the gravels at various locations within the tributaries;
- The period of redd construction varied among years and tributaries, possibly reflecting differences in hydrologic conditions, low overall population numbers within the drainage, and adult upstream passage opportunities;
- Redd dimensions were variable. Redd length ranged up to 18 feet, but typically varied from 2.2 to 9.8 feet. Redd widths typically ranged from 1.4 to 3.9 feet;
- CPWA biologists have observed large, anadromous steelhead constructing redds as small as three feet in length, as compared to steelhead redds with minimum lengths of 6-7 feet in Oregon and Washington streams (Quinn 2005; Wydoski and Whitney 2003). Redd dimensions in the SYR and tributaries can vary depending on the degree of imbeddedness of the substrate;
- Redds were constructed in a variety of microhabitats. Redds were typically constructed in tail-out areas, riffle-run transitions, downstream of barriers such as beaver dams and creek crossings, near cover components (e.g., large woody debris, overhanging vegetation, bubble curtains, and other physical structures providing cover), and at the downstream end of pools;
- Water velocities measured upstream and downstream of redds showed relatively consistent flow rates across the redds. In the three reaches associated with most anadromous spawning (upper and Lower Salsipuedes Creek and El Jaro Creek), water velocity ranged from 1.4 to 2.6 ft/sec upstream of redds and 0.4 to 2.1 ft/sec at the downstream tail of the redds. Velocities in the range from approximately 1 to 3 ft/sec (Bovee and Milhous 1978) are within the general range preferred by spawning steelhead and are thought to provide suitable inter-gravel flows. Because habitat measurements at the redds were taken at an unknown time after redd construction, they may not represent the water velocity and flow conditions when redds were being constructed;
- On several occasions, small resident (sneaker males) and adult steelhead/rainbow trout were observed near redds;

- Spawning behavior by two adult steelhead/rainbow trout measuring 16-18 inches was observed in the Highway 154 reach in the tail of the Stilling Basin (LSYR-0.2) in the slack water on the south side of the Stilling Basin (no reservoir release) in 2002;
- In 2002 on Los Amoles Creek (tributary to El Jaro Creek) four redd sites were found, two of which contained small resident steelhead/rainbow trout between approximately 4 and 7 inches in length actively spawning on April 8-9. In the same time frame, a different redd site nearby contained YOY (from fish estimated to have spawned at least five weeks earlier); and
- Very large redd sites thought to potentially be anadromous steelhead redds have been observed in Lower and Upper Salsipuedes creeks.

5.3.4 Lagoon Trapping

A number of estuarine species were found inhabiting the lagoon during limited trapping in 1997-1999 (Table 5-16). Data from trapping in 1998 are not shown on Table 5-16, due to sampling problems with grebes that made accurate sampling infeasible. Sampling in 1998 did result in the capture of two large steelhead/rainbow trout (344 mm and 280 mm in length). One large steelhead/rainbow trout (357 mm) was collected in 1999 (Table 5-16).

In addition to results of trapping at three sites within the lagoon shown on Table 5-16, a fourth exploratory site between the mid-lagoon (LSYR-47.2) and upper-lagoon sites (LSYR-46.6) was sampled only in 1997. At that site during that year, four species were captured at this site: stripped mullet (2), largemouth bass (3), staghorn sculpin (46) and starry flounder (150).

Although lagoon salinities were generally low near the confluence of the river and lagoon (LSYR-46.6), due in part to inflow from the Lompoc wastewater treatment plant, freshwater species were not abundant in the lagoon, suggesting only incidental use, perhaps associated with downstream movement during a period of high river flow. The lagoon also was isolated from upstream steelhead/rainbow trout spawning and rearing habitat by dry channel reaches during the summer and fall. As a result of these factors, and because of sampling difficulties and the potential for incidental take of tidewater goby and grebes, lagoon sampling was discontinued after 1999.

5.3.5 Electrofishing Surveys

During the initial phase of the fishery monitoring program (1993-1995) reconnaissance-level (presence/absence) electrofishing surveys were conducted at habitat units within both the mainstem river and tributaries. During electrofishing surveys twelve species of fish were collected including small numbers of steelhead/rainbow trout from lower Hilton Creek and at other sites within the tributaries. Other fish species include sculpin, Arroyo chub, stickleback, smallmouth bass, largemouth bass, and green sunfish. Sculpin were numerically the most abundant fish species collected. As a result of the listing of steelhead as an endangered species in 1997 the electrofishing surveys were discontinued in response to concerns that electrofishing may harm or kill steelhead. The electrofishing surveys were replaced with snorkel surveys that are now conducted as part of the fishery monitoring program.

5.4 Findings of the 1993-2004 Fishery Monitoring Program

Results of 1993-2004 fishery monitoring on the LSYR and tributaries are consistent with results and findings presented in the 1997 Synthesis Report. Key findings are broken out into four sections.

5.4.1 Steelhead/Rainbow Trout Distribution in the LSYR

- In general, steelhead/rainbow trout were most abundant near the dam in the Highway 154 Reach and less abundant in the Refugio and Alisal reaches in snorkel surveys conducted in the LSYR mainstem.
- Although steelhead/rainbow trout were not often found in large numbers in the mainstem LSYR downstream of the Highway 154 Bridge (LSYR-3.2), they were found in greater numbers in downstream reaches (e.g., Refugio and Alisal reaches) in wet years when flows extend further downstream.
- Results of snorkel surveys and migrant trapping in the tributaries indicate that steelhead/rainbow trout successfully reproduced and reared in Hilton, Salsipuedes, El Jaro, Quiota, and San Miguelito creeks.
- The population dynamics and expression of life history characteristics varied among years, depending, in part, on hydrologic conditions and whether the sandbar at the lagoon was breached to provide access to and from the ocean.
- Juvenile and adult steelhead/rainbow trout were found more frequently in the tributaries where more suitable habitat was present when compared to the LSYR (Chapter 4). However, almost all of the 154 Reach (miles 0.7-3.2), as well as miles 3.2-5.0, have been inaccessible to surveyors and likely contain moderate to abundant numbers of steelhead/rainbow trout. This important management reach now receives continuous flow with the inception of the HCWS and other flow-related fish support measures (i.e., meeting target flows) (Chapter 6).
- Young-of-year steelhead/rainbow trout were primarily observed in the mainstem river in the Highway 154 Reach (between the Stilling Basin (LSYR-0.2) and Long Pool (LSYR-0.5) and downstream of the Long Pool) and to a lesser extent in the Refugio and Alisal reaches. These were thought to have originated in Hilton Creek because successful reproduction has been documented in the creek since the inception of the HCWS. Steelhead/rainbow trout may have also been produced in the Highway 154 Reach downstream of Reclamation property, however, limitations on access to private lands, have prevented surveys to determine spawning and production in this reach.

5.4.2 Ecological Factors

- Results of upstream migrant trapping and redd surveys showed that steelhead/rainbow trout responded rapidly to favorable flow conditions (e.g., wet years) to spawn in upstream tributary areas; favorable environmental conditions have been shown to increase steelhead/rainbow trout production as reflected in results of snorkel surveys during the spring and summer.
- Water quality, particularly elevated summer water temperatures and depressed DO, have been identified as significant environmental factors affecting the habitat quality and

availability for steelhead/rainbow trout both within the mainstem river and tributaries (Chapter 3).

- Exposure to seasonally elevated water temperatures and depressed DO, especially within isolated pools where algal accumulations occur during the summer months, frequently were at levels considered to be highly stressful and potentially lethal within the range resulting in acute mortality to steelhead/rainbow trout (Myrick and Cech 1996, 2000a, 2001). These conditions negatively affected habitat quality and availability for steelhead/rainbow trout and provide habitat opportunities for largemouth bass and other warm water fish species.
- Some steelhead/rainbow trout juveniles survived, apparently in healthy condition, in isolated pools in the LSYR mainstem through the summer and fall despite exposure to elevated water temperature and depressed DO conditions that exceeded standard tolerance criteria for the species. Survival in these habitats may be related to upwelling of cool water forming thermal refugia within the mainstem pools, higher tolerance levels of LSYR steelhead/rainbow trout, or a combination of factors. If steelhead/rainbow trout currently inhabiting the LSYR and/or its tributaries are of native southern California steelhead stock, they may be adapted to warmer temperatures than more northern stocks (Myrick pers. com., 2006).

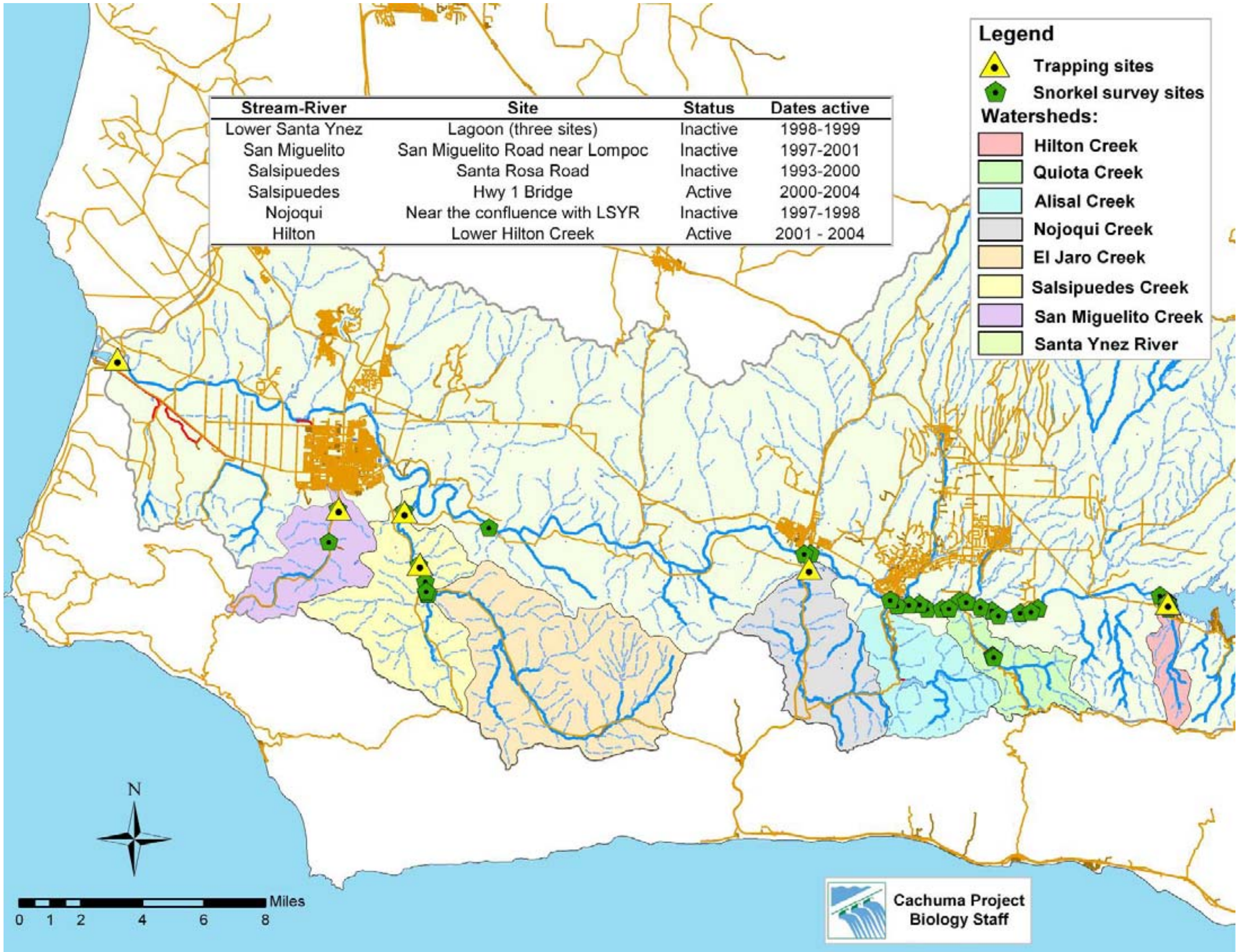
5.4.3 Steelhead/Rainbow Trout in the Tributaries

- Seasonal variation in streamflows and water temperatures within Hilton Creek (prior to activation of the HCWS), particularly during normal and dry water years, has been a limiting factor affecting the suitability of habitat within the creek based on results of the water quality and habitat monitoring conducted during the early years of the fishery program. Results of migrant trapping between 2001 and 2004, after the watering system began operations, showed a promising trend of increasing steelhead/rainbow trout abundance and juvenile production.
- Salsipuedes, Hilton, El Jaro, Quiota, and San Miguelito creeks supported a reproducing population of steelhead/rainbow trout based on the presence of a range of age classes, including YOY. Steelhead/rainbow trout redds were observed in Salsipuedes, El Jaro, Quiota, and Hilton creeks. The capture of juvenile steelhead /rainbow trout exhibiting evidence of smoltification in downstream migrant trapping within both Hilton Creek and Salsipuedes Creek indicated the presence of anadromous traits within the population.
- No evidence of steelhead /rainbow trout was found in the lower sections of Nojoqui Creek (NC 1.5-3.0) but good spawning and rearing habitat existed there during above average rain years. The lower section of Nojoqui Creek was dry every year.
- Numerous redds, YOY, and small (6-9 inch) steelhead/rainbow trout were observed in San Miguelito Creek, but numerous and significant passage barriers prevent anadromous steelhead from entering the creek.

5.4.4 Community Structure/Predation

- The LSYR downstream of Bradbury Dam supports fluctuating and transient populations of native and introduced fish species. The fish community in larger, deeper pools included many introduced species, including largemouth and smallmouth bass, green sunfish, bluegill, redear sunfish, channel and bullhead catfish; species preferring warm, low velocity aquatic habitats. Largemouth bass, in particular, reproduced successfully and were observed in high numbers in some years in the river below Bradbury Dam. Bass and other fish are transported from Lake Cachuma into the lower river during periods when the dam spills. All of the native species reported for the river in the 1940s were still present.

- According to a one-time seining operation in 1997, 92 percent of the 1,028 fish captured within the Stilling Basin (mile 0.2) contained non-native warm-water species. The disproportionate number of steelhead/rainbow trout captured (11 total) during the survey manifested the need for management actions within the Stilling Basin and Long Pool below Bradbury Dam.
- The tributaries support populations of native species including steelhead/rainbow trout, stickleback, and sculpin. The introduced arroyo chub and mosquitofish were also widespread.



Stream-River	Site	Status	Dates active
Lower Santa Ynez	Lagoon (three sites)	Inactive	1998-1999
San Miguelito	San Miguelito Road near Lompoc	Inactive	1997-2001
Salsipuedes	Santa Rosa Road	Inactive	1993-2000
Salsipuedes	Hwy 1 Bridge	Active	2000-2004
Nojoqui	Near the confluence with LSYR	Inactive	1997-1998
Hilton	Lower Hilton Creek	Active	2001 - 2004

Figure 5-1. Trapping and snorkel survey sites throughout the LSYR. The table lists all trapping sites starting with the bottom of the watershed and going up towards the dam. Trapping was briefly conducted on lower Alisal, Alamo Pintado, and Quiota creeks but was done for less than 30 days in each case and was not included in this report. (Source: CPWA 2006)

THIS PAGE INTENTIONALLY BLANK

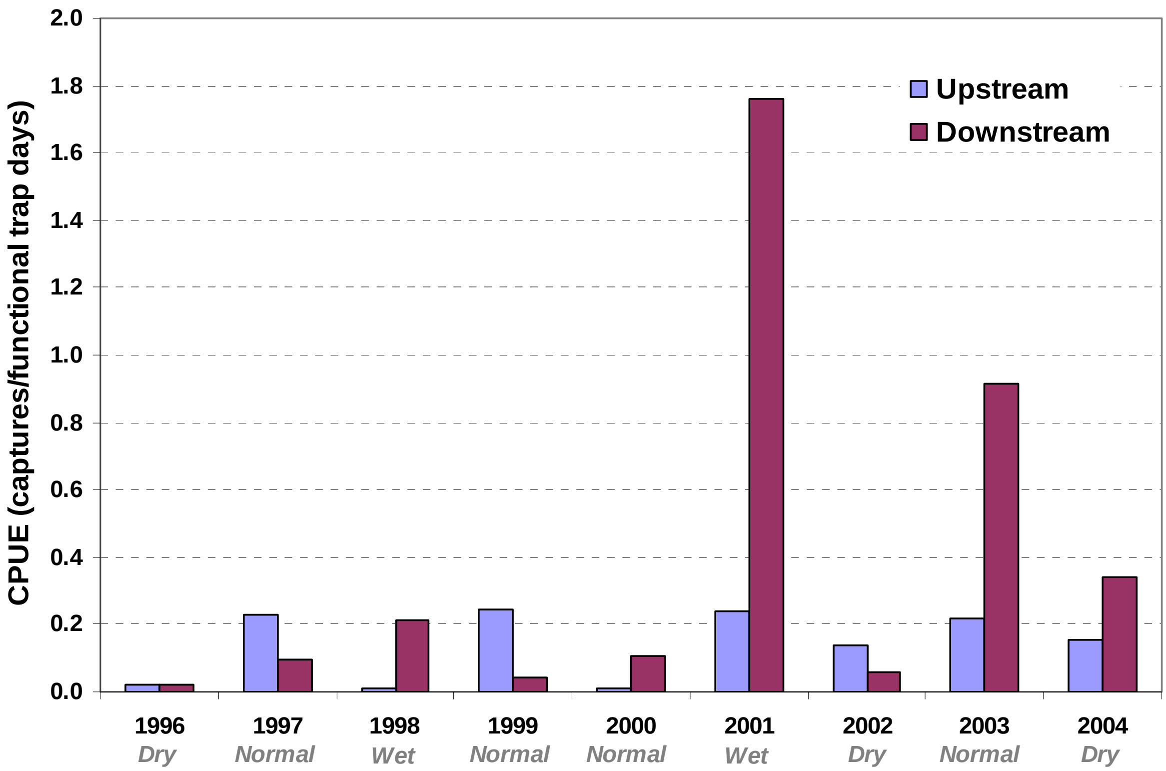


Figure 5-2. **Relationship over Time between CPUE per day for Upstream and Downstream Traps within Salsipuedes Creek (Note: Water Year Type: dry years <15" of rainfall, normal years = 15"-22" of rainfall, wet years = >22" of rainfall, Section 2)**

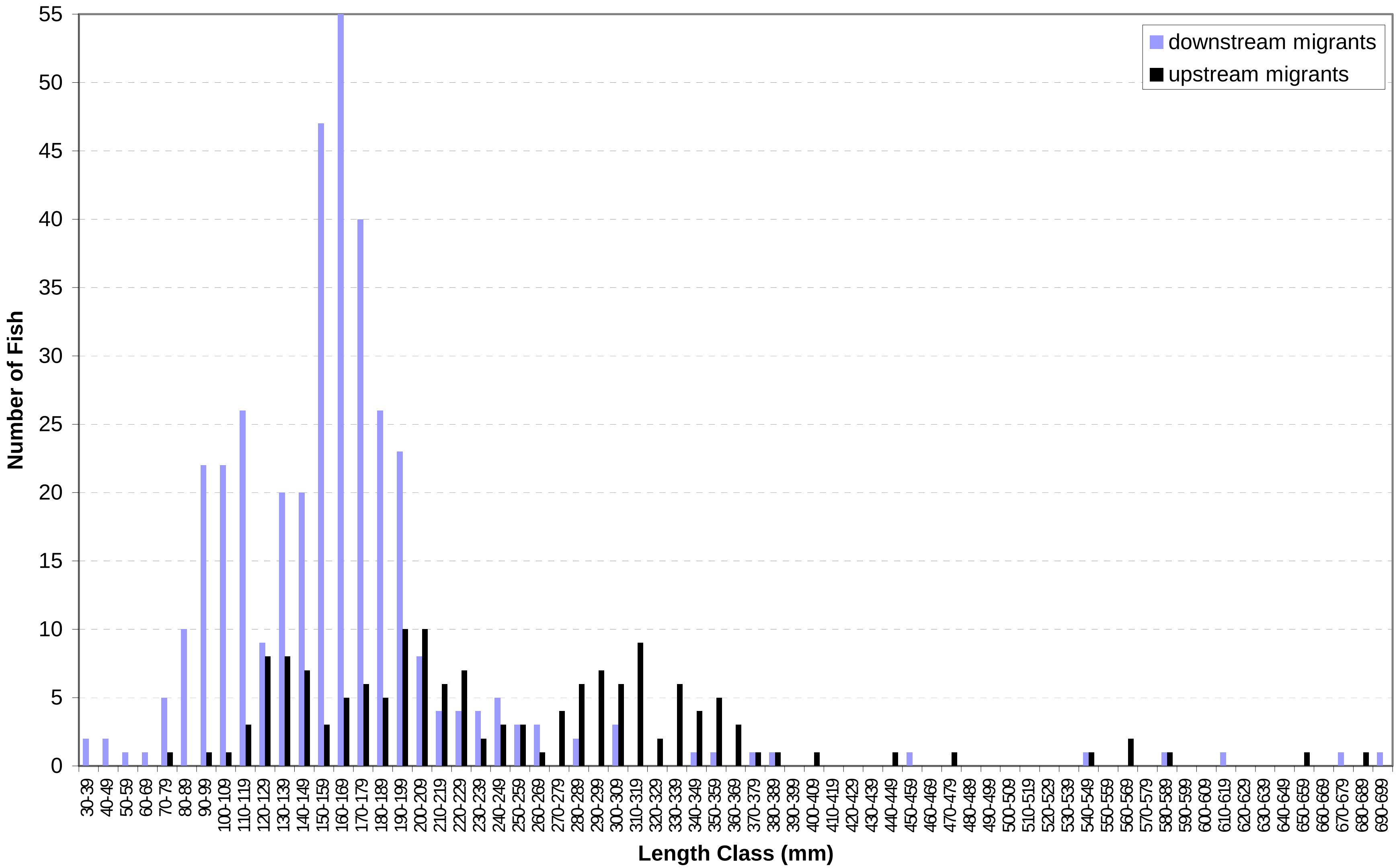


Figure 5-3. 1996-2004 Salsipuedes Creek upstream and downstream steelhead/rainbow trout length frequency (Note: total number per length class throughout the time period. (Source: CPWA 2005))

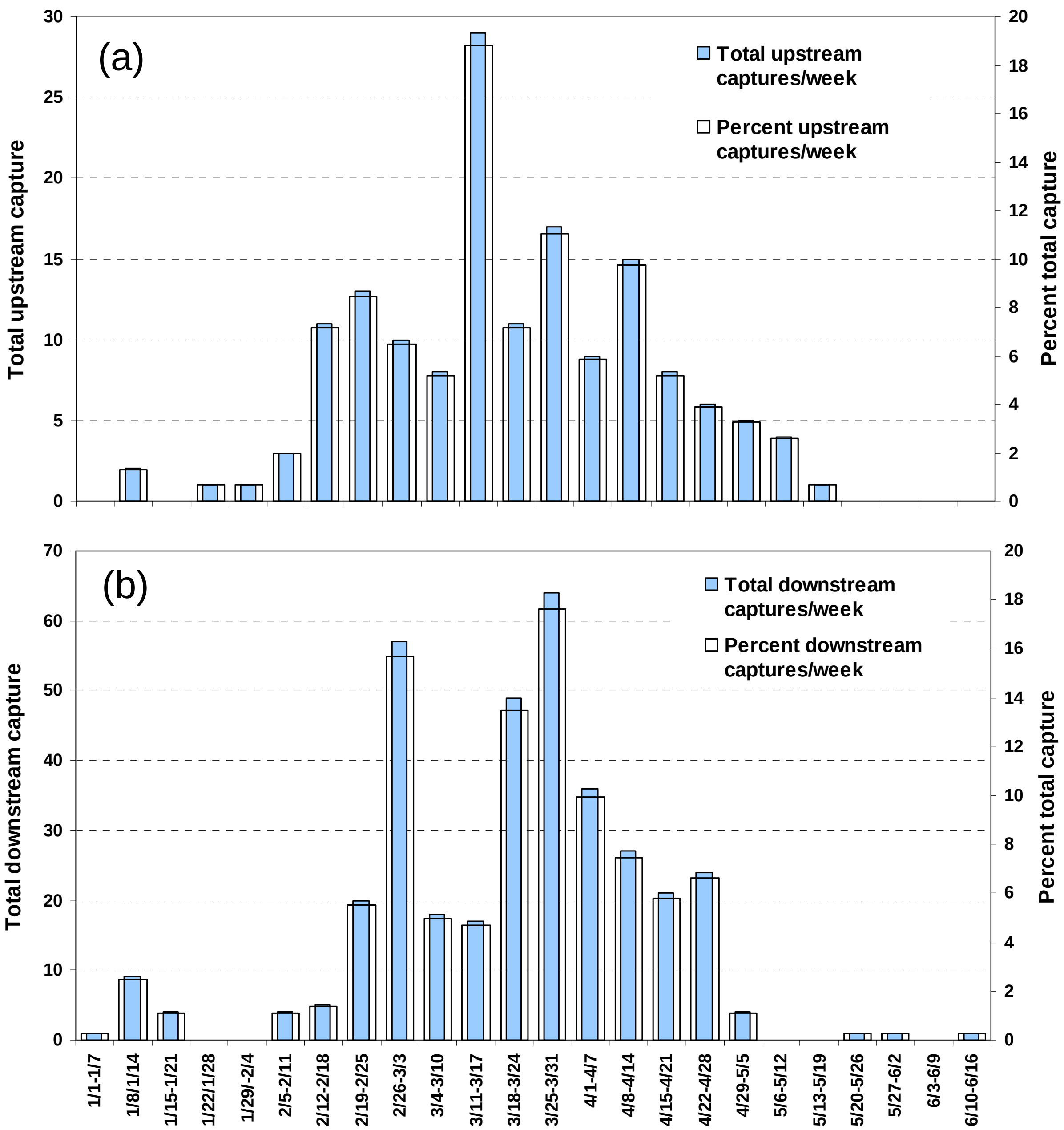


Figure 5-4. **Salsipuedes Creek total upstream and downstream captures and as percent total capture 1996-2004 by week. (a) Upstream migration totals; (b) Downstream migration totals**

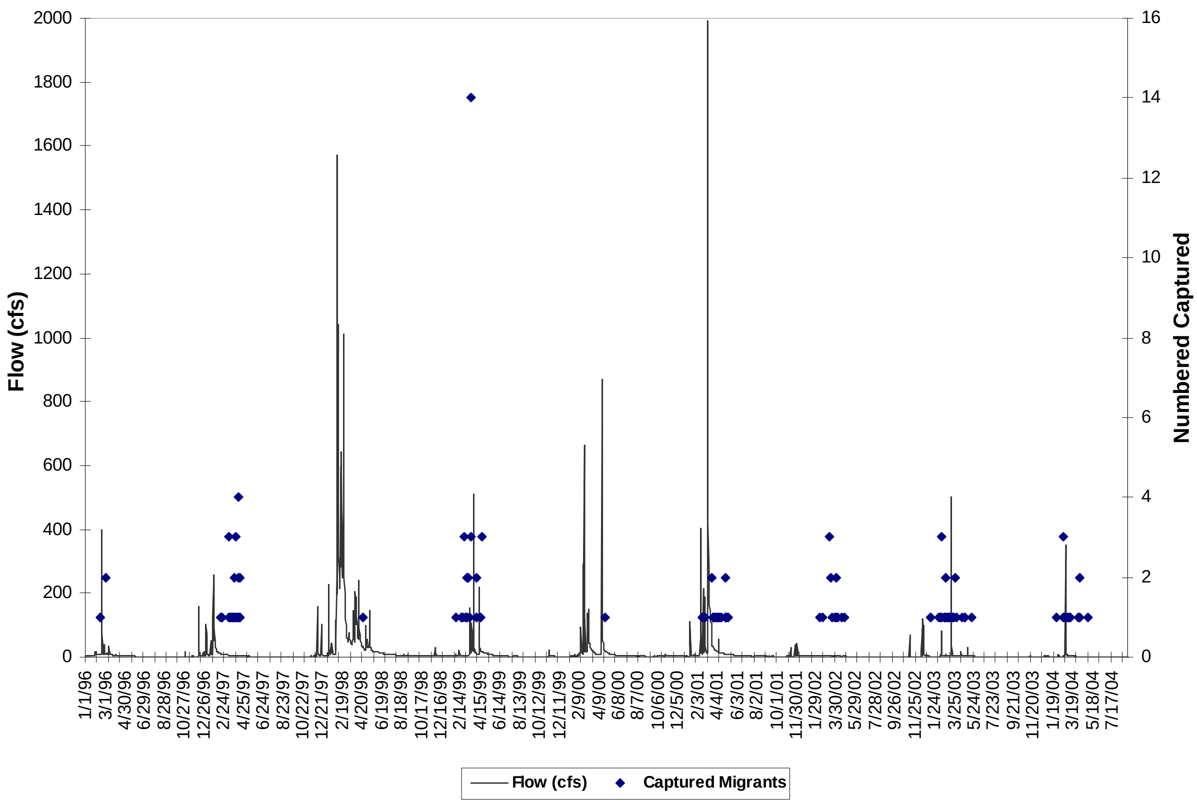


Figure 5-5. 1996-2004 comparison of flow and upstream migrant captures in Salsipuedes Creek

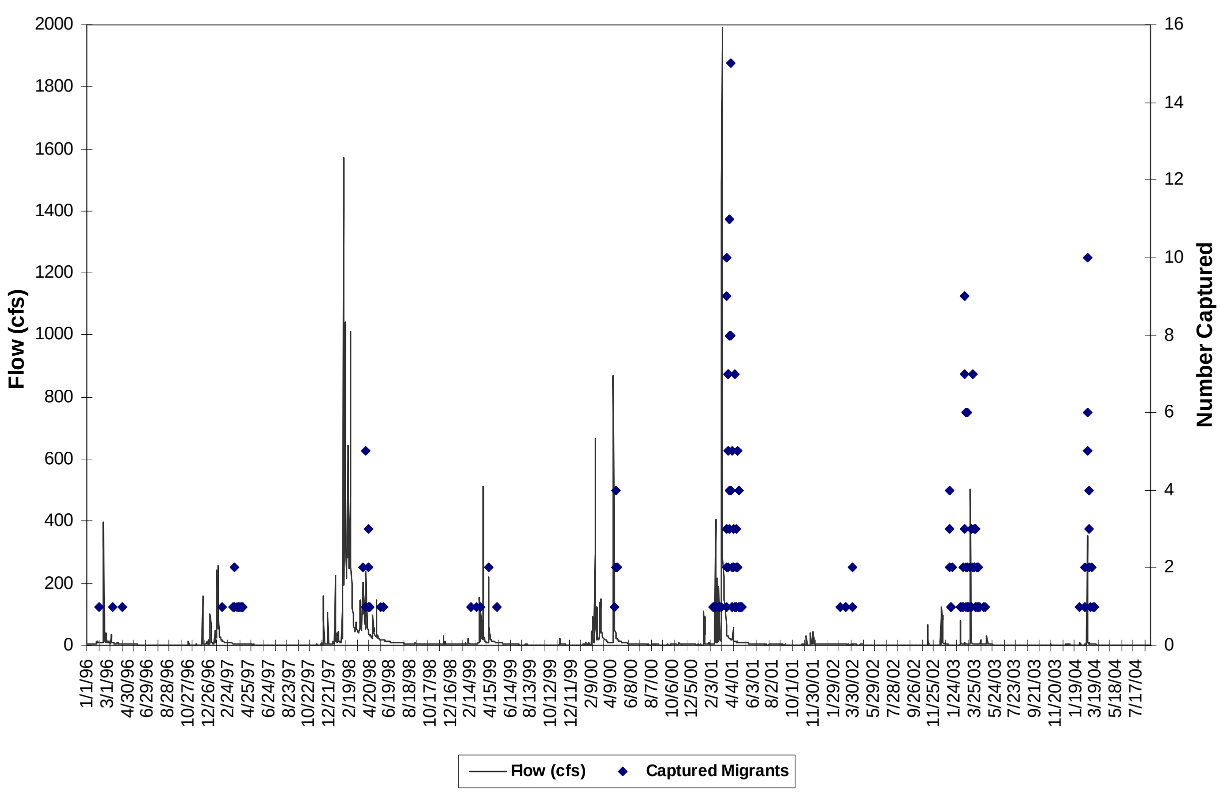


Figure 5-6. 1996-2004 comparison of flow and downstream migrant captures in Salsipuedes Creek

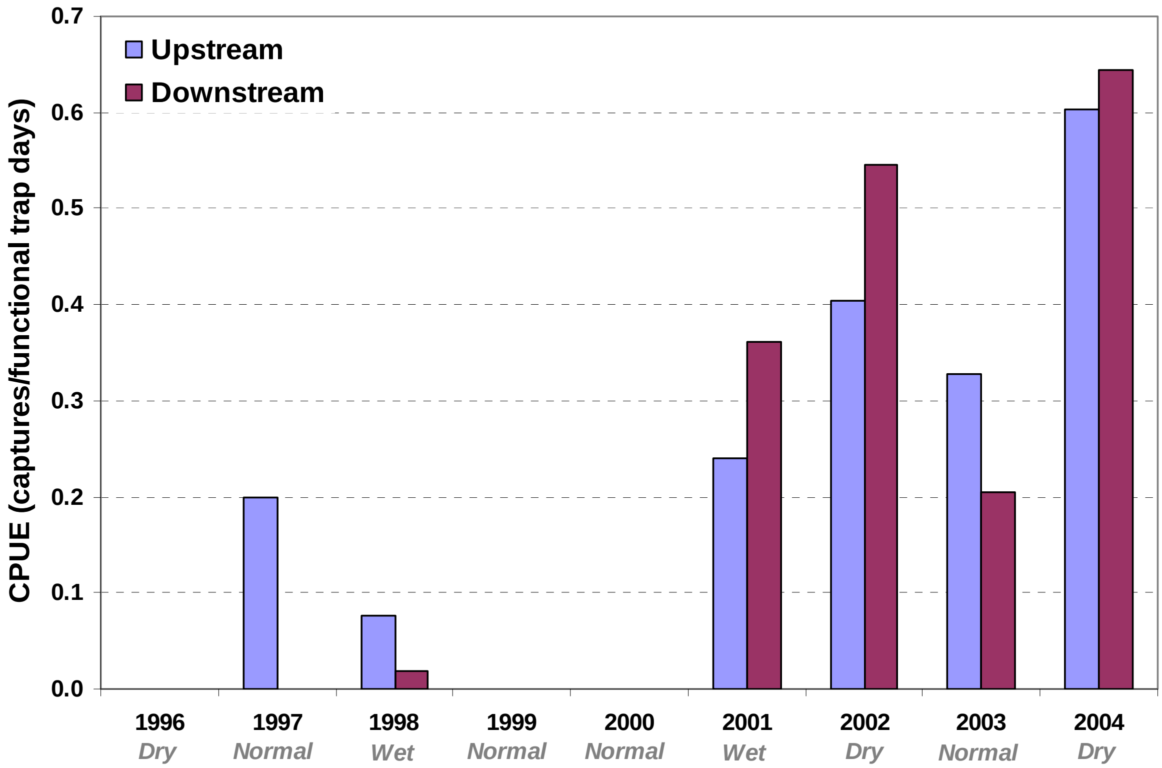


Figure 5-7. Relationship over Time between CPUE per day for Upstream and Downstream Traps within Hilton Creek (Note: Water Year Type: dry years <15" of rainfall, normal years = 15"-22" of rainfall, wet years = >22" of rainfall, Section 2)

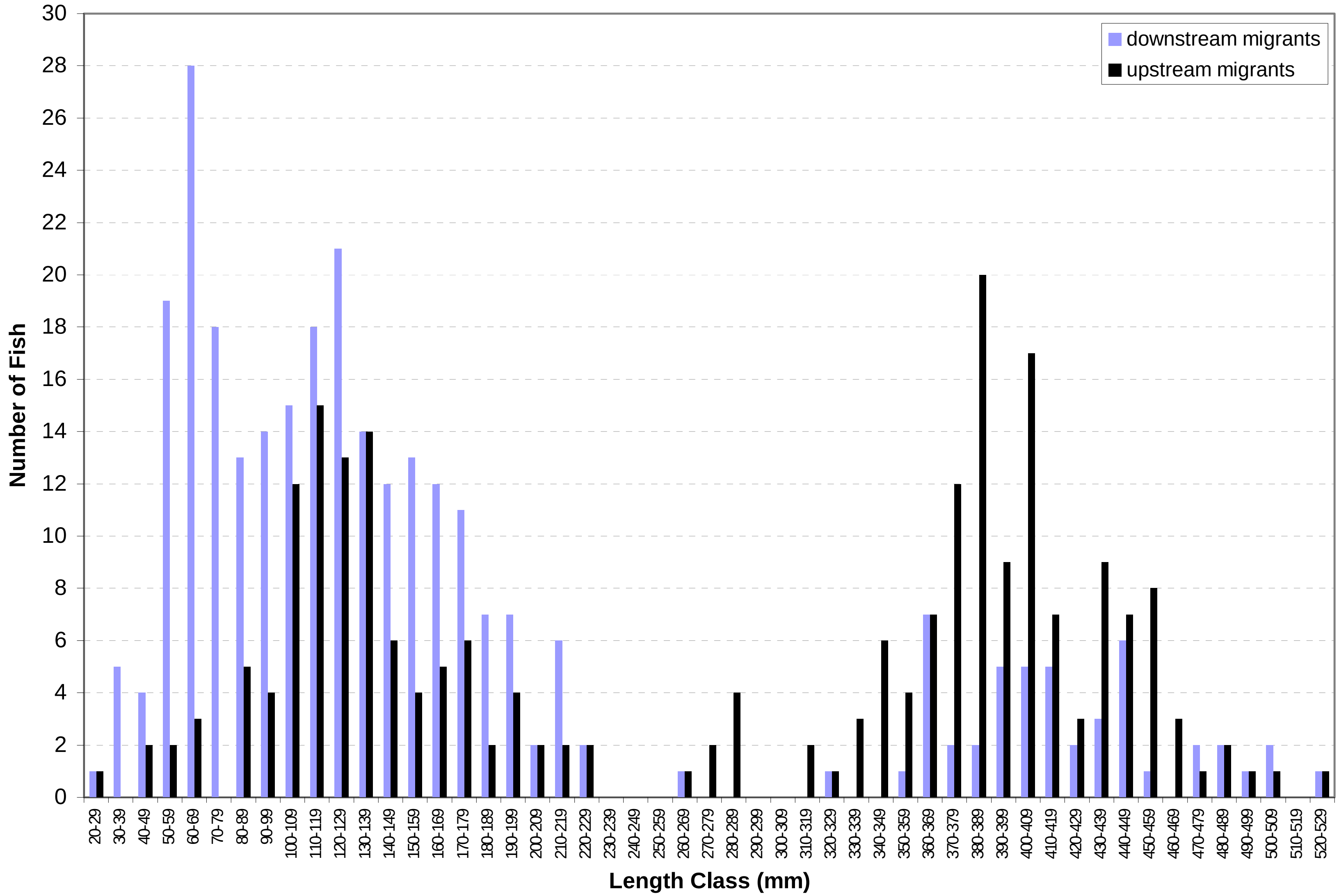


Figure 5-8. **1996-2004 Hilton Creek Upstream and Downstream Steelhead/Rainbow Trout Length Frequency (Note: Total Number per Length Class throughout the Time Period (Source: CPWA 2005))**

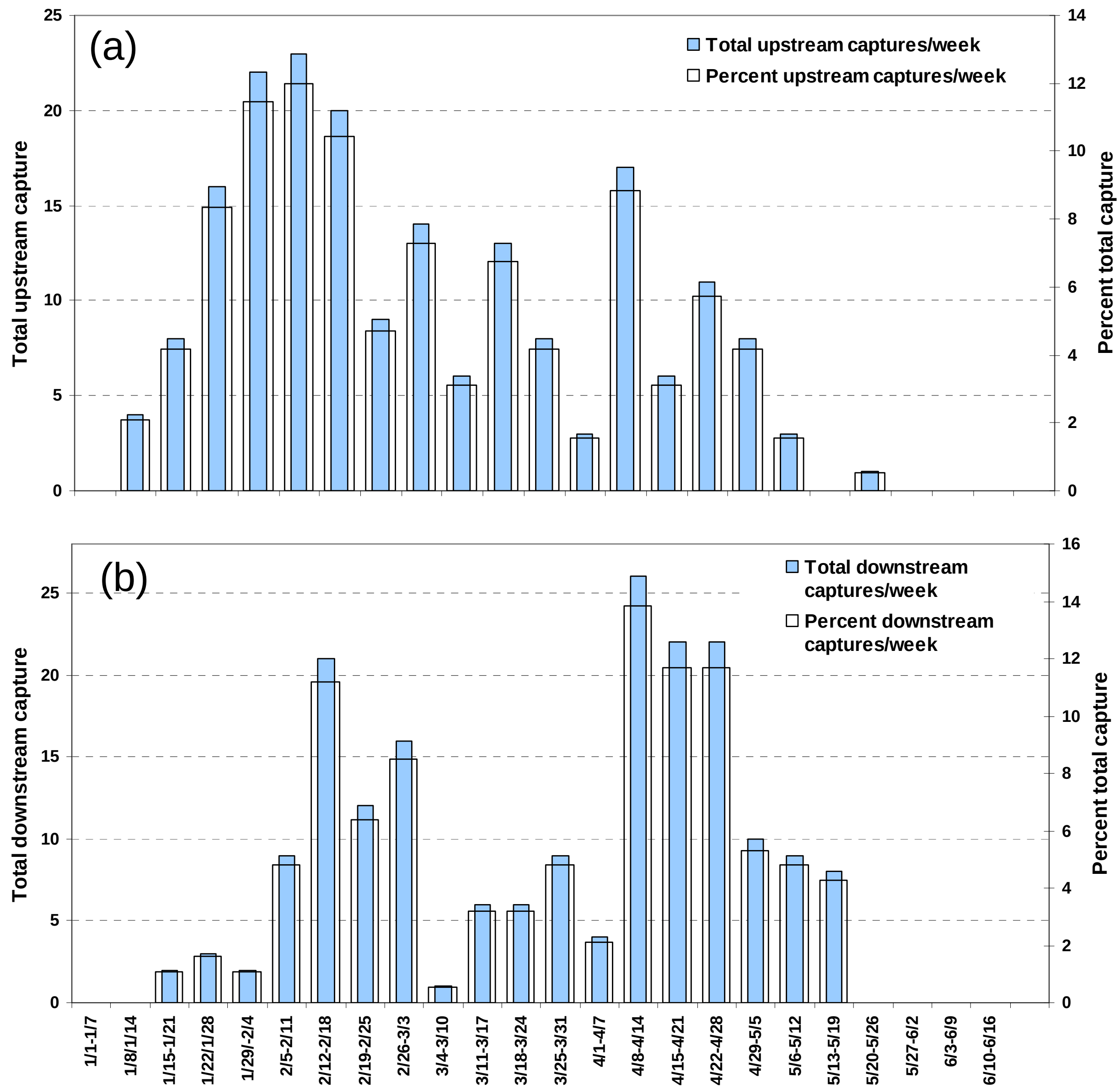


Figure 5-9. **Hilton Creek total upstream and downstream captures as well as percent total capture 1996-2004 by week. (a) Upstream migration totals; (b) Downstream migration totals**

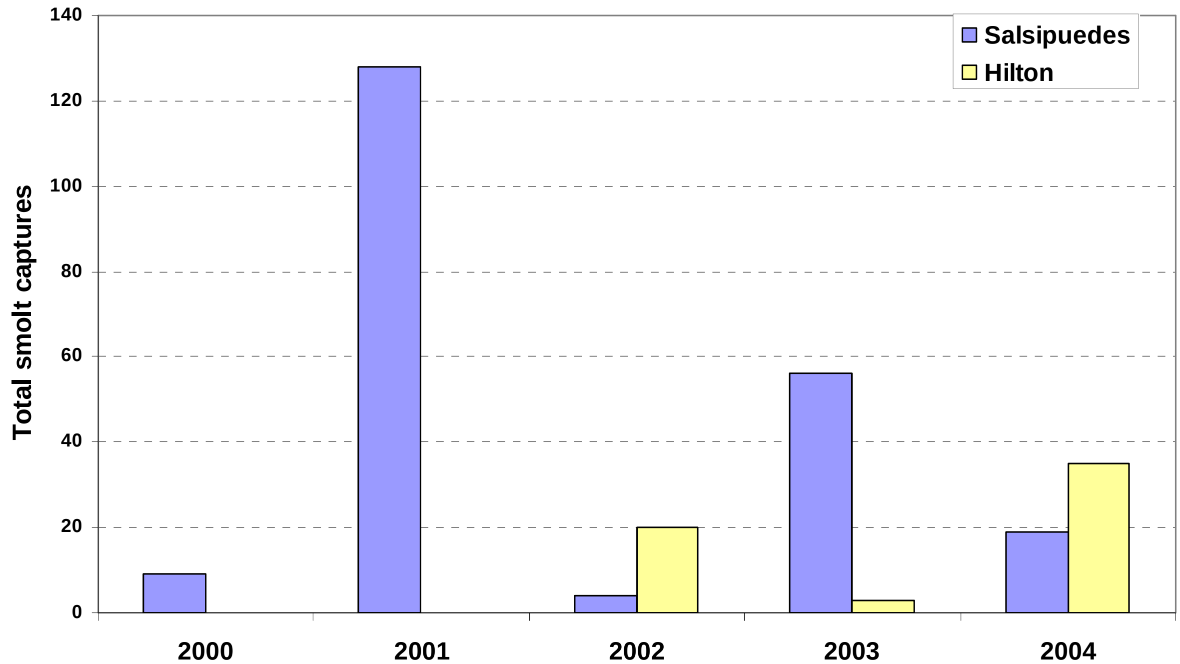


Figure 5-10. **Juvenile steelhead/rainbow trout captures from 2000 through 2004 that showed smolting characteristics. The year range shown reflects the year prior to and all years after the installation of the HCWS. (Source: CPWA 2004)**

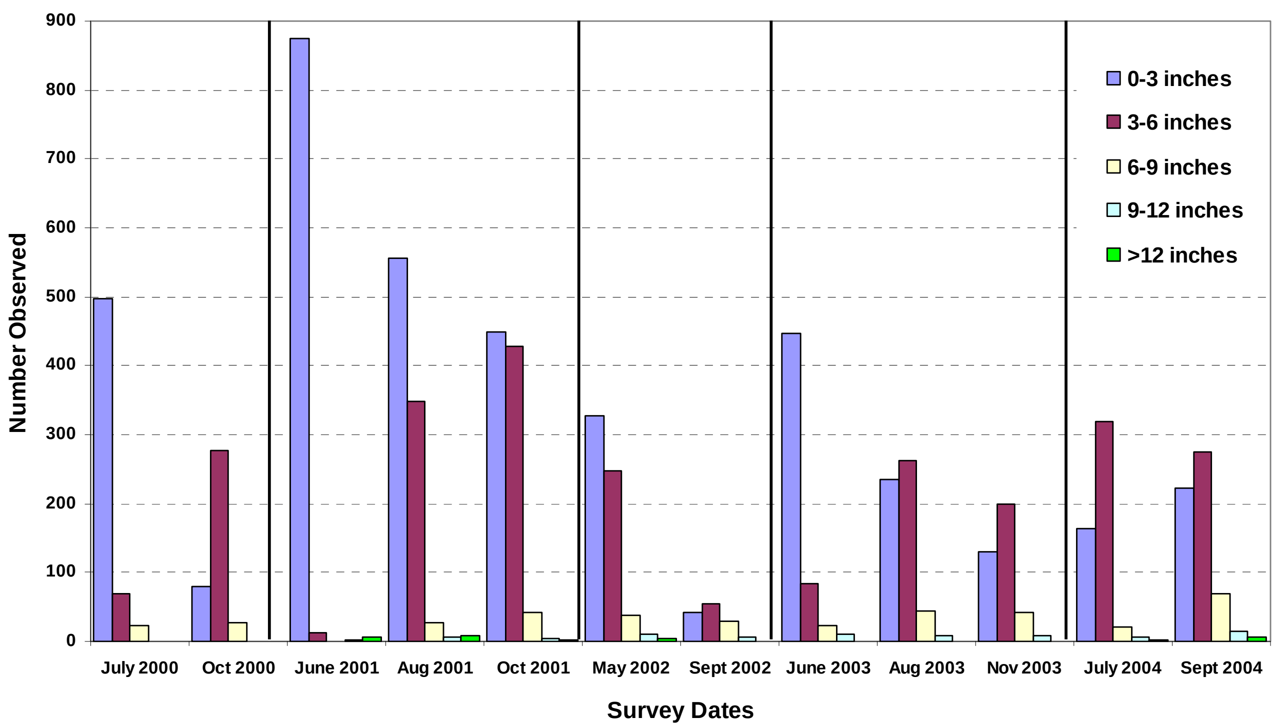


Figure 5-11. **Numbers and size ranges of steelhead/rainbow trout observed during snorkel surveys within lower Hilton Creek. (Source: CPWA 2004)**

Table 5-1. Migrant trapping in LSYR mainstem and tributaries, 1994-2004

Stream	Year										
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Hilton Creek	U	U/D	U	U/D	U/D	U/D	U/D	U/D	U/D	U/D	U/D
Quiota Creek		U/D									
Alamo Pintado Creek				D							
Alisal Creek		U/D									
Nojoqui Creek		U/D		D	U/D						
Salsipuedes Creek	U/D	U/D	U/D	U/D	U/D	U/D	U/D	U/D	U/D	U/D	U/D
San Miguelito Creek				D	D	D	D				
LSYR Mainstem – Alisal Reach			U/D	U/D							

Footnote:

U = Upstream; D = Downstream
Blank = Not trapped
Trapping locations on Figure 5-1

Table 5-2. Steelhead/rainbow trout migrant trapping effort, 1994-2004

Year	Traps (U, D)	Location	Beginning Date	End Date	Trapping Period (Days)	Functional Trap Days
1994	U	Hilton Creek	1/19/1994	4/21/1994	94	N/A - NF
1995	U, D	Hilton Creek	1/16/1995	4/19/1995	95	N/A - NF
1996	U	Hilton Creek	2/23/1996	2/25/1996	3	3
1997	U, D	Hilton Creek	1/23/1997	5/9/1997	108	55
1998	U, D	Hilton Creek	3/26/1998	6/1/1998	68	53
1999	U, D	Hilton Creek	3/26/1999	4/16/1999	22	12
2000	U, D	Hilton Creek	2/24/2000	4/22/2000	59	14
2001	U, D	Hilton Creek	1/12/2001	5/13/2001	123	84
2002	U, D	Hilton Creek	1/30/2002	5/8/2002	100	100
2003	U, D	Hilton Creek	1/9/2003	5/21/2003	134	123
2004	U, D	Hilton Creek	1/20/2004	5/20/2004	122	121
1995	U, D	Quiota Creek	2/2/1995	2/22/1995	21	2*
1997	D	Alamo Pintado Creek	2/1/1997	4/5/1997	65	49
1995	U, D	Alisal Creek	1/18/1995	2/7/1995	21	21*
1995	U, D	Nojoqui Creek	2/25/1995	4/24/1995	60	33
1997	D	Nojoqui Creek	1/27/1997	3/9/1997	43	20
1998	U, D	Nojoqui Creek	3/30/1998	6/1/1998	64	48
1994	U, D	Salsipuedes Creek	3/3/1994	4/21/1994	50	44
1995	U, D	Salsipuedes Creek	10/20/1994	6/22/1995	247	N/A
1996	U, D	Salsipuedes Creek	2/9/1996	7/1/1996	144	137
1997	U, D	Salsipuedes Creek	1/5/1997	5/31/1997	146	135
1998	U, D	Salsipuedes Creek	3/30/1998	7/1/1998	94	79
1999	U, D	Salsipuedes Creek	12/30/1998	6/28/1999	180	162
2000	U, D	Salsipuedes Creek	1/4/2000	6/30/2000	178	94
2001	U, D	Salsipuedes Creek	1/29/2001	5/26/2001	119	89
2002	U, D	Salsipuedes Creek	1/29/2002	5/8/2002	101	101
2003	U, D	Salsipuedes Creek	1/9/2003	5/20/2003	133	118
2004	U, D	Salsipuedes Creek	1/20/2004	5/20/2004	122	117
1997	D	San Miguelito Creek	2/22/1997	5/29/1997	98	98
1998	D	San Miguelito Creek	4/6/1998	6/1/1998	57	44
1999	D	San Miguelito Creek	1/1/1999	6/28/1999	180	169
2000	D	San Miguelito Creek	1/5/2000	1/26/2000	22	17
2000	D	San Miguelito Creek	4/19/2000	6/13/2000	56	56
1996	U, D	Mainstem-Alisal Reach	2/29/1996	5/1/1996	63	N/A-NF
1997	U, D	Mainstem Alisal Reach	1/3/1997	5/31/1997	150	150

Note:
U = upstream
D = downstream
* = removed at the request of the landowner
NF = Insufficient flow
N/A= none, see above

Source:
SYRTAC 1997; CPWA 2005

Table 5-3. Snorkel survey locations and characteristics, 1993-2004

Reach	Study Site Location (Miles)	Notes
Santa Ynez Mainstem (upstream to downstream)		
Highway 154	0.0 - 0.7	Spilling Basin, Long Pool, BOR boundary; confluence with Hilton Creek; Long Pool = 1200 feet long, 2 - 10 feet deep at Mile 0.5
	3.2	Small site downstream of Highway 154 Bridge with access via Caltrans easement
Refugio	5.0 - 7.8	Meadowlark Crossing/Upper Gainey; parts of reach have intermittent summer flow
Alisal	7.8-10.5	Includes confluence with Quiota and Alamo Pintado creeks; parts of reach have intermittent summer flow
Weister/Sanford	19.0-19.3	Approximately ½ mile upstream of Sanford Property
Cadwell	22.1-22.7	Also known as Santa Rosa Park
Cargasacchi	26.1-26.7	Near Sweeney Road Crossing; surveyed only in 1997
Tributaries (miles upstream of Santa Ynez River confluence)		
Hilton Creek	0.0-0.35	Supplemental flows allow for survey
Quiota Creek	2.7-2.83	Summer pool habitat
Nojoqui Creek	0.9-3.2	1998 survey only
Lower Salsipuedes	0.0-4.0	Access restricted in 2001, limited access below confluence with El Jaro
Upper Salsipuedes	4.0-5.1	1.1 miles upstream surveyed. Access denied in 2002
El Jaro	0.0-0.9	Post 2002, survey is limited to lower 0.6 miles. Access granted on 12/04

Source: CPWA 2005

Reach boundaries are presented in Figure 1-2

Table 5-4. Lagoon Trap Designs Used During 1993-1999[1]

Method	Number of Traps	Years Used	Dimensions (H-W-L In Feet)	Mesh Size	Lead Lines	Anchors
Beach Seine[3]	1[2]	1993[3]	50 foot long bag seine deployed by boat	Not Available	Yes	N/A
Beach Seine[3]	1[2]	1994[3]	50 foot long bag seine deployed by boat, 5' deep	0.125 inch	Yes	N/A
Large Onieda fyke	1	1997	N/A	0.5 inch	25 foot	10 pound anchor and t-posts
	3	1998-1999	N/A			
Small fyke	1	1997	3 x 6 x 8	0.25 inch	N/A	t-post
Hoop trap	1	1997	3:1 diameter opening	0.125 inch	25 foot	t-post
Two-box trap	2	1997	N/A	N/A	No	t-post

Notes:
[1]No trapping has been conducted in the lagoon since 1999 due to take concerns of USFWS regarding the presence of the federally endangered tidewater goby.
[2]The take limit for tidewater goby was exceeded in the first pass so sampling discontinued thereafter.
[3]During the early years of monitoring, trapping was conducted on a pilot-study scale and thus, these methods have not been employed throughout the duration of the program.

Source: SYRTAC 1993; CPWA 2005

Table 5-5. Aquatic Species in the LSYR and its Tributaries, Including Native and Introduced Species Collected and/or Observed in the Santa Ynez River Downstream of Bradbury Dam

Common Name	Scientific Name
FISH-Native	
Pacific herring	*Clupea harengus*
Pacific lamprey	*Lampetra tridentate*
Prickly sculpin	*Cottus asper*
Shiner perch	*Cymatogaster aggregate*
Staghorn sculpin	*Leptocottus armatus*
Starry flounder	*Platichthys stallatus*
Steelhead/Rainbow trout	*Oncorhynchus mykiss*[1]
Threespine stickleback	*Gasterosteus aculeatus*
Tidewater goby	*Eucyclogobius newberry*[1]
Topsmelt	*Atherinops affinis*
FISH-Introduced	
Arroyo chub	*Gila orcutt*[3]
Black bullhead	*Ameiurus melas*
Black crappie	*Pomoxis nigromaculatus*
Bluegill	*Lepomis macrochirus*
Carp	*Cyprinus carpio*
Channel catfish	*Ictalurus punctatus*
Fathead minnow	*Pimephales promelas*
Goldfish	*Carassius auratus*
Green sunfish	*Lepmois cyanellus*
Largemouth bass	*Micropterus salmoides*
Mosquitofish	*Gambusia affinis*
Redear sunfish	*Lepomis microlophus*
Smallmouth bass	*Micropterus dolomieui*
AMPHIBIANS-Native	
California Newt	*Taricha torosa*
California Tree Frog	*Pseudachis cadaveri*
Red-Legged Frog	*Rana-aurora draytonii*[2]
Southwestern Pond Turtle	*Clemmys marmorata*[3]
AMPHIBIANS-Introduced	
Bullfrog	*Rana catesbeiana*
CRUSTACEANS-Introduced	
Crayfish	*Procambarus spp.*
MAMMALS-Introduced	
American Beaver	*Castor Canadensis*

Notes:
[1]Endangered species under the Federal ESA
[2]Threatened species under the Federal ESA
[3]California Species of Special Concern

Source: CPWA 2005 data

Table 5-6. Trapping Dates in Salsipuedes Creek, 1994-2004

Year	Date Trap First Installed	Date Trap Removed	Total Number of Trap Days	Date Removed Before Storm Event	Date Installed Following Storm Event	Number of Days Not Trapping	Total Number of Functional Trap Days	Percent of Time Trap was Functioning	Yearly Amount of Rainfall (inches)	Water-Year Type[1]
1994[2]	4/6/1994	7/1/1994	86	No storms	No storms	0	86	100%	17.4	Normal
	10/20/1994	12/27/1994	68	No storms	No storms	0	68	100%		
1995[2]	1/4/1995	7/1/1995	178	N/A	N/A	N/A	N/A	N/A	45.6	Wet
1996	2/9/1996	7/1/1996	144	2/19/1996	2/24/1996	5	137	95%	13.4	Dry
				2/27/1996	2/28/1996	1				
				3/4/1996	3/5/1996	1				
1997	1/5/1997	5/31/1997	146	1/14/1996	1/16/1996	2	135	92%	15.7	Normal
				1/20/1997	1/29/1997	9				
1998	3/30/1998	7/1/1998	94	4/11/1998	4/15/1998	4	79	84%	53.7	Wet
				5/2/1998	5/8/1998	6				
				5/11/1998	5/16/1998	4				
				5/28/1998	5/29/1998	1				
1999	12/30/1998	6/28/1999	180	1/15/1999	1/20/1999	5	162	90%	16.7	Normal
				1/23/1999	1/25/1999	2				
				2/8/1999	2/10/1999	2				
				3/14/1999	3/16/1999	2				
				3/18/1999	3/21/1999	3				
				3/25/1999	3/27/1999	2				
				4/10/1999	4/12/1999	2				
2000	1/4/2000	6/30/2000	178	1/26/2000[3]	4/20/2000	84	94	53%	21.5	Normal
2001	1/29/2001	5/26/2001	119	2/11/2001	2/15/2001	4	91	76%	31.8	Wet
				2/19/2001	2/27/2001	9				
				3/3/2001	3/16/2001	13				
				4/6/2001	4/8/2001	2				
2002	1/29/2002	5/8/2002	101			0	101	100%	8.8	Dry
2003	1/9/2003	5/20/2003	133	2/11/2003	2/17/2003	6	118	89%	19.8	Normal
				2/24/2003	2/25/2003	1				
				3/14/2003	3/17/2003	3				
				4/12/2003	4/14/2003	2				
				5/1/2003	5/4/2003	3				
2004	1/20/2004	5/20/2004	122	2/2/2004	2/3/2004	1	117	96%	10.6	Dry
				2/21/2004	2/23/2004	2				
				2/24/2004	2/26/2004	2				

Notes:
[1]Water Year Type: dry years <15" of rainfall, normal years = 15"-22" of rainfall, wet years = >22" of rainfall.
[2]1994 and 1995 were pilot study years with a level of effort not comparable to 1996-2004, therefore results are not included in the following analysis
[3]Trapping suspended due to regulatory agency permitting.
N/A: Not Available – Storm data for 1995 was not recorded specifically when the traps were removed due to high flows.

Table 5-7. 1996-2004 Catch-Per-Unit Effort (CPUE[1]) for Upstream and Downstream Migrant Steelhead/Rainbow Trout Captures within Salsipuedes Creek

Year	Number of Upstream Captures	Number of Downstream Captures	Functional Trap Days	Trap Season	Trapping Efficiency (%)	CPUE Upstream (captures /day)	CPUE Downstream (captures/ day)	CPUE (Captures/ Season) (captures/ day)	CPUE (Captures/ Functional Period) (captures/ day)	Water-Year Type
1996	3	3	137	144	95	0.02	0.02	0.04	0.04	Dry
1997	31	13	135	146	92	0.23	0.10	0.30	0.33	Normal
1998	1	17	79	94	84	0.01	0.22	0.19	0.23	Wet
1999	40	7	162	180	90	0.25	0.04	0.26	0.29	Normal
2000	1	10	94	178	53	0.01	0.11	0.06	0.12	Normal
2001	22	160	91	119	76	0.24	1.76	1.53	2.00	Wet
2002	14	6	101	101	100	0.14	0.06	0.20	0.20	Dry
2003	26	108	118	133	89	0.22	0.92	1.01	1.14	Normal
2004	18	40	117	122	96	0.15	0.34	0.48	0.50	Dry

[1]CPUE = Number of fish captured divided by total functional trap days, which equals the total number of fish captured per day of effort

Table 5-8. 1996-2004 Hilton Creek Upstream and Downstream Migrant Trap Removal and Installation Dates

Year	Date Trap First Installed	Date Trap Removed	Total Number of Trap Days	Date Removed Before Storm Event	Date Installed Following Storm Event	Number of Days Not Trapping	Total Number of Functional Trap Days	Percent of Time Trap was Functioning	Yearly Amount of Rainfall (inches)	Water Year Type[1]
1995[2]	1/20/1995	5/19/1995	119	N/A	N/A	N/A	N/A	N/A	45.6	Wet
1996	2/23/1996	2/25/1996	3			0	3	100%	13.4	Dry
1997	1/23/1997	5/9/1997	108	2/8/1997	4/2/1997	53	55	51%	15.7	Normal
1998	3/26/1998	6/1/1998	68	3/31/1998	4/2/1998	2	53	78%	53.7	Wet
				4/12/1998	4/12/1998	1				
				5/2/1998	5/13/1998	11				
				5/28/1998	5/29/1998	1				
1999	3/26/1999	4/16/1999	22	3/28/1999	4/7/1999	10	12	55%	16.7	Normal
2000	2/24/2000	4/22/2000	59	2/26/2000	2/27/2000	1	14	24%	21.5	Normal
				2/29/2000	3/6/2000	6				
				3/11/2000	4/18/2000	38				
2001	1/12/2001	5/13/2001	123	1/13/2001	1/29/2001	16	84	68%	31.8	Wet
				1/30/2001	2/6/2001	7				
				2/9/2001	2/14/2001	5				
				2/24/2001	2/25/2001	1				
				3/3/2001	3/13/2001	10				
2002	1/30/2002	5/8/2002	100			0	100	100%	8.8	Dry
2003	1/9/2003	5/21/2003	134	2/11/2003	2/13/2003	2	123	92%	19.8	Normal
				2/24/2003	2/25/2003	1				
				3/14/2003	3/16/2003	2				
				4/12/2003	4/15/2003	3				
				5/1/2003	5/4/2003	3				
2004	1/20/2004	5/20/2004	122	2/2/2004	2/3/2004	1	121	99%	10.6	Dry

Notes:
[1]Water Year Type: dry years <15” of rainfall, normal years = 15”-22” of rainfall, wet years = >22” of rainfall.

[2]1994 and 1995 were pilot study years with a level of effort not comparable to 1996-2004, therefore results are not included in the following analysis
[3]Trapping suspended due to regulatory agency permitting.

N/A: Not Available – Storm data for 1995 was not recorded specifically when the traps were removed due to high flows.

Table 5-9. 1996-2004 Catch-Per-Unit Effort (CPUE[1]) for Upstream and Downstream Migrant Steelhead/Rainbow Trout Captures within Hilton Creek

Year	Number of Upstream Captures	Number of Downstream Captures	Functional Trap Days	Trap Season	Trapping Efficiency (%)	CPUE Upstream (captures/ day)	CPUE Downstream (captures/ day)	CPUE (Captures/ Season) (captures/ day)	CPUE (Captures/ Functional Period) (captures/ day)	Water-Year Type
1996	0	0	3	3	100	0.00	0.00	0.00	0.00	Dry
1997	11	0	55	108	51	0.20	0.00	0.10	0.20	Normal
1998	4	1	53	68	78	0.08	0.02	0.07	0.09	Wet
1999	0	0	9	22	41	0.00	0.00	0.00	0.00	Normal
2000	0	0	14	59	24	0.00	0.00	0.00	0.00	Normal
2001	20	30	83	122	68	0.24	0.36	0.41	0.60	Wet
2002	40	54	99	99	100	0.40	0.55	0.95	0.95	Dry
2003	40	25	122	133	92	0.33	0.20	0.49	0.53	Normal
2004	73	78	121	122	99	0.60	0.64	1.24	1.25	Dry

[1]CPUE = Number of fish captured divided by total functional trap days, which equals the total number of fish captured per day of effort

Table 5-10. Adult (> 6 inches) and Juvenile (< 6 inches) Steelhead/Rainbow Trout Observed During Snorkel Surveys in the LSYR Mainstem, 1995-2004

Survey Date		154 Reach (LSYR 0.2-0.7)	Long Pool (LSYR 0.5)	Refugio (LSYR 5.0-7.8)	Alisal (LSYR 7.8-10.5)	Weister/ Sanford (LSYR 19.0-19.3)	Cadwell (LSYR 22.1-22.7)	Cargasacchi (LSYR 26.1-26.7)
August 1995	Adult	84	79	43	20	-	-	0
	Juvenile	89	6	9	14	-	-	0
September 1995	Adult	72	64	4	27	-	-	0
	Juvenile	42	1	0	0	-	-	0
October 1995	Adult	52	48	10	37	-	-	0
	Juvenile	48	0	0	2	-	-	0
November 1995	Adult	0	-	17	38	-	-	0
	Juvenile	0	-	0	0	-	-	0
December 1995	Adult	-	-	14	31	-	-	0
	Juvenile	-	-	0	0	-	-	0
January 1996	Adult	-	-	14	29	-	-	0
	Juvenile	-	-	8	0	-	-	0
May 1996	Adult	14	-	0	26	-	-	0
	Juvenile	0	-	0	5	-	-	0
June 1996	Adult	30	-	0	31	-	-	0
	Juvenile	0	-	0	0	-	-	0
July 1996	Adult	-	P	0	13	-	-	-
	Juvenile	-	P	0	0	-	-	-
August 1996	Adult	20	P	1	-	-	-	0
	Juvenile	0	P	0	-	-	-	0
June 1997	Adult	-	P	0	0	0	-	0
	Juvenile	-	P	0	0	0	-	0
October 1997	Adult	0	-	-	-	-	-	-
	Juvenile	0	-	-	-	-	-	-
July 1998	Adult	14	10	34	25	-	6	-
	Juvenile	346	58	229	229	-	1	-
August 1998	Adult	-	-	13	6	-	-	0
	Juvenile	-	-	213	295	-	-	0
September 1998	Adult	60	55	-	-	-	-	-
	Juvenile	241	22	-	-	-	-	-
June 1999	Adult	11	44	-	-	-	-	-
	Juvenile	8	0	-	-	-	-	-
July 1999	Adult	-	-	9	51	-	-	-
	Juvenile	-	-	0	3	-		-
October 1999	Adult	-	-	0	0	-	-	-
	Juvenile	-	-	0	2	-	-	-
June 2000	Adult	-	P	0	2	-	-	-
	Juvenile	-	P	0	7	-	-	-
July 2000	Adult	0	8	-	5	-	-	-
	Juvenile	8	10	-	5	-	-	-
August 2000	Adult	-	-	-	2	-	-	-
	Juvenile	-	-	-	2	-	-	-
September 2000	Adult	0	-	0	0	-	-	-
	Juvenile	0	-	0	0	-	-	-
June 2001	Adult	1	19	14	10	-	-	-
	Juvenile	29	1	133	113	-	-	-

Table 5-10. Adult (> 6 inches) and Juvenile (< 6 inches) Steelhead/Rainbow Trout Observed During Snorkel Surveys in the LSYR Mainstem, 1995-2004

Survey Date		154 Reach (LSYR 0.2-0.7)	Long Pool (LSYR 0.5)	Refugio (LSYR 5.0-7.8)	Alisal (LSYR 7.8-10.5)	Weister/ Sanford (LSYR 19.0-19.3)	Cadwell (LSYR 22.1-22.7)	Cargasacchi (LSYR 26.1-26.7)
August 2001	Adult	1	P	-	-	-	-	-
	Juvenile	37	P	-	-	-	-	-
September 2001	Adult	-	-	-	2	-	-	-
	Juvenile	-	-	-	9	-	-	-
October 2001	Adult	2	P	-	0	-	-	-
	Juvenile	30	P	-	1	-	-	-
November 2001	Adult	-	56	0	1	-	-	-
	Juvenile	-	0	6	0	-	-	-
May 2002	Adult	1	-	-	-	-	-	-
	Juvenile	18	-	-	-	-	-	-
June 2002	Adult	-	19	1	1	0	0	-
	Juvenile	-	0	0	1	0	0	-
September 2002	Adult	24	-	3	3	0	0	-
	Juvenile	2	-	0	0	0	0	-
November 2002	Adult	5	56	2	1	0	0	-
	Juvenile	0	0	0	0	0	0	-
June 2003	Adult	1	0	0	0	0	0	-
	Juvenile	81	9	0	0	0	0	-
August 2003	Adult	3	-	-	-	-	-	-
	Juvenile	25	-	-	-	-	-	-
September 2003	Adult	0	-	-	-	-	-	-
	Juvenile	0	-	-	-	-	-	-
November 2003	Adult	0	15	-	-	-	-	-
	Juvenile	3	0					
July 2004	Adult	-	-	0	0	-	0	-
	Juvenile	-	-	0	0	-	0	-
August 2004	Adult	-	-	0	0	-	-	-
	Juvenile	-	-	0	0	-	-	-
September 2004	Adult	0	P	-	-	0	0	-
	Juvenile	1	P	-	-	0	0	-
October 2004	Adult	-	-	0	0	-	-	-
	Juvenile	-	-	0	0	-	-	-
December 2004	Adult	P	P	0	0	0	0	-
	Juvenile	P	P	0	0	0	0	-

Notes:
dash (-) indicates no survey conducted
P = Present
Please refer to Figure 5-1 for snorkel locations
Source: CPWA 2005

Table 5-11. Adult (> 6 inches) and Juvenile (< 6 inches) Steelhead/Rainbow Trout Observed During Snorkel Surveys in the LSYR Tributaries, 1995-2004

Survey Date		Adult and Juvenile Steelhead/Rainbow Trout					
		Salsipuedes					
		Lower	Upper	Hilton	Quiota	Nojoqui	El Jaro
May 1995	Adult	-	-	25	-	-	-
	Juvenile	-	-	224	-	-	-
September 1995	Adult	0	-	-	-	0	-
	Juvenile	21	-	-	-	0	-
November-December 1996	Adult	P	P	0	-	-	P
	Juvenile	P	P	0	-	-	P
June 1997	Adult	189	1	-	-	-	9
	Juvenile	54	59	-	-	-	83
October 1997	Adult	32	-	13	-	1	223
	Juvenile	0	-	7	-	0	0
July 1998	Adult	94	-	4	0	-	-
	Juvenile	11	-	300	0	-	19
July 1999	Adult	7	0	-	-	-	25
	Juvenile	33	43	-	-	-	12
November 1999	Adult	33	0	-	-	-	12
	Juvenile	18	0	-	-	-	0
June 2000	Adult	-	-	-	6	-	-
	Juvenile	-	-	-	61	-	-
July 2000	Adult	-	-	18	-	-	-
	Juvenile	-	-	436	-	-	-
August-September 2000	Adult	55	0	-	8	-	-
	Juvenile	P	P	-	79	-	-
June 2001	Adult	454	31	225	2	-	0
	Juvenile	50	520	888	271	-	61
August 2001	Adult	-	-	415	-	-	1
	Juvenile	-	-	909	-	-	18
September 2001	Adult	-	-	575	4	-	-
	Juvenile	-	-	845	164	-	-
October 2001	Adult	-	-	-	3	-	3
	Juvenile	-	-	-	158	-	36
May 2002	Adult	-	-	-	10	-	37
	Juvenile	-	-	-	0	-	0
June 2002	Adult	-	-	51	-	-	0
	Juvenile	-	-	573	-	-	9
September 2002	Adult	-	-	38	-	-	-
	Juvenile	-	-	101	-	-	86 (Ytias Creek)
June 2003	Adult	1	-	34	7	-	4
	Juvenile	17	-	530	42	-	15
July-August 2003	Adult	4	-	54	7	-	-
	Juvenile	33	-	500	41	-	-
September 2003	Adult	5	-	-	-	-	2
	Juvenile	8	-	-	-	-	8
November 2003	Adult	-	-	49	-	-	-
	Juvenile	-	-	332	-	-	-

Table 5-11. Adult (> 6 inches) and Juvenile (< 6 inches) Steelhead/Rainbow Trout Observed During Snorkel Surveys in the LSYR Tributaries, 1995-2004

Survey Date		Adult and Juvenile Steelhead/Rainbow Trout					
		Salsipuedes					
		Lower	Upper	Hilton	Quiota	Nojoqui	El Jaro
July 2004	Adult	-	-	28	6	-	-
	Juvenile	-	-	482	16	-	-
September 2004	Adult	-	-	140	-	-	-
	Juvenile	-	-	906	-	-	-

dash (-) indicates no survey conducted

P = Present

Please refer to Figure 5-1 for snorkel locations

Source: CPWA 2005

Table 5-12. Coincident Observations of Other Species During Steelhead Rainbow Trout Snorkel Surveys in the LSYR and Tributaries, 1997-2004

Species	Year	Reach	Number/Habitat
Smallmouth Bass (*Micropterus dolomieui*)	1997-2004	Mainstem	0-41/year, various
	2001	Mainly Long Pool	248, mostly fry
Largemouth Bass (*Micropterus salmoides*)	1995-2004	Mainstem	10,000/mostly pool
	2000-2002	Hilton	114, juvenile
	1999	Salsipuedes	3, juvenile
Green Sunfish (*Lepomis cyanellus*)	1997-2004	Mainstem	15-99/year, various
	1997-1999	Salsipuedes	27-61
	1998	Nojoqui	1
	2000	Hilton	4, lower Reach
	2001	U/L Salsipuedes	4, 3 upstream
Bluegill (*Lepomis macrochirus*)	2002	Weister and Refugio	4 and 1 respectively
Red-ear Sunfish (*Lepomis microlophus*)	2000	Alisal	4, pools
	2002	Alisal	5, pools
Black Crappie (*Pomoxis nigromaculatus*)	2002	Alisal	2, pool at Refugio Bridge
Bullhead Catfish (*Ictalurus* spp)	1997-2004	Mainstem	Low incidental observations
	2003	Cadwell	401, 1 adult and 400 fry, pool
	1997-1998	Salsipuedes	Not counted, in migrant traps
Channel Catfish (*Ictalurus punctatus*)	2004	Santa Ynez River Found in pool near confluence with Hilton Creek	1, large, stomach with 2 STL/RBT
	1997-2004	Mainstem – mostly Weister	9-173/year, a few large, pools None found in snorkel surveys
Mosquitofish (*Gambusia affinis*)	1997-2004	Mainstem pools, lower Reaches	>25,000 in 1997
	1997-2004	Salsipuedes Creek	Not counted, low numbers in lower Reach
Fathead Minnow (*Pimephales promelus*)	2001	Alisal, Weister, Santa Rosa Park	163, mostly in Weister
	2001	Salsipuedes	175
SW Pond Turtle (*Clemmys marmorata*)	1997-2004	Spill basin, Long Pool, Refugio, Alisal, Salsipuedes, Hilton, Nojoqui, Quiota	Not counted, in permanent pool habitats
Pacific Lamprey *(Lampetra tridentate)*	1995-1996	Hwy 154 Reach below dam and mainstem trap site (Alisal Reach)	2 in 1995; 3 in 1996
Beaver (*Castor canadensis*)	1997-2004	Mainstem, Salsipuedes, El Jaro Creek	Near pool habitats, may create pools
Red-Legged Frog (*Rana-aurora draytonii*)	1997-2004	Salsipuedes, Upper Salsipuedes, El Jaro, San Miguelito, Quiota, Nojoqui	Incidental observations
Bullfrog (*Rana catesbeiana*)	1997-2004	Mainstem, Hilton, Salsipuedes	Increasingly frequent observations in pool habitats in the mainstem
Crayfish (*Procambarus* spp.)	1997-2004	Mainstem, Salsipuedes, Hilton	Incidental observations

Notes:
Prior years of data, 1993-1997, did not collect detailed records for presence of these species.
See Tables 5-13 and 5-14 for additional information on largemouth bass abundance.
Source: CPWA 2005

Table 5-13. Incidental Observations of Adult (>6 inches) and Juvenile Largemouth Bass (<6 inches) during Steelhead/Rainbow Trout Snorkel Surveys in the LSYR Mainstem, 1995-2004

Survey Date		154 Reach (LSYR 0.2-0.7)	Long Pool (LSYR 0.5)	Refugio (LSYR 5.0-7.8)	Alisal (LSYR 7.8-10.5)	Weister/ Sanford (LSYR 19.0-19.3)	Cadwell (LSYR 22.1-22.7)	Cargasacchi (LSYR 26.1-26.7)
August 1995	Adult	0	44	0	8	-	-	1
	Juvenile	24	29	1	104	-	-	195
September 1995	Adult	0	32	0	5	-	-	6
	Juvenile	60	75	0	164	-	-	856
October 1995	Adult	8	35	0	49	-	-	6
	Juvenile	148	27	3	640	-	-	727
November 1995	Adult	0	-	2	39	-	-	1
	Juvenile	19	-	22	178	-	-	557
December 1995	Adult	-	-	7	27	-	-	0
	Juvenile	-	-	9	128	-	-	89
January 1996	Adult	-	-	8	93	-	-	2
	Juvenile	-	-	16	135	-	-	80
May 1996	Adult	33	-	0	50	-	-	17
	Juvenile	434	-	0	25	-	-	114
June 1996	Adult	35	-	0	78	-	-	74
	Juvenile	604	-	0	36	-	-	80
July 1996	Adult	-	P	-	209	-	-	-
	Juvenile	-	P	-	81	-	-	-
August 1996	Adult	60	P	169	-	-	-	42
	Juvenile	167	P	195	-	-	-	3
June 1997	Adult	-	P	18	0	12	-	22
	Juvenile	-	P	42	0	5	-	8
October 1997	Adult	1	-	-	-	-	-	-
	Juvenile	1	-	-	-	-	-	-
July 1998	Adult	0	P	0	0	-	0	-
	Juvenile	0	P	0	26	-	0	-
August 1998	Adult	-	-	0	0	-	-	0
	Juvenile	-	-	7	53	-	-	0
September 1998	Adult	0	28	-	-	-	-	-
	Juvenile	0	0	-	-	-	-	-
June 1999	Adult	1	9	-	-	-	-	-
	Juvenile	3	1	-	-	-	-	-
July 1999	Adult	-	-	0	33	-	-	-
	Juvenile	-	-	0	1	-	-	-
October 1999	Adult	-	-	0	0	-	-	-
	Juvenile	-	-	3	0	-	-	-
June 2000	Adult	-	7	0	16	-	-	-
	Juvenile	-	54	10	78	-	-	-
July 2000	Adult	0	P	-	4	-	-	-
	Juvenile	27	P	-	98	-	-	-
August 2000	Adult	-	-	-	23	-	-	-
	Juvenile	-	-	-	51	-	-	-
September 2000	Adult	0	-	3	30	-	-	-
	Juvenile	0	-	21	99	-	-	-
June 2001	Adult	1	P	6	3	-	-	-
	Juvenile	165	P	0	69	-	-	-

Table 5-13. Incidental Observations of Adult (>6 inches) and Juvenile Largemouth Bass (<6 inches) during Steelhead/Rainbow Trout Snorkel Surveys in the LSYR Mainstem, 1995-2004

Survey Date		154 Reach (LSYR 0.2-0.7)	Long Pool (LSYR 0.5)	Refugio (LSYR 5.0-7.8)	Alisal (LSYR 7.8-10.5)	Weister/ Sanford (LSYR 19.0-19.3)	Cadwell (LSYR 22.1-22.7)	Cargasacchi (LSYR 26.1-26.7)
August 2001	Adult	2	P	-	-	-	-	-
	Juvenile	127	P	-	-	-	-	-
September 2001	Adult	-	-	-	52	-	-	-
	Juvenile	-	-	-	5	-	-	-
October 2001	Adult	0	P	-	-	-	-	-
	Juvenile	409	P	-	-	-	-	-
November 2001	Adult	-	P	15	1	-	-	-
	Juvenile	-	P	21	20	-	-	-
May 2002	Adult	1	-	-	-	-	-	-
	Juvenile	82	-	-	-	-	-	-
June 2002	Adult	-	9	41	28	0	7	-
	Juvenile	-	0	48	30	0	11	-
September 2002	Adult	8	-	95	40	0	7	-
	Juvenile	4	-	538	208	7	1	-
November 2002	Adult	0	12	29	85	0	5	-
	Juvenile	0	0	172	88	8	0	-
June 2003	Adult	0	P	122	31	3	11	-
	Juvenile	0	P	2	29	9	0	-
August 2003	Adult	2	-	-	-	-	-	-
	Juvenile	23	-	-	-	-	-	-
September 2003	Adult	0	-	-	-	-	-	-
	Juvenile	0	-	-	-	-	-	-
November 2003	Adult	0	0	-	-	-	-	-
	Juvenile	0	0	-	-	-	-	-
July 2004	Adult	-	-	1	21	-	28	-
	Juvenile	-	-	0	0	-	0	-
August 2004	Adult	-	-	3	11	-	-	-
	Juvenile	-	-	66	92	-	-	-
September 2004	Adult	0	P	-	-	2	3	-
	Juvenile	1	P	-	-	0	2	-
October 2004	Adult	-	-	14	18	-	-	-
	Juvenile	-	-	112	146	-	-	-
December 2004	Adult	0	P	10	0	2	15	-
	Juvenile	0	P	95	3	0	0	-

Notes:

dash (-) indicates no survey conducted

Please refer to Figure 5-1 for snorkel locations

Source: CPWA 2005

Table 5-14. Juvenile Largemouth Bass (LMB <6 inches) Observed During Snorkel Surveys in Hilton and Salsipuedes Creeks, 1997-2004

Survey Period	Number of LMB	Tributaries (Site)
June 1997	0	N/O[1]
July 1998	0	N/O[1]
July 1999	3	Salsipuedes Creek
November 1999	0	N/O[1]
July 2000	4	Hilton Creek
October 2000	47	Hilton Creek
June 2001	0	N/O[1]
August 2001	0	N/O[1]
September 2001	43	Hilton Creek
October 2001	0	N/O[1]
May 2002	0	N/O[1]
June 2002	20	Hilton Creek
September 2002	0	N/O[1]
June, July, August, September, November 2003	0	N/O[1]
July and September 2004	0	N/O[1]

Notes:

[1]N/O = not observed; no LMB were observed in either Hilton or Salsipuedes creeks

Source: CPWA 2005

Table 5-15. Summary of Redd Surveys, LSYR and Tributaries, 1996-2004

Year	Begin Date	End Date	Days surveyed	# Redds
Tributaries				
Lower Salsipuedes Creek				
1996	4/3	4/25	2	7
1997	1/9	5/7	7	14
1998	1/15	2/17	2	None Observed
1999	2/12	5/28	10	49
2000	1/6	5/11	12	5
2001	1/15	5/8	7	None Observed
2002	-	-	-	-
2003	4/23	4/23	1	7
2004	1/16	3/26	4	None Observed
Upper Salsipuedes Creek				
1996	4/5	4/8	2	None Observed
1997	1/9	3/27	6	11
1998	1/22	5/21	3	3
1999	2/12	5/12	6	16
2000	1/7	5/22	9	14
2001	1/17	5/8	7	12
2002	Denied Access			
2003	Denied Access			
2004	Denied Access			
El Jaro Creek				
1996	4/5	4/25	4	6
1997	2/11	5/7	7	18
1998	1/2	1/22	2	None Observed
1999	2/15	5/28	4	None Observed
2000	1/7	5/12	7	None Observed
2001	1/22	2/5	2	None Observed
2002	-	-	-	-
2003	3/27	5/1	2	3
2004	1/16	3/26	4	None Observed
Los Amoles Creek (Tributary to El Jaro Creek)				
1996	Denied Access			
1997	Denied Access			
1998	Denied Access			
1999	Denied Access			
2000	Denied Access			
2001	Denied Access			
2002	4/8	4/9	2	4
2003	-	-	-	-
2004	3/02	3/02	1	1
San Miguelito Creek				
1997	3/20	5/8	5	49
1998	1/15	5/20	6	1
1999	2/7	5/13	9	35
2000	1/13	2/1	3	None Observed
2001	-	-	-	-

Table 5-15. Summary of Redd Surveys, LSYR and Tributaries, 1996-2004

Year	Begin Date	End Date	Days surveyed	# Redds
2002	-	-	-	-
2003	-	-	-	-
2004	-	-	-	-
		LSYR Mainstem		
154 Reach				
1997	1/29	5/16	5	None Observed
1998	4/27	4/27	1	None Observed
1999	2/10	5/7	6	5
2000	1/12	5/16	8	None Observed
2001	1/30	4/5	2	None Observed
2002	2/15	4/5	3	2
2003	-	-	-	-
2004	1/16	2/17	3	None Observed
Refugio Reach				
1997	2/3	5/16	7	None Observed
1998	1/27	1/27	1	None Observed
1999	2/5	5/6	5	1
2000	3/22	1/5	3	None Observed
2001	1/24	1/24	1	None Observed
2002	-	-	-	-
2003	4/17	4/17	1	None Observed
2004	1/26	3/31	4	None Observed
Alisal Reach				
1997	2/3	5/9	5	None Observed
1998	1/26	1/26	1	None Observed
1999	2/21	5/5	3	None Observed
2000	3/21	5/23	4	None Observed
2001	3/1	4/4	2	None Observed
2002	-	-	-	-
2003	4/17	4/17	1	None Observed
2004	1/26	3/29	3	None Observed
Avenue of Flags				
1997	2/4	5/15	5	None Observed
1998	1/26	1/26	1	None Observed
1999	2/19	3/4	7	None Observed
2000	4/11	5/8	3	6
2001	1/23	1/24	2	None Observed
2002	-	-	-	-
2003	-	-	-	-
2004	-	-	-	-

Notes:
dash (-) indicates no survey conducted
Reach boundaries are presented in Figure 1-2
Source: CPWA 2005

Table 5-16. Fish Species Captured in the LSYR Lagoon in 1997 and 1999

Species	Lower Lagoon		Mid Lagoon		Upper Lagoon	
	1997	1999	1997	1999	1997	1999
Steelhead	0	0	0	1[a]	0	0
Staghorn sculpin	50	4,570	5	1,080	69	154
Shiner perch	2	101	0	4	0	1
Striped mullet	17	1	0	3	0	0
Pacific herring	700	984	0	16	0	0
Fathead minnow	0	0	0	0	3	1
Largemouth bass	0	0	0	0	7	0
Tidewater goby	0	0	2,000	0	4	0
Bullhead	0	0	6	2	101	3
Mosquito fish	0	0	0	0	1	0
Top smelt	0	785	0	2,480	22	2
Starry flounder	0	43	1	11	0	6
Prickly sculpin	0	0	0	7	0	14
Green sunfish	0	0	0	4	0	0
Crayfish	0	0	0	16	0	0
Arroyo chub	0	0	0	0	0	4
Pond turtle	0	0	0	0	0	2
Stickleback	0	0	0	0	0	2

[a]357 mm

Source: SYRTAC 1994

SECTION 6

STATUS OF MANAGEMENT ACTIONS

Section 6: Status of Management Actions

6.1 Introduction

The LSYR FMP (SYRTAC 2000) and the BA Proposed Action (Reclamation 2000) identify specific management actions, and the NMFS BO (2000a) specifies Terms and Conditions, all of which are designed to protect and enhance habitat conditions for southern California anadromous steelhead, rainbow trout, and other aquatic and riparian resources inhabiting the LSYR and its tributaries. The management actions outlined in the FMP and BA Proposed Action include, but are not limited to, the following:

- Make target flow releases in accordance with the interim instream flow schedule in the BA Proposed Action to support steelhead/rainbow trout habitat within the reach downstream of Bradbury Dam to the Highway 154 Bridge. The interim rearing target flows applicable during this period vary according to reservoir storage level and the occurrence of spill events (Table 2-7).
- After 2005, provide flows to augment winter storm flows to improve opportunities for adult and juvenile steelhead migration into and out of the LSYR and its tributaries. Flow releases are made consistent with the criteria set forth by the AMC in accordance with the BA Proposed Action and the BO requirements (AMC 2004). The fish passage account is filled when the reservoir fills and spills.
- Construct a pipeline and pumping system, HCWS with multiple release locations to convey cool water from Lake Cachuma to the Hilton Creek to create perennial rearing habitat;
- Improve fish passage at existing barriers and impediments to migration within tributaries where upstream habitat is suitable for adult spawning, egg incubation, and juvenile steelhead/rainbow trout rearing;
- Conduct fishery and habitat investigations within the upper watershed and a feasibility assessment of the potential ways to allow steelhead access to habitat upstream of Lake Cachuma (results of the Upper Basin investigations are addressed in a separate technical report); and
- Conduct education and public information programs to increase public awareness of steelhead and their habitat needs.

The actions identified in the FMP and BA Proposed Action were based, in large part, on results of preliminary habitat and biological monitoring conducted within the lower river and tributaries presented in the 1997 Synthesis Report (SYRTAC 1997) and subsequent investigations. Based on results of these fishery and habitat investigation a series of management actions were developed that would serve to protect and enhance habitat conditions for steelhead within the mainstem river and tributaries. As discussed above, these management actions included, but were not limited to, minimum instream flow releases from Bradbury Dam, water supplies to Hilton Creek, and a variety of modifications at passage barriers and impediments within the tributaries to improve the ability of steelhead to access suitable upstream habitat for spawning and juvenile rearing. These management actions were proposed as part of the project description included in the BA as part of the Section 7 consultation with NMFS under the federal ESA. After critically reviewing the management actions outlined in the BA, NMFS agreed that implementation of the proposed management plan would avoid jeopardy to steelhead. The subsequent BO issued by NMFS acknowledged the management plan, established a specific schedule for implementation of the management actions, and issued an incidental take permit for the continued operations of the Cachuma Project in accordance with the management plan outlined in the BA and BO.

The management actions identified in the FMP, BA, and BO, their status as of 2004, and future implementation, are summarized in Table 6-1. This table is being used to monitor the status of program implementation. As of 2004, many of the plan actions have been implemented or are in the design phase. Implementation of the full program is expected to take a number of years to complete and the status of implementation outlined in this summary table will be updated periodically in subsequent annual reports.

Additional actions and specific scientific investigations, such as passage flow supplementation in the mainstem river for winter passage by adult and juvenile steelhead using reservoir surcharge, are beyond the scope of this report and are being addressed and documented separately as part of the ongoing AMC activities. One of the primary objectives of compiling and analyzing the 12-year monitoring results is to reevaluate the scientific and technical foundation for the management actions in light of a longer-term data set representing a wider range of environmental and hydrologic conditions within the watershed.

As discussed in Sections 2, 3, 4, and 5, results of the compilation and analysis of the 12-year dataset are consistent and confirm the earlier findings presented in the 1997 Synthesis Report (see Section 7). Results of subsequent monitoring have provided greater insight and refinement of our understanding of the dynamic nature of habitat conditions within the LSYR watershed, the fish community, and their geographic distribution. Monitoring results also have provided insight into habitat characteristics and constraints and opportunities for enhancing habitat conditions within the lower river and tributaries for steelhead/rainbow trout. Additional studies have also provided better definition of the geographic patterns of critical water quality parameters including seasonal and diel variation in both water temperature and DO concentrations affecting habitat suitability. The subsequent monitoring has not, however, identified any fundamental changes in the interpretation of the factors affecting steelhead and other aquatic resources within the lower river and tributaries that would lead to a change in the direction of the management actions contained in the FMP and the BA Proposed Action.

Many of the management actions identified in the FMP and BA Proposed Action have been implemented during the 12 year period covered by this report. Other actions were implemented in subsequent years and additional actions are scheduled to be implemented over the next several years. Monitoring activity as part of the continued implementation of the FMP include three components (1) continued baseline monitoring of habitat conditions and population dynamics to track the overall contribution of management actions to increase the abundance of southern California steelhead/rainbow trout in the LSYR and its tributaries, (2) special studies and investigations designed to answer specific study questions, and (3) conducting investigations designed to inform adaptive management decisions and provide guidance on future modifications and refinements to management actions and project operations.

This section provides a brief status of implementation of management actions within the lower river and tributaries. Preliminary performance evaluation of actions is also discussed. The program of monitoring and investigation to assess the short- and long-term performance of management actions implemented as part of this program is ongoing.

6.2 Mainstem River Supplemental Flow Releases

As part of developing the FMP and BA Proposed Action, instream flow augmentation on the mainstem Santa Ynez River downstream of Bradbury Dam was identified as an important management action to improve habitat conditions for various life-history stages of steelhead/rainbow trout. Mainstem flow augmentation includes year-round baseflows below Bradbury Dam with the primary management zone extending from the dam and Hilton Creek downstream to the Highway 154 Bridge.

6.2.1 Rearing/Target Baseflows for Rearing Habitat

The reach of the LSYR between Bradbury Dam and Highway 154 has good habitat structure for fish and with supplemental releases provides year-round habitat for juvenile steelhead/rainbow trout and other aquatic resources. Year-round baseflow releases are intended primarily to support juvenile steelhead/rainbow trout rearing extending from Bradbury Dam downstream to the Highway 154 Bridge. Flow releases are managed to provide suitable water temperatures and physical habitat throughout the year. Flow releases to support steelhead/rainbow trout habitat are summarized in Table 2-7.

The target baseflow releases are indexed to the hydrologic cycle via storage levels in Lake Cachuma and vary in response to interannual variation in precipitation and runoff (water-year type) within the watershed. Based on observations made during the initial phase of this program it has been hypothesized that steelhead/rainbow trout populations in the LSYR respond to variable hydrologic conditions in a boom-bust cycle. During dry years the extent of suitable habitat, particularly in summer months, is constricted thereby providing less habitat and other resources for rearing fish and typically result in reduced population abundance. In wet years, with high flows, suitable habitat is expanded and population abundance increases. To simulate the natural variation in hydrologic conditions the FMP and BA Proposed Action included variable baseflow targets with higher flows during wet years to take advantage of the “boom” cycle of the steelhead/rainbow trout population. The interim streamflow release schedule is presented in Section 2 (Table 2-7). The streamflows identified in the FMP and BA Proposed Action are target flows specifically intended to support and maintain habitat for steelhead and other aquatic resources. As discussed in Section 2, releases for fish from Bradbury Dam have been made in every year between 1993 and 2004 (Table 2-4) as part of scientific investigations and to enhance habitat conditions for steelhead/rainbow trout. From October 2000 through 2004, and continuing to date, flow releases were made to meet target flows of 2.5 – 5.0 cfs have been made through the HCWS for fishery habitat enhancement on Hilton Creek and the mainstem LSYR, and have been made in compliance with the flow schedule identified in the FMP and BA Proposed Action.

Access to the Highway 154 Reach for data collection is limited to Reclamation property located at the upstream end of the reach. To supplement the monitoring on in the Highway 154 Reach aerial overflights were begun to observe flow conditions in the primary management reach. The aerial survey confirmed that the LSYR from Bradbury Dam down to the San Lucas Ranch property boundary, has more suitable habitat for oversummering than in the downstream reaches of Refugio and Alisal (Figure 1-2). The instream flow releases support suitable oversummering conditions in the Highway 154 Reach. Overflights conducted in September 2003 (an average rain year in which there were no spills) confirmed that water was flowing through the Highway 154 Reach[1] (Engblom 2003). As discussed below, performance evaluations have been made to determine the habitat response and biological benefits associated with releases from Lake Cachuma into Hilton Creek (Section 6.2.1). The streamflow releases have provided year-round flows within Hilton Creek, the Highway 154 mainstem reach, and ancillary benefits further downstream. Instream target flows are providing good habitat conditions within the primary management areas (e.g., Hilton Creek, the mainstem river reach between Bradbury Dam and the Highway 154 Bridge) and improved habitat conditions in pools habitats in the Refugio and Alisal reaches.

6.3 Hilton Creek Projects

The habitat within Hilton Creek was characterized in the 1997 Synthesis Report as suitable for steelhead/rainbow trout spawning and rearing, but habitat utilization was historically limited by intermittent flows and several passage impediments. The watershed is approximately 4 square miles, and approximately 2,980 feet of the creek including the confluence with the LSYR is located on Reclamation property. The Hilton Creek watershed had the potential to become an important area for steelhead/rainbow trout spawning and rearing habitat, especially due to the presence of an existing population that utilizes the creek as well as its proximity to Bradbury Dam (a complete passage barrier). Its proximity to Bradbury Dam makes it possible to maintain flow and improve habitat for steelhead/rainbow trout through releases into Hilton Creek from the HCWS. Management actions and their status (in parenthesis) on Hilton Creek as part of the fishery program include:

- HCWS: Augmenting streamflow through use of a watering system to deliver cool water from Lake Cachuma to Hilton Creek to provide year round flow (implemented 2000);
- Riparian Habitat Program: Planting willow waddles and increase overhead cover, shading, and provide wildlife benefits (implemented 2000);
- Improved Passage: Improving fish passage facilities within Hilton Creek to facilitate upstream migration for spawning and juvenile rearing within the reach upstream of the Chute Pool (HC-0.28) (to be implemented in 2005);
- Improving fish passage at the Highway 154 culvert (HC-0.81) by Caltrans to facilitate upstream migration for spawning and juvenile rearing in the upper reaches of Hilton Creek (ongoing); and
- Channel Extension: Potential for extending the existing Hilton Creek channel downstream or creating a secondary channel to provide additional habitat (ongoing);

These actions are briefly discussed and evaluated below.

[1] The only portion of this reach without flowing water was the gravel bar located near the 154 Bridge where the flows were subsurface.

Several additional projects were identified in the 1997 Syntheses Report, FMP, BA, and/or BO that were intended to further benefit steelhead access and habitat on Hilton Creek. For example improving fish passage facilities within Hilton Creek to facilitate upstream migration for spawning and juvenile rearing within the reach upstream of the Chute Pool (HC-0.28) was identified; however completion of this project occurred in 2005 and is beyond the scope of this synthesis reporting period.

6.3.1 Hilton Creek Watering System

Construction of the HCWS was completed in April 2000, and the system has been in operation since October 2000. The watering system withdraws cool water from Lake Cachuma that is then conveyed to Hilton Creek. The watering system has resulted in the conversion of Hilton Creek from intermittent-flow to year-round flow downstream of the Upper Release Point (totaling > 2,800 feet) with suitable temperature and DO conditions. The water delivery pipeline extends from Lake Cachuma to Hilton Creek, delivering flows to three separate release points. Two release sites are located in Hilton Creek while the third outlets into the Stilling Basin below the dam. The upper release point into Hilton Creek (HC-0.54) is situated near the upper Reclamation property boundary. As a result of the downstream passage barrier (HC-0.28, bedrock chute and cascade), the upper release point had not been used extensively up to 2004 to avoid unnecessary thermal heating from the upper to lower release point. The Chute passage barrier was modified in 2005 to facilitate improved access to upstream habitat. The lower release point (HC-0.3) is located just upstream of the bedrock chute.

Steelhead/rainbow trout smolts were observed migrating out of lower Hilton Creek (HC-0.14) from 2001 through 2004; the highest abundance in any given year was 2002 when nearly 20 smolts were observed moving downstream (Section 5). As a result of ephemeral seasonal flows within Hilton Creek prior to implementation of the watering system in 2000, summer habitat for juvenile rearing was poor or unsuitable and hence few juvenile steelhead/rainbow trout were able to successfully rear to smolt stage within the creek. Since the completion and operation of the watering system, smolts have been documented moving downstream during the winter and spring migration period (Section 5). Interestingly, the largest number of smolts captured since the watering system began operations occurred in 2002, the second driest year on record. The number of smolts captured in Hilton Creek downstream migrant trapping (HC-0.14) in 2002 was nearly four times the number of smolts captured in Salsipuedes Creek in the same year (Section 5). This may reflect the availability of spawning and rearing habitat in a creek with a sustained water supply in a dry year when such habitat may not be as readily available or suitable in lower reaches of other tributaries. Also, 2002 migrant trapping within Hilton Creek consisted of 99 consecutive days of trapping, which equated to a 100 percent trapping efficiency rating (Table 5-8). No large storms affected the creek which would have otherwise rendered trapping within the creek unsuitable due to the risk concerns for trapped steelhead, personnel, and equipment. Furthermore, the HCWS allowed downstream smolts the ability to move throughout the entire trapping season.

Since 2000, the re-watered portion of Hilton Creek downstream of the lower release point (1,500 feet) has consistently produced between 400 to 900 young steelhead/rainbow trout annually following the spawning season as observed in spring snorkel surveys (Section 5). The decrease in the numbers of rearing steelhead/rainbow trout seen in October 2002 is thought to be the influence of avian and/or mammalian predation, coupled with the newly re-watered section of creek that was lacking significant cover. Increases in riparian vegetation, overhead cover, and habitat complexity (e.g., root wads, large woody debris, etc.) are expected to reduce levels of predation on juvenile steelhead/rainbow trout. Increased numbers of steelhead/rainbow trout observed since 2002 suggest that habitat conditions within the creek are continuing to improve.

6.3.2 Riparian Vegetation Enhancement

Riparian vegetation downstream of the lower release point (HC-0.28) along Hilton Creek has increased in density and cover since 2000, with recruitment of native willow, cottonwood, sycamore and alder trees along the banks of the creek (Figures 6-1 through 6-3). Tree recruitment and growth began to accelerate after the watering system began releases to Hilton Creek. By 2004, numerous 20-foot-high trees lined the creek channel and the width of the riparian zone has increased to approximately 50-100 feet along the channel. In the lower section of the creek, willow waddles were used to accelerate the natural recovery of the riparian area. Even in this area, the vast majority of the new growth has been a result of natural riparian vegetation recruitment. The new riparian zone is expected to provide many benefits to the aquatic habitat including:

- Increased cover and protection from bird predation;
- Increased habitat for riparian species including amphibians, reptiles, mammals, and riparian birds;
- Increased shading which helps reduce thermal heating of the water during the summer providing more suitable conditions for young steelhead/rainbow trout;
- Increased food availability (terrestrial insects falling into the water, more instream habitat for aquatic insects);
- Increased bank stabilization during high flow events and excellent rearing habitat (root wads, fallen large woody debris, overhanging vegetation, etc.);
- Potential for less sediment (fines and gravel) input from stream banks due to phreatophytes growth and stabilization of channel erosion; and
- Greater likelihood of a permanent channel, particularly in the lower reaches of Hilton Creek which had been subject to erosional processes and channel migration before the HCWS.

6.3.3 Passage Barrier Fixes

Two barriers and impediments to upstream migration have limited access to spawning and juvenile rearing habitat within the upper portions of Hilton Creek. These two migration barriers include (1) a bedrock outcrop associated with the cascade chute pool (HC-0.28) located approximately 0.28 mile upstream from the confluence with the LSYR, and (2) a culvert passing under Highway 154 (HC-0.81) located 0.81 mile upstream of the confluence with the LSYR.

The cascade and bedrock chute is located approximately 1,380 feet upstream from the confluence with the mainstem river and is a passage impediment for upstream migrating steelhead/rainbow trout. The cascade is approximately 6 feet in height with a shallow pool at the base of the cascade. The bedrock chute immediately above the cascade is approximately 140 feet long. Passage is possible only during very brief windows of opportunity when streamflow is sufficient, but upstream passage is still extremely difficult due to high velocity and the lack of deeper pool habitat and resting sites.

Since the passage impediment could be caused by either the height of the cascade or the high-flow velocity in the bedrock chute, the improvement project concentrated on modifying the hydraulic conditions at both of these impediments. Specifically, the project focused on improving passage upstream of the plunge pool since adult steelhead/rainbow trout have been observed in the pool habitat. The design of the passage improvements involved creating a backwater effect in the plunge pool by constructing one cast in place concrete channel control structures (weir), which increased the depth of the pool. Three concrete step pools were created within the cascade, thereby greatly reducing the jump height. The project also created several resting pools within the chute section. Six cast-in-place control structures were proposed to be constructed in the bedrock chute to reduce water velocities and create resting places for steelhead/rainbow trout as they migrate upstream. Construction of the passage enhancements was planned to be completed in the fall of 2005. Based on results of habitat surveys and GIS mapping it was expected that, when both the cascade and chute improvements were completed, passage upstream of this impediment would double the length of Hilton Creek available for spawning and rearing. It was anticipated that monitoring and evaluation of the performance of the fish passage enhancement structure at the chute pool would begin in the winter 2006. Since completion of the passage project extends beyond the scope of this synthesis reporting period, final documentation of the completion of the project and results of the performance evaluation will be addressed in future reports.

The design and implementation of fish passage enhancement facilities at the Highway 154 culvert (HC-0.81) crossing has been developed and submitted to Caltrans for approval and subsequent construction. The schedule for completing the fish passage improvements at the Highway 154 culvert is unknown, as the project relies on approval from Caltrans to proceed.

6.3.4 Channel Extension

Results of migrant trapping and snorkel surveys over the period since implementation of the watering system on Hilton Creek in 2000 have shown substantially higher densities of juvenile steelhead/rainbow trout produced in Hilton Creek when compared to the mainstem river and other tributaries (Section 5). Based on the observed productivity of Hilton Creek over the period when the supplemental watering system has been operational (2000-2004 as part of this analysis), and its value as spawning and juvenile rearing habitat, investigations are ongoing as of 2004 to develop designs and evaluate the feasibility of extending the Hilton Creek channel further downstream or creating an additional channel to provide additional high-quality habitat. Extending the Hilton Creek channel downstream would take advantage of flows provided by the watering system and could be constructed on lands owned by Reclamation. As part of developing proposed designs for a Hilton Creek channel extension, a series of investigations have been implemented to monitor soil conditions within potential channel alignments, and develop additional engineering information as part of the technical foundation for evaluating the potential feasibility of various alternative channel extension configurations and alignments. As of 2004, results of groundwater monitoring and a preliminary feasibility analysis for the channel extension project on Hilton Creek were ongoing.

6.4 Salsipuedes Creek Fish Passage Projects

Salsipuedes Creek was identified as an area to improve access for migrating steelhead/rainbow trout to reach good quality spawning and rearing habitat in the upper reaches of the tributary drainage (SYRTAC 1997, 2000). Results of field habitat surveys identified two high-priority fish passage barriers/impediments within the Salsipuedes Creek drainage. The first migration barrier was associated with the Highway 1 Bridge crossing (SC-3) and is listed in the BA Proposed Action as a barrier to be addressed. The second barrier was associated with the Jalama Road Bridge crossing (SC-3.5) and was not listed in the BA Proposed Action as a barrier to be addressed. As part of the FMP management actions, passage for adult and juvenile steelhead/rainbow trout has been improved at both of these structures, which expands the access to approximately 16.4 miles of available habitat for spawning and rearing steelhead/rainbow trout in the lower river.

6.4.1 Highway 1 Bridge Passage Project

When the Highway 1 Bridge (SC-3) over Salsipuedes Creek was constructed, the concrete apron caused the stream to downcut, creating a low flow passage barrier (Figure 6-4). The 5 to 6 foot vertical elevation change at the concrete apron under Highway 1 acted as a complete passage barrier at flows of less than approximately 20 cfs. Passage of adult steelhead/rainbow trout over the concrete apron at higher flows could have potentially resulted in abrasion and laceration injuries to the fish. Additionally, large adult steelhead/rainbow trout were vulnerable to poaching in the pool downstream of the apron because they were visible from the Highway 1 Bridge. In addition, juvenile steelhead/rainbow trout rearing downstream of the barrier in summer would be unable to migrate from the warm water (up to 25° C, Section 3) at the Highway 1 Bridge to cooler water upstream.

The passage impediment was removed in 2002 by creating an opening in the apron by excavating three small step pools, each reinforced with a concrete wall at its downstream end (Figure 6-5). Following removal of the passage barrier in 2002 (the first year of operation and the second driest winter on record), a total of 14 adult and juvenile steelhead/rainbow trout ranging in length from 5.1 to 15.3 inches were captured in the upstream migrant trap (located just upstream of the passage impediment fix), indicating successful migration upstream through the structure when flows were less than 5.0 cfs (Section 5). During 2002, after completing the passage enhancement, average flows through the structure when steelhead/rainbow trout were captured were 2.6 cfs (range 2.2 to 3.3 cfs) (Figure 6-6). Visual observations made before the passage enhancement was implemented showed that without this barrier repair, it was unlikely that these fish would have been able to migrate upstream as flows did not increase above 5 cfs during the remainder of the migration season.

In 2003, a normal rain year, adult steelhead/rainbow trout were observed migrating upstream through the Highway 1 fish passage structure. At an average flow through the structure of 3.7 cfs (Figure 6-7), 25 upstream migrants were captured ranging in length from 3.5 to 27 inches (Figure 6-8); the largest fish was a 27-inch female steelhead/rainbow trout that moved upstream when flow was 6.2 cfs.

In 2004, a dry year, there were 18 upstream migrants captured, ranging in size from 4.3 -13.7 inches (109 – 348 mm) in length. The average flow during all of the captures was 3.1 cfs (range 1.0 – 6.6 cfs). The largest fish captured was 13.7 inches (348 mm) in length, which was probably not an anadromous trout since breaching of the bar and mainstem flows were not conducive to upstream migration by adult steelhead, when the flow was 3.9 cfs in Salsipuedes Creek.

Data from 2002 through 2004 show that steelhead/rainbow trout have been able to successfully gain access through an area that previously acted as a complete passage barrier at low flows.

6.4.2 Jalama Road Bridge Fish Passage Project

Although not originally listed in the BA Proposed Action or FMP as a passage impediment on Salsipuedes Creek, an impediment to passage was identified in 2004 approximately 70 feet downstream of the Jalama Road Bridge (SC-3.5) and approximately 1/2 mile upstream of the Highway 1 project on Salsipuedes Creek. Working with local stakeholders and granting agencies, an opportunity arose to modify the concrete low-flow passage impediment to allow passage by adults and juvenile steelhead (Figure 6-9 a, b). At this site, a concrete apron caused downcutting into the streambed creating a deep pool and requiring a large vertical jump by fish migrating upstream. At flows of approximately 20 cfs and less, the concrete apron downstream of Jalama Bridge required a 5 to 6 foot leap in order to successfully migrate upstream past the barrier. When flows exceeded 20 cfs, it was expected that larger steelhead/rainbow trout would be able to move past the impediment. The passage enhancement project (Figure 6-9) modified the left streambank and channel (facing upstream) adjacent to the grade control structure to create a migration pathway for fish during low and moderate flow events. A series of three step-pools were constructed that reduced the overall jump height to approximately 1 foot at each pool (Figure 6-10). Visual observations have documented both YOY and juvenile steelhead/rainbow trout rearing in each of the three step pools since 2004, indicating successful migration through each pool, as well as the secondary benefit of creating new oversummering pool habitat for steelhead/rainbow trout within the drainage.

In summary, the improvements to the Highway 1 bridge crossing and Jalama Bridge crossing (see Figures 6-5 and 6-10) have had positive effects on the ability of steelhead/rainbow trout to successfully migrate upstream into the Salsipuedes Creek watershed by:

- Allowing access past the barriers to suitable upstream spawning habitats at substantially lower flows than in the past;
- Eliminating the lengthy delay between storms for upstream migrants that are otherwise unable to pass at these two locations if flows decreased to less than approximately 20 cfs;
- Reducing the likelihood of poaching since the fish are no longer trapped in the pools below the bridge crossings;
- Allowing multiple size classes of fish to move upstream to seek cooler rearing locations during the summer; and
- Creating habitat within the Jalama Road fish ladder for oversummering steelhead/rainbow trout as fish now live year-round in the pools created by the fish ladder.

6.5 El Jaro Creek Demonstration Projects

Erosion and deposition of fine sediments was a factor identified in habitat surveys on El Jaro Creek as adversely affecting habitat quality for steelhead/rainbow trout spawning and rearing. The El Jaro Creek watershed is characterized by rolling hills of oak savanna and Mediterranean annual grasses. Lands in the Salsipuedes/El Jaro watershed are all in private ownership. Existing land uses include cattle ranching, dry farming, and mining. A management strategy within the FMP was to work with landowners to protect habitat within the south side tributaries through mechanisms such as landowner education. The El Jaro Creek Demonstration Projects informed local private landowners about technically feasible and cost-effective sediment management solutions to reduce excessive sediment in El Jaro Creek, and thereby encourage the landowners to participate in programs to decrease sedimentation. Demonstration projects on El Jaro Creek involved (Figures 6-11, 6-12, and 6-13):

- Removal of an undersized culvert and stabilization of the stream channel and adjacent streambanks within the small ephemeral drainage;
- Stabilization of an exposed side draw located 100 feet downstream of an existing culvert; and
- Stabilization of an eroding streambank along El Jaro Creek.

First, the undersized culvert (EJC-6.22) was removed and replaced with a properly-sized culvert. The culvert area was then stabilized to prevent the release of sediment captured upslope of the culvert, and to stop the headcut migration in the gully upslope of the culvert.

Second, immediately downstream of the culvert project, flows had eroded a near-vertical streambank situated along a bend in the drainage, resulting in erosion of fine sediments into the creek (EJC-6.22). The project filled in the scour hole with large boulders to reduce and eliminate the storm related erosive processes.

Third, a floodplain enhancement project was implemented immediately downstream of the bank stabilization site to (1) reduce the amount of silt input into the creek, (2) stabilize the bank to prevent future bank failures, and (3) enhance the floodplain in the project area with native riparian vegetation. A hard toe of 4- to 5-ton boulders was constructed against an unstable hillside. The boulders were placed so that the top of the rocks was consistent with bankful elevation. Native soil obtained from an existing slump along the bank was backfilled behind the boulders, and the backfilled area was planted with willows.

Public workshops (before and after Demonstration Project construction) were held with local landowners to discuss non-point source sediment discharges to the stream associated with streambank and upland soil erosion. The focus of the workshops was on positive management actions property owners can take to reduce soil erosion on their properties. The follow-up workshop provided details for the technical implementation of the demonstration projects and methods for monitoring project success in terms of water quality and instream habitat restoration.

6.6 Quiota Creek Fish Passage Projects

Quiota Creek watershed is a relatively large tributary (7.6 square miles) of the LSYR located about 8.4 miles downstream of Bradbury Dam (Figure 1-1). Refugio Road is a Santa Barbara County road that crosses the creek nine times in approximately 3 miles (Figure 1-1, Table 1-1).

The nine creek crossings are in poor condition and represent passage impediments and in some cases direct barriers that limit access and opportunities for steelhead/rainbow trout spawning and rearing in the upper reaches of Quiota Creek. Based on habitat and snorkel surveys along portions of the creek adjacent to the road and within the county easement, a resident population of steelhead/rainbow trout inhabits the middle and upper reaches of Quiota Creek (Section 5). The creek also provides among the coolest water temperatures observed in the LSYR watershed (Section 3), and has suitable habitat to support steelhead/rainbow trout and perennial flows even during drought periods.

The County of Santa Barbara originally committed to repair three of the crossings with permanent bridges while the remaining six crossings would be modified by CPWA and Reclamation as part of the fishery program to increase passage opportunities for migrating steelhead/rainbow trout. Conflicts with regulatory agencies have caused Santa Barbara County to revoke their commitment, now leaving all nine passage fixes under the purview of CPWA and Reclamation. Repairing these crossings will provide access to approximately 2 miles of additional habitat for steelhead/rainbow trout spawning and juvenile rearing. The instream habitat is considered to be of high quality and the adjacent riparian zone is well developed and comprised of mature coastal live oak, California bay laurel, California sycamore, big leaf maple, and red alder.

Installation of passage enhancements at the road crossings has been delayed. Reclamation has submitted a request to NMFS to amend the BO implementation schedule for completing these passage enhancements. CPWA and Reclamation are continuing to work toward completing these passage projects in the next several years.

6.7 Fish Rescue and Relocation

Conditions such as declining water levels, high water temperatures, or low DO levels may result in mortalities of endangered steelhead/rainbow trout. To reduce mortalities, fish rescue was a recommended management action in the FMP and BA Proposed Action. Fish rescues and relocations were undertaken when instream conditions were detrimental to rearing steelhead/rainbow trout, such as drying and isolation of habitat units (Table 6-2). Such conditions occurred in Hilton Creek prior to the construction of the watering system and in Quiota Creek on an almost annual basis since 2000. Fish trapping and relocation efforts in the Long Pool (LSYR-0.5) and Stilling Basin (LSYR-0.2) were made in 1997 in response to seismic corrective actions at Bradbury Dam. Two major fish rescue operations were conducted from 1997 – 2004, along with several smaller rescue and relocation operations on Quiota Creek.

Following the 1998 fish rescue in Hilton Creek, a Fish Rescue/Management Plan was prepared for Hilton Creek in 2000. Although the watering system provides flow to Hilton Creek in most years, it may not be feasible to provide streamflow during the summer and fall in dry or critically dry years when the lake level declines to an elevation where cold water can no longer be supplied to Hilton Creek. Under natural conditions, oversummering steelhead/rainbow trout inhabiting lower Hilton Creek would then be restricted to isolated pools as flows decline and would be vulnerable to predation by birds and mammals, desiccation, and exposure to elevated water temperatures. Hydrologic analysis indicates that a fish rescue operation would be necessary in approximately 2 percent of all water years. During most of these years, it is likely that the sand bar at the lagoon would not be open during the winter, but resident rainbow trout may still spawn, and juvenile steelhead from the previous year may reside in the stream (residualize) if winter flows or other environmental cues are not sufficient to stimulate emigration.

At present, a fish rescue and relocation to other habitats in the LSYR system would be the expected adaptive management response to unfavorable hydrologic conditions impacting the ability to sustain suitable habitat conditions within Hilton Creek. In the event of a suspension in water deliveries to Hilton Creek, daily water temperatures, DO, and habitat monitoring will be used by the AMC to inform management decisions.

There may also be a need to rescue fish located in the mainstem LSYR and its tributaries. Consultation and review with NMFS and CDFG should be ongoing in order to develop a fish rescue plan so that qualified personnel can quickly respond to these unfavorable conditions when they arise. It is expected that fish rescue operations would follow the basic procedures outlined in the Hilton Creek Fish Rescue/Management Plan.

6.8 Upper Basin Investigations

Although the main focus of the FMP and BA Proposed Action is for the protection and monitoring steelhead/rainbow trout habitat within the LSYR, a portion of the FMP allows for the investigation of feasibility in providing steelhead/rainbow trout access to historical habitat located within the Upper Santa Ynez River. The purpose of the investigations is to identify the existing gene pool of rainbow trout inhabiting waters upstream of Bradbury Dam, document habitat conditions, and to consider the feasibility and location of various alternative methods to allow steelhead adults and juveniles successful passage or transport between the lower river and upper watershed that may take place in the future A series of scientific monitoring investigations have been designed and conducted to assess habitat conditions and potential habitat suitability for steelhead/rainbow trout within the mainstem river and tributaries upstream of Lake Cachuma. As part of these investigations, resident trout have been sampled at various locations to obtain tissue used in genetic analyses. Information on historic stocking of hatchery-produced trout to support recreational fisheries within the upper portions of the watershed has also been compiled and analyzed (ENTRIX 2004). Results of these investigations on the conditions within the upper portions of the watershed will be used in an assessment of the potential habitat suitability, opportunities, and constraints for relocating anadromous steelhead within the watershed upstream of Lake Cachuma. Results of the Upper Basin investigations have been submitted to the AMC for review and the genetic analyses being conducted by NMFS are underway.

6.9 Education and Public Information Activities

Another important management action is to educate the public in understanding the importance of improving habitat conditions and protecting steelhead/rainbow trout populations in the LSYR (i.e., deter poaching, increase awareness, and inform landowners). Management actions also included public outreach to encourage voluntary participation from private landowners and the public in restoration and protection activities. Education and public information and outreach activities implemented as part of the FMP included a workshop and demonstration project on El Jaro Creek designed to improve (stabilize) stream channel banks to reduce erosion. Informational workshops with landowners and other interested parties on habitat protection and enhancement have been offered to the public. As one element in developing the monitoring program, a training session was held with biologists and other professionals in the application of "properly functioning conditions" as a habitat assessment tool.

CPWA staff, working with Reclamation and others, have prepared and distributed environmental documents to the public and convened public meetings as part of implementing elements of the program. The FMP and results of monitoring as part of the program have been presented at a variety of public meetings as well as at technical workshops and scientific meetings (e.g., American Fisheries Society, Salmonid Restoration Federation). Several lectures have also been given to students at the University of California Santa Barbara, specifically the Bren School of Environmental Science and Management and Environmental Studies Department, explaining how the FMP, BA Proposed Action, and BO are being used to help restore steelhead populations and their habitats on the LSYR. CPWA has prepared and distributed brochures and summaries of the FMP and program accomplishments to the public. The CPWA web site presents additional information to the public describing the fishery program.

6.10 Summary

The FMP and the BA Proposed Action include a multifaceted set of management actions designed to protect anadromous steelhead, improve quality and availability of instream habitat, improve opportunities for fish passage and access to suitable upstream habitat within the tributaries, and provide additional scientific and technical information to inform future management decisions. The BO also requires implementation of these actions. Management actions that have been implemented within the watershed or are currently scheduled for implementation as part of the FMP and the BA Proposed Action include (year[s] of implementation or completion is indicated in parentheses):

- Maintenance of year-round baseflow releases from Bradbury Dam (1994 to present) and the HCWS (2000 to present) to provide habitat within the mainstem river and Hilton Creek in support of juvenile steelhead/rainbow trout summer rearing;
- Provide long-term summer rearing target flow releases following spill events (three-foot surcharge) from the HCWS to provide habitat in both the creek and the mainstem through mile 10.5 (2005 to present);
- Provide flow augmentation during the winter and early spring period of adult and juvenile steelhead migration to enhance mainstem river passage flows (2006 to present);
- Plant willow waddles and promote recruitment of riparian vegetation along the channel margins of Hilton Creek to increase overhead cover, increase habitat diversity and complexity, provide stream shading, and provide wildlife benefits (2000 to present);
- Improve fish passage within Hilton Creek at the Chute pool and cascade to allow access to upstream habitat for steelhead/rainbow trout spawning, egg incubation, and juvenile rearing (2005);
- Develop engineering designs and investigate the feasibility of extending the existing Hilton Creek channel further downstream to provide additional high-quality steelhead/rainbow trout habitat (ongoing);
- Improve upstream passage for adult steelhead/rainbow trout within Salsipuedes Creek at the Highway 1 Bridge crossing (2002);

- Improve upstream passage for adult steelhead/rainbow trout within Salsipuedes Creek at the Jalama Road Bridge crossing (2004);
- Conduct demonstration projects on El Jaro Creek to illustrate habitat enhancement measures to local landowners including removal of an undersized culvert and stabilization of the stream channel and adjacent banks, stabilization of an exposed side draw, and stabilization of an eroding stream bank to reduce sediment discharge into the creek (2002);
- Implement fish passage enhancement projects at nine road crossings within Quiota Creek; six road crossings would be modified to enhance fish passage as part of the FMP implementation (ongoing);
- Conduct fish rescues and relocations when instream habitat conditions are detrimental to the health and survival of steelhead/rainbow trout. Fish rescues and relocations during the 12-year period occurred on Hilton Creek, Quiota Creek, the Long Pool, and Stilling Basin (as needed);
- Develop a fish rescue and relocation plan for juvenile steelhead/rainbow trout rearing within Hilton Creek to be implemented under adverse hydrologic and water quality conditions when the watering system is not able to provide suitable habitat (water temperature) conditions within the creek (2000);
- Conduct investigations within the watershed upstream of Lake Cachuma to assess habitat conditions and suitability for various life-history stages of steelhead/rainbow trout, determine the genetic characteristics of resident trout inhabiting the upper reaches of the watershed, evaluate historic hatchery trout planting practices, and assess the feasibility and cost for providing access to the upper portions of the watershed to anadromous steelhead for spawning, egg incubation, and juvenile rearing (ongoing); and
- Provide a public education and outreach program to inform interested individuals and stakeholders about implementation of the FMP and accomplishments of the program in achieving the goal of providing increased protection and enhanced habitat conditions for steelhead to increase population abundance and contribute to the recovery of the species (2000 to present).

Implementation of management actions, as part of the FMP and BA Proposed Action, and in compliance with the BO, began in 2000 and is ongoing. The actions identified in the FMP and BO were based, in large part, on results of preliminary habitat and biological monitoring conducted within the watershed presented in the 1997 Synthesis Report (SYRTAC 1997) and subsequent investigations. One of the primary objectives of compiling and analyzing the 12-year monitoring results was to reevaluate the scientific and technical foundation for the management actions in light of a longer-term data set representing a wider range of environmental and hydrologic conditions within the watershed.

As discussed in Sections 2, 3, 4, and 5, results of the compilation and analysis of the 12-year dataset are consistent and confirm the earlier findings presented in the 1997 Synthesis Report. Results of subsequent monitoring have provided greater insight and refinement of our understanding of the dynamic nature of habitat conditions within the LSYR watershed, the fish community and their geographic distribution, suggestions for improving sampling methods, program priorities and efficiency, and database development. Monitoring results have also provided insight into habitat characteristics and constraints and opportunities for enhancing habitat conditions within the watershed for steelhead/rainbow trout, and seasonal and geographic patterns in critical water quality parameters including seasonal and diel variation in both water temperature and DO concentrations affecting habitat suitability. Results of the subsequent monitoring have not, however, identified any fundamental changes in our interpretation of the factors affecting steelhead/rainbow trout and other aquatic resources within the watershed. This fundamental finding of the 12-year synthesis of available physical and biological monitoring information for the mainstem LSYR and its tributaries indicates that the management actions implemented as part of the FMP were appropriate for the LSYR. Long-term data collection and monitoring should be continued to evaluate the performance of management actions and trends in the status of steelhead/rainbow trout and their habitat.

Figure 6-1. Lower Hilton Creek, February 1998, showing bank erosion and scour

Figure 6-2. Lower Hilton Creek, September 2000, showing early stages of riparian vegetation colonization following installation of the watering system

Figure 6-3. Lower Hilton Creek, December 2002, showing riparian colonization and growth after approximately 30 months of watering system operations

Figure 6-4. Highway 1 Bridge at Salsipuedes Creek (SC-3), pre-project, November 30, 2001

Figure 6-5. Highway 1 Bridge at Salsipuedes Creek (SC-3), post-project, January 11, 2002

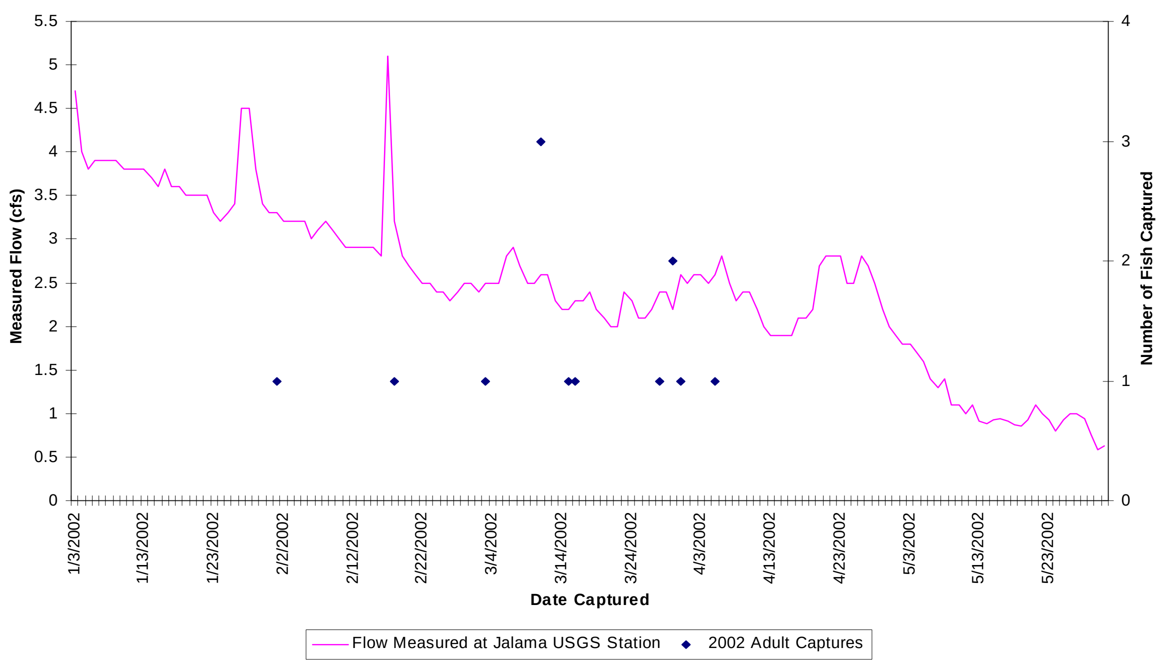


Figure 6-6. Capture of steelhead/rainbow trout in 2002 upstream migrant traps and streamflows in Salsipuedes Creek following completion of the Highway 1 passage

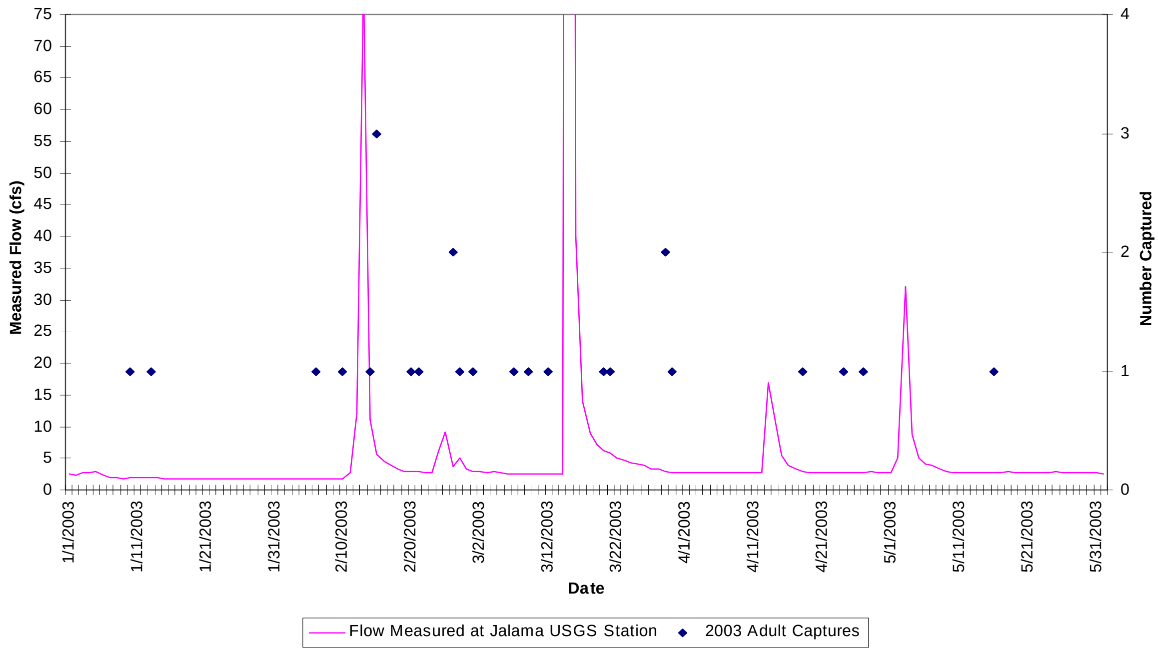


Figure 6-7. Capture of steelhead/rainbow trout in 2003 upstream migrant traps and streamflows in Salsipuedes Creek following completion of the Highway 1 (SC-3) passage enhancement project

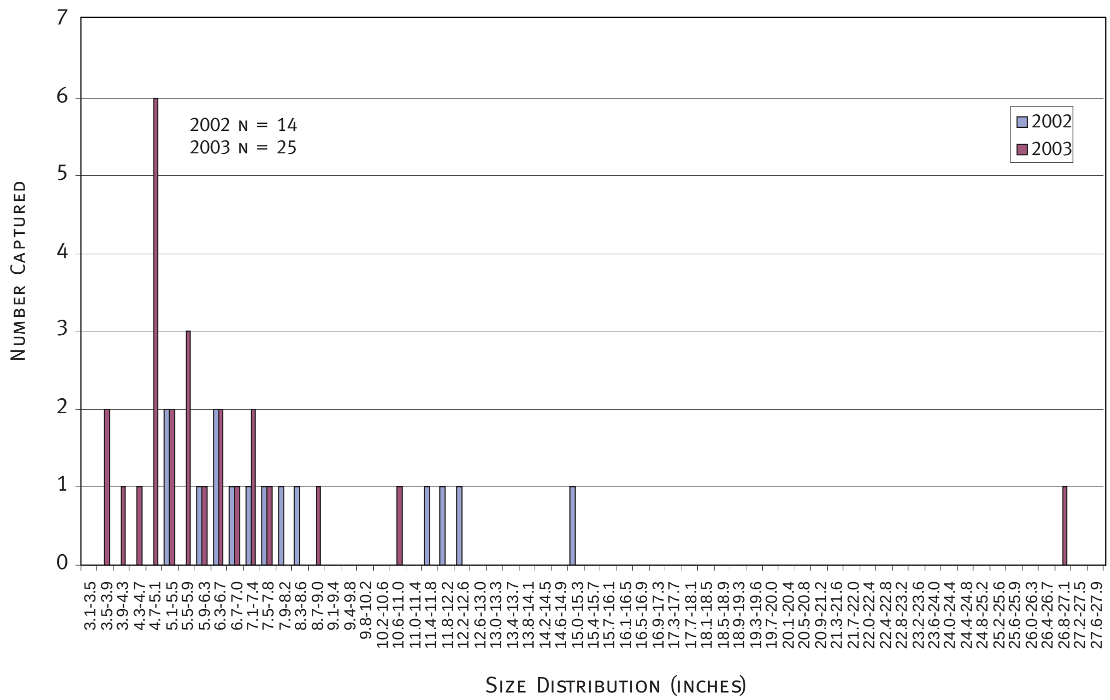


Figure 6-8. Length frequency distribution of steelhead/rainbow trout collected in upstream migrant traps in Salsipuedes Creek after completion of the fish passage enhancement project at Highway 1 Bridge (SC-3)

Figure 6-9. Salsipuedes Creek at Jalama Bridge (SC-3.5), pre-project, November 15, 2000

Figure 6-10. Salsipuedes Creek at Jalama Bridge (SC-3.5), post-project, January 2004

Figure 6-11. El Jaro Creek Demonstration Project: Undersized culvert and ephemeral stream channel

Figure 6-12. El Jaro Creek Demonstration Project: Stabilization of exposed side draw

Figure 6-13. El Jaro Creek Demonstration Project: Stabilization of eroding streambank

Table 6-1. Summary of Management Actions Identified in the FMP, BA Proposed Action and BO

Reference[1]	Management Actions Identified in the FMP, BA and BO	Status through 2004	Completed[2]	Future Implementation[3]
Mainstem:				
FMP/BA	Maintenance of year-round baseflow releases from Bradbury Dam and the HCWS to provide habitat within the mainstem river and Hilton Creek in support of juvenile steelhead/rainbow trout summer rearing	releases from Bradbury Dam implemented in 1994; Releases from HCWS implemented in 2000	✓	ongoing
FMP/BA	Ramping of downstream water rights releases	Ramping Schedule implemented in 2001	✓	
FMP/BA	Long-term rearing target flow releases		✓	Implemented in 2005
FMP/BA	Interim (1.8' surcharge) Fish Passage Account	Implemented in 2002	✓	
FMP/BA	Long-term Fish Passage Account		✓	Implemented in 2005
FMP/BA	Fish passage releases as identified in the Revised BA		✓	Implemented in 2005
FMP/BA	Adaptive Management Account		✓	Implemented in 2005: 500 acre feet available for AMC allocation to support fishery
RPM 01 T&C 1[1]	Maintain and monitor residual pool depth in Alisal and Refugio reaches during spill years and the first year after spill years if steelhead are present until the 3 foot surcharge is achieved (done) <u>and</u> the 11 passage barrier fixes are completed		✓	Implemented in 2005
RPM 03 T&C 3[1]	Revised fish passage releases Reclamation shall design a strategy within six months of the issuance of this opinion to further refine the supplemental flow releases for steelhead migration. Such a strategy shall include shifting migration supplementation releases away from dry years when releases may not be helpful to the steelhead population in the Santa Ynez and review of storm flow decay curves (mean, median, etc.,) and other methodologies for providing increased migration availability		✓	Proposed revisions sent to NMFS and authorized in 2005
RPM 05 T&C 5[1]	Do not mix CCWA water into the SYR during December through June unless flow is discontinuous in the mainstem	Implemented in 2001	✓	
RPM 06 T&C 6[1]	During the next 3 years of water rights releases, monitor steelhead downstream of Bradbury to confirm that they are not encouraged to move downstream	First monitoring completed during the 2004 water rights release.	*in progress*	Second monitoring completed during the 2007 water rights release. Third, and final monitoring, pending next water rights release.
RPM 07 T&C 7[1-2]	Monitor mainstem and Hilton Creek stage and wetted width during first year of ramping	WR 89-18 Implemented in 2001	✓	
RPM 13 T&C 13[1-2]	Temporary road crossing maintenance during seismic retrofit	Implemented in 2000	✓	
RPM 15 T&C 15[1]	Reclamation shall work with NMFS to design and implement a strategy to further verify the analysis of migration supplementation and mainstem rearing targets within six months of the issuance of this opinion.			Verification of migration passage and rearing limited by lack of access to private property. A study plan for rearing and passage is in development.
Hilton Creek:				
FMP/BA	Plant willow waddles and promote recruitment of riparian vegetation along the channel margins of Hilton Creek to increase overhead cover, increase habitat diversity and complexity, provide stream shading, and provide wildlife benefits	Implemented in 2000	✓	
FMP/BA	Installation of pump for the Hilton Creek Supplemental Watering Facility	Implemented in 2004	✓	

Table 6-1. Summary of Management Actions Identified in the FMP, BA Proposed Action and BO

Reference[1]	Management Actions Identified in the FMP, BA and BO	Status through 2004	Completed[2]	Future Implementation[3]
FMP/BA	Installation of flexible intake for the Hilton Creek Supplemental Watering Facility		✓	Implemented in 2005
FMP/BA	Ramping of Hilton Creek flows	Implemented in 2000	✓	
FMP/BA	Cascade/chute project on Hilton Creek		✓	Implemented in 2005
FMP/BA	Highway 154 Culvert project on Hilton Creek		X	Unlikely to progress in near future due to landowner and Caltrans constraints
FMP/BA	Hilton Creek channel extension	ongoing		Feasibility study anticipated in 2009
RPM 02 T&C 2[1]	Maintain flow in Hilton Creek at flows ≥ 2 cfs unless 1) the AMC decides otherwise and NMFS approves or 2) the transect data indicate that habitat space does not decrease significantly at flows less than 2cfs.	Implemented in 2000	✓	
RPM 02 T&C 2[2]	Hilton Creek habitat monitoring: Reclamation shall implement the Hilton Creek Habitat Monitoring study plan described in the Revised Project Proposal and report the results to NMFS in each year the study is conducted.	Implemented in 2001 Monitoring report for habitat work 2000 to 2002 submitted to NMFS 2003	✓	
RPM 12 T&C 12[1-3]	Reclamation shall relocate steelhead in Hilton Creek in danger of becoming stranded should releases fail due to mechanical or human error.	Ready to implement since 2000 pending need	✓	Not needed to date
Tributaries:				
FMP/BA	Bank stabilization and flood plain enhancement projects (3) on El Jaro Creek	Completed in 2004	✓	
FMP/BA	Highway 1 crossing on Salsipuedes Creek	Implemented in 2003	✓	
FMP/BA	Jalama Road Bridge crossing on Salsipuedes Creek	Implemented in 2004	✓	
FMP/BA	Abandoned road crossing on El Jaro Creek (Cross Creek Ranch property)			Ready for construction; anticipated completion in 2009
FMP/BA	Refugio Road crossings on Quiota Creek (6 crossings)			1 crossing completed in 2008; Remaining 5 crossings applied for through grant funds
FMP/BA	Culvert on Nojoqui Creek	Project determined infeasible	X	
FMP/BA	Conservation easements	No willing landowners	X	Several changes in landownership since 2004 have resulted in a general shift in interest on behalf of landowners with respect to conservation actions and conservation easements; Reclamation acting through the CCRB/ID#1 will continue to pursue conservation easements with interested landowners
FMP/BA	Mainstem and tributary habitat enhancement projects	In progress – evaluation of potential sites	✓	
RPM 08 T&C 8[1-19]	Tributary enhancement projects: monitoring and BMPs: Nineteen best management practices and project monitoring requirements designed to protect steelhead individuals, instream habitat, and streambank vegetation. Requires NMFS's approval of final project designs for the tributary passage fixes, the El Jaro Creek demonstration projects, and future Reclamation enhancement measures.	Implemented for all projects	✓	

Table 6-1. Summary of Management Actions Identified in the FMP, BA Proposed Action and BO

Reference[1]	Management Actions Identified in the FMP, BA and BO	Status through 2004	Completed[2]	Future Implementation[3]
RPM 09 T&C 9[1-3]	Fish Rescue and Predator Removal requirements: three terms & conditions with respect to rescue implementation	Ready to implement since 2000	✓	
Additional Actions:				
FMP/BA	Public education and outreach: ▪ Public workshops ▪ Toll-free number for news on habitat improvements, ▪ Newsletters ▪ Project Biologist Field trips	Implemented in 2001 and ongoing	✓	Workshops, newsletters, public meetings, landowner meetings and technical support, website, phone numbers, scientific conferences, regional fishery coordination are on-going in support of the project.
FMP/BA	AMC	Implemented in 2001	✓	Meets as needed
RPM 10 T&C 10[1]	All decisions that affect steelhead made by the AMC must be approved by NMFS before they are implemented	Implemented in 2001	✓	

1 Reference is the FMP, BA Proposed Action or BO; BO references include the Reasonable and Prudent Measure (RPM) number and the Term and Condition (T&C) numbers; RPMs not included in this table refer to project monitoring and NMFS notification and are not considered management actions.

2 ✓ means completed, X means not feasible or possible, blank means action feasible but not fulfilled

3 Management actions completed after 2004 are beyond the scope of this synthesis reporting period. Final documentation of the completion of the project and results of the performance evaluation will be addressed in future reports.

Table 6-2. Fish rescue operations conducted within the Santa Ynez River, Hilton Creek, and Quiota Creek

Date	Stream and Reach	Cause
March 17 – 31, 1997, April 6, 1997	Stilling basin and Long Pool	Bradbury Dam seismic retrofit required dewatering of the stilling basin
June 23 – 25, 1998	Lower reaches of Hilton Creek	Low DO and high temperatures
Various	Lower 2 miles of Quiota Creek	Channel drying and habitat fragmentation

SECTION 7

COMPARISON OF FINDINGS TO OTHER SOUTHERN CALIFORNIA WATERSHEDS

Section 7: Comparison of Findings to Other Southern California Watersheds

7.1 Introduction

The listing of southern California steelhead in 1997 as an endangered species under the federal ESA has prompted a large number of scientific investigations and the development of fishery management plans to protect and enhance anadromous steelhead within coastal rivers and streams in southern California. Many of the scientific investigations have focused on improving our understanding of the life-history, population dynamics, genetics, and factors limiting habitat quality and availability for southern California steelhead. Many of the studies also have been used to characterize existing habitat conditions within a watershed and identify management actions, such as removal of barriers and impediments to anadromous steelhead migration that can be incorporated into the development of fishery management plans for individual watersheds, as well as a more comprehensive regional approach to conservation and recovery of the species.

In contrast to the fishery investigations on the LSYR which began in 1993, many of the investigations conducted on other southern California watersheds and described below have taken place primarily since approximately 2000. The long-term monitoring and fishery investigations on the LSYR have provided an opportunity to assess changes in conditions over a wide range of hydrologic conditions (Section 2) reflecting the variability in conditions experienced in southern California watersheds. As part of the re-examination of information developed on habitat conditions and the steelhead/rainbow trout population inhabiting the LSYR watershed over the past 12 years, information from a variety of other southern California investigations was reviewed to help provide a broader regional context for the LSYR FMP, and to determine whether or not information developed from other southern California investigations would alter the approach and scientific foundation for elements implemented as part of a LSYR FMP.

The review of results from other investigations used for comparison with the findings of the LSYR fishery studies focused specifically on coastal watersheds within southern California. Southern California coastal watersheds, including the LSYR, are unique in terms of their climate, hydrology, physical characteristics, and other attributes when compared to rivers and streams supporting steelhead within northern California and the Pacific Northwest. In addition, it has been hypothesized that steelhead inhabiting southern California watersheds may have adapted and evolved to respond to unique environmental conditions, such as protracted periods with no precipitation, ephemeral reaches within the watersheds, the existence of naturally occurring sand bars affecting migration into and out of river systems, and exposure to seasonally elevated water temperatures (SYRTAC 1997). Since one of the primary objectives of the FMP is to improve protection and enhance habitat conditions leading to an increase in population abundance contributing to recovery of the southern California steelhead population, it is most appropriate that information from scientific investigations and management strategies focusing on southern steelhead be considered as part of this review. In the following sections two fundamental management questions are briefly addressed that include:

- Has information been developed on life-history, limiting factors, or management strategies from scientific investigations conducted on southern California steelhead that would fundamentally alter or modify the technical foundation used in developing the FMP or its implementation?

- Has scientific information been developed over the 12-year monitoring period between 1993 and 2004 on the mainstem LSYR and its tributaries that would alter or modify key findings presented in the 1997 Synthesis Report and subsequent studies used as the foundation for developing the FMP?

The review of fishery investigations and monitoring from both a regional and site-specific perspective regarding the identification and implementation of the management actions and/or monitoring and assessment methods is intended to assist both the CC and the AMC in the overall program review and identification of program modifications, if needed, as part of the ongoing implementation and monitoring effort for anadromous steelhead and their habitat on the LSYR and its tributaries.

The compilation and review of available information included papers published in scientific journals as well as a number of technical reports and unpublished documents (gray literature). The compilation of available information from steelhead investigations in southern California is not exhaustive or comprehensive, but can be used to provide representative information from a small number of investigations in various watersheds to augment and enhance results of the fishery and habitat monitoring conducted over the past 12-years on the LSYR.

To address the second management question, the preliminary key findings of the 1997 Synthesis Report were reviewed. Monitoring and studies have continued within the LSYR basin providing a longer-term record, which represents a wider variety of environmental conditions than that available for use in the 1997 Synthesis Report. Key findings of the 1997 Synthesis Report and some of their management implications are discussed briefly below in light of the expanded 12-year monitoring period to assess whether the earlier findings continue to be supported by the available information or should be modified.

7.2 Steelhead Life-History and Habitat Requirements

Development of the FMP was based, in part, on an understanding of the life-history and habitat requirements of steelhead. Information on habitat requirements for steelhead/rainbow trout and information collected from the monitoring program on seasonal flows, water temperatures, DO, habitat characteristics, passage barriers and impediments, species composition, geographic distribution and abundance, and other factors were evaluated to identify factors limiting habitat quality and availability and to identify opportunities for enhancement as part of the FMP. Although information on steelhead habitat requirements developed from studies conducted in the Pacific Northwest was useful, the application of this information to southern steelhead was modified based on results of investigations conducted in southern California to better reflect the potential biological response (e.g., adaptation or evolution in response to environmental conditions typical in Southern California watersheds) of various life stages to hydrologic, habitat, and water quality conditions occurring in coastal drainages located in the southern reach of the steelhead geographic distribution. Information from several of the studies conducted in central and southern California that provides insight into the habitat requirements and tolerances of southern steelhead are briefly described below.

Depending upon the life history stage of steelhead, habitat requirements may vary (Bjornn and Reiser 1991). For example, sufficient instream flows are required during the winter and early spring to breach downstream sand bars to allow adult steelhead access into a stream or river, provide sufficient water depths for upstream migration, and provide attraction flows to guide adult steelhead from coastal marine waters into the stream. The availability of suitable spawning gravels (e.g., gravel size, percentage fine material, permeability, etc.) with suitable instream flows and water temperatures are important for successful spawning and egg incubation. Juvenile steelhead require suitable water temperatures throughout the spring, summer, and fall for rearing in addition to suitable gravel substrate, water velocities, water depths, and instream cover from predators and for use as velocity refugia during rearing. Availability of a suitable food supply (quantity and quality) is also an important factor affecting juvenile rearing, growth, survival, and tolerance to environmental factors (e.g., exposure to seasonally elevated water temperatures, lack of low velocity rearing habitat, etc.). The presence of predatory fish and birds as well as inter-specific and intra-specific competition for physical habitat and food resources also affect juvenile rearing. Juvenile steelhead migrating downstream to the ocean (smolts) require sufficient instream flows to provide adequate water depths and velocities in addition to surface water connectivity to the ocean. Exposure to elevated water temperatures during downstream migration, the length and duration of the migration, exposure to passage barriers and impediments, and exposure to predators are all factors affecting the survival of downstream migrating steelhead. Information on these factors developed from studies conducted in the Pacific Northwest have been useful as a foundation for assessing habitat requirements and identifying potentially limiting factors as part of the site-specific investigations conducted as part of this program on the LSYR.

The LSYR is noted for warm summer temperatures that exceed published criteria for the thermal maximum for steelhead/rainbow trout (Section 3). Mathews and Berg (1997) monitored water temperature, DO concentrations, and rainbow trout distribution within two adjacent pools on Sespe Creek, in Ventura County, during the summer (August) 1994. Maximum water temperature recorded from the pools was 28.9° C (which may have potentially been influenced by exposure to air temperatures in a pool where trout were subsequently observed to have died). Results of laboratory thermal tolerance studies conducted by Myrick and Cech (2001) suggest that the chronic lethal exposure threshold for juvenile steelhead is within the range from 22.8 to 25.9° C. Myrick and Cech (2001) also reported that the range of acute critical lethal temperatures is from 27.5 to 32° C for steelhead/rainbow trout. Mathews and Berg (1997) hypothesized that groundwater upwelling within one of the pools provided thermal refugia for fish by reducing water temperatures near the bottom. Temperatures were higher in the pool that did not have seeps of cooler water and trout did not successfully oversummer in the pool. The second pool had cooler water seeps and trout successfully inhabited the pool throughout the summer observation period. DO concentrations near the bottom of the pools studied by Mathews and Berg (1997) ranged from less than 1 to 5 mg/L following a diel cycle with lowest DO concentrations observed during pre-dawn hours. Hicks (2000) reported that salmonid mortality increased at DO concentrations less than 3 mg/L. Mathews and Berg (1997) reported higher DO concentrations (typical diel range of 4 to 10 mg/L) near the surface. Trout were observed to preferentially select areas within the pool where water temperatures were lowest and avoid locations where water temperatures were highest. Mathews and Berg (1997) concluded that seeps and groundwater upwellings are important thermal refugia for trout in many southern

California areas and acknowledged that increased understanding of the role and dynamics of thermal refugia is important in steelhead/rainbow trout management.

Results of the LSYR investigations (Sections 3, 4, and 5) point to the importance of cold-water refugia for maintenance of summer juvenile rearing habitat. Cool-water upwelling locations typically are observed to develop in the mainstem LSYR at the downstream end of riffle bars where pool habitats usually are formed. These upwelling areas were especially evident during normal and dry-season conditions when the majority of the mainstem LSYR downstream of Highway 154 was characterized by a series of isolated pools and fragmented habitat. With the exception of the Long Pool (LSYR – 0.5) where cool water is available from dam releases and underflow, locations further downstream dried significantly or became dewatered during the summer. In addition, other factors, such as beaver activity, may affect surface water flow and water temperature.

Nielsen et al. (1994) also acknowledged the importance of thermally stratified pools as summer rearing habitat for juvenile steelhead. Cold water thermal refugia associated with tributary inflows and/or inter-gravel flows and upwelling created microhabitat refugia where water temperatures were substantially (average 3.5° C) cooler than surrounding waters (26 to 29° C). Pools deeper than approximately 9 feet were observed to thermally stratify when summer surface water flows were low. Nielsen et al. (1994) concluded that thermally stratified pools provided refuge habitat for juvenile, yearling, and adult steelhead in marginal river habitats where summer water temperatures reach or exceed the upper incipient lethal threshold.

Results of water quality monitoring (Section 3) within LSYR mainstem pools, and in other southern California streams (Nielsen et al. 1994, Mathews and Berg 1997), have shown that DO concentrations are frequently depressed near the bottom in stratified pools. Although cool underflow upwelling into a pool may provide a thermal refuge for steelhead/rainbow trout, low DO contributes to a reduction in habitat quality and availability. Depressed DO levels are typically lowest during the night and early morning hours (Section 3) in response to diel variation in algal respiration during the night and photosynthesis during the day. Under conditions of high algal accumulations within an isolated pool, diel DO cycles may result in DO concentrations reduced to a level that is highly stressful or unsuitable (e.g., less than 3 mg/L: Hicks 2000). Under these conditions steelhead/rainbow trout have been observed to select microhabitats based on a combination of both surface water temperatures and DO levels.

Observations during the 1993 – 1996 monitoring period were used in the 1997 Synthesis Report to conclude that low summer flow in the mainstem and tributaries resulted in habitat fragmentation and intermittent surface water connectivity among habitat units that serve as rearing areas for juvenile steelhead/rainbow trout. Results of the 12-year monitoring program confirm this earlier key finding of the 1997 Synthesis Report. At least some of the fragmentation of habitats observed in the tributaries and mainstem river (e.g., downstream of the Alisal and Refugio Reaches) in the summer appears to be the result of natural low-flow hydrology that occurs within the watershed that would be independent of Cachuma operations. Inflow to Lake Cachuma from the upper reaches of the watershed is extremely low during the summer and fall in most years, and would not have been expected to support suitable oversummering habitat for steelhead throughout the mainstem river extending downstream to the lagoon. Isolation of pools with rearing juvenile steelhead/rainbow trout poses a problem for these fish, primarily in the mainstem (Section 5). Steelhead/rainbow trout rearing in the mainstem and lower reaches of major tributaries may not have access to upstream tributary habitats during low-flow seasonal periods (except for the continuously wetted habitat in lower Hilton Creek). Water quality monitoring within the fragmented pools has shown seasonally elevated water temperatures, depressed DO concentrations, and thermal stratification in some pools associated with groundwater accretions within both the mainstem and tributaries (Section 3). All age classes of steelhead/rainbow trout have been observed in fragmented habitats within both the mainstem river (e.g., Alisal and Refugio Reaches) and tributaries. Results of investigations by Nielsen et al. (1994) and Mathews and Berg (1997) are consistent with observations from the LSYR in showing that steelhead/rainbow trout may persist within isolated pools, even when water temperatures are seasonally elevated and diel DO concentrations are depressed to levels reported in the literature to be highly stressful or unsuitable/lethal, particularly when groundwater upwelling provides thermal refugia within the pools. Results of these studies also are consistent in demonstrating high diel variation in DO concentrations with steelhead/rainbow trout surviving minimum DO concentrations that have been reported to be unsuitable/lethal in the literature (Hicks 2000). Results of the investigations conducted on the importance of microhabitat thermal refugia within pools are consistent with the observations of steelhead/rainbow trout on the LSYR.

Spina (2000) investigated habitat partitioning by three age classes of steelhead/rainbow trout within pool habitats. Young-of-the-year steelhead/rainbow trout occupied habitat characterized by shallower water depths close to the pool tail when compared to yearling and two-year-old fish that typically occupied areas near the head of a pool where water depths were greater. Observations of spatial microhabitat segregation by different size classes of steelhead/rainbow trout by Spina (2000) are similar to observations from snorkel surveys conducted as part of the LSYR investigations (Section 5) in showing that smaller steelhead/rainbow trout are frequently observed near the channel and pool margin with larger individuals observed within deeper higher velocity areas of the habitat. On the LSYR and its tributaries, snorkel observations have demonstrated spatial microhabitat segregation not only among various size classes of steelhead/rainbow trout but also spatial segregation between steelhead/rainbow trout and other fish species inhabiting a pool, including largemouth bass. Observations on habitat use within pools by steelhead/rainbow trout reported by Spina (2000), as well as observations from the LSYR fishery monitoring provide insight into pool habitat characteristics selected by various size classes and species of fish. For example, steelhead/rainbow trout have been observed in microhabitats characterized by overhead bubble curtains, large woody debris, algal mats, and deeper pool areas that appear to offer cool groundwater upwelling thermal refugia. Within the LSYR Long Pool steelhead/rainbow trout have been observed to coexist with predatory fish such as largemouth bass.

The HCWS provides habitat improvements through flow augmentation (Sections 3, 4, and 5). These results are consistent with findings by Spina et al. (2005) on juvenile steelhead abundance and downstream migration within San Luis Obispo Creek, San Luis Obispo County. Habitat within San Luis Obispo Creek was supported by flow augmentation using tertiary-treated municipal wastewater. The study demonstrated that flow augmentation was an effective method of providing summer rearing habitat for juvenile steelhead. Results of this investigation are similar to the observations and findings that flow augmentation using the watering system was an effective strategy and method for supporting juvenile steelhead summer rearing habitat within Hilton Creek. For example, after the HCWS began operations the observed abundance of juvenile steelhead/rainbow trout was higher in all water year types when compared to observations within Hilton Creek prior to initiation of the HCWS (Section 5). In addition, riparian vegetation along the channel margins of Hilton Creek has increased substantially (Section 6) after the HCWS began operations.

Findings presented in the 1997 Synthesis Report acknowledged the importance of hydrologic conditions within the watershed as a factor affecting both adult and juvenile steelhead migration opportunities. Wet year conditions provide higher flow rates of longer duration during the winter and spring period of steelhead migration within both the tributaries and mainstem, particularly in years when Bradbury Dam spills. Higher river flows also increase the likelihood that the sandbar is breached and remains open, providing extended passage opportunities for upstream and downstream migration. Data collected from 1993 – 2004 offered the opportunity to assess the relationship between hydrologic conditions and steelhead passage and spawning over a wider range of flow conditions, including wet years when the dam spilled, when compared to the limited data set available for use in the 1997 report. Results of the 12-year monitoring program continue to support the finding that passage and spawning opportunities increase within the mainstem and tributaries in response to higher flows and wet-year hydrology. Although the general pattern of migration and spawning by steelhead and hydrology has been supported by the 12-year monitoring data, the functional and statistical relationship between specific flow rates within the mainstem and tributaries and adult passage and spawning, juvenile rearing success, or breaching of the sandbar, have not been established. The response of steelhead/rainbow trout to specific flow rates in the mainstem river and tributaries is dynamic and complex. Given the inherent variability in these relationships, the relatively short period that the monitoring program and FMP actions have been in place, and a historically depressed population of steelhead/rainbow trout inhabiting the lower river, it is not surprising or unexpected that strong statistically significant relationships have not been detected between the population response of steelhead/rainbow trout and specific flows. To enhance the ability of the monitoring program to detect and statistically analyze relationships in the future between steelhead/rainbow trout movement patterns and population response (e.g., spawning, successful reproduction as reflected by increased juvenile abundance, migration and movement in response to flow cues, etc.) refinements have been recommended to the monitoring program to standardize the level of sampling effort for trap and visual observations (CPUE), increase trapping efficiency, add an additional trapping location on the LSYR mainstem, improve monitoring of the flow conditions associated with breaching the sand bar, and to continue to monitor flow conditions on the mainstem and tributaries associated with fishery monitoring.

Both upstream and downstream migrant trapping results in the LSYR suggest that anadromous steelhead spawning is favored by above normal to wet year hydrology. This is not an unexpected result, but it confirms the functionality of tributary habitats. Downstream migrant juveniles, many exhibiting characteristics of smolts, suggest successful rearing in several tributary areas. Although the number of juveniles trapped varies between wet, average, and dry year types (Section 5), generally more smolts are captured during wet years. Data collected to date indicate wet/dry year hydrology plays an important role in the total number of smolts that outmigrate in any given year.

Spina et al. (2005) observed downstream migration by juvenile steelhead (smolts) within San Luis Obispo Creek during the spring period extending from March through May, with a small number of juveniles observed to be migrating downstream during the fall. Elevated seasonal discharge within the creek was hypothesized to be the principal factor stimulating juvenile steelhead downstream migration. Steelhead parr were observed to migrate downstream from tributaries during the spring to rear in mainstem habitats. Lower summer streamflows, seasonally elevated water temperatures, and changes in seasonal photoperiod were all identified as possible factors contributing to the cessation of downstream migration by juvenile steelhead after June 1. Results of this investigation are consistent with observations reported by Spina et al. (2005), in showing that juvenile steelhead smolt emigration on both San Luis Obispo Creek and the LSYR occurred during the spring months and the importance of migration flows as a factor affecting steelhead movement. Visual observations using snorkel survey techniques have been used by Spina et al. (2005) and as part of the LSYR monitoring programs to assess changes in the behavior and movement of steelhead/rainbow trout. Many of the alternative fishery survey methods such as electrofishing have not been allowed in an effort to reduce the potential for collection and handling mortality of endangered southern California steelhead. Results of the study by Spina et al. (2005) and these investigations have demonstrated the value of snorkel surveys in assessing the abundance and geographic distribution of juvenile rearing steelhead as well as the application of trapping techniques for determining downstream migration by juvenile steelhead, while reducing the risk of incidental mortality that may occur as a result of electrofishing or other sampling methods (e.g., gill nets). The observation that steelhead parr migrated downstream to rear in the mainstem of the creek prior to emigration supports the value of both mainstem snorkel surveys on the LSYR and a recommendation for mainstem trapping as part of the fishery monitoring program (Section 8).

Results of fishery surveys within the mainstem river, particularly immediately downstream of Bradbury Dam, presented in the 1997 Synthesis Report, identified predation by warmwater fish as a potentially significant source of mortality for juvenile steelhead/rainbow trout. Although predation on juvenile steelhead/rainbow trout within the mainstem river has not been quantified, observations of relatively high abundance and in some cases large sized predatory fish such as largemouth bass, sunfish, and others within the Long Pool and other mainstem habitats throughout the 1993 – 2004 survey periods support a finding that predation by warmwater fish may significantly affect the survival of juvenile steelhead/rainbow trout rearing within the mainstem or during migration downstream from tributary habitats. It is also hypothesized that avian and/or mammalian predation was an important factor resulting in a reduction in the abundance of juvenile steelhead/rainbow trout rearing within lower Hilton Creek in 2002 (Section 5). The increase in riparian vegetation along Hilton Creek after implementation of the watering system operations (Section 6) has provided enhanced overhead cover and contribute to a reduction in vulnerability of juvenile steelhead/rainbow trout to predation.

Fish surveys and the results of fish rescue operations show that (a) largemouth bass, sunfish, and catfish are present in mainstem reaches where summer rearing conditions for juvenile steelhead/rainbow trout are often suitable, (b) these predatory fish are known to prey on juvenile steelhead/rainbow trout (Moyle 2002), compete for similar food resources, and occupy space within a habitat that may otherwise be used by trout, (c) reaches occupied by largemouth bass and catfish such as the Stilling Basin and Long Pool have also been observed on the LSYR to be inhabited by juvenile steelhead/rainbow trout, however, the predator-prey relationships have not been investigated as part of the LSYR fishery studies and (d) that largemouth bass spawn successfully in the tail-out of the Stilling Basin and Long Pool habitats. The data from fishery surveys conducted in recent years (and not available in the 1997 report) also show that there are relatively high numbers of juvenile steelhead/rainbow trout produced and rearing in the lower reaches of Hilton Creek, a direct result of the HCWS releases which began operating in 2000. Adult largemouth bass do not appear to have established themselves in this portion of Hilton

Creek; however they regularly occupy the head of the Long Pool (LSYR -0.5) where Hilton Creek joins with the LSYR (HC – 0.01). Data from snorkel surveys indicate that largemouth bass, catfish, and steelhead/rainbow trout frequently occupy the same pools in the mainstem, but that they partition the habitat, with steelhead/rainbow trout utilizing areas of cooler water with cover (Section 5).

Juvenile salmonids may comprise a significant portion of the diet in warmwater fish (Fayram and Sibley 2000; Tabor et al. 1993, Rieman et al. 1991, Poe et al. 1991, Beamesderfer 2000, and others). There is some indication in the LSYR that predation by warmwater species may contribute to steelhead/rainbow trout mortality (Section 5). However, other factors such as water quality, fragmented habitat, and poor habitat complexity also may contribute to steelhead/rainbow trout mortality. The relative importance of these factors is important, because adaptive management to enhance juvenile steelhead/rainbow trout rearing in this apparently suitable rearing habitat depends on understanding the abundance, survival, growth, and habitat use by juveniles and adults rearing in the mainstem river. Predation mortality on juvenile steelhead migrating downstream also may be a major factor affecting the overall population dynamics of steelhead produced in the mainstem river and tributaries.

7.3 Genetic Characteristics

Nielsen et al. (2003) and Greenwald and Campton (2005) investigated the genetic characteristics of resident rainbow trout inhabiting the Santa Ynez River watershed upstream of Lake Cachuma. Many of the stream reaches within the upper portions of the Santa Ynez River watershed have been planted historically using hatchery-produced rainbow trout and support recreational fisheries. Results of the genetic analysis of tissue samples collected from trout inhabiting the upper watershed, in combination with information on historic hatchery planting practices within the watershed, provide evidence of the effects of hatchery stocking on genetic integrity of native trout populations above Bradbury Dam. Although there is interest in relocating anadromous steelhead into portions of the upper basin for use as spawning and juvenile rearing habitat, results of these genetic studies demonstrate the importance of evaluating the potential for genetic integration between resident trout (particularly those planted from hatcheries) and anadromous steelhead if they were to be transported in the upper portions of the watershed.

Results of the genetic investigations by Nielsen et al. (2003) and Greenwald and Campton (2005) also support the collection of tissue samples from steelhead/rainbow trout during upstream and downstream migrant trapping within the lower river. Results of genetic analysis of fish collected in the migration trapping provide additional information on the genetic composition of the population inhabiting the mainstem river and tributaries. Although rainbow trout are no longer planted into the LSYR, there is the possibility that hatchery-produced trout planted in the lower river in the past may be affecting population genetics. There is also the possibility that hatchery-produced trout planted in the upper portions of the watershed (including Lake Cachuma) may migrate downstream during wet years when Lake Cachuma spills and populate the lower river where there would be a possibility to interbreed with anadromous steelhead. Investigations have demonstrated the ability of resident rainbow trout to interbreed with anadromous steelhead (Zimmerman and Reeves 2000; Johnsson and Abrahams 1991). Recent developments in fishery management and conservation biology have focused more closely on management techniques designed to improve and protect the genetic integrity of listed fish species. The genetic studies included in the FMP and monitoring activities within both the upper and lower reaches of the Santa Ynez River are consistent with the concern that management actions should protect the genetic integrity of listed species.

Results of these and other recent scientific investigations provide insight into the life-history, population dynamics, limiting factors, habitat enhancement and fishery management opportunities, and genetics of steelhead/rainbow trout inhabiting coastal watersheds within southern California (Neilsen et al. 2003, Cachuma Resources Conservation District and Carpinteria Creek Watershed Coalition 2005, Stoecker 2004, Ackerman and Schiff 2003, Padre Associates 2002). Results of these studies are consistent with and support the elements and basic approach adopted in the LSYR FMP such as improving streamflow within Hilton Creek, improving streamflows within the Highway 154 Reach of the mainstem river, and improving fish passage and access to suitable spawning and juvenile rearing habitat within the tributaries. Based upon review of these investigations, it is concluded that no new scientific information has been identified that would fundamentally alter the technical foundation for the FMP or its implementation. Results of these and other investigations do, however, provide additional insight into sampling protocols and monitoring techniques such as alternative trapping designs that could be considered for the mainstem river and tributaries to increase trapping efficiency over a larger range of flows and to standardize sampling effort CPUE to improve the statistical ability to compare results from one location to another or from one sampling period to another, and the identification of issues to be addressed as part of a comprehensive FMP for the river.

7.4 Habitat Assessment and Steelhead Recovery Opportunities

A number of habitat assessments have been performed (Questa Engineering 2005, Carpinteria Creek Watershed Coalition 2005, Leydecker and Grabowsky 2005, ENTRIX 2004, Payne 2003, Padre 2002, Stoecker 2002, ENTRIX 2001), primarily in the past 10 years, to determine habitat suitability and limiting factors affecting steelhead and other aquatic resources within coastal watersheds of San Luis Obispo, Santa Barbara, and Ventura Counties. Many of these assessments have been performed as part of specific projects supported by private, local, state, and federal funding as well as many performed by environmental interest groups and local citizens. For example, Santa Barbara County, with funding provided by the U.S. Environmental Protection Agency (EPA), conducted an extensive hydro-geomorphic assessment of approximately 50 creek watersheds. The city of Santa Barbara also conducted an assessment of the riparian corridor of several local watersheds and funded creek restoration efforts designed to not only enhance habitat conditions for steelhead and other aquatic resources, but also contribute to improved water quality at coastal beaches. The city of Carpinteria conducted an assessment of four local creeks as part of an assessment to determine the priority for various creeks that could be enhanced to benefit steelhead, as well as a prioritization and inventory of barriers and impediments to anadromous steelhead migration.

The creek and watershed assessments in southern California are continuing to expand and provide useful information in the development of more comprehensive watershed and coastal management plans. The growing interest in watershed assessments and the development of management plans to benefit steelhead and other biological resources are continuing to gain public support and involvement within California coastal counties. Results of habitat typing and the identification of barriers and impediments to steelhead migration and other opportunities for habitat enhancement, such as stream bank stabilization to reduce erosion and establish riparian corridors that have been undertaken as part of the LSYR FMP are consistent and compatible with watershed assessments and the development of management plans for other watersheds within Santa Barbara County and elsewhere within southern California.

7.4.1 Steelhead Spawning and Rearing Habitat

Spawning redd descriptions frequently denote the upstream presence of instream cover such as large woody debris, rock outcrops, and other adjacent cover and channel features that allow spawning steelhead/rainbow trout a secure location to hide from potential predators when needed (Opperman 2005, Mossop and Bradford 2004, Rosenfeld and Huato 2003, Bjornn and Reiser 1991, Roni and Quinn 2001, Wu et al. 2000, Cederholm et al. 1997, Harvey and Nakamoto 1996, Bryant 1983). These habitat features alter flows and sedimentation patterns in the stream and thus create conditions for gravel beds to form and to be maintained relatively clear of fines. Large woody debris, for example, also form pools with significant shade and aquatic cover for juvenile rearing steelhead/rainbow trout. Large woody debris is not a major component of current habitat conditions within the LSYR watershed, and historically may not have been abundant within the LSYR or its tributaries (as opposed to steelhead habitat in the northern portion of the geographic range), but may be a beneficial structure for rearing juveniles and pool formation under current conditions with changes in channel hydrology and land use.

The 1997 Synthesis Report described the characteristics of suitable spawning and rearing habitat and presented results of habitat surveys conducted during the 1993 – 1996 period. Results of the earlier habitat surveys identified opportunities to enhance habitat conditions within the mainstem and tributaries, where access was allowed to conduct the studies. Additional habitat surveys have been conducted over the 12-year monitoring period where access has been allowed. The habitat surveys conducted over the longer monitoring period have provided results that are consistent with the 1993 – 1996 surveys and findings. Other studies (Payne 2003; Padre 2002; ENTRIX 2001) have utilized habitat typing methods similar to those used in the FMP for application to other southern California watersheds.

Payne (2003) reported on the assessment of steelhead habitat within upper Matilija Creek based on results of a qualitative stream survey. Similar habitats are thought to only be found in the upper reaches of the Santa Ynez River watershed. The creek provided historic steelhead spawning and rearing habitat within the Ventura River system, however several impassable barriers have blocked access to upstream habitat. A multidisciplinary team approach was used in developing the assessment as part of the foundation for an ecosystem restoration feasibility study to determine the ecological benefits of dam removal and providing additional access to spawning and juvenile rearing habitat for steelhead. The assessment included consideration of streamflow, water temperature, pH, channel type including gradient and dominant substrate, riparian type including dominant vegetation and density, and the occurrence and appearance of adult steelhead holding pools. Information was also collected as part of the habitat assessment on the size and quality of gravel deposits suitable for steelhead spawning, as well as potential barriers to upstream migration for adult steelhead. The general approach to habitat typing and the identification of factors affecting habitat quality and availability were similar to the approach used in developing the foundation for the LSYR FMP, despite differences in habitat types between the two surveys. The inclusion of parameters such as stream gradient as a factor to be considered in habitat typing within the LSYR, which has not been included in previous habitat surveys, may be a beneficial refinement based on the survey protocols used by Payne (2003) and CDFG habitat typing criteria.

Padre (2002) prepared a draft watershed management plan for San Jose Creek for the County of Santa Barbara. Development of the draft management plan included consideration of the land use characteristics, geology and geomorphology, hydrology, watershed management, habitat and biological conditions of both terrestrial and aquatic species, and cultural resources within the watershed. Although not specifically targeted on management for anadromous steelhead, consideration was given to all of the protected and special status species known to occur within the area. The multidisciplinary approach used to assess conditions within the San Jose Creek watershed is consistent with the approach used in developing the technical foundation for the LSYR FMP. Many of the surveys conducted within San Jose Creek, including stream corridor habitat typing and aquatic macroinvertebrate surveys are similar to monitoring activities undertaken on the LSYR. One of the primary differences between the FMP and restoration plans developed for San Jose Creek is that the San Jose Creek restoration plan primarily focuses on bank stabilization projects through riparian revegetation and removal of non-native plant species.

ENTRIX (2001) conducted a habitat evaluation for the Ventura River in support of the development of a Habitat Conservation Plan (HCP) to address ESA species issues within the watershed. In addition to addressing habitat and protection for anadromous steelhead, the HCP would also address red-legged frog (threatened), tidewater goby (endangered), and least Bell's vireo (endangered). The HCP is based, in part, on the Ventura River Steelhead Restoration and Recovery Plan specifically addressing management actions designed to protect and enhance conditions for anadromous steelhead. As part of the technical foundation for the HCP habitat evaluation, surveys were conducted within various reaches of the river to identify habitat features such as bed substrate, canopy cover, instream cover, algal growth, quality and availability of spawning gravels, and the occurrence of barriers and impediments to steelhead migration. Based on results of these habitat surveys, which are similar in nature to the habitat surveys conducted on the LSYR, a series of habitat enhancement opportunities were identified within both the mainstem and important tributaries. Low seasonal flows, seasonally elevated water temperatures, and algal growth were also identified as factors affecting quality and availability of habitat for steelhead within several of the tributaries. Many of the factors identified in the Ventura River habitat evaluation, including conditions within several of the tributaries, are similar to conditions identified within the LSYR watershed.

7.4.2 The Role of Tributary Spawning and Rearing Habitat for Steelhead/Rainbow Trout

The information available for inclusion in the 1997 Synthesis Report indicated that tributaries such as Salsipuedes and Hilton creeks provided the primary spawning and juvenile rearing habitat downstream of Bradbury Dam. However, based on observations directly above and below the Highway 154 Reach, it is possible that moderate to large numbers of spawning adults and rearing juveniles occupy this section of the mainstem, while also serving as a migration corridor.

Information collected over the 12-year monitoring period is consistent and supports the earlier finding regarding the importance of tributary habitat for steelhead and resident trout spawning and rearing. The data from migrant trapping, snorkel surveys, and redd surveys (Section 5) all indicate that, under present conditions, anadromous steelhead spawning is concentrated in the major tributaries, primarily in Salsipuedes and Hilton creeks and (based on limited data) El Jaro Creek. The relatively larger size of redds in Salsipuedes and Hilton creeks argues strongly that these tributaries support the primary spawning habitat for anadromous steelhead in the LSYR system. However, upstream migrant trapping within Hilton Creek show that many adult rainbow trout move upstream prior to the breaching of the lagoon and may account for most of the large spawning sites within Hilton creek. Preliminary scale analysis of the majority of upstream migrating adults collected within Hilton Creek help to confirm this hypothesis. There is some incidental evidence that other creeks may also support anadromous steelhead spawning, such as reports of a few large fish spawning in Quiota and Alisal creeks. A few instances of potential anadromous steelhead spawning were also noted during redd surveys in the mainstem LSYR.

The tributaries that have surface water flows throughout the year also appear to be the preferred spawning area for resident rainbow trout. Most of the available data suggest that resident trout are spawning before anadromous steelhead have the opportunity to migrate into the river. Additionally, small resident trout have been observed spawning with larger anadromous female steelhead.

To some extent, the management implications of this finding are already being addressed, with removal of passage barriers and impediments accomplished in several locations and proposed for others (Section 6). Improved adult steelhead/rainbow trout access to tributary spawning grounds is expected to result in improved overall system production and increased steelhead abundance.

It is also clear that rearing conditions in the tributaries are, at least in reaches with year-round water and cool water conditions, enhanced by good riparian cover, better than in the lower reaches of the mainstem LSYR, except in unusually wet years (such as 1998) when extended releases from the reservoir and tributaries maintained reasonable rearing conditions in the Refugio and Alisal reaches. Even though diurnal water temperatures do not often appear to exceed incipient lethal thresholds, and are often low enough during the evening hours to create optimal/suitable steelhead/rainbow trout rearing habitat, the mainstem below mile 3.2 (Highway 154 Bridge; LSYR – 3.2) is not routinely populated by rearing steelhead/rainbow trout except during wet years. However, once the 3-foot surcharge is completed and new target flows are initiated (2005), it is anticipated that steelhead/rainbow trout may become more abundant within the Refugio and Alisal reaches of the mainstem, primarily in years when target flows are maintained to Alisal Bridge (LSYR – 10.5) due to spill and post spill conditions. Low DO levels and elevated water temperatures in mid-summer in many reaches downstream from Bradbury Dam (Section 3), in combination with low surface water flows and habitat fragmentation during summer months, help explain the low numbers of steelhead/rainbow trout in these reaches in most years. During dry and average rain year types there is less water available during the summer and reduced opportunities for upstream migration during the winter and spring, which may also explain the low numbers of steelhead/rainbow trout inhabiting the mainstem. Predation by largemouth bass and other warmwater species found in the mainstem (and the relatively low numbers found in tributaries) also may contribute to the apparent patchy distribution of rearing juveniles. It is expected that surcharging Lake Cachuma as outlined in the LSYR FMP will improve adult steelhead upstream passage and improve habitat quality and availability for juvenile steelhead/rainbow trout rearing within the LSYR as a result of higher flows and improved summer rearing conditions in the future.

These distribution and habitat quality data suggest that management of habitat in the tributaries is important. These findings are consistent with Stoecker (2002), who conducted an extensive inventory, compilation, and synthesis of information available on the occurrence and recovery opportunities for steelhead within coastal streams in southern Santa Barbara County. As part of this investigation, information was compiled on the numbers, sizes, sources of information, and observations of steelhead/rainbow trout inhabiting coastal tributaries. Information on the habitat use by steelhead/rainbow trout in coastal waters in the general vicinity of the LSYR provides a broader perspective on the geographic distribution of the species and a regional context for assessing population status and species recovery.

Steelhead observed and/or caught by recreational anglers in nearby coastal marine waters also were reported in Stoecker (2002). Results of this assessment and inventory of the occurrence of steelhead/rainbow trout are consistent with the findings of the LSYR fishery investigation regarding the importance of small tributary habitats for spawning and juvenile rearing by steelhead/rainbow trout. Results of these surveys also demonstrate the geographic distribution of steelhead/rainbow trout within many coastal watersheds in the coastal region surrounding the Santa Ynez River.

7.4.3 Impediments and Barriers to Migration

The 1997 Synthesis Report found that barriers and impediments to upstream and downstream migration by steelhead and resident rainbow trout reduced access to suitable upstream spawning and rearing habitat in many of the tributaries. The 1997 report found that improving passage at many of the barriers at lower flow rates would increase habitat area available to steelhead/rainbow trout and would be expected to increase the overall abundance of steelhead/rainbow trout produced within the watershed. Barriers to migration into the mainstem and tributaries were characterized by the 1993 – 1996 surveys in all areas where CPWA field staff had access. These barriers are typically located at the downstream end of bridge/road structures where scour associated with concrete aprons has lowered the channel by many feet resulting in passage impediments during low to moderate flow rates. Additional surveys conducted over the 12-year monitoring period confirm the earlier findings showing that many of the bridge crossing (e.g., Highway 1 bridges) and low-flow road crossings create barriers and/or impediments to upstream and downstream migration by adult and juvenile steelhead/rainbow trout. Many of the passage impediments were found to be obstructions to migration during low-flow periods but may be passable under higher flow conditions. Results of the 1997 Synthesis Report and the more recent observations indicate that modification or removal of these passage impediments would provide improved access to potentially suitable upstream habitat within the LSYR tributaries for steelhead/rainbow trout spawning and juvenile rearing.

The management team recognized the importance of barrier removal in developing the FMP. Passage has been improved at several barrier locations (Section 6) with additional passage improvement projects planned over the next several years.

Accelerated erosion from adjacent land uses may contribute to the excessive sediment in the channel. Sedimentation that reduces stream depth should be monitored and sediment sources identified to the extent feasible. Grazing, road cuts, and other land uses such as farming on steep slopes may adversely affect sediment deposition within a stream resulting in an impediment to steelhead/rainbow trout access to suitable spawning and rearing habitat.

The 12-year monitoring program results have shown that existing physical structures, frequently associated with bridges and low-flow road crossings, create barriers and/or impediments to steelhead/rainbow trout migration and access to upstream reaches of LSYR tributaries where habitat conditions are suitable for steelhead spawning and juvenile rearing. Based on the identification of suitable habitat conditions (e.g., seasonal flows, water temperatures, substrate, cover) upstream of locations identified as passage impediment or barriers it was concluded that improved passage and upstream access will benefit the steelhead/rainbow trout populations inhabiting the watershed.

Stoecker (2004) identified and inventoried barriers to steelhead migration and opportunities for habitat enhancement on the LSYR that are thought to contribute to recovery of the southern steelhead population. Barrier removal and improvement to passage is a key element of the LSYR FMP.

7.4.4 The Dynamic Nature of the Mainstem and Tributary Channels, Especially During Periods of High Flow

The 1997 Synthesis Report acknowledged the relationship between high flows in the LSYR and tributaries and their effect on geomorphic processes including channel sediment scour, deposition, and changes in channel features (e.g., channel alignment, formation of pools, etc.). The floods of 1998 and 2001 (Section 2) demonstrate the dynamic nature of the tributary and mainstem channels. Hilton Creek's channel outlet moved twice during 1998 storms and there were numerous reported examples in the mainstem of pools converting to riffles or complete channel migration. Redd surveys documented instances in which high flows following spawning apparently resulted in erosion and sedimentation that may have destroyed redds. The observations of channel dynamics over the 12-year monitoring period, which included high flow events that exceeded conditions observed during 1993 – 1996 period, are consistent with and support the earlier finding regarding the dynamic characteristics of the mainstem river and tributaries.

The dynamic characteristics of the mainstem river and tributary channels are not unexpected within a system with highly variable hydrology (Section 2), steep topography, human impacts, and large areas of sedimentary soils. Geomorphic processes associated with periodic high stream flows and stormwater runoff affecting channel form and erosion/deposition patterns are typical of many southern California and central coast rivers and streams (Storlazzi and Griggs 2000; Inman and Jenkins 1999; Critelli et al., 1997). The LSYR mainstem substrate is characterized primarily by sand and small gravel that can be mobilized in response to increased river flows such as those that occur during a large spill event. Under these conditions observations of channel bed forms show evidence of sediment movement resulting in channel erosion (scour) in some areas and sediment deposition in other areas. For example, areas that may have been deep pools have been substantially altered by deposition of sediment and the river course has been observed to change in response to high flows. Scour and deposition of sediment within the mainstem river during high flows in the winter and spring would potentially adversely impact the success of incubating steelhead/rainbow trout eggs. The dynamic effects of sediment movement on channel form may partially explain why spawning within the mainstem is not commonly observed. The upstream portions of tributaries, with their smaller drainages, may have less potential to adversely affect redds in areas without heavy sedimentation, and in years of high flows may represent the most stable and productive environment for spawning. In all water year types, upstream areas maintain higher rates of flow from saturated soils and groundwater, which may be the only locations where suitable rearing habitat is available. In wet years, the linear length of tributary habitat is increased because of additional flow, but besides Salsipuedes and Hilton creeks, all other tributaries dry in their lower reaches.

7.4.5 Interdisciplinary Studies

Several other interdisciplinary studies have been conducted along the southern California coast that can be compared with the approach taken in the LSYR. Questa Engineering (2005) conducted an assessment of the existing habitat conditions within the Arroyo Burro, Mission, Sycamore, and Laguna Creek watersheds on behalf of the city of Santa Barbara Creeks Restoration/Water Quality Improvement Division. The investigation summarized creek and watershed policies and programs, land use, cultural resources, infrastructure, watershed conditions including consideration of geology and soils, geomorphology and hydrology, groundwater, water quality, terrestrial biology, and fisheries. Information is presented as part of the assessment for each of the creeks on the fish community inhabiting the watershed, fishery habitat conditions, and the identification of fish passage barriers and issues of concern. The assessment of existing conditions within these watersheds serves as the technical foundation for developing a more comprehensive watershed action plan. The interdisciplinary approach of evaluating conditions that affect habitat quality and availability for anadromous steelhead, including consideration of hydrology, water quality, land use, existing habitat conditions, and the identification of key constraints, such as barriers and impediments to migration, is consistent with the approach used in developing the LSYR FMP.

ENTRIX (2004) provided a status report on the Tri-County Funding for Improved Salmonid Habitat (F.I.S.H.) team activities that focuses on steelhead restoration and recovery in San Luis Obispo, Santa Barbara, and Ventura counties. The effort represents a partnership between non-governmental organizations, landowners, and local governmental agencies involved in restoration activities to benefit southern California steelhead. The report documents a broad range of both short- and long-term maintenance and management activities that potentially affect or benefit stream habitat for steelhead and other aquatic resources. Many of the activities that have been implemented include public education programs, public awareness, restoration projects, landowner outreach, watershed forums, fishery rearing programs, environmental training, fish passage programs, and water quality and hydrology monitoring. The program report also identifies the potential effect of various activities, such as road surfacing, grading and excavation, levee construction, culvert installation, and other activities on stream hydrology, riparian vegetation, sedimentation, instream modifications, water quality impairment, and the creation of barriers and/or impediments to steelhead migration. The program reflects an interdisciplinary regional effort for coordination and communication to benefit stream restoration activities. The F.I.S.H. program includes many of the components that have been identified and addressed on a more site-specific basis as part of the fishery monitoring program and development of the LSYR FMP. CPWA and Santa Ynez River Water Conservation Improvement District #1 participate in the LSYR FMP development and implementation, as well as the regional Tri-County F.I.S.H. team activities.

The Carpinteria Creek Watershed Coalition is comprised of private landowners, farmers, ranchers, nonprofit organizations, researchers, as well as local, state, and federal agencies working together to develop a watershed management plan for the creek (Cachuma Resources Conservation District and Carpinteria Creek Watershed Coalition 2005). The watershed management plan focuses on six goals and objectives that included: a self-sustaining steelhead population in Carpinteria Creek; sustainable and functional riparian corridors throughout the creek watershed; persistent high water quality throughout the creek; community wide participation in collaborative watershed protection and management; public access to the creek corridor; and public education regarding the natural resources of the watershed.

The interdisciplinary approach used in developing the Carpinteria Creek watershed plan, designed to protect and enhance habitat conditions for anadromous steelhead spawning, egg incubation, and juvenile rearing in addition to other resource benefits, is consistent with the general approach used in developing the LSYR FMP.

Review of information from watershed assessments used as the technical foundation for identifying appropriate habitat management and enhancement measures within coastal watersheds in southern California has shown the benefit of an interdisciplinary approach integrating water quality, hydrology, habitat mapping, and biological surveys in developing an understanding of opportunities and constraints within a given watershed. Results of these investigations have also demonstrated the importance of identifying and prioritizing barriers and impediments to anadromous steelhead migration as part of an overall management plan designed to benefit steelhead. In general, the monitoring and habitat assessment conducted on the LSYR over the 1993 – 2004 period and the resulting technical foundation used in developing the FMP, is consistent with the approach for addressing steelhead/rainbow trout and other habitat issues in southern California watersheds. The approach used in developing the technical foundation for the LSYR FMP is consistent and compatible with other restoration and enhancement activities designed to benefit steelhead/rainbow trout within the region. Based upon results of this review, no substantial changes or modifications to the fundamental approach used in developing the LSYR FMP or its implementation have been identified.

7.5 Monitoring and Assessment Methods

Results of the review of the basic approach used to monitor and assess habitat conditions within various southern California coastal watersheds (Questa Engineering 2005, Carpinteria Creek Watershed Coalition 2005, ENTRIX 2004, Payne 2003, Padre 2002, ENTRIX 2001) are generally consistent with the monitoring and assessment techniques implemented on the LSYR. Monitoring methods for stream hydrology as well as monitoring for water temperature, DO, and other water quality parameters implemented on the LSYR are similar, and in many cases more robust, than the level of data collection used in habitat assessment on many of the other watersheds (Leydecker and Grabowsky 2005, Payne 2003), including the use of high frequency time series data with deployable sondes that began in 2004. One of the primary differences is that much of the monitoring conducted as part of watershed assessments elsewhere within southern California has been characterized by a relatively short monitoring duration, frequently representing conditions over a 1- to 5-year period. In several of the habitat assessments, monitoring was either qualitative or limited to a relatively narrow range of parameters and monitoring locations. One of the major benefits of monitoring on the LSYR system has been the wide geographic distribution of monitoring activities (Figure 1-3, Table 1) within the mainstem, tributaries, lake, and lagoon, as well as monitoring over a relatively long period of time reflecting a range of hydrologic and other environmental conditions.

Fishery monitoring used as part of the development of many of these watershed assessments has focused on habitat mapping similar to that conducted within the LSYR watershed and fishery surveys conducted using either direct observation during snorkeling and/or migrant trapping. The fishery monitoring techniques used in other southern California stream surveys for steelhead/rainbow trout are similar to those being employed on the LSYR and its tributaries.

Although not specific to southern California steelhead populations or their habitat, Bisbal (2001) and Roset et al. (2007) provide a useful overview of stream resource monitoring protocols as part of the threatened and endangered aquatic species and stream fish assemblages indicator program. The overview provides useful guidance in identifying measurable monitoring objectives, monitoring questions, sampling designs for summer and fall stream fish surveys, smolt outmigration trapping, adult escapement monitoring as well as field methods, data handling, analysis, reporting, personnel requirements and training, and operational requirements for implementing and conducting an effective monitoring program. The structure of developing an integrated monitoring program, identifying specific monitoring objectives and hypotheses, and developing quantitative indicators of the physical and biological response to various environmental conditions and management actions identified by Bisbal (2001) and Roset et. al. (2007) provide applicable guidance to enhancing and refining the existing LSYR monitoring program.

A second useful document providing guidance on stream fishery monitoring has been presented by Thom and Wellman (1996) titled “Planning Aquatic Ecosystem Restoration Monitoring Programs” that includes information on aquatic restoration monitoring and methods to assess the effectiveness of implemented management actions. The report also presents guidance on developing a monitoring program that includes the identification of specific monitoring objectives, development of a conceptual model, identifying performance criteria, choosing monitoring parameters and methods, determining the appropriate level of effort and duration of monitoring, implementing and managing monitoring activities, and the application of monitoring results as a management tool within an adaptive management framework. Guidance in the design of an effective monitoring program has been used in developing recommendations for refinement of the LSYR fishery program presented in Section 8. Additional guidance was provided by Harris et al. (2005) on monitoring both the implementation and effectiveness of fisheries habitat restoration projects.

The CDFG has also developed useful manuals, protocols, and guidance on conducting stream habitat typing, habitat restoration and enhancement, and the identification of potential passage barriers and impediments and their modification to improve passage. These protocols and criteria have been used as part of the foundation for developing the monitoring program implemented on the LSYR.

The Center for Ecosystem Management and Restoration (CEMR) is developing a comprehensive database management system as part of the southern steelhead resources project. The database management project will compile, digitally archive, and analyze available data on anadromous steelhead and their habitat in central and southern California. The database is intended to be used, in part, for assessing regional trends in the anadromous steelhead population and their habitat conditions, restoration activities, and the response of steelhead populations to these management activities. As part of the LSYR monitoring program a large volume of data has been collected on hydrology, water quality, habitat typing, and biological monitoring within the mainstem river and its tributaries (Sections 2 to 5). As part of developing this synthesis report an effort has been made to develop a systematic framework and nomenclature for identifying sampling locations (Table 1-1) that will serve as the foundation for compiling an integrated relational database, compatible with GIS analyses. Development of the comprehensive database will facilitate, in the future, the synthesis of multidisciplinary datasets and generation of statistical analyses and data reports that will make monitoring information readily available for application in informing adaptive management decisions and evaluating performance of various management actions.

The monitoring conducted on the LSYR over the 12-year period from 1993 to 2004 has provided insight into the assessment of existing habitat conditions as well as opportunities and constraints to further protect and enhance conditions for anadromous steelhead. Results of these monitoring programs have served as the technical foundation for the identification of specific management actions in the development of the FMP. As the fishery program moves into the implementation and performance evaluation phase, both baseline and project-specific monitoring will be required to quantitatively evaluate various management objectives and assess the contribution of the management program to the population dynamics of steelhead inhabiting the LSYR, and their contribution to recovery of the species within southern California. The existing monitoring program will require refinement to provide more systematic and quantitative monitoring results for use in evaluating program performance and trends in steelhead population abundance to enable informed AMC decisions. Guidance provided by Thom and Wellman (1996), Bisbal (2001) and Roset et al. (2007) on monitoring programs for restoration programs and ESA fish species, in addition to guidance available on the structure and tools for database management and analysis, should be reviewed and integrated as part of refinements to the LSYR monitoring program. Results of this review suggest a number of areas where the existing monitoring and evaluation program can be refined (see Section 8).

7.6 Summary of 1993 – 2004 Findings

The following conclusions have been made based on the review of other southern California steelhead/rainbow trout investigations and results of monitoring conducted during 1993 – 1996 and subsequently extended through 2004 on the LSYR and its tributaries:

- The role of tributaries and the mainstem LSYR as spawning and rearing habitat for steelhead/rainbow trout is relatively well established as it relates to wet year and dry year hydrology;
- The summer distribution of both juvenile and adult steelhead/rainbow trout is patchy, varying by reach, by year, and by season, as reflected in results of migrant trapping and direct visual observations;
- The relationship between wet and dry year hydrology and migration and spawning by anadromous steelhead is reasonably clear;
- The dynamic nature of the mainstem and tributary channels, especially during periods of high flow, has been documented and changes in habitat types have been observed;
- Redds constructed prior to high flow events have been destroyed by scour and sediment deposition in many years within the tributaries, specifically in Salsipuedes Creek, (based on follow-up surveys), that is expected to result in a decrease in juvenile recruitment;
- Problems associated with impediments and barriers to migration have been identified, and corrected in several cases;

- The phenomenon of summer-fall habitat fragmentation in the mainstem and in the tributaries is better understood, however the factors affecting the dynamics of isolated pools and fragmented habitat in the mainstem river and tributaries are not understood and should be investigated further;
- The timing of migration and spawning by anadromous and resident steelhead/rainbow trout is better understood as it relates to wet and dry year hydrologic conditions;
- Predation of steelhead/rainbow trout by warmwater species continues to be a possible source of steelhead/rainbow trout mortality although the extent is unknown until further studies can be conducted; and
- The general approach taken in the LSYR FMP and BA Proposed Action is consistent with other studies conducted in the central and southern California coast.

The results of fishery and habitat monitoring on the LSYR show trends which are similar to many other southern California coastal streams and rivers. Exposure to seasonally elevated water temperatures, exposure to diel depression in DO, sediment erosion and deposition, lack of intact riparian vegetation, and passage barriers and impediments have been identified as constraints on steelhead/rainbow trout habitat within many watersheds. The multidisciplinary approach used to develop the LSYR FMP is consistent with the strategy and approach being implemented in many other watersheds. The LSYR program is unique from many of the other southern California investigations in that there is a 12-year period of monitoring and investigation, the FMP has been established, and implementation of management actions is occurring. Many of the other watersheds are in the early stages of monitoring and management plan development. Based on the review of other southern California investigations and re-examination of the 1993 – 2004 monitoring data for the mainstem river and tributaries, no major changes in the management plan actions or their implementation have been identified. Refinements to specific elements of the monitoring program to improve the ability of the baseline and project-specific investigations to quantitatively evaluate performance of management actions and assess trends in the abundance of steelhead/rainbow trout are recommended for consideration (Section 8).

SECTION 8

RECOMMENDATIONS TO THE MONITORING PROGRAM

Section 8: Recommendations to the Monitoring Program

8.1 Introduction

Monitoring and data collection have been a fundamental element in developing the multidisciplinary approach to identifying and implementing management actions on the LSYR and its tributaries to protect and enhance habitat for anadromous steelhead. Key elements of the 12-year monitoring program performed over 1993 – 2004 include the collection of data on hydrology, water quality, instream and riparian habitat, and fish species. Results of these monitoring activities are described in Sections 2 through 5. The focus of the monitoring program has been on anadromous steelhead and their habitat within the mainstem river and tributaries downstream of Bradbury Dam. Steelhead were selected as the primary species of interest based on their occurrence in the LSYR, the role of the LSYR in supporting an important part of the overall regional steelhead population, the potential for operations of the Cachuma Project to affect steelhead and their habitat, and opportunities for management actions implemented on the LSYR to contribute to recovery of the species. Although steelhead are the primary species of interest in the management and monitoring program, observations are recorded for all species. Incidental information on species like tidewater goby inhabiting the lagoon and observations of red legged frogs are also valuable additions to the USFWS and CDFG in their understanding of the distribution and relative abundance of these and other protected and special status species. Incidental observations of protected and special status species collected as part of the LSYR monitoring activities will be compiled and provided to USFWS for inclusion in the California Natural Species Diversity Database (managed by CDFG) and for inclusion as part of the broader regional studies and analyses for these species. In addition, consideration of the potential beneficial and adverse effects of Cachuma Project operations and management actions on these sensitive species (e.g., red legged frog reproduction and egg clusters, disturbance resulting from monitoring or management actions, benefits of increased willow growth on habitat, plunge pools and other habitat features for species such as willow flycatcher and least bells vireo, periodic dewatering of stream reaches on controlling bull frogs and warmwater predatory fish, etc.) as well as the effect of beaver activity on habitat conditions along the mainstem LSYR and tributaries.

In addition to these baseline monitoring activities developed to inform our collective understanding of the system and how fish use it, implementation of project-specific management actions as part of the FMP and the BA Proposed Action (Section 6) has led to the need to evaluate the performance of the management actions. Furthermore, the implementation of the FMP, BA Proposed Action, and Terms and Conditions of the BO are based on an adaptive management framework that uses specific monitoring results and observations to make informed AMC decisions. To provide a measure of success or failure of the management actions conducted under the FMP or BA Proposed Action, and to support the adaptive management process overseen by the AMC, the monitoring program has been supplemented to include the following three fundamental goals:

- **Quantify the trends in the status of steelhead/rainbow trout, habitat and/or community.** Provide a consistent baseline for use in quantifying trends and changes within and among years reflecting various environmental conditions (e.g., hydrologic conditions, seasonal water temperature conditions, changes in habitat, etc.) to the extent feasible given constraints on access and field monitoring logistics, and the numbers and geographic distribution of adult steelhead returning to the LSYR each year, reproductive success, and the abundance and survival of juvenile steelhead/rainbow trout rearing and emigrating from the river system. Analysis of the trends allows the AMC and resource agencies to evaluate the performance of management actions in accomplishing their intended goals in promoting an increase in species abundance and contribution to species recovery;

- **Quantify the performance and response of steelhead/rainbow trout, habitat and/or the associated aquatic community to management actions.** Quantitatively evaluate the response of various life-history stages of steelhead/rainbow trout to specific management actions implemented as part of the FMP and BA Proposed Action, such as the effect of passage flows on adult immigration and smolt emigration, increased spawning activity within the mainstem and tributaries, population changes upstream of passage enhancement projects, juvenile oversummering success as it relates to increased flows within the mainstem and Hilton Creek, changes to the quality or availability of habitat, factors contributing to mortality such as predation by warmwater species, and the overall increase in population abundance in response to management actions implemented as part of this program; and
- **Provide the technical information necessary to identify and inform adaptive management decisions as part of program implementation.** Monitor environmental conditions and trends in habitat and fishery populations and document, through annual technical reports, implementation of the LSYR FMP actions and BA Proposed Action in compliance with the requirements identified in the BO. Provide the necessary scientific and technical information needed, on an appropriate time scale, for use in identifying and informing adaptive management decisions by the LSYR AMC.

Within the framework identified by these broad monitoring program goals and guidelines, specific objectives of each element of the monitoring program should be stated and periodically reassessed as part of the ongoing critique and review of the monitoring program.

As part of the process of compiling and analyzing data collected over the 12-year period from the monitoring program, and management actions implemented in accordance with the FMP, BA Proposed Action, and BO, over the 12-year period a number of recommendations and refinements were identified. The ongoing program of monitoring activities and implementation of FMP and BA Proposed Action management actions has been modified and refined since 2004 in response to the recommendations developed through this review process. In addition, a number of management actions and targeted scientific investigations have been successfully implemented in compliance with the FMP and BO after 2004 that are not included in this report. As part of the ongoing AMC process, technical memoranda and reports have, and are continuing to be prepared, for review by the AMC. The program has undergone a transition between the 12-year period extending through 2004 and the current program efforts. The program will continue to be refined and periodically reviewed through development of a sequence of future annual reports and other technical documents that reflect results of the continuing monitoring program, implementation of the FMP and BA Proposed Action, and compliance with the BO. Results of the ongoing monitoring program are also being used to identifying data needs and decisions regarding program implementation that respond to adaptive management decisions.

Recommendations for refinements to the ongoing management and monitoring program have been implemented that address specific elements of the program through design of focused, targeted, experiments and data collection activities. Results of these focused investigations could be used to identify functional relationships between fish and habitat parameters and various physical and biological processes using correlation, regression, and other analytical tools. Results of these focused investigations would provide input to the AMC for use in evaluating alternative management strategies.

To help manage and coordinate these diverse monitoring and management activities a long-term monitoring program plan is being developed that reflects recommendations from this synthesis as well as new information from recent years for review by the AMC. Based on annual priorities for monitoring developed collaboratively with the AMC a specific annual monitoring program will be developed each year and implemented by CPWA staff. The monitoring plan would include a brief description of the experimental design, monitoring protocol, identification of testable hypotheses, and proposed methods for analysis, and focused short-term investigations that would be reviewed and approved by the AMC prior to implementation.

Refinement of the existing monitoring program to meet these needs requires a continuing commitment to a rigorous and consistent approach to data collection and analysis. In developing the scientific foundation for an effective monitoring plan, it is not uncommon to conduct exploratory investigations during the initial phase of the monitoring program. The monitoring conducted during the 1993 – 2004 period included a wide range of descriptive baseline monitoring elements that provided valuable information on hydrology, water quality, habitat, and the fishery community, targeting steelhead/rainbow trout, within the lower mainstem river and tributaries downstream of Bradbury Dam. Early results of the monitoring program provided the technical basis for developing the LSYR FMP and BA Proposed Action and confirmed project-specific hypotheses that led to the development of various management actions.

To meet the information needs of the next phase of the project, the focus of the monitoring program changes from broad-based exploratory investigation to more focused quantitative investigations addressing specific objectives relative to the management actions being implemented. The investigations are needed to make informed adaptive management decisions, evaluate performance of the specific management actions being implemented to benefit steelhead/rainbow trout and other aquatic species, and to monitor trends in the abundance and status of adult and juvenile steelhead/rainbow trout inhabiting the LSYR system. To meet these new monitoring demands with available technical staff and budget, the future long-term monitoring program should be refined to focus resources on the primary monitoring objectives linked to specific management actions and decisions.

The adaptive management aspect of the program is now ready for the next stage of the fishery monitoring program, which is an important milestone in the implementation of the LSYR FMP, BA Proposed Action, and BO. As the elements of the monitoring program are defined to guide future actions, the plan is to organize the monitoring program around specific study questions. The general criteria, goals, and guidelines that were used as a basis in identifying recommendations for refinement to the monitoring program in the future, include:

- The objectives for each element of the monitoring program will be clearly identified and articulated;
- The elements of the monitoring program will identify testable hypotheses and/or specific linkages between monitoring elements, associated management actions, and program guidance documents;

- Develop an experimental design adequate and appropriate for achieving the specific objectives of each monitoring program element and the available resources to conduct the investigation;
- Develop specific protocols, methods, and analytical procedures robust enough to provide reliable, reproducible, quantitative and qualitative information on the backdrop of the variability in streamflow, access to sampling sites, and ability to perform the prescribed protocols; and
- The monitoring program will include an analytical framework for the management, integration, and analysis of monitoring results on both a temporal and geographic scale (e.g., GIS database framework) that includes appropriate quality control and management of large interdisciplinary datasets.

One of the specific objectives of this synthesis and review of the monitoring program conducted to date is to offer guidance in the continued development of a rigorous, analytical, well-designed, and managed long-term monitoring program that meets the scientific standards in the most cost-effective manner available. The information collected over the 1993 – 2004 period presented in Chapters 2 through 7 of this Synthesis Report is intended for use as a milestone for the current program. Results presented in this report reflect on the findings developed from the past monitoring activities. Monitoring results have also been used to re-evaluate that the ideas and thoughts of how the basin operates, which served as the underpinnings of the LSYR FMP, BA Proposed Action, and BO, using additional data collected over a wider range of hydrological conditions. The information can now serve as part of the technical foundation for refining the long-term fishery monitoring program to provide more specific information on the performance of the various management actions.

In general, the analysis leads to a series of recommendations for (a) continued refinement of the current monitoring program in the development of a long-term dataset for trend analysis, and (b) focused experiments and statistical analyses designed to (1) identify the response of steelhead/rainbow trout to various management actions, (2) quantify changes and functional responses among physical habitat conditions and biological responses of adult and juvenile steelhead, and (3) identify statistical relationships among monitored parameters. In the sections presented below, various aspects of the 12-year monitoring program are reviewed, including the limitation and constraints affecting the program, with recommendations and guidance for refining the monitoring program in the future are suggested.

8.1.1 Monitoring Program Limitations and Constraints

A variety of factors have affected the design and implementation of monitoring procedures and protocols within the LSYR and tributaries over the 1993 – 2004 period. One of the primary factors has been the limitation on access to habitats within the lower mainstem river, specifically the Highway 154 Reach, and portions of the tributaries located on private lands where habitat and fishery monitoring and observations have been prohibited. Results of habitat typing conducted to date, have been limited by restrictions on access to private lands. Given limitations on the ability to systematically conduct habitat typing where access to private lands is prohibited, consideration should be given to the use of high-resolution aerial photographs of the mainstem and tributaries as a basis for monitoring trends and changes in habitat conditions (a program implemented in 2006). Aerial photographs would only need to be taken periodically, following channel altering flow events or in response to other specific monitoring objectives (e.g., monitoring changes in riparian vegetation, etc.) or every 3 to 5 years if no major discharge event occurred to track land use changes.

Other factors affecting the design and implementation of the monitoring plan include:

- Reconnaissance-level exploratory studies were conducted on the LSYR, as is common in the early stages of most monitoring programs. Many of the studies have been designed and conducted to provide basic descriptive information on the general abundance and distribution of steelhead/rainbow trout and the suitability of habitat conditions within the mainstem river and tributaries. These studies have provided useful information on constraints and limiting factors affecting steelhead/rainbow trout. As a reflection of the small population of steelhead/rainbow trout inhabiting the LSYR, regulatory constraints due to the endangered species designation of southern California steelhead, complexities of environmental conditions and data collection, and to some degree the monitoring program design, results of the 1993 – 2004 studies provide a limited ability to quantitatively evaluate functional relationships between the population response of steelhead/rainbow trout and changes in habitat and environmental conditions resulting from either naturally-occurring events or FMP/BO management actions;

- The methods used to survey steelhead/rainbow trout have been adversely affected by high flow events associated with the flashy nature of mainstem and tributary watersheds, limitations on sampling methods imposed by regulatory constraints intended to reduce the potential mortality of endangered steelhead resulting from fishery sampling, and the fact that the LSYR fishery program is the first long-term comprehensive monitoring program for southern California steelhead in the region. Migrant trapping has been suspended at times when hazardous hydrologic conditions and debris flow would rapidly destroy the equipment, and potentially harm steelhead/rainbow trout if it were deployed. The ability to constantly survey steelhead/rainbow trout movement within the mainstem river and tributaries over a wide range of flows, with a consistent sampling effort and trapping efficiency, is important to quantify trends in steelhead/rainbow trout abundance, changes in production among areas and in response to environmental and management conditions. Enhancements in migrant trapping procedures in recent years have improved the ability to quantify catch-per-unit-effort (CPUE) and the extension of migrant trapping from the tributaries into the mainstem LSYR will improve the fishery monitoring program. These changes in the migrant trapping program are expected to improve the ability to compare CPUE within and among years. High flows, access restrictions, high inter- and intra-annual storm flows , however, continue to be factors affecting the ability to develop estimates of adult and juvenile abundance within various regions of the tributaries and lower river, and support statistical analyses. Strong variation in storm flow patterns within and between years will continue to complicate the desired long-term trend analysis;

- Regulatory issues have interrupted scientific surveys for several extended periods of time, coincidentally in years when conditions for steelhead/rainbow trout migrations and spawning would have hypothetically been their best (1998 and 2000). Monitoring methods and protocols have been established as part of the current monitoring program that comply with regulatory requirements for the protection of sensitive fish and wildlife, and future interruptions of fishery surveys (specifically migrant trapping) should not occur; and,

- Limitations caused by the inability to use more quantitative sampling methods because of the endangered status of southern steelhead, such as electrofishing, PIT tagging, weighing stomach content analysis, and otolith removal are a result of regulations regarding incidental take associated with increased handling stress and mortality.

These constraints and limitations on the monitoring program are well understood by both the technical and management staff implementing the field program. These constraints and limitations have been raised in this discussion to point out that (a) these issues need to be resolved if possible, and (b) that the data collected over the 1993 – 2004 period provide a reasonable foundation for their resolution. During the exploration process of the 1993 – 2004 survey periods, important knowledge has been gained about the inner workings of the LSYR system, as presented in Sections 1 through 6. With these data, it will be possible to develop the more rigorous long-term monitoring program needed as part of the evolution of the implementation and evaluation of the FMP and BO.

8.2 Recommendations

8.2.1 Instrument Calibration and Protocols

During the 1993 – 2004 monitoring period observations of water quality measurements were noted within the database that appeared to be outliers. Based upon a review of the available records it could not be determined whether these apparent outliers were the result of an instrument calibration problem, data recording error, or whether they reflected actual conditions occurring at the time of the monitoring. To address these uncertainties, refinements to the existing monitoring program have been put in place and include a systematic instrument calibration and documentation procedure.

8.2.2 Quality Assurance and Control

As part of the long-term monitoring program, it is recommended that the existing quality control program be continued to review various datasets being collected and used for analysis, as well as documentation procedures for changes or modifications made to the original data. In addition, as part of the quality control and documentation effort, the long-term monitoring program benefits from the systematic nomenclature for sample station identification described in Section 1, a structured relational database (that may have the capability for automated error checking for data input to help identify typographical and recording errors), and a systematic filing system to maintain quality control documentation as well as all original data sheets.

8.2.3 Database Management, Synthesis, and Analysis

During the 1993 – 2004 monitoring period datasets were documented in a variety of computer file formats. As part of the long-term monitoring program, it is recommended that a relational database format (or a database management framework or model), be established using standardized naming conventions (e.g. Table 1-1 in Section 1) and recording formats for each element of the monitoring program. Continuing to expand on the existing data management program will help maintain, control, and integrate the interdisciplinary data being collected as part of this effort. Furthermore, to facilitate data analysis over various geographic areas, the database should be GIS compatible.

Within the FMP and BA Proposed Action a number of specific management actions and/or investigations are identified that require monitoring and analysis. The monitoring program has been designed to include two tiers that include (1) long-term baseline monitoring to assess trends in the biological response of steelhead/rainbow trout over time, and (2) targeted, short-term experimental investigations and analyses to address specific elements of the FMP and BA Proposed Action. Focused experiments and measurements can be used in statistical hypothesis testing and to help establish relationships and correlations within identifiable statistical confidence intervals. The database management system, and identification of focused experiments to be performed as part of the long-term monitoring program, should be designed to accommodate graphical and statistical analyses of the available data. It is recommended that periodic consultation and review of the database and results of analyses, with a biostatistician or other qualified individuals, be performed based upon the needs and requirements of the monitoring program.

A series of annual technical reports should be prepared summarizing all data collected, describing any significant events in monitoring and management, and recommending any potential changes to monitoring or research protocols for the following year. The annual reports should build on the long-term trend analyses, providing additional years of information and interpretation from this highly variable system.

8.2.4 Hydrology and Operations

Hydrologic conditions occurring on the LSYR and its tributaries are highly variable within and among years (Section 2). Over the 12-year monitoring period from 1993 through 2004, hydrologic conditions included one of the wettest years (1998) and one of the driest years (2002) on record. Lake Cachuma spilled during five years of the 12-year monitoring period. In addition, a variety of releases were made from the reservoir; i.e., downstream water rights releases and water releases for steelhead (Section 2). Given the high inherent variability in hydrologic conditions occurring within the watershed, no individual year of fishery monitoring can be considered to be representative of conditions on the river affecting steelhead/rainbow trout, and has been one of the primary difficulties in determining trends in fish population and migration data. One of the primary values of investing in a long-term monitoring program is the ability to characterize changes in habitat conditions and the biological responses of the target species over a wide range of environmental conditions that typically occur within the basin. Information collected from the monitoring program has shown differences in passage opportunities, water quality, seasonal flows within the mainstem river and tributaries, channel and habitat changes, and other factors between wet and dry hydrologic conditions. One of the primary goals of future long-term monitoring should focus on the consistent collection of information as it relates to management actions, which may include refining the fundamental relationships between changes in habitat quality and availability, and associated changes in the abundance, geographic distribution, habitat usage, reproductive success, juvenile survival, and other biological attributes of steelhead/rainbow trout in response to the variable hydrologic conditions occurring within the mainstem LSYR and its principal tributaries.

8.2.4.1 Hilton Creek

Results of the 1993 – 2004 monitoring have clearly demonstrated the value of habitat within Hilton Creek for steelhead/rainbow trout spawning and juvenile rearing. Prior to implementation of the HCWS, streamflows and habitat for juvenile steelhead/rainbow trout, particularly during the summer and fall months, were ephemeral. With construction and operation of the HCWS, streamflows and water temperatures have been maintained within a suitable range to support juvenile steelhead/rainbow trout rearing throughout the year. In addition to providing improved habitat for juvenile steelhead/rainbow rearing, streamflow augmentation within Hilton Creek has contributed substantially to enhancing riparian vegetation and cover along the creek corridor (Section 6).

Hilton Creek, like other LSYR tributaries, is characterized by flashy winter hydrologic conditions, with high flows creating geomorphic processes that substantially altered the creek channel and riparian corridor (Section 6). Periodic high flow events resulting in channel modifications are part of the natural stream system and future habitat management and enhancement activities will need to integrate both high- and low-flow hydrologic conditions. For example, fish passage projects should be designed to allow steelhead/rainbow trout access both during low- and high-flow conditions, while being constructed to withstand high flow events.

Continued improvement to fish passage on Hilton Creek should be investigated and implemented. For example, (1) a habitat enhancement project completed in 2005 was the construction of fish passage facilities at the Hilton Creek chute and cascade to allow adult steelhead/rainbow trout to migrate further upstream and thereby expand the availability of spawning and juvenile rearing habitat up to the Highway 154 culvert, (2) the Highway 154 culvert should be replaced through efforts by California Department of Transportation (Caltrans), and (3) consideration is being given to the feasibility of constructing another channel around the lower reaches of Hilton Creek to provide further habitat and to maximize the habitat benefits for steelhead/rainbow trout supported by the HCWS.

As part of the long-term monitoring plan, it is proposed that the AMC review and comment on the design of focused experimental investigations and data analysis developed by the CPWA biologists to be used in evaluating alternative flow release strategies for Hilton Creek, using the three available release outlet locations that maximize the quality and availability of juvenile rearing habitat within Hilton Creek and the mainstem river. One goal of the experimental investigations is to evaluate functional relationships between streamflow releases of various magnitude within the management range of the Hilton Creek outlet structures at one or multiple release locations on suitability of downstream habitat (e.g., habitat area, water depth, water velocity, pool/riffle ratios, habitat connectivity, etc.) as well as the response of water temperatures at downstream locations under alternative release strategies. Water temperature monitoring data collected since 2000 at various locations within Hilton Creek will help serve as part of the technical basis for designing additional monitoring and analysis of the response of habitat conditions to alternative operational strategies. Results of the focused experimental investigation would then be used as a guide by the AMC in developing management strategies for Hilton Creek.

8.2.4.2 Lower Santa Ynez River and Tributaries

The high variability and flashy nature of streamflows within both the mainstem LSYR and the major tributaries observed over the 1993 – 2004 monitoring period (Section 2) underscores the difficulty in designing and operating migrant traps during periods of high flows. Juvenile and adult steelhead typically migrate during periods when streamflows and turbidity are increased by precipitation and stormwater runoff. Fishery monitoring using trapping techniques is particularly difficult, and often hazardous, under these high flow conditions.

As part of the long-term monitoring program it is recommended that the AMC evaluate the feasibility and applicability of alternative fishery monitoring methods (i.e., remote sensing, alterative trap designs, etc.) for use in quantifying trends in juvenile and adult steelhead/rainbow trout abundance and distribution during migrant trapping, particularly during periods of high flows. If other alternative fishery monitoring methods are found to be feasible and applicable in the LSYR, these methods would need to be discussed with the resource agencies. Many of the fundamental management objectives to be addressed by the long-term monitoring program depend on the ability to effectively monitor changes in the steelhead/rainbow trout population over a wide range of hydrologic conditions.

Monitoring juvenile and adult steelhead/rainbow trout within a river system is extremely challenging, particularly given the hydrologic variability occurring within the LSYR watershed and the relatively small population size of steelhead/rainbow trout within the lower river. One of the primary goals of the long-term monitoring program is to provide managers and NMFS/CDFG reliable information on trends in the LSYR steelhead population over time as part of the technical foundation for evaluating the overall success of the FMP, the success of the actions identified in the BA Proposed Action, and the contribution of the LSYR to the overall status and recovery of steelhead. It is recognized that the constraints on the monitoring program, including limitations on access to private lands, high seasonal flows, debris loading, and other factors need consideration in the design, implementation, and interpretation of monitoring program results.

Recognizing the limitations and constraints of monitoring within the LSYR, it is recommended that the AMC work with the CPWA staff to refine the current monitoring program outlining fishery monitoring methods and sampling design that can be applied to the mainstem LSYR and major tributaries to monitor movement of adult and juvenile steelhead/rainbow trout over a wider range of hydrologic conditions, specifically, high flow rates in excess of 100 cfs in the tributaries and flow rates in excess of 400 cfs in the mainstem. Development of the plan for long-term fishery monitoring should include consideration of alternative monitoring locations, monitoring methods, and developing a systematic approach for establishing quantitative indices of juvenile and adult abundance. Long-term monitoring will provide the basis for assessing trends in population response, as well as variability in the response of steelhead/rainbow trout to variation in hydrologic conditions, habitat enhancement activities, and habitat usage patterns within the watershed. Although these data have been collected (e.g., response of steelhead/rainbow trout to variation in hydrologic conditions and habitat usage patterns within the watershed), refinement and augmentation of the current fishery monitoring activities is an important AMC and CPWA goal for program and database improvements.

8.2.5 Lagoon Dynamics

Steelhead/rainbow trout use of the lagoon as juvenile rearing habitat has been observed in similar river systems in central/southern California (Bond 2006); however, trapping studies have captured very few steelhead/rainbow trout in the lagoon, based on three years of limited data in the beginning of this 12-year monitoring period (Section 5). It is important to note that these trapping operations were also conducted before most of the management actions outlined in the LSYR FMP and BA Proposed Action had been implemented (e.g., passage supplementation, reservoir surcharge, etc.). The lagoon is an important component of the migratory corridor for both upstream and downstream adult and juvenile steelhead passage and may serve as important juvenile oversummering and rearing habitat.

Results of water quality monitoring within the lagoon (Section 3) have shown that seasonal water quality conditions at least at one monitoring location were within the suitable range for juvenile steelhead/rainbow trout. The lagoon frequently is isolated from upstream steelhead/rainbow trout spawning and rearing habitat by dry channel reaches during the summer and fall. Furthermore, none of the management actions identified in the FMP or BA Proposed Action for steelhead are targeted at improving conditions within the lagoon. No trapping has been conducted in the lagoon since 1999 due to take concerns of USFWS regarding the presence of the federally endangered tidewater goby.

High flow conditions, frequently in combination with ocean surf, generally are suitable for breaching the lagoon and provide steelhead upstream and downstream migration opportunities during the winter and spring. Although observations of the formation and breaching of the sandbar over the 12-year monitoring program have been conducted at irregular intervals, the observations have shown that higher magnitude storms breach the sandbar, and that Salsipuedes Creek is capable of breaching the sandbar itself. For example, in some very dry and normal years (i.e., 2004) when there was no flow in the lower portion of the LSYR mainstem upstream of Salsipuedes Creek, the lagoon was breached by Salsipuedes Creek flows, in combination with ocean surf, and remained open for a short period of time. As part of the long-term monitoring program, it is recommended that regular monitoring be conducted to determine whether the lagoon is open or closed, to assist the CPWA staff, AMC, and Real Time Decision Making Group (RTDG) in initiating passage flow augmentation.

To provide continuous information throughout the steelhead migration period on the dynamics of sandbar formation and breaching, it is recommended that (1) a continuously recording water surface elevation (stage) gauge (or alternative remote monitoring method) be installed in the lagoon to monitor changes in water surface elevation and/or (2) a daily or every other day visual observation program be established. Installation and maintenance of a continuously recording water surface gauge and/or access to specific locations to observe the condition of the sandbar and assess potential passage opportunities for steelhead will require approvals from Vandenberg Air Force Base. Results showing trends in increasing water surface elevation within the lagoon could then be correlated with formation of the sandbar creating a barrier to steelhead migration. A sudden reduction in water surface elevation within the lagoon could be correlated with breaching of the bar and reestablishing surface water connectivity that would allow for upstream and downstream migration by steelhead. Information on river flow, tributary flow, storm activity, and wave activity could also be correlated with the periods of sandbar formation and breaching.

8.2.6 Reservoir Dynamics

Over the 12-year period between 1993 and 2004, vertical profile measurements of water temperature and DO concentrations have been collected within Lake Cachuma during various seasonal periods (Section 3). Results of the monitoring have shown a consistent pattern in seasonal stratification within the reservoir, with the formation of a clearly defined thermocline during late spring, summer, and early fall. Stratification within the reservoir is weak during the spring months, becoming progressively more defined throughout the summer and early fall. The reservoir destratifies during the late fall, with reservoir turnover. Monitoring within the reservoir conducted to date provides the necessary technical foundation for identifying the water depth for the HCWS inlet to take advantage of the cold water pool and improve water temperatures released to Hilton Creek during the summer months for juvenile steelhead/rainbow trout rearing.

Monitoring of water temperature and DO profiles within the reservoir was a useful element in describing baseline conditions and characterizing seasonal conditions during the 1993 – 2004 period. In the absence of a nexus between reservoir profile measurements and specific management actions to be implemented as part of the FMP and BA Proposed Action, it is recommended that routine reservoir profile measurements be reduced in scope to address specific management issues such as the location of the Hilton Creek water supply intake location within the coldwater strata of the reservoir during the summer months, and discontinue other monitoring sites. Reservoir profile measurements may be reinstated, in the future, as part of a focused monitoring program objective. Some examples may include under severe drought conditions, when the reservoir elevation is at substantially lower levels than have occurred over the past 12 years, or as specifically needed to make an informed management decision by the AMC.

8.2.7 River and Tributary Water Quality Monitoring

8.2.7.1 Water Temperature

Extensive water temperature monitoring has been conducted at a variety of locations within the mainstem LSYR and major tributaries over the 12-year period from 1993 through 2004 (Section 3). Water quality monitoring has provided important qualitative and quantitative baseline information on how water quality (e.g., water temperature, DO) within the mainstem and tributaries affects habitat for steelhead/rainbow trout. Seasonal water temperature has been identified as one of the key environmental factors affecting habitat quality and availability for steelhead/rainbow trout within various areas of the watershed. Results of water temperature monitoring within the mainstem river have shown a consistent longitudinal gradient during the summer and early fall months with increasing water temperature as a function of distance downstream from Bradbury Dam. Water temperatures showed consistent patterns during the summer and early fall, exceeding temperature criteria for suitable steelhead/rainbow trout rearing habitat at and beyond a location approximately 3.2 miles downstream of Bradbury Dam. Results of the water temperature monitoring showed a consistent pattern with results of the 1993 – 1996 temperature monitoring used in developing findings presented in the 1997 Synthesis Report.

Given the importance of water temperature as a factor influencing habitat quality and availability for various life-history stages of steelhead/rainbow trout, it is recommended that the fixed array of water temperature monitoring locations established over the 1993 – 2004 monitoring period be maintained, where access is allowed, to provide ongoing consistent baseline information on temperature effects to seasonal habitat conditions within the watershed. As discussed above, water temperature monitoring instrumentation should be subject to routine calibration and validation as part of the program quality control procedures.

8.2.7.2 Dissolved Oxygen

As part of the long-term monitoring program, additional focused water quality measurements, including continuously recorded diel DO and water temperature measurements during the summer, should be made part of focused experimental investigations. For example, juvenile steelhead/rainbow trout have been observed over the 1993 – 2004 monitoring period inhabiting isolated pools within the Alisal and Refugio reaches of the mainstem river in the spring and early summer (Section 5). Observations made during routine snorkel surveys indicated that steelhead/rainbow trout inhabiting isolated pools during the summer months were frequently in areas where water temperatures were noticeably cooler that surrounding areas within the pool. Measurements with hand held temperature meters confirmed that several of the pools had localized areas where water temperatures were cooler which corresponded with microhabitat locations of many of the fish. It was hypothesized that these cooler areas within the pools were related to cool groundwater flows through the gravel and into the pools (the local areas frequently also had lower DO concentrations (Section 3) which was consistent with the groundwater accretion hypothesis. Cool groundwater accretions have also been shown to provide summer habitat refugia for steelhead/rainbow trout in other Southern California rivers (Section 7). As discussed below, the dynamics of these pool habitats and the factors that influence local water temperatures and DO levels in isolated pools on the LSYR mainstem have been identified as a subject for further investigation as part of the ongoing monitoring program.

Monitoring results have also shown substantial diel variation in DO concentrations within isolated pool habitats, which has been attributed to be the result of algal respiration and photosynthesis. Results of these past observations have shown successful oversummering by many of the juvenile steelhead/rainbow trout despite exposure to what would be considered highly stressful elevated water temperatures and highly stressful depressed DO concentrations.

8.2.7.3 Pool Dynamics

Observations of juvenile steelhead/rainbow trout within isolated pools were consistent with observations made during the 1993 – 1996 period as reported in the 1997 Synthesis Report. As part of the long-term monitoring program it is recommended that focused measurements of temperature and DO concentrations within isolated pools continue within the mainstem, particularly in years when Bradbury Dam spills and steelhead/rainbow trout are observed in the Refugio or Alisal reaches. Locations of focused management actions should continue to occur in those habitats where steelhead/rainbow trout are observed to rear during the summer months.

Pools within the LSYR mainstem (particularly the Highway 154 Reach) and key tributaries are used as summer rearing habitat by the majority of the juvenile steelhead/rainbow trout inhabiting the basin. It is recommended that an element of the long-term monitoring program be focused on experimental investigations of the physical processes influencing the dynamics and habitat conditions within the pools. Factors affecting water quality conditions within many of the pools may include changes in water surface elevation (pool depth), surface area to volume ratio within a pool, residence time, surface water flows, local groundwater flows, geologic and geomorphic characteristics of the channel, substrate, and bedrock formations, wind driven turbulence and mixing, and the accumulation, respiration, and decomposition of algal mats. Continuously recording data sondes are recommended to be deployed to monitor changes in water quality conditions within a pool over an extended period of time (e.g., weeks). In addition, parameters such as air temperature, wind speed and direction, time of day, and water surface elevation should be monitored to identify patterns and factors affecting habitat conditions within the pools and how those relate to fish location, either by snorkeling, bank surveys, or remote video observation. Meteorological data used in examining pool dynamics should be obtained from local weather stations, such as the station located at the Santa Ynez airport. If these data were not considered to be representative of the microclimate conditions potentially affecting mainstem pools, then a temporary portable meteorological station could be used.

8.2.8 Fishery Habitat Surveys

Fishery habitat surveys were conducted within reaches of the mainstem river and tributaries over the 1993 – 2004 monitoring period where access to the river was possible (Section 4). The purpose of the fishery habitat surveys was to determine habitat composition and quality in the LSYR mainstem and tributaries. These surveys served as inventories to track available habitat for steelhead/rainbow trout and to identify where restoration activities may be useful. Results of these on-the-ground surveys found that the majority of excellent or good habitat for various life-history stages of steelhead/rainbow trout occurs within the tributaries, with only a small portion of the mainstem reach available for study within the Highway 154 Reach (LSYR-0-0.7) was classified as good. While the habitat surveys conducted on-the-ground were limited to where access was granted to private property, data collected from 1993 to 2004 has proven to be useful for such things as characterizing baseline conditions, likely steelhead/rainbow trout oversummering habitat, identifying barriers and impediments to upstream or downstream migration, and areas where channel modifications could reduce erosion. The habitat surveys conducted also provided information on pool characteristics and pool habitat availability within each area of interest. Additionally, habitat typing data has been used in the past to stratify and randomize (e.g., 2001) habitats for snorkel surveys.

As part of the future long-term monitoring program, it is recommended that routine ground-based habitat surveys (i.e., sites actually visited) be discontinued from the program. Baseline habitat conditions have already been identified and limitations on access to private lands along the lower mainstem river and tributaries prohibit continuous habitat surveys of many key locations. As an alternative to on-the-ground habitat surveys it is recommended that high-resolution aerial photographs be periodically taken of the lower mainstem river and tributaries that can be used to monitor and assess trends in habitat features such as riparian vegetation colonization and growth. Georeferenced aerial photographs could be purchased after the occurrence of channel altering flow events within the river or in response to other specific focused management objectives. Results of aerial surveys, which would not be constrained by limitations on access to private lands, could be validated by ground surveys at selected locations where access is permitted.

It is recommended that future habitat surveys (ground and/or aerial) be designed and conducted to address specific focused management objectives, rather than continue with routine ground-based habitat surveys. For example, habitat surveys could be conducted within areas upstream of a passage barrier or impediment where passage improvements are proposed in order to quantitatively assess the increased availability of suitable habitat that would be made accessible through improved fish passage or to randomize and stratify habitat to be snorkeled. Similarly, habitat surveys could be conducted periodically to assess changes in conditions within an area (i.e., Hilton Creek) to assess the performance and benefits of management actions (i.e., the watering system operations), on changes in riparian vegetation and other habitat features. Focused habitat surveys should also be conducted within key spawning and juvenile rearing areas, where access is available, to assess changes in habitat quality and availability before and after high flow events. Several key tributaries and areas of the mainstem should be extensively surveyed to determine how current land-use practices (i.e., urbanization, vineyards, cattle grazing, bank stabilization, etc.) are affecting the quality of rearing habitats and water quality (including nutrient enrichment). Each of these focused habitat surveys should be clearly linked to a specific management goal or objective of the fishery program and should be designed, in advance, to address a specific management issue or inform the AMC as part of the adaptive management decision process.

Section 4 describes five criteria used to rank habitat quality in the Santa Ynez River basin (streamflow, temperature, habitat structure, DO and presence of steelhead/rainbow trout). Additional criteria in habitat ranking also should consider the extent of potential fish refugia and stream gradient.

8.2.9 Steelhead Abundance and Distribution

As discussed in Section 5, fishery surveys conducted within the mainstem river and tributaries, where access is available, have primarily relied on snorkel surveys, visual observations, and redd surveys, in combination with migrant trapping. These survey techniques have provided important qualitative and quantitative baseline information on the relative abundance and geographic distribution of steelhead/rainbow trout within various portions of the watershed. Refinements to the existing monitoring program protocols for conducting fishery investigations within the mainstem river and tributaries as part of the long-term future fishery monitoring program should be identified and developed by the AMC and CPWA staff.

Redd surveys were periodically conducted, where access was available, over the 1993 – 2004 monitoring period to identify the locations and relative numbers of adult steelhead/rainbow trout spawning within various areas of the mainstem river and tributaries (Section 5). Steelhead/rainbow trout redd surveys can be difficult to conduct in flashy drainages such as the LSYR and adjoining tributaries because of high winter flows and turbidity, and the difficulty of visual surveys to reliably detect steelhead/rainbow trout redds under those conditions. The difficulty of conducting redd surveys is further compounded by low numbers of returning anadromous adults, and limited access to potentially significant spawning areas, including much of the Highway 154 Reach of the mainstem river and large sections of potential spawning habitat within the tributaries. Redd surveys conducted on the LSYR and tributaries are considered to be a qualitative indicator of the general location and seasonal timing of steelhead/rainbow trout spawning.

However, results of redd surveys have been limited by restrictions on access to private lands within the watershed. Due to the current access limitations, it is recommended that redd surveys be given a moderate priority as part of a future long-term monitoring program to provide information to NMFS as part of recovery planning and monitoring the status of southern

California steelhead populations. Results of redd surveys can also be used to demonstrate the success of a passage improvement project in allowing upstream access of adult steelhead/rainbow trout to suitable spawning habitat. As an alternative to conducting redd surveys, the monitoring program currently assesses successful access and reproduction within an area following implementation of a fish passage improvement project based on the occurrence of juvenile steelhead/rainbow trout during the spring or summer.

Condition factor, defined as the relationship between fish length and fish weight, provides an indicator of the overall health and condition of individuals within a population. As part of the expanded upstream and downstream trapping program conducted on the mainstem river and tributaries, the length and weight of each individual salmonid captured could be recorded. Results of the length-weight analysis could then be used as an additional indicator of potential changes within the population of juvenile or adult salmonids among locations within the watershed or for individuals exposed to seasonally elevated water temperatures or other stressful habitat conditions (e.g., fish captured as part of a fish rescue and relocation effort). However, the BO stipulates that any fish removed from the water for the purpose of collecting data must be anesthetized with MS-222 or carbon dioxide before measuring fish length and weight. It is recommended that alternative methods be explored with NMFS and others regarding the most effective methods for obtaining condition factor information on individual fish while minimizing handling stress.

One of the primary goals of the long-term monitoring program is the identification of functional relationships between various physical habitat parameters, environmental variability, and the corresponding biological response of steelhead/rainbow trout to management actions. Environmental factors affecting, or correlated with, trends in the number of returning adult steelhead, reproductive success within various portions of the watershed, survival and growth of oversummering juvenile steelhead/rainbow trout, condition factor, and other population dynamic responses (e.g., cohort replacement rate[1], relative proportion of resident to anadromous salmonids, etc.) can be used as indicators of success of the FMP and BO. The limitations and difficulties inherent in quantitatively monitoring many of these parameters are recognized, however it is recommended that refinements to the current monitoring program continue to be made as one of the program goals. As noted above, developing functional relationships within the LSYR system relies fundamentally on the ability to successfully monitor and develop quantitative indices of abundance for both juvenile and adult life-history stages. In the absence of reliable estimates of indices of abundance from locations within the mainstem river and key tributaries, the ability to define functional relationships between habitat and environmental parameters, and the response of steelhead/rainbow trout to these environmental conditions, in addition to the response to some specific management actions implemented within the basin, will be limited to some degree of qualitative assessment partly due to the inherent difficulty of this type of environmental monitoring program. Given the importance of improving the ability to quantitatively monitor and assess juvenile and adult steelhead/rainbow trout abundance as part of a future long-term monitoring program, identification of refined monitoring methods, locations, and protocols as well as analytic techniques have been identified as the highest priority goal by the AMC and CWPA staff.

---

[1] Cohort replacement rate is the rate at which each successive cohort, or generation, replaces the previous one.

Based on a review of the results of fishery monitoring over the 12-year period refinements and modifications to the fishery monitoring proem have been identified. Recommendations for refinements to the fishery monitoring program in the future include:

- Alternative migrant trap designs and deployments should be evaluated for high flow conditions in an effort to maximize trapping and to improve trapping efficiency. Standardization and the quantification of trapping effort (e.g. CPUE) should be used in evaluating the performance of the FMP in contributing to an increasing trend in steelhead abundance and recovery;
- Alternative migrant trapping locations should be evaluated on the mainstem and tributaries. It would be desirable to develop a trapping site at the downstream boundary of the management zone near the Highway 154 bridge (e.g., CalTrans easement) to monitor steelhead/rainbow trout movement and production within the reach from the dam to the Highway 154 bridge. An alternative to this location would be a mainstem trapping site within the upper portion of the Refugio Reach (miles 5.0-7.3);
- Largely due to access restrictions, surveys have not been conducted in a way that allows easy comparison of population abundances in the tributaries to that in the mainstem. Survey results provided useful information on the species composition of the fish community, seasonal patterns in habitat use, and the general geographic distribution of habitat used by various life history stages of steelhead/rainbow trout. Increased access to the 154 reach of the LSYR mainstem would allow improved information on this reach which appeared to support good instream habitat and perennial flow;
- Results of the snorkel surveys provide descriptive information on trends in abundance, geographic distribution and habitat selection by steelhead/rainbow trout within the mainstem river and tributaries. The geographic distribution of juvenile steelhead/rainbow trout demonstrates the importance of tributary habitat for spawning and juvenile rearing. Results of the surveys to date also provide a technical basis for identifying modifications to the monitoring program that will improve the ability to quantitatively assess trends in population abundance within the watershed in the future and improve the ability to evaluate the contribution of the program to steelhead recovery;
- To improve the ability to quantitatively compare results of snorkel surveys in the future, it is recommended that survey protocols be standardized to the extent possible (number of divers making observations, diver training in identifying and estimating lengths for steelhead-rainbow trout, standardizing survey reach lengths and locations for comparisons within and among years, etc.) and reporting survey results as a CPUE (e.g., number per 1,000 m^2).
- Based on observations during the 12-year study period, it is hypothesized that under low flow conditions with little variance in flow rate, and without an influx of anadromous steelhead, resident rainbow trout within the drainage may vary spawning time. This could be a beneficial life-history strategy even for a resident trout population. Late-season storm events in a flashy system, coupled with a mobile streambed, can inundate and destroy redd sites. A population of trout that spawn at different time intervals helps assure some YOY survival in an unpredictable stream system. Analysis of redd survey data in conjunction with snorkel survey results where YOY are observed can be used in the future to assess this hypothesis; and

- Largemouth bass spawn within Lake Cachuma and have escaped during spillway releases into the river where they spawn as well. Given the importance and value of Hilton Creek as a juvenile steelhead/rainbow trout rearing habitat and the associated habitat use expected downstream within the Highway 154 Reach, monitoring should continue to assess the potential for predation mortality by bass on juvenile steelhead/rainbow trout rearing within this section of the watershed. The abundance and geographic distribution of predatory fish such as largemouth bass within the various mainstem and tributary habitats, and the relative importance of predation mortality as a factor affecting the abundance and population dynamics of steelhead/rainbow trout within the watershed, should be investigated further as part of adaptive management. Depending on results of these investigations, various control strategies should be considered which may include management within the lake, habitat modification, periodic eradication below Bradbury Dam, or other actions.

8.2.10 Anadromous/Resident Population and Genetics Investigations

One of the significant uncertainties regarding the salmonid population inhabiting the watershed downstream of Bradbury Dam is the relative contribution of anadromous steelhead and resident rainbow trout to the general salmonid population. In addition, management questions also exist regarding changes in the relative contribution of resident and anadromous salmonids within the population among high-flow and low-flow water year types. During low-flow years, when the sandbar at the lagoon does not breach, adult anadromous steelhead would not have the opportunity to migrate into the river and under these conditions there would be no contribution of anadromous steelhead to the spawning population. Given their flexible life history, steelhead may remain resident (rainbow trout) and rear/spawn within the watershed until the sand bar is breached and migration between freshwater and the ocean is re-established. However, in those years when the bar is breached and mainstem flows are sufficient for adult migration, there may be a variable contribution between anadromous and resident steelhead/rainbow trout to the spawning population. As part of the current fishery monitoring program tissue samples are collected for genetic analysis, scale samples, and photographs and morphometric characteristics are being used in an effort to differentiate resident trout from anadromous steelhead. In addition to these methods, as part of developing the future long-term monitoring program, consideration could also be given to other methods that distinguish between resident and anadromous salmonids. One potential technique would be the use of passive integrated transponder (PIT) tags inserted into all juvenile and adult salmonids collected as an addition to the migrant trapping program. PIT tags provide a unique identification code that can be detected in the future (over the entire life of the fish) without sacrificing the individual. Each of the migrant traps could be equipped with either a portable or fixed PIT tag detection system and each tagged individual subsequently recaptured could be identified. Since each of the tags is individually coded, specific information could be obtained regarding fish length, condition, location, and timing when the individual was originally released and corresponding information at recapture. PIT tagging, as part of the long-term monitoring program, would require authorization by NMFS.

Analytical techniques are currently being developed and perfected for microchemistry assays of constituents deposited in the otolith. The ratio of calcium to strontium within the otolith of an adult fish can be used to determine whether the individual reared in coastal marine waters (anadromous steelhead) or resided only in fresh water (resident rainbow trout; Zimmerman and Reeves 2000, 2002; Zimmerman and Nielson 2003). Unfortunately, analysis of otoliths requires that the individual be sacrificed. As part of the long-term monitoring program, no steelhead/rainbow trout are planned to be sacrificed, due to their endangered status. However, in the event that deceased adult steelhead/rainbow trout are observed, such as post spawning mortality, the otolith could be dissected and submitted to a qualified laboratory for microchemistry analysis. Although moribund fish have been collected as part of the fishery monitoring program (typically less than 10 per year) and provided to NMFS for analysis, results of these analysis are not available to date for inclusion as part of monitoring program results. The lack of results may require a more clearly defined protocol in the program to obtain otolith analyses from NMFS. It is recommended that tissue collection continue for genetic analysis, but that a greater emphasis be placed on making results of the analyses available by NMFS to the program in a timely manner and provided in future annual data reports and summary of trends.

8.3 Fish Management Plan and Biological Opinion Actions – Evaluation of Performance

Results of monitoring conducted over the 1993 – 1996 period were used to identify a number of management actions designed to protect and enhance habitat quality and availability for steelhead/rainbow trout spawning and juvenile rearing, and upstream/downstream migration within the LSYR watershed. Results of recent fishery and habitat surveys are consistent with the findings presented in the 1997 Synthesis Report and the FMP and BA Proposed Action regarding management actions that would benefit steelhead/rainbow trout on the mainstem river and key tributaries. A number of the management actions have been implemented, or are planned to be implemented over the next several years (e.g., Section 6). As part of the process of compiling data over the 12-year period and through discussions and analyses of the resulting information a number of recommended refinements have been identified. In addition, a number of the management actions included in the FMP and BA Proposed Action have been implemented after 2004 and are continuing to be implemented within the watershed. Through the collaborative process of working within the AMC the monitoring and management program continues to be refined. The current and future implementation of the FMP and BA Proposed Action , including both management actions and monitoring, benefit from this and future periodic reviews of program results. The AMC provides a collaborative, multi-agency, forum for ongoing review of the program and the identification of changes in priorities, implementation of alternative management actions and monitoring, and refinements to program implementation in response to current information and environmental conditions within the watershed.

Fishery data collected in the past several years on Hilton Creek have clearly demonstrated the benefits of the water supplementation system in providing suitable juvenile rearing habitat throughout the year. The performance of other management actions, such as summer releases to support juvenile rearing habitat within the Highway 154 Reach (and in wet years habitat in the Refugio and Alisal reaches) have not yet been evaluated because surcharge water to make summer target flow releases was not available until 2005. Reservoir surcharge became available in 2005 for use in augmenting fishery passage flow releases and summer target flow releases, but those evaluations have not been included in this report. Many of the other management actions that have been implemented, such as providing improved fish passage and access to upstream habitat within several of the tributaries (Section 6) have directly improved opportunities for fish passage over a wider range of flow conditions (e.g., greater opportunities for adult passage at lower flows than was available prior to the passage enhancement). For example, results of migrant trapping at a location upstream of the Highway 1 passage improvement project (SC - 3.0) on Salsipuedes Creek since 2002 has documented successful juvenile and adult migration over a wider range of flows (Section 5).

Over the 1993 – 2004 monitoring period, evaluation of the performance of various management actions primarily focused on (1) compliance with commitments outlined in the FMP and BA Proposed Action; (2) design and construction of fish passage facilities based on established design criteria for fish passage facilities; and (3) observations collected as part of routine baseline monitoring. It is recommended that as part of the future long-term monitoring program, specific elements be identified that focus on management action-specific experimental evaluations within a framework of before and after comparisons, and quantitative measurements. Performance evaluation of specific actions would be based on a written Annual Monitoring Plan (e.g., outlining the experimental design, specific objectives and testable hypotheses, methods and protocols for data collection, and the types of information that would be used to analyze performance of the management action) and results documented in a series of Annual Reports and technical memoranda. The Annual Monitoring Plans and Annual Reports would be prepared by CWPA staff and reviewed by the AMC as part of the overall development of the long-term monitoring program.

The performance metrics for each individual management action would vary, but may include consideration of changes in physical conditions, measurements of water depth and passage velocities over a range of flows, and/or biological monitoring of the actual response of juvenile and adult steelhead/rainbow trout to a specific management action. Information developed through these focused investigations and analyses would then be available for use by the AMC and CPWA staff to identify potential refinements or modifications to a specific management action intended to improve program performance and the overall benefit of actions implemented as part of the FMP and BO for improving habitat quality and availability for steelhead/rainbow trout.

8.4 Summary of Recommendations

The analysis of findings from the 1993 – 2004 monitoring program lead to a series of recommendations and long-term program goals for (a) more rigorous and focused monitoring as part of an Annual Monitoring Plan; and (b) focused management experiments under specific conditions to identify the response of steelhead/rainbow trout to management actions which may be affecting their behavior or condition. One of the goals of this synthesis report was to reflect on the implementation of the program of management actions and monitoring elements outlined in the FMP and/or BA Proposed Action over the period from 1993 to 2004 and to transition and refine the monitoring and implementation program into the future. The discussion and recommendations developed through the 2004 Synthesis Report have lead to a series of recommendations designed to benefit the overall program in the future. Recommendations based upon program goals, the review of data, and information collected as part of the 1993 – 2004 LSYR monitoring program are summarized in Table 8-1.

Through the process of reviewing and analyzing data collected over the 12-year period a number of recommendations have been developed and implemented as part of the ongoing long-term program. For example, CPWA staff has developed a standardized nomenclature for use in the monitoring program that is integrated into a GIS compatible database management system. In addition, a number of management actions outlined in the FMP and BA Proposed Action were implemented after 2004 and are not included in this report, however, the biological benefits and operations/implementation of these actions has occurred since 2004 and is ongoing, as part of the continuing program of improving and enhancing conditions on the LSYR and its tributaries for steelhead/rainbow trout in accordance with the FMP and BA Proposed Action . Results of these more current activities are being documented in a series of separate technical memoranda and reports as part of the AMC process. Based on results of the compilation and review of information as part of the process of completing this 2004 Synthesis Report recommendations for refinements to the program have been identified and implemented, and it is recommended that a similar review of the program be undertaken as part of the regular and ongoing involvement by the AMC in the program as we continue to implement and monitor actions beneficial to steelhead and their habitat within the watershed in the future.

Table 8-1. Summary of recommendations for the management and monitoring program

Establish a specific nexus between each of the monitoring program goals and objectives and specific management actions or decision points within the framework established by the FMP and BA Proposed Action, specifically compliance requirements of the terms and conditions of the reasonable and prudent measures.
Continue implementation of a two-tiered long-term monitoring program that includes: • Systematic quantitative long-term baseline monitoring for use in comparative analyses of conditions and trends among years in response to various environmental variables (e.g., hydrologic conditions) and comparisons within and among various regions of the watershed, including the lower mainstem river and tributaries to management actions such as passage flow supplementation, HCWS operations, mainstem baseflows, and improvements to fish passage within the tributaries; and • Conduct specific focused experimental investigations designed to address specific management objectives, evaluate specific physical or biological responses and functional relationships (i.e., the relationship between river flow and breaching of the sandbar to provide opportunities for upstream and downstream migration by steelhead), and evaluate performance of various management actions implemented as part of the program.
Recognize the inherent limitations and constraints imposed by access restrictions, periodic high flow events, and other factors on achieving the goals of the monitoring program. It is recommended that CPWA staff and the AMC continue to evaluate alternative methods and refinements to current monitoring activities to meet the long-term program goals
Develop a written Annual Monitoring Plan that summarizes findings in relation to long-term trends, and protocols for conducting baseline monitoring and focused experimental investigations for review by the AMC prior to implementation.
Prepare reports to USFWS on observations of the distribution and relative abundance of protected or special status species observed in the course of conducting routine monitoring and implementing management actions
Record systematic observations on changes in the distribution or abundance of non-native invasive species such as beaver, arrundo, and tamarisk.
Continue to expand and refine efforts to: • Implement management actions within the tributaries identified within the FMP and/or BA Proposed Action (e.g., passage improvements) with the goal of designing and completing 1-2 projects per year; and, • Evaluate the performance and biological benefits to steelhead/rainbow trout of passage improvement projects and other management actions implemented as part of the FMP and BO.
Prepare an Annual Technical Report, focusing on reporting findings in tabular and graphical form, so that issues may be identified and addressed by the AMC on a timely basis. The annual report format also provides a standardized framework for reporting, updating data, and analysis of trends over time. The report should summarize all data collected, describe any significant events in monitoring or management, and should describe any changes in monitoring or research protocols proposed for the next year.
It is recommended that Reclamation and CPWA, in cooperation with the AMC, establish a routine procedure for triggering AMC and/or regulatory agency discussions. One goal of the monitoring program is to identify issues to be addressed by the AMC and insure that monitoring data are available to the AMC in a timely manner to make informed adaptive management decisions. This is essential for the AMC to perform its mandated function of providing an overview of the monitoring and management effort. To this regard, it is proposed, at a minimum, bi-annual informal meetings of the AMC and CPWA staff to discuss issues and review findings as part of the AMC meeting schedule.
Refine AMC operations to enable timely processing of all proposed recommendations.

SECTION 9

REFERENCES

Section 9: References

Ackerman D. and J. Schiff. 2003. Modeling storm water mass emissions to the Southern California bight. Environmental Engineering: 129-308.

Adaptive Management Committee (AMC) memo regarding winter passage flow augmentation to the lower Santa Ynez River for adult steelhead passage. Unpublished.

Andonaegui C. 1999. Salmon and steelhead habitat limiting factors report for the Entiat Watershed Water Resource Inventory Area (WRIA) 46, Version 3. Washington State Conservation Commission, Headquarters Office, Olympia, Washington. 51 pp.

Aquatic Bioassay & Consulting Laboratories, Inc. 2004. Bioassessment Monitoring of Piru Creek. Prepared for United Water Conservation District FERC Licensing Project. September 2004.

--- 2005. Malibu Creek Watershed Monitoring Program Bioassessment Monitoring Spring / Fall 2005. Prepared for the Malibu Creek Watershed Monitoring Program. March 2005.

--- 2006. Ventura County Stormwater Monitoring Program Ventura River Watershed 2005 Bioassessment Monitoring Report. Prepared for Ventura County Watershed Protection District. August 2006.

--- 2007. Ventura Countywide Stormwater Monitoring Program Ventura River Watershed 2006 Bioassessment Monitoring Report. Prepared for Ventura County Watershed Protection District.

Bacey J. and F. Spurlock. 2007. Biological assessment of urban and agricultural streams in the California Central Valley. Environmental Monitoring and Assessment 130:483-493.

Baker P.F., T.P. Speed and F.K Ligon. 1995. Estimating the influence of temperature on the survival of chinook salmon smolts (*Onchorhyncus tshawytscha*) migrating through the Sacramento-San Joaquin River delta of California. Can. J. Fish. Aquat. Sci. 52:855-863.

Barbour M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and rivers: Periphyton, benthic macroinvertebrates, and fish, Second Edition, EPA 841-D-99-002. Environmental Protection Agency, Washington, D.C. (http://www.epa.gov/owow/monitoring/AWPD/RBP/bioasses.html)

Barngrover B.G. 1990. Rainbow trout strains in California state hatcheries. California Fish and Game 76: 91–102.

--- 1998. Personal Communication with Chuck Hanson. California Department of Fish and Game.

Bates K. and R. Fuller. 1992. Salmon Frv Screen Mesh Study. State of Washington, Department of Fisheries, Habitat Management Division. Olympia, Washington. 22 pp.

Bauer S.B. and S.C. Ralph. 1999. Aquatic habitat indicators and their application to water quality objectives within the Clean Water Act. US Environmental Protection Agency USEPA-910-R-99-014. Seattle, WA.

Beamesderfer, R.C.P. 2000. Managing fish predators and competitors: Deciding when intervention is effective and appropriate. Fisheries (25)6:18–23.

Berggren T.J., and M.J. Filardo. 1991. An analysis of variables influencing the migration of juvenile salmonids in the Snake and Lower Columbia Rivers. FPC report submitted to the ESA record.

--- 1993. An analysis of variables influencing the migration of juvenile salmonids in the Columbia River Basin. N. Am. J. Fish. Management 13, 48-63.

Bisbal G.A. 2001. Conceptual design of monitoring and evaluation plans for fish and wildlife in the Columbia River ecosystem. Environmental Management 28(4):433-453.

Bjornn T.C., and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. Influences of Forest and Rangeland Management. Edited by Meehan WR. Special publication 19. Bethesda (MD). American Fisheries Society, 83-138.

Bond M.H. 2006. Importance of estuarine rearing to central California steelhead (*Oncorhynchus mykiss*) growth and marine survival. M.A. Thesis, University of California Santa Cruz.

Bovee K.D., and R. Milhous. 1978. Hydraulic simulation in instream flow studies: theory and techniques. Instream Flow Information Paper 5. FWS/OBS-78/33. Cooperative Instream Flow Service Group.

Boles G. 1988. Water temperature effects on chinook salmon (*Oncorhynchus tshawytscha*) with emphasis on the Sacramento River: a literature review. Report to the California Department of Water Resources. Northern District, 43 p.

Brett J.R. 1952. Temperature tolerance in young Pacific salmon, Genus *Oncorhynchus*. Journal of the Fisheries Research Board of Canada 9(6):265-323.

Brett R.J., W.C. Clarke, and J.E. Shelbourn. 1982. Experiments on thermal requirements for growth and food conversion efficiency of juvenile chinook salmon *Oncorhynchus tshawytscha*. Can. Tech. Rep. Fish. Aquat. Sci. No. 1127.

Brown R. and W. Kimmerer. 2001. Environmental and Institutional Background for CALFED's Environmental Water Account. Sacramento (CA): CALFED Bay-Delta Program. 53 p.

Bryant M.D. 1983. The role and management of woody debris in west coast salmonoid nursery streams. North American Journal of Fisheries Management 3:322-330.

Buchan, Lucy A.J. 2003. Assessment of Watershed Assessment Methods. Final Technical Memorandum. Prepared for the Santa Clara Valley Urban Runoff Pollution Prevention Program.

Cachuma Project Water Agencies. 2004. Annual Monitoring Data 2004.

--- 2005. Annual Monitoring Data 2005.

--- 2006. Annual Monitoring Data 2006.

Cachuma Resource Conservation District (RCD) and the Carpinteria Creek Watershed Coalition. 2005. Carpinteria Creek Watershed Plan. Prepared for the California Department of Fish and Game. Available at: http://carpinteriacreek.org/documents.htm.

California Department of Fish and Game (CDFG). 1998. CDFG 1998 Salmonid Stream Habitat Restoration Manual.

California Department of Fish and Game. California Interagency Wildlife Task Group. 2005. Wildlife Habitat Relationships version 8.1 personal computer program. Sacramento, California.

Cech J.J. Jr. and C.A. Myrick. 1999. Steelhead and chinook salmon bioenergetics: temperature, ration, and genetic effects. University of California Water Resources Center, Davis, CA.

Cederholm C.J., R.E. Bilby, P.A. Bisson, T.W. Bumstead, B.R. Fransen, W.J. Scarlett, and J.W. Ward. 1997. Response of juvenile coho salmon and steelhead to placement of large woody debris in a coastal Washington stream. North American Journal of Fisheries Management 17:947–963.

Clay, C.H. 1995. Design of fishways and other fish facilities. CRC Press, Boca Raton, Florida.

Colt, J., S. Mitchell, G. Tchobanoglous, and A. Knight. 1979. The use and potential for aquatic species for wastewater treatment: Appendix B, the environmental requirements of fish. Publication No. 65, California State Water Resources Control Board, Sacramento, CA.

Critelli S., E. Pera, and R.V. Ingersoll. 1997. The effects of source lithology, transport, deposition and sampling scale on the composition of southern California sand. Sedimentology (44) 4:653-671.

Deas M.L. and G.T. Orlob. 1999. Klamath River Modeling Project Center for Environmental and Water Resources Engineering, Department of Civil and Environmental Engineering, Water Resources Modeling Group, University of California, Davis.

Deas M.L., R. Sutton, R. Faux, R.A. Corum, T.L. Soto. 2004. Klamath River thermal refugia study-Summer 2003. Klamath Area Office, Bureau of Reclamation.

East Bay Municipal Utilities District (EBMUD). 2007. unpubl. data. Miyamoto, J. Personal communication with Chuck Hanson. July 19th, 2007.

Engblom S. 2003. Lower Santa Ynez River steelhead studies. Annual report. Santa Barbara County, California.

ENTRIX, Inc. 1995. Cachuma contract renewal fish resources technical report. Prepared for Woodward Clyde Consultants. December 5, 1995.

--- 2001. Baseline chapter for the SWRCB EIR on Cachuma Project Operations. 2001 May 10. Prepared for URS Corporation.

--- 2003. Nojoqui Creek Fish Passage Enhancement Alternatives Analysis Nojoqui Creek Santa Barbara County, CA. Prepared for Cachuma Conservation Release Board and Santa Ynez River Water Conservation District, Improvement District #1, Santa Barbara, CA. September 2, 2003.

--- 2004. Historical rainbow trout/steelhead stocking in the Santa Ynez River above Bradbury Dam. Prepared for Cachuma Project Adaptive Management Committee, Santa Barbara, California. Prepared by ENTRIX, Inc., Walnut Creek, California. Project No. 3080802. January 20, 2004.

Evans, W.A., and B. Johnston. 1980. Fish migration and fish passage: a practical guide to solving fish passage problems. U.S. Department of Agriculture, Forest Service. EM-7100-2. Washington D.C.

Fayram A.H., and T.H. Sibley. 2000. Impact of predation by smallmouth bass on sockeye salmon in Lake Washington, Washington. North American Journal of Fisheries Management(20)1:81–89.

Giorgi, A.E., T.W. Hillman, J.R. Stevenson, S.G. Hays, and C.M. Peven. 1997. Factors that influence the downstream migration rates of juvenile salmon and steelhead through the hydroelectric system in the mid-Columbia River basin. North American Journal of Fisheries Management 17:268–282.

Greenwald G.M. and D.E. Campton. 2005. Genetic influence of hatchery-origin fish to natural populations of rainbow trout in the Santa Ynez River, California. A synopsis and supplemental evaluation of: Nielsen, Jennifer L., Christian E. Zimmerman, Jeffrey B. Olson, Talia C. Wiacek, Eric J. Kretschmer, Glenn M. Greenwald, and John K. Wenburg. 2003. Population genetic structure of Santa Ynez River rainbow trout – 2001 based on microsatellite and mtDNA analyses. Final report submitted to U.S. Fish and Wildlife Service under Intra-agency Agreement No. 11440-1-4000 between the U.S. Fish and Wildlife Service (Ventura, CA) and the U.S. Geological Survey (Anchorage, AK). California-Nevada Operations Office (CNO), U.S. Fish and Wildlife Service, Sacramento, California. 20 pp.

Groot, C. and L. Margolis. 1991. Pacific Salmon Life Histories. University of British Columbia Press. British Columbia. 1991.

Hanson, C., J. Coil, B. Keller, J. Johnson, J. Taplin, and J. Monroe. 2004. Assessment and Evaluation of the Effects of Sand Mining on Aquatic Habitat and Fishery Populations of Central San Francisco Bay the Sacramento-San Joaquin Estuary.

Harrington, J. and M. Born. 1999. Measuring the Health of California Streams and Rivers. A Methods Manual for: Water Resource Professionals, Citizen Monitors, and Natural Resources Students. Second edition, revision 4. Sustainable Land Stewardship International Institute, Sacramento, California. 1999.

Harris R.R., C.M. Olson, S.D. Kocher, J.M. Gerstein, W. Stockard, and W.E. Weaver. 2005. Procedures for monitoring the implementation and effectiveness of fisheries habitat restoration projects. Center for Forestry, University of California, Berkeley. 24 pp. and attachments.

Harvey B.C., and R.J. Nakamoto. 1996. Effects of steelhead density on growth of coho salmon in a small coastal California stream. Transactions of the American Fisheries Society 125:237–243.

Healey M.C., and C. Groot. 1987. Marine migration and orientation of ocean-type chinook and sockeye salmon. American Fisheries Society. Symp. 1: 298–312.

Healey M.C. 1991. Life history of chinook salmon (*Oncorhynchus tshawytscha*). Pp. 311–393 *in* C. Groot and L. Margolis, eds. Pacific salmon life histories. Univ. of British Columbia Press, Vancouver, BC.

Hicks M. 2000. Evaluating criteria for the protection of aquatic life in Washington's surface water quality standards—dissolved oxygen. Draft discussion paper and literature summary. Revised December 2002. Pp. 44–46, pg. 76. Washington State Department of Ecology, Pub. No. 00-10-071, Olympia, WA.2

Howick G.L. and J. O'Brien. 1983. Piscivorous Feeding Behavior of Largemouth Bass: An Experimental Analysis. Transactions of the American Fisheries Society 112:508-516.

Inman D.L. and S.A. Jenkins. 1999. Climate change and the episodicity of sediment flux of small California rivers. *J Geol* 107: 251–70.

Johnsson J.I. and M.V. Abrahams. 1991. Interbreeding with domestic strain increases foraging under threat of predation in juvenile steelhead trout *(Oncorhynchus mykiss).* An experimental study. 48:243-247. Canadian Journal of Fisheries and Aquatic Sciences.

Katopodis,C., P.Eng. 1992. Introduction to Fishway Design. Freshwater Institute Central and Arctic Region, Department of Fisheries and Oceans. Winnipeg, Manitoba Canada.

Kennedy T. 2004. Personal Communication with Chuck Hanson. The Fishery Foundation.

Landsat. 2000. Landsat Image Database March-April 2000. http://landsat.gsfc.nasa.gov.

Luce, S. 2003. Urbanization and Aquatic Ecosystem Health in Malibu Creek, California: Impacts on Periphyton, Benthic Macroinvertebrates, and Environmental Policy. University of California, Los Angeles, 2003.

Leydecker A. and L.A. Grabowsky. 2005. Annual Report: The State of the Ventura River. Draft Report.

Maas-Baldwin, J., T. Anderson, C. Clark, Z. Croyle, K. Urquhart (Instructor) and F. Watson (Editor, Instructor). 2007. Carmel Lagoon Water Quality and Steelhead Soundings: Central Coast Watershed Studies. CSUMB Class ESSP 660: Fall 2007. The Watershed Institute Division of Science and Environmental Policy. California State University Monterey Bay. Seaside, CA. http://watershed.csumb.edu.

MacDonald D.D. and C.P. Newcombe. 1991. Effects of Suspended Sediments on Aquatic Ecosystems. North American Journal of Fisheries Management: Vol. 11, No. 1 pp. 72–82.

Maezono Y, and T. Miyashita. 2002. Community-level impacts induced by introduced largemouth bass and bluegill in farm ponds in Japan. Laboratory of Biodiversity Science, School of Agriculture and Life Sciences.

Marine K.R. and J.J. Cech Jr. 2004. Effects of high water temperature on growth, smoltification, and predator avoidance in juvenile Sacramento River Chinook salmon. North American Journal of Fisheries Management 24:198–210.

Mason and Chapman. 1965. Significance of early emergence, environment rearing capacity, and behavioral ecology of juvenile coho salmon in stream channels. Journal of Fisheries Research Board Canada. 22:173-190.

Matthews K.R. and N.H. Berg. 1997. Rainbow trout responses to water temperature and dissolved oxygen stress in two southern California stream pools. J. Fish Biology 50:50-67.

McCullough D.A., S. Spalding, D. Sturdevant, and M. Hicks. 2001. Summary of technical literature examining the physiological effects of temperature on salmonids. Seattle, WA: U.S. Environmental Protection Agency. Issue Paper 5, EPA Region 10 Temperature Water Quality Criteria Guidance Development Project.

Meehan, W. R. and M. L. Murphy. 1991. Stream ecosystems: Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19:17-46, Bethesda, Maryland.

Memorandum of Understanding (MOU) for Cooperation in Research and Fish Maintenance on the Santa Ynez River Downstream of Bradbury Dam. 2004. Signatories include U.S. Bureau of Reclamation, California Department of Fish and Game (CDFG), U.S. Fish and Wildlife Service (USFWS), NMFS, Cachuma Project Member Units, Santa Ynez River Water Conservation District (SYRWCD), downstream water right holders, and representatives of the local environmental community.

Mossop B. and M.J.Bradford. 2004. Importance of large woody debris for juvenile chinook salmon habitat in small boreal forest streams in the upper Yukon River basin, Canada. Canadian Journal of Forest Research 34(9):1955-1966.

Moyle P.B. 2002. Inland fishes of California. Berkeley (Ca): University of California Press.

Myrick C.A.and J.J. Cech Jr. 1996. The effects of elevated rearing temperatures and genetics on trout bioenergetics. Pages 41-47 in C. Swanson, P. Young, and D. MacKinlay, editors. Applied Environmental Physiology of Fishes Symposium Proceedings, American Fisheries Society, Bethesda, Maryland, USA.

--- 2000a. Temperature influences on California rainbow trout physiological performance. Fish Physiology and Biochemistry 22:245–254.

--- 2000b. Growth and thermal biology of Feather River steelhead under constant and cyclical temperatures [dissertation]. Davis (CA). University of California Department of Wildlife, Fish and Conservation Biology.

--- 2001. Swimming Performances of Four California Stream Fishes: Temperature Effects. Environmental Biology of Fishes. Vol. 58.

Myrick CA. 2006. Personal Communication with Chuck Hanson. Colorado State University.

National Marine Fisheries Service (NMFS). 2000a. Biological Opinion. U.S. Bureau of Reclamation Operation and Maintenance of the Cachuma Project on the Santa Ynez River in Santa Barbara County, California. September 11, 2000.

--- 2000b. Endangered Species Act status of west coast salmonids, March 29, 2000. NMFS, Northwest Region, Portland, Oregon. Available through the internet at *http://www.nwr.noaa.gov* (accessed 14 May 2000).

--- 2004. Approval letter from R. McInnis (NMFS) to W. Luce (Reclamation) regarding revisions to the Cachuma Project Fish Passage Supplementation Program. National Marine Fisheries Service, NOAA, Long Beach, CA. November 2004.

--- 2005. Endangered and Threatened Species; Designation of Critical Habitat for Seven Evolutionarily Significant Units of Pacific Salmon and Steelhead in California; Final Rule. Federal Register Vol. 70, No. 170. September 2, 2005.

Nielsen J.L., C.A. Gan, J.M. Wright, D.B. Morris, and W.K. Thomas. 1994. Biogeographic distributions of mitochondrial and nuclear markers for southern steelhead. Molecular Marine Biology and Biotechnology (3): 281–293.

Nielsen J.L., C.E. Zimmerman, J. Olsen, T. Wiacek, E. Kretschmer, G. Greenwald, and J. Wenburg. 2003. Population genetic structure of Santa Ynez rainbow trout - 2001 based on microsatellite and mtDNA analyses. Technical report submitted to Mary Ellen Mueller, U.S. Fish and Wildlife Service California/Nevada Operations Office, Sacramento, CA. November 11, 2003.

Nobriga, M.L., and F. Feyrer. 2007. Shallow-water piscivore-prey dynamics in California's Sacramento-San Joaquin Delta [Internet]. 2007. San Francisco Estuary and Watershed Science. Vol. 5, Issue 2 [May 2007]. Article 4. Available from: http://repositories.cdlib.org/jmie/sfews/vol5/iss2/art4

Opperman J.J. 2005. Large woody debris and land management in California's hardwood-dominated watersheds. Environmental Management 35(3): 266-277.

Pacific EcoRisk. 2007. U.S. EPA EMAP Physical Habitat Worksheet.

Padre Associates, Inc. 2002. Carpinteria Creeks Preservation Program DRAFT. Prepared for the City of Carpinteria.

Poe T.P., H.C.Hansel, S. Vigg, D.E. Palmer, and L.A. Prendergast. 1991. Feeding of predaceous fishes on out-migrating juvenile salmonids in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society (120)4:405–420.

Questa Engineering Corporation. 2005. Integrated Water Quality Management Feasibility Study. Prepared for the City of Malibu.

Quinn T.P. 2005. The behavior and ecology of Pacific Salmon and trout. Seattle (WA). University of Washington Press. Xii + 378 pp.

Raymond H.L. 1979. Effects of dams and impoundments on migrations of juvenile chinook salmon and steelhead from the Snake River, 1966 to 1975.Transactions of the American Fisheries Society 108:505–529.

Reed G. 2005. Benthic Macroinvertebrate Sampling in the Arroyo Corte Madera Del Presidio Watershed Marin County, California. Mill Valley Streamkeepers: Mill Valley California.

Rehn A., P. Ode, and C. Hawkins. 2007. Comparisons of targeted-riffle and reach-wide benthic macroinvertebrate samples: implications for data sharing in stream-condition assessments. California Aquatic Bioassessment Laboratory, Office of Spill Prevention and Response, Department of Fish and Game, Rancho Cordova, California.

Miguel Restrepo M. and P. Waisanen. 2004. Strategies for Stream Classification Using GIS. U.S. Geological Survey, 2004.

Rieman B.E., R.C. Beamesderfer, S. Vigg, T.P. Poe. 1991. Estimated loss of juvenile salmonids to predation by northern squawfish, walleye, and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:448–458.

Roni P. and T.P. Quinn. 2001. Density, and size of juvenile salmonids in response to placement of large woody debris in western Oregon, and Washington streams. Canadian Journal of Fisheries and Aquatic Sciences 58:282–292.

Rosenfeld J.S. and L. Huato. 2003. Relationship between large woody debris characteristics and pool formation in small coastal British Columbia streams. Northern American Journal of Fisheries Management 23:928–938.

Roset N., G. Grenouillet, D. Gouffaux, D. Pont, P. Kestemont. 2007. A review of existing fish assemblage indicators and methodologies. Fisheries Management and Ecology 14(6):393-405.

Santa Ynez River Technical Advisory Committee (SYRTAC). 1997. Synthesis and Analysis of Information on the Fisheries Resources and Habitat Conditions of the Lower Santa Ynez River: 1993-1996. Prepared for Santa Ynez River Consensus, Santa Barbara, CA.

--- 2000. Lower Santa Ynez Fish Management Plan. Volumes I and II. Prepared for the Santa Ynez River Consensus Committee, Santa Barbara, CA. Final Report. Oct 2, 2000.

Savino J.F. and R.A. Stein. 1982. Predator-Prey Interaction between Largemouth Bass and Bluegills as Influenced by Simulated, Submersed Vegetation. Transactions of the American Fisheries Society:111(3):255–266.

Smith, J.J. 1990. Effects of Sandbar Formation and Inflows on Aquatic Habitat and Fish Utilization in Specadero, San Gregorio, Waddell and Ponponio Creek Estuary/Lagoon Systems, 1985-1989. December 21, 1990. Prepared Under Interagency Agreement 84-040324 between trustees for California State University and the California Department of Parks and Recreation.

Spina A.P., M.A. Allen, and M. Clarke. 2005. Downstream Migration, Rearing Abundance, and Pool Habitat Associations of Juvenile Steelhead in the Lower Main Stem of a South-Central California Stream. North American Journal of Fisheries Management 25:919–930.

Spina A.P. 2000. Habitat Partitioning in a Patchy Environment: Considering the Role of Intraspecific Competition. *Environmental Biology of Fishes* 57:393–400.

--- 2006. Thermal ecology of juvenile steelhead in a warm-water environment. Environmental Biology of Fishes, Accepted 6/06, In Press (DOI 10.1007/s10641-006-9103-7).

Stetson Engineers. 2004. Evaluation of Outflows and Inflows Between Bradbury Dam and Highway 154 Bridge. October 2004.

Stetson Engineers. 2005. Evaluation of Outflows and Inflows Between Bradbury Dam and Highway 154 Bridge.

Stetson Engineers. 2008. Evaluation of Outflows and Inflows Between Bradbury Dam and Highway 154 Bridge.

Stoecker M.W. 2002. Steelhead assessment and recovery opportunities in southern Santa Barbara County, California. Conception Coast Project, Santa Barbara, California.

--- 2004. Steelhead migration barrier inventory and recovery opportunities for the Santa Ynez River, CA. Prepared for the Community Environmental Council, Santa Barbara, California. January 29, 2004. 228 pp.

Storlazzi C.D. and G.B. Griggs. 2000. The influence of El Nino- Southern Oscillation (ENSO) events on the evolution of central California's shoreline. Geol. Soc. Am. Bull (112) 2: 236-249.

Sullivan, K., D.J. Martin, R.D. Cardwell, J.E. Toll, and S. Duke. 2001. An analysis of the effects of temperature on salmonids of the Pacific Northwest with implications for selecting temperature criteria. Sustainable Ecosystems Institute. Portland, OR.

Tabor R.A., R.S. Shiverly, and T.P. Poe. 1993. Predation on juvenile salmonids by smallmouth bass and northern squawfish in the Columbia River near Richland, Washington. North American Journal of Fisheries Management (13)4:831–838.

Thom R.M., and K.F. Wellman. 1996. Planning aquatic ecosystem restoration monitoring programs. 96-R-23, U.S. Army Corps of Engineers Institute for Water Resources and Waterways Experiment Station, Vicksburg, Mississippi.

Thomas R. Payne and Associates (Payne). 2003. Assessment of steelhead habitat in Upper Matilija Creek Basin, Arcata, California. Report prepared for Ventura County Flood Control District (Currently Ventura County Watershed Protection District).

Tidwell J.H., S.D. Coyle, and T.A. Woods. 2003. Species profile: largemouth bass. SRAC Publication No. 722, Southern Regional Aquaculture Center, Stoneville, Mississippi.

Uyehara, J., Ph.D. 2006. MESM 2006 Group Project Proposal: Identifying Environmental Stressors on Biotic Conditions and Responses in Streams on Four Southern California Forests. USDA Forest Service, Southern Province.

U.S. Bureau of Reclamation (Reclamation). 1999. Biological assessment for Cachuma project operations and the lower Santa Ynez River. Prepared for National Marine Fisheries Service.

--- 2000. Revised Section 3 (Proposed Project) of the Biological Assessment for Cachuma Project Operations and he Lower Santa Ynez River. June 13, 2000.

U.S. Environmental Protection Agency (EPA). 2002. Summary of Biological Assessment Programs and Biocriteria Development for States, Tribes, Territories, and Interstate Commissions: Streams and Wadeable Rivers. EPA-822-R-02-048. U.S. Environmental Protection Agency, Office of Environmental Information and Office of Water. Washington, D.C.

--- 2003. Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards. U.S. Environmental Protection Agency; Office of Water; Washington, D.C. April 2003.

U.S. Federal Register. 1997. Final Rule, Endangered and Threatened Species: Listing of Several Evolutionarily Significant Units (ESUs) of West Coast Steelhead. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. U.S. Federal Register, Vol. 62, No. 159. August 18, 1997. Rules and Regulations. Pgs. 43937-43954.

--- 2006. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Federal Register Vol. 71 No. 3 2006.

U.S. Geological Service (USGS). 2005. Real-Time Water Data. http://waterdata.usgs.gov/nwis/rt.

Williams J.G. 2006. Central Valley Salmon: A Perspective on Chinook and Steelhead in the Central Valley of California. San Francisco Estuary and Watershed Science. (4)3:Article 2.

Williams J.G., S.G. Smith, R.W. Zabel, W. Muir, M.D. Scheuerell, B.P. Sandford, D.M. Marsh, R. McNatt, and S. Achord. 2005 (in press). Effects of the Federal Columbia River Power System on salmon populations. Technical memorandum, NOAA-TM-NMFS-

NWFSC- 63. National Oceanic and Atmospheric Administration, Washington, D.C. Available from: http://www.nwfsc.noaa.gov/publications/techmemos/index.cfm.

Wu J., R.M. Adams, and W.G. Boggess. 2000. Cumulative effects and optimal targeting of conservation efforts: steelhead trout habitat enhancement in Oregon. American Journal of Agricultural Economics (82)2:400-413.

Wydoski R.S. and R.R. Whitney. 2003. Inland Fishes of Washington. 2nd ed. Bethesda (MD). University of Washington Press. American Fisheries Soc Xii + 322 pp.

Zimmerman C.E. and G.H. Reeves. 2000. Population structure of sympatric anadromous and nonanadromous *Oncorhynchus mykiss*: evidence from spawning surveys and otolith microchemistry. Can J Fish Aquat Sci 57: 2152–62.

--- 2002. Identification of steelhead and resident rainbow trout progeny in the Deschutes River, Oregon, revealed with otolith microchemistry. Trans. Am. Fish. Soc. 131: 986–993.

Zimmerman C.E. and R.L. Nielsen. 2003. Effect of analytical conditions in wavelength dispersive electron microprobe analysis on the measurement of strontium-to-calcium (Sr/Ca) ratios in otoliths of anadromous salmonids. Fish. Bull. 101: 712–718.

THIS PAGE INTENTIONALLY LEFT BLANK

Santa Ynez River Technical Advisory Committee,
Adaptive Management Committee

Contact Information:

Timothy H. Robinson, Ph.D.
Sr. Resource Scientist,
Cachuma Conservation Release Board (CCRB)
3301 Laurel Canyon Road
Santa Barbara, CA 93105-2017

805-569-1391